# PROCESSING, TECHNOLOGY
# AND
# MARKETING

PLACROSYM III

# PROCESSING, TECHNOLOGY AND MARKETING

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# WELCOME ADDRESS

K. V. GEORGE
*(General Chairman, PLACROSYM III)*

It is my proud privilege to welcome you to this symposium on Plantation Crops, the third in the series organised by PLACROSYM, on behalf of the Standing Committee of PLACROSYM and the Working Committee of PLACROSYM III.

PLACROSYM is a scientists forum sponsored by the Indian Cardamom Research Institute of the Cardamom Board, Central Plantation Crops Research Institute of the Indian Council of Agricultural Research, Central Coffee Research Institute of the Coffee Board, Indian Society for Plantation Crops, Rubber Research Institute of India of the Rubber Board and Tea Research Institute of United Planters Association of Southern India. The annual meets organised by the PLACROSYM apart from promoting understanding and goodwill amongst the scientists working on different plantation crops in the country, also provide a forum to meet and discuss the programmes and progress of scientific research on various plantation crops. The idea of PLACROSYM was first mooted in November 1977 and the first in the series of the annual symposia was organised at the Rubber Research Institute of India, Kottayam on March 20th to 23rd, 1978, the theme of the symposium being Agronomy, Soils, Crop Physiology and Economics. The second in the series was held during December 1979 at Ootty, the local sponsors being the Tea Research Institute, UPASI, the theme of the symposium being Plant Protection.

The current session will centre around recent developments in the fields of Technology, Processing and Marketing related to the various Plantation Crops grown in this country.

Shri Mohana Chandran, IAS, Chairman, Cardamom Board has kindly agreed to preside over the inaugural function. I welcome you Sir. We are extremely lucky in getting Shri S.G. Sundaram, IAS, Chairman, Rubber Board, who is an expert on marketing and market promotion techniques, to inaugurate this function.

I welcome you Sir. Considering the very long and useful agenda we have before us, I think it not proper on my part to spend the time required to extend an individual welcome to the various dignitaries who have assembled here today in response to our invitation. On behalf of the Standing Committee of PLACROSYM and the Working Committee of PLACROSYM-III, I extend to you all our most sincere and warm welcome. On this occasion, I think it only proper to remember two of our colleagues who were earlier associated with PLACROSYM, but who have retired from service in the recent past. I have in mind Dr. C.K.N. Nair, who retired as Director of the Rubber Research Institute of India, Rubber Board and Shri P.K. Mathew, who retired as Director of the Central Coffee Research Institute of the Coffee Board. On this occasion, I wish to place on record the valuable services rendered by them to the cause of the PLACROSYM movement.

The Press in Ernakulam has been very generous and have given wide coverage to this Symposium and many of them are physically present today. To the Press delegates, I extend a hearty welcome. I also welcome the A.I.R. for their patronage.

# VALEDICTORY ADDRESS

K. V. George
*(General Chairman, PLACROSYM III)*

After 2½ days of deep deliberations, we are now at the close of the plenary session, where I have to give a brief resume of the proceedings.

At the inaugural session, Shri K. Mohanachandran, IAS, Chairman, Cardamom Board in his presidential address, exhorted the scientists to be dedicated and emotionally involved on the task of improving productivity and quality of produce. Shri S.G. Sundaram, IAS, Chairman, Rubber Board in his inaugural address mentioned that it is not enough to improve production, but it is imperative that we evolve sound technology for process and product innovation as well as marketing strategies. He adviced that in facing the marketing problems, there is no need to be apologetic, but to face with a sense of confidence and to project the image of the country. Professor Rege, in his guest lecture, opened out a vistarama of unlimited opportunities of new fields of studies that could be taken up profitably.

41 papers centering round fields of analytical aspects of technology and quality improvements, process and product development, as also marketing and market developments on tea, coffee, cardamom, cocoa, pepper, cashewnut, coconut, arecanut, nutmeg, ginger and rubber have been presented and discussed. Development of a carbonated tea beverage, a manually operated arecanut husker, applicator of liquid fertilizers, motorized mechanical aids for pruning tea, a small scale cocoa drier working on ordinary electric bulbs, a through-flow cardamom drier operated by electric power, processing of Arecanut leaf sheaths for utilization as ply board for tea chests, file pads etc., as also for throw away cups and plates, were some of the new innovations presented.

Improved processing techniques for reducing acidity of cocoa beans, extraction and purification of caffein from tea waste, improvement of storage life of coconut oil, and use of indigenously available fillers for preparation of transparent natural rubber compound, discussed in some of the papers, promise practical application. Markets, market structure, market prospects, marketing problems, pricing efficiency, economic evaluation, etc., in respect of rubber, coconut, cashew, coffee, pepper and ginger were also discussed.

Apart from the Cardamom Board, Central Plantation Crops Research Institute, Coffee Board, Indian Society for Plantation Crops, Rubber Board and the UPASI, the primary sponsoring institutions, we had good response from other sister institutions interested in plantation crops. We are thankful to the Department of Chemical Technology, University of Bombay, The Tocklai Tea Research Station, the Central Food Technological Research Institute, Mysore, Flavours and Essences Ltd., Mysore, the Regional Research Laboratory, Trivandrum, the Kerala Agricultural University, the Plantation Corporation of Kerala, the Kerala Forest Development Corporation, the Directorate of Cashew Development Ernakulam, the Directorate of Arecanut, Spices and Cocoa Development, Calicut, the Bureau of Economics and Statistics, Trivandrum and the various other concerns connected with plantation crops who had sent delegates to participate in the symposium.

We are thankful to M/s. A.V. Thomas and Co., M/s. Pyrites, Phosphats and Chemicals Ltd., M/s. Travancore Chemical manufacturers, M/s. Union Carbide, M/s. Premier Irrigation Ltd., M/s. Crop Care Ltd., M/s. Palm Chemicals Ltd., M/s. American Spring and Pressing Works, M/s. Sujirkars Ltd., M/s. Ninan's Chemical House and M/s. Sandoz Ltd., for various facilities extended which contributed to the success of the symposium.

I would once again thank the concerned authorities of the Central Institute of Fisheries Technology for making the conference hall and associated facilities available for conducting this symposium. The sponsors are highly thankful to All India Radio and Press in Cochin for the excellent coverage being given to the symposium.

The sponsors are also thankful to the chairmen and rapporteurs of the different sessions for conducting the deliberations very efficiently.

I take this opportunity to thank the sponsoring institutions for their continued patronage. I also wish to express my sincere thanks to the standing committee and working committee members of PLACROSYM for their unstinted co-operation and assistance.

I would also like to express my personal thanks and gratitude to Dr. N.P. Jayasankar, Co-convener and Shri Antony Cherian, Joint Convener for the responsibilities shouldered by them. In fact they were the architects responsible for the smooth running of this symposium.

Now, I would thank you one and all, ladies and gentlemen, for your presence, for the excellent way in which all of you have conducted yourself and for your very valuable observations and suggestions.

Thank you and wish you the Season's greetings. I declare the Placrosym-III closed.

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# TECHNOLOGY - ANALYTICAL ASPECTS

(Session I)

*Chairman* : **C. M. George**

*Rapporteur* : **Babu Kuriakose**

# ANALYSIS OF DIFFERENT PEPPER GRADES

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## ABSTRACT

**Pepper (*Piper nigrum*) is the major exportable spice grown in India. The significant constituents of the quality of pepper are the pungent principle piperine and essential oil though starch, fibre and fat form the major constitutents. The paper reports the chemical analysis of different commercial grades of mixed varieties as being exported and also different grades obtained from four isolated varieties. A comprehensive study of change in chemical composition from the earliest maturity to ripe stage shows that piperine and volatile oil content increase up to a stage just before maturity.**

## INTRODUCTION

Pepper (*Piper nigrum*) referred as 'Karuthaponnu' in Kerala is a major exportable spice grown in India. The exporters after collecting pepper of different varieties from various sources pool and grade them as per Agmark specifications (Anonymous, 1975) based on physical characteristics such as size, density, moisture content, presence of extraneous matter, damaged produce etc. The ungarbled black pepper contains pin heads, hollows, immature, mature pepper and large berries. Half pepper and light pepper grades are separated by air classification. Half pepper which is relatively immature berries has density between normal black pepper and light pepper. Pin heads which come along with garbled black pepper are separated by using 8 mesh sieves. From the remaining which consists of mainly the average sized Malabar garbled grade (MG) Tellicherry Garbled Extra Bold (TGEB) with a diameter of 4.25 mm and Tellicherry Garbled special extra bold (TGSEB) with a diameter of 4.75 mm are separated by suitable sieves. The bulk of the export and consumption of pepper is in the form of Malabar garbled grade which can also be classified into MG1 and MG2 depending on their light pepper content.

There are scattered reports in the literature about the chemical analysis of pepper of various cultivars (Dwarakanath *et al.*, 1958; Dwarakanath *et al.*; 1963; Lewis, *et al;* 1969; Jose and Nambiar, 1972; Lewis *et al,* 1976) as well as different regions of India (Dwarakanath, 1961) and different trade grades and by-products (Dwarakanath *el al,* 1959). Maturity studies have been conducted by various workers (Dwarakanath *et al.*, 1963; Pruthi, *et al,* 1976; Govindarajan, 1976; Sumathykutty *et al,* 1979). Though starch, fibre and fat form the major constituents, the more significant ones from the point of view of quality will be the pungent principle piperine and essential oil. The present study is a comparison of important quality determining factors of different commercial grades of mixed varieties and different grades obtained from four pure cultivars. It also reports the difference in chemical composition of pepper berries of a spike as being plucked to make black pepper. These berries at different stages of maturity may also follow a pattern of change as far as size is concerned which is the main basis for grading of pepper.

## MATERIALS AND METHODS

The berries at different stages of maturity were sorted out by colour difference and hand feeling from a single batch of harvest done from Nedumangad area in Trivandrum District into six stages (i.e.) (1) 'Pin head' (2) 'between pin head and immature' (3) 'immature' (4) 'under mature' (5) 'mature' and (6) 'ripening'.

Volatile oil was determined by hydrodistillation method using Clevenger trap (Clevenger, 1928) and piperine by spectrophotometric method (Tausig *et al,* 1956). Oleoresin contents were determined by cold percolation using ethylene dichloride as solvent. Crude fibre, non-volatile ether extract (NVEE) and starch were determined by AOAC (AOAC, 1975). Moisture was determined by toluene distillation method (AOAC, 1975).

Weight of a single berry was calculated by taking a fixed number of berries (20–100 depending upon size) and dividing the weight by the number of berries taken.

## RESULTS AND DISCUSSION

Analysis of various commercial grades are tabulated in Tables 1 and 2. Light pepper consisting of berries which are hollow inside due to microbial and insect attack, shows a low starch content and high fibre content. Since the core has more of the starch and less of fibre (Lewis *et al*, 1969) it is understandable that it shows a low starch and high fibre content. Compared to other grades it gives maximum yield of extractives (NVEE) and shows high piperine and essential oil content. Half pepper is believed to be of a lower maturity stage and it shows the highest piperine and essential oil content, with a very good yield of extractives. Pin head shows a low volatile oil, piperine, starch and high crude fibre contents. With increasing grade size, while active constituents like volatile oil and piperine do not show any definite pattern of change, the starch content by a small increasing trend and fibre content by a decreasing trend indicates the possibility of larger grades being of higher maturity stages. Among the ungarbled grades, Tellicherry ungarbled shows a higher volatile oil and piperine content. Probably this grade contains a larger proportion of berries that have reached undermature or immature stage.

**Table 1: Analysis of different commercial grades of pepper**

| *Grades* | *Av. wt of berry (g)* | *Bulk density(g/L)* | *Density (G/ml)* |
|---|---|---|---|
| Pin heads | 0.004 | 280 | 0.571 |
| Light | 0.010 | 240 | 0.476 |
| MG | 0.042 | 540 | 0.952 |
| TGEB | 0.057 | 544 | 1.000 |
| TGSEB | 0.061 | 592 | 1.053 |
| Malabar ungarbled | 0.039 | 540 | 0.952 |
| Tellicherry ungarbled | 0.034 | 528 | 0.952 |
| High range ungarbled | 0.040 | 600 | 1.053 |
| Half pepper | — | — | — |

**Table 2: Comparison of quality factors between various grades.**

| | *Quality factors* | *pin head* | *Light* | *MG* | *TG* | *TGSEB* |
|---|---|---|---|---|---|---|
| *Piperine %* | Panniyur | 0.8 | 5.4 | 4.8 | 4.6 | 4.3 |
| | Kalluvalli | 1.1 | 5.1 | 5.2 | 4.6 | 3.9 |
| | Karimunda | 0.6 | 5.4 | 4.8 | 3.9 | 3.8 |
| | Kottanadan | 2.2 | 5.3 | 3.9 | 4.0 | 3.6 |
| *Volatile Oil %(v/w)* | Pan., | 1.0 | 3.0 | 3.1 | 3.0 | 3.0 |
| | Kall., | 0.9 | 2.7 | 2.9 | 3.4 | 3.0 |
| | Kari., | 0.9 | 3.0 | 2.4 | 2.2 | 1.3 |
| | Kotta., | 1.0 | 3.0 | 3.3 | 2.7 | 2.2 |
| *Extractives %* | Pan., | 3.5 | 10.1 | 8.8 | 8.9 | 8.0 |
| | Kall., | 3.5 | 8.7 | 8.9 | 8.3 | 7.6 |
| | Kari., | 2.3 | 8.0 | 7.6 | 6.5 | 6.9 |
| | Kotta., | 5.7 | 10.9 | 7.6 | 7.0 | 5.8 |

The results of analysis of different grades from the four cultivars (i.e.) Panniyur, Kalluvalli, Karimunda and Kottanadan are given in Table 2. The Grades TG and MG give comparable values with respect to volatile oil and extractives with piperine content slightly more in the latter. TGSEB has slightly lower volatile oil, extractives and piperine values compared to TG and MG grades. It can be attributed to higher starch content in the bold berries as was seen in the case of commercial grades wherein also the MG grade analysed for higher essential oil, piperine content and extractives yield. The pattern of change in quality factors is more or less similar to the commercial grades with increasing grade size. The Panniyur variety analysed for fairly good quality factors. The yield of extractives is also high. As in the case of commercial grade, the pin heads of all the varieties show to be very poor in quality factors. Both in the commercial grade and the grades from the pure cultivars, the light pepper give the maximum value for piperine and extractives yield. The volatile oil content is also comparable. Thus along with half pepper, it could probably be best sources for oleoresin manufacture and should be used properly.

Analysis of pepper berries of different maturities are given in Table 3. Average weight of the berries increase upto about mature stage but during ripening the wet weight actually records a decrease. Moisture content comes down from 82.5% at pin head stage to 60% at mature stage and thereafter. There is a sharp drop to about 40% on the ripening stage. Because of this the dry weight of the berry continues to show an increase even at the ripening stage.

**Table 3 : Composition of pepper at different maturity stages**

| *Maturity of pepper sample* | *Moisture (%) wt* | *Av. berry wt* | | *Vol. Oil % v/w* | *Piperine %* | *Crude fibre %* | *Starch %* |
|---|---|---|---|---|---|---|---|
| | | *Wet (mg)* | *Dry (mg)* | | | | |
| Pin head stage | 82.5 | 24 | 4 | 2.0 | 0.4 | 18.0 | 15.3 |
| Between pin head and immature stage | 77.5 | 68 | 15 | 2.0 | 1.9 | 14.7 | 18.5 |
| Immature stage | 75.0 | 101 | 25 | 4.8 | 6.8 | 13.0 | 38.4 |
| Undermature stage | 65.0 | 151 | 53 | 4.4 | 6.2 | 11.8 | 38. |
| Mature Stage | 60.0 | 156 | 62 | 3.7 | 4.2 | 10.5 | 40.9 |
| Ripening stage | 40.8 | 132 | 78 | 2.2 | 4.0 | 8.7 | 46.2 |

Both volatile oil and piperine concentration on dry weight basis, show an increase upto just before full maturity and thereafter decrease upto ripening stage. In the case of piperine, it reaches the maximum at about a stage slightly less than normal maturity. Starch content shows an increasing trend during entire maturation period studied. There is a sharp increase during early maturation stages and there is gradual increase during ripening stage. The crude fibre content steadily drops during maturation. The decrease shown in the concentration is obviously due to large increase in dry weight contributed significantly by starch and other constituents.

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# RAPID METHODS FOR DETERMINATION OF MOISTURE IN CARDAMOM CAPSULES

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## ABSTRACT

**Both dielectric and conductivity moisture meter readings have shown some relationship with moisture determined by toluene distillation method. Kappa moisture meter based on dielectric property/concept has shown satisfactory results as a possible rapid method of determination of moisture, if calibration is carried out in each case of similar samples.**

## INTRODUCTION

Moisture contents of commercial samples of cardamom have been found to be varying from 7 to 20% depending upon the region and mode of curing. (George Varkey, 1980 and Krishnamurthy *et al.*, 1967). Moisture content of above 10% is detrimental to the chlorophyll and will result in fading of green cardamom. In the trade circles 8 to 9% of moisture is considered ideal. Drying standards and the moisture level are of prime importance in buying the commodity. The traders at present judge this by shaking the capsules in hand. Well dried samples produce a typical tinkling noice on shaking. Experience usually leads towards a sound judgement, but the method is arbitrary and not fool proof.

No quick objective method is available for moisture determination of cardamom. Oven method of moisture determination is not suitable because of the presence of volatile oil. The only reliable but time consuming method now employed is the Dean and Stark toluene distillation method. Evaluation of the conductivity and dielectric moisture determination methods and their results are reported in this paper.

## MATERIALS AND METHODS

Samples of Cardamom were collected from different parts of Kerala and Karnataka States.

Moisture content was determined by Dean and Stark toulene distillation method, 1960. 10 g of cardamom after crushing with a mortar and pestle was distilled with 100 ml of toluene.

Cardamon capsules (5–10 g) were ground in a dry grinder to determine moisture in a Marconi conductivity moisture meter. Whole capsule lots of different sizes were used to determine moisture using Kappa moisture meter.

## RESULTS AND DISCUSSION

The moisture contents as determined by the different methods and the relations with dielectric moisture meter reading are presented in Table 1. It can be seen that both oven method and IR moisture determination method gave very high values as compared to values obtained by toluene distillation method. This was because of the evaporation of volatile oil. Kappa moisture readings based on dielectric constant, with different sample sizes have shown a reasonable linear relationship with moisture content as determined by toluene distillation method.

Two samples, one each from Mailadumpara and an estate near Nagercoil were used in drying trials employing an electrical through flow drier. Samples were drawn at different stages of drying for moisture determination. Depending upon the bulk density in the case of the former lot size was fixed at 400 g and in the case of later 460 g. The results are represented in Fig. 1 and 2. In both cases it could be seen that there existed a fairly good relationship. In the case of Mayiladumpara sample with a sample size of 400 g, the correlation coefficient was $r = 0.990$ while in the case of Nagercoil sample with a sample size of 460 g it was $r = 0.987$.

Another rapid moisture determination equipment based on conductivity was also tried. The moisture content by toluene distillation and Marconi meter readings are given in Table 2.

**Table 1. Relationship between moisture content and dielectric moisture meter readings**

| *Sample descriptions* | *Moisture* | | | *By Kappa moisture meter (readings)* | | | | |
|---|---|---|---|---|---|---|---|---|
| | *By toluene distillation %* | *By oven method %* | *By IR moisture meter %* | 375 *g* | 400 *g* | 425 *g* | 450 *g* | 475 *g* |
| Alkali treated dried in cross flow drier | 6.0 | — | — | 172 | 183 | 195 | 206 | 216 |
| Control dried in cross flow drier | 6.0 | — | — | 174 | 185 | 196 | 205 | 212 |
| Kallar flue pipe store | 7.0 | 15.86 | 15.0 | 205 | 213 | 226 | 238 | 248 |
| Pambadumpara flue pipe store | 7.0 | 16.3 | 15.0 | 203 | 212 | 221 | 232 | 242 |
| Through flow dried bottom layer | 7.5 | — | — | 208 | 218 | 231 | 245 | 254 |
| Mercara flue pipe store | 7.5 | 15.49 | 15.0 | 243 | 252 | 271 | 286 | 298 |
| Through flow dried top layer | 8.0 | — | — | 208 | 220 | 233 | 266 | 252 |
| Through flow dried bottom layer | 10.0 | — | — | 236 | 246 | 261 | 272 | 285 |
| Mercara platform dried | 11.0 | 17.2 | 16.0 | 268 | 281 | 297 | 311 | 321 |
| Mercara flue pipe dried | 12.2 | 19.92 | 18.0 | 530 | 554 | 578 | 598 | 609 |
| Through flow dried top layer | 13.0 | — | — | 430 | 441 | 461 | 485 | 505 |
| Sakelespur sun dried | 18.0 | 26.04 | 21.0 | — | Out of range ............... | | | |

Fig. 1 RELATIONSHIP BETWEEN DIELECTRIC MOISTURE METER READING AND MOISTURE CONTENT OF DRIED CARDAMOM CAPSULES (Sample size 400g)

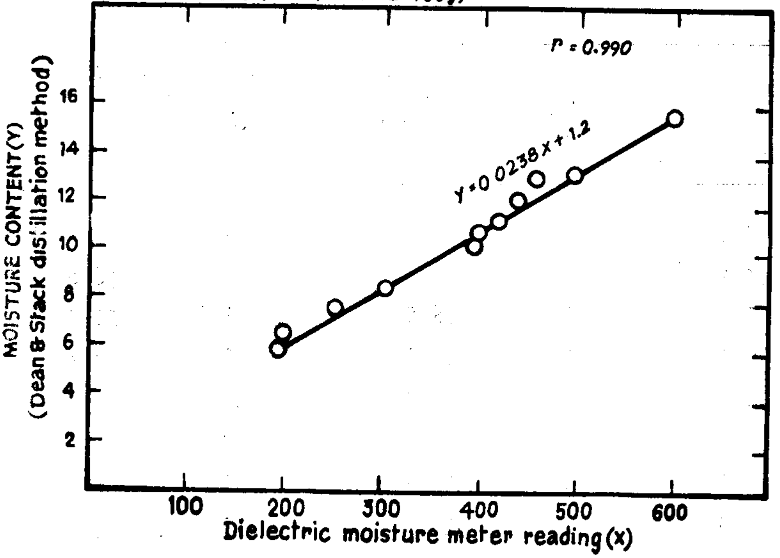


Fig. 2 RELATIONSHIP BETWEEN DIELECTRIC MOISTURE METER READING AND MOISTURE CONTENT OF DRIED CARDAMOM CAPSULES (Sample size 460g)

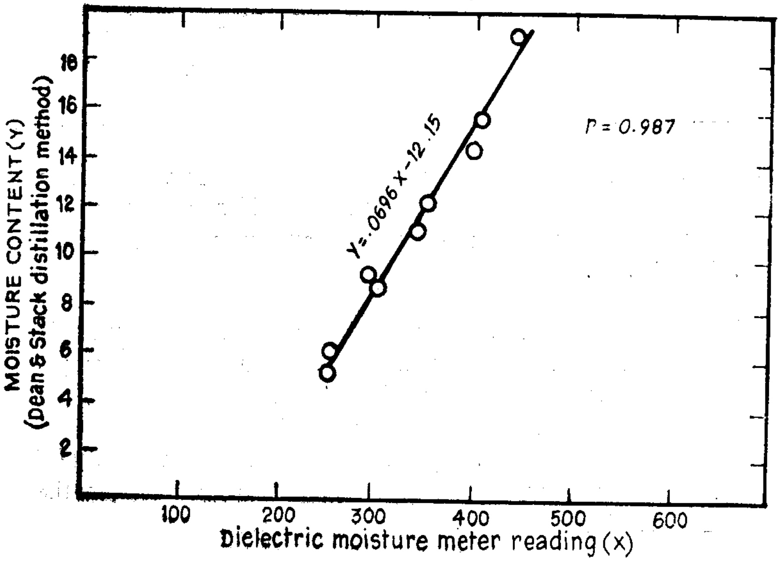


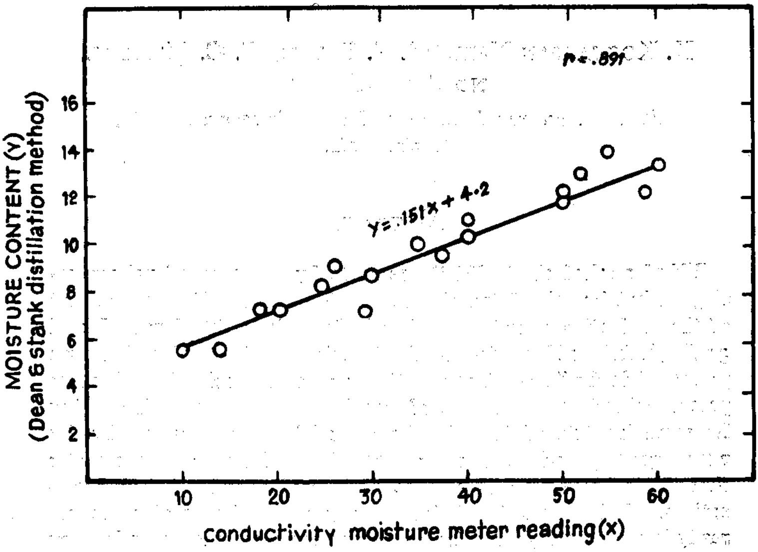
Table 2. **Relationship between moisture content and Marconi conductivity moisture meter readings**

| *Moisture content Dean & Stark* | *No. of samples* | *Marconi conductivity reading* | | |
|---|---|---|---|---|
| | | *Lower limit* | *Upper limit* | *Mean* |
| 6.0 | 7 | 7.0 | 23.5 | 15.6 |
| 6.5 | 1 | — | — | 18.5 |
| 7.0 | 7 | 18.5 | 23.0 | 23.0 |
| 7.5 | 2 | 16.0 | 39.0 | 27.5 |
| 8.0 | 5 | 15.0 | 25.0 | 21.5 |
| 9.0 | 2 | 27.5 | 37.5 | 26.7 |
| 9.5 | 2 | 37.5 | 39.5 | 38.5 |
| 10.0 | 5 | 25.5 | 39.5 | 32.0 |
| 11.0 | 2 | 40.0 | 50.0 | 45.0 |
| 12.0 | 3 | 50.0 | 59.0 | 53.0 |
| 13.0 | 2 | 50.0 | 52.0 | 51.0 |
| 14.0 | 1 | — | — | 55.0 |
| 18.0 | 1 | | Not readable | |

It can be seen that within each moisture range there was a more or less large variation although the average itself was fairly linear. The coefficient of correlation worked out was found to be r = 0.891 (Fig. 3).

Use of Kappa moisture meter appears to be more suitable on account of operational convenience, in addition to the sample used being in tact without involving grinding as compared to the conductivity meter. Variations due to differing bulk densities could be best avoided by taking sample size for an accuracy of ±0.2%. Uniform packing in the sample container increases the precision of the determination.

Fig.3 RELATION BETWEEN CONDUCTIVITY MOISTURE METER READING AND MOISTURE CONTENT OF DRIED CARDAMOM CAPSULES



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# A COMPARATIVE STUDY OF VISUAL GRADING AND TECHNICAL SPECIFICATION FOR RIBBED SMOKED SHEETS

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## Abstract

**Ribbed smoked sheets (RSS) are made by the conventional processing method by using latex obtained in plantations. 60 to 70 percent of the production of natural rubber in India is in this form. Visual grading is followed in marketing ribbed smoked sheets based on the norms prescribed in the "Green Book". The grading of block rubber (modern process rubber) is on the basis of technical specifications. The rubber Research Institute of India has been receiving regularly samples for visual grading and technical specifications. Sheet rubber samples thus received have been subjected to visual grading and technical specifications. It has been found that visually graded low grades are not really lower in quality when the parameters as per technical specifications are examined. A suggestion to improve the visual grading system is given.**

## Introduction

The major marketable forms of processed natural rubber are ribbed smoked sheets (RSS) pale latex crepe (PLC), estate brown crepe (EBC), solid block rubber and concentrated latex. Seventy to eighty five precent of estate produce is in the form of field latex which can be processed into ribbed smoked sheets, pale latex crepe, concentrated latex or block rubber. About 10 percent of the total rubber produced in India is sold as concentrated latex and less than 3 per cent is in the form of pale latex crepe. The scrap rubber which constitutes 15 to 30 percent of the total production in an estate is processed in the form of estate crepe. Thus, 60 to 70 percent of the natural rubber produced in India is processed in the form of ribbed smoked sheets.

In the case of major rubber producing countries like Malaysia and Indonesia, 40 to 45 percent of the produce is in the form of modern process rubber viz. solid block rubber. However, even today in these countries 40 percent of the rubber produced is marketed as visually graded ribbed smoked sheets.

Progress in the production of technically specified rubber in India has been reported earlier. (Thomas and Kochappan Nair, 1976). Visual grading system as per the norms prescribed in the "Green Book" published on "International standards of quality and packing for natural rubber grades" by the Rubber Manufacturers' Association, U.S.A. is followed with respect to ribbed smoked sheets and crepe rubbers. (Rubber Manufacturers' Association, 1969). There are six grades viz. RSS 1 X, RSS 1, RSS 2, RSS 3, RSS 4 and RSS 5 for ribbed smoked sheets. The grading is based on visual examination of the sheet rubber for the extent of mould growth, distribution of foreign matter, degree of dryness, strength and soundness of sheets etc. The grading of modern process rubber is done by the analysis of rubber for dirt, volatile matter, ash and nitrogen contents and Po and PRI. The significance of technical specifications for rubber has been reported in an earlier publication (Kochappan Nair, 1978). There are five grades according to Indian standards and these are ISNR 5 Special, (Indian standard natural rubber), ISNR 5, ISNR 10, ISNR 20 and ISNR 50 (Indian Standards Institution, 1977). The detailed procedure for the analysis has been given in the Indian Standard.

Earlier workers have assessed the relationship of visual grading of a few grades with the technical specification (Nair, S. 1975 and Abraham and Matthan 1975). In this paper an attempt has been made to compare visual grading with technical specifications for ribbed smoked sheets using as many sheets as possible under each of the visual grades.

## MATERIALS AND METHODS

The ribbed smoked sheet samples sent by M/s.Ceat Tyres, Bombay were used for the study. The number of samples under each of the visual grades is given in Table 1. The sheets were visually graded according to the norms laid out in the "Green Book". The samples were analysed for grading them according to the technical specifications of Indian Standard Natural Rubber. The procedures prescribed in IS:3660 (Parts I, II and III) were followed for the estimation of parameters like dirt, volatile matter, ash and nitrogen contents as well as Po and PRI (Indian Standards Instituion, 1966, 1971 and 1972).

**Table—1. Number of samples analysed under each of the visually graded sheets**

| | |
|---|---|
| RSS. 1 X | Nil |
| RSS. 1 | 67 |
| RSS. 2 | 106 |
| RSS. 3 | 100 |
| RSS. 4 | 39 |
| RSS. 5 | 13 |
| Rejection | 9 |

## RESULTS AND DISCUSSION

### Dirt

The percentage of sample of different visually graded rubbers falling under different ranges of dirt content is given in table 2.

**Table–2. Results of analysis of samples for dirt content.**

| *Grade* | *Less than* 0.05% | *Above* 0.05 *and below* 0.10% | *Above* 0.10 *and below* 0.20% | *Above* 0.20 *and below* 0.50% | *Above* 0.50% |
|---|---|---|---|---|---|
| | | (Percentage of samples) | | | |
| RSS. 1 | 89.5 | 10.5 | Nil | Nil | Nil |
| RSS. 2 | 89.5 | 10.5 | Nil | Nil | Nil |
| RSS. 3 | 87.0 | 12.0 | Nil | 1.0 | Nil |
| RSS. 4 | 72.9 | 18.0 | 8.0 | 2.0 | Nil |
| RSS. 5 | 62.0 | 23.0 | 7.5 | 7.5 | Nil |
| Rejection | 11.0 | 33.0 | 44.0 | Nil | 11.0 |

The results show that higher the visual grade, greater the number of samples having lowest dirt content. But the majority of the sheet samples of all the visual grades had dirt equivalent to that prescribed for the high grades viz. ISNR 5 special and ISNR 5. The samples classified as lower grade as per visual classification system are not really low grades as per technical specification for an important parameter like dirt content. Even the rejected rubber as per visual grading was having dirt content in a low limit as is evident from the fact that only one out of the nine rejected samples had dirt content more than 0.5 percent.

**Volatile matter**

Table 3 gives the results of the number of samples falling under different ranges of volatile matter content for different visually graded rubbers.

**Table—3. Results of volatile matter content**

| *Grade* | *Percentage of samples with less than 1% volatile matter* | *Percentage of samples with more than 1% volatile matter* |
|---|---|---|
| RSS. 1 | 96.0 | 4.0 |
| RSS. 2 | 92.0 | 8.0 |
| RSS. 3 | 92.0 | 8.0 |
| RSS. 4 | 95.0 | 5.0 |
| RSS. 5 | 69.0 | 31.0 |
| Rejection | 33.0 | 67.0 |

It is seen that the lowest grade ie. RSS 5 had a higher percentage of samples having more than 1% volatile matter indicating failures. RSS 1 to 4 grades had followed a trend of having more than 90% of the samples within the specified limits. A good percentage of the rejected samples had higher volatile matter having more than 1%.

**Ash**

The results of analysis of the samples for ash content are given in Table 4.

**Table. 4. Results of ash content—Percentage of samples under different ranges of ash content**

| *Grade* | *Less than* 0.6% | *Above* 0.6 *and less than* 0.75% | *Above* 0.75 *and below* 1% | *Above* 1% *but below* 1.5% | *Above* 1.5% |
|---|---|---|---|---|---|
| RSS. 1 | 95 | 4 | — | 1 | Nil |
| RSS. 2 | 96 | 2 | 2 | Nil | Nil |
| RSS. 3 | 95 | 4 | 1 | Nil | Nil |
| RSS. 4 | 87 | 11 | 2 | Nil | Nil |
| RSS. 5 | 85 | 7.5 | 7.5 | Nil | Nil |
| Rejection | 78 | 11 | 11 | Nil | Nil |

The limits of ash content specified for ISNR 5 spl, ISNR 5, ISNR 10, ISNR 20 and ISNR 50 grades are 0.6, 0.6, 0.75, 1.0, and 1.5% respectively. The results indicate that a good percentage of samples of all the visual grades falls under the highest grade ie. ISNR 5 special or ISNR 5.

**Nitrogen**

Table 5 gives the results of analysis of the samples for nitrogen content.

**Table–5. Results of nitrogen content—Percentage of samples under different ranges of nitrogen content**

| *Grade* | *Less than* 0.7% | *Above* 0.7% |
|---|---|---|
| RSS. 1 | 100.0 | Nil |
| RSS. 2 | 100.0 | Nil |
| RSS. 3 | 100.0 | Nil |
| RSS. 4 | 100.0 | Nil |
| RSS. 5 | 100.0 | Nil |
| Rejection | 100.0 | Nil |

The limit of nitrogen content fixed for all the ISNR grades is 0.7%. It is seen that all the visual grades and the rejections are having a nitrogen content within the limit specified as per technical specifications. No sample failed in this parameter.

**Po (Initial Wallace Plasticity)**

The results of testing the sheet rubber samples of different grades for Po are given in Table 6.

**Table–6. Results of Po testing**

| Grade | *Percentage of samples under different ranges of Po*<br>*Less than* 30 | <br>*Above* 30 |
|---|---|---|
| RSS. 1 | Nil | 100 |
| RSS. 2 | Nil | 100 |
| RSS. 3 | Nil | 100 |
| RSS. 4 | Nil | 100 |
| RSS. 5 | Nil | 100 |
| Rejections | Nil | 100 |

It is seen that none of the samples under any of the visual grades failed to conform to the minimum requirement of Po specified as 30 for all the ISNR grades. The rejection as per visual grading too had a Po above 30.

**PRI (Plasticity Retention Index)**

The results of PRI testing of the samples are given in Table 7.

**Table–7. Results of PRI testing**

| *Grade* | *Percentage of samples falling under different ranges of PRI* | | | | | |
|---|---|---|---|---|---|---|
| | *Less than* 30 | *Above* 30 *and below* 40 | *Above* 40 *and below* 50 | *Above* 50 *and below* 60 | *Above* 60 *and below* 80 | *Above* 80 |
| RSS. 1 | Nil | Nil | Nil | Nil | 34 | 66 |
| RSS. 2 | 1.0 | Nil | 1.0 | 1.0 | 34 | 63 |
| RSS. 3 | Nil | Nil | Nil | Nil | 41 | 59 |
| RSS. 4 | Nil | Nil | Nil | Nil | 44 | 56 |
| RSS. 5 | Nil | Nil | Nil | Nil | 46 | 54 |
| Rejections | Nil | Nil | 11.0 | Nil | 44 | 44 |

PRI indicates the ageing resistance of rubber. Higher the degree of oxidation undergone due to contamination of rubber with pro-oxidants like Copper and Manganese or due to poor storage conditions, lower will be the PRI. The minimum limits of PRI prescribed for the ISNR 5 special, ISNR 5, ISNR 10, ISNR 20, and ISNR 50 grades are 80, 60, 50, 40 and 30 respectively. The results obtained show that the failures for this property is significantly negligible for all the visual grades. Further, even lower grades as per visual grading had high oxidation resistance as evidenced by high PRI. The results indicate that there is no relation between visual grading system and technical specification as far as this property is concerned. A similar trend is observed for the properties like dirt, ash, nitrogen and initial wallace plasticity. There is every possibility that sheet rubber classified as lower quality as per visual grading may qualify for higher grades when examined as per technical specification.

In the case of technically specified rubber, cases of samples of off specifications have been reported in earlier references (Sekharan Nair and Lee Long Hing, 1971 and Anonymous, 1972). So it is quite common to expect failures for visually graded rubber for certain parameters according to technical specifications. The results obtained here suggest the need to have a thorough revision of the present visual grading system for the ribbed smoked sheets. The modern trend in grading is to follow simplicity in grading and to minimise the number of grades avoiding complexity and multiplicity of grades. As such, it will be of use if the present six grades of ribbed smoked sheets can be limited either to two or three grades viz. High and low grades or High, Medium and Low grades. The only important thing to be stressed is the degree of dryness. If the degree of dryness is perfected, the presence of foreign matter by way of distribution of dirt, bark particles etc. can be taken into account for assessing the grade. Degradation evidenced by stickiness, presence of burnt portion and blisters have to be further considered in judging the grade. The suggested grades are as follows:

**Three grade system**

RSS. High grade: The rubber should be firm, strong, sound, free of fungal and bacterial growth, free of foreign matter and evenly smoked.

RSS. Medium grade : The rubber should be firm, strong, sound, dry, slightly distributed with foreign matter.

RSS. Low grade : The rubber can be slightly under cured and slightly ovesmoked.

### Two grade system

RSS. High Grade : The rubber should be strong, firm, sound, dry, free of foreign matter and fungal and bacterial growth, evenly smoked.

RSS. Low grade : The rubber should be strong, sound and firm, can be slightly undercured and slightly oversmoked and slightly distributed with foreign matter. Presence of mould growth and bacterial growth to a small extent need not be objected to.

(In all grades the raw material used for processing should be clean field latex which has not undergone pre-coagulation. In no grade blisters, burnt sheets with oxidised spots or sticky rubber should be allowed. Type samples can be prepared to suit the different grades).

### Suggested pricing pattern

An average price of the present RSS IX, RSS 1 and RSS 2 can be fixed for the high grade and that of RSS 3, 4 and 5 can be fixed for the low grade as per the two grade system. If the three grade system is followed, the average price of RSS IX and RSS 1 can be fixed for the High grade, that of RSS 2 and 3 for Medium grade and RSS 4 and 5 for Low grade.

A fruitful dialogue between the producers, products manufacturers and dealers is suggested to probe the possibility of introducing such a revised grading system at least to suit the Indian conditions of marketing.

### Conclusions

Visually graded low grade rubbers may qualify for high grades of technically specified rubbers. For a number of parameters there is no relation between visual grading and technical specification. Based on the results, it is suggested that the six grades of ribbed smoked sheets as per the present visual grading system may be reduced to two or three grades viz. High and Low or High, Medium and Low grades. The policy of pricing the suggested modified grades is also indicated.

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# CUP QUALITY OF SOME COFFEE SELECTIONS AND VARIABILITY FOR CAFFEINE CONTENT IN SOME COFFEE SPECIES, HYBRIDS AND VARIETIES

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## ABSTRACT

***Coffea canephora*** **(robusta coffee) does not possess such fine aroma as arabica; has acidity but of a harsh type and possesses better body. In arabica, washed coffees (wet processed) generally possess better appearance, fine aroma, mildness and acceptable acidity. The new strains of coffee evolved at Central Coffee Research Institute possessing superior vegetative vigour, higher yield potential and resistance to leaf rust have acceptable quality standards as shown by cup test results.**

**A study of the relationship between fruit and bean characters and cup quality in hybrids of *C. canephora* x *C. arabica* showed the importance of bean thickness, liquor body and acidity in influencing quality.**

**A survey of *Coffea* species and *C. arabica* varieties for caffeine content has shown the species *C. bengalensis, C. khasiana, C. salvatrix* and *C. travancorensis* with only traces of caffeine (nil to 0.70%). The species *C. eugenioides, C. liberica, C. aruwimiensis, C. racemosa* and some varieties of *C. arabica* possessed low values of this constituent (0.07 to 1.28%). The species *C. Arnoldiana, C. abeokutae, C. Dewevrei, C. canephora, C. stenophylla* and *C. excelsa* possessed a high concentration (1.50 to 2.91%).**

## INTRODUCTION

The two principal species of coffee under cultivation namely *Coffea arabica* L. (arabica coffee) and *Coffea canephora* Pierre ex Froehner (robusta coffee) differ for a number of characters of which quality of the produce is one. Arabica bean is known for its fine aroma and acidity but gives a thinner body in the liquor whereas robusta liquor is devoid of aroma, has acidity but of a harsh type and possesses better body. Apart from liquor characteristics, raw bean appearance and roasting properties are also taken into consideration while assessing for overall quality in coffee.

A number of factors such as elevation, cultural practices, nutrition, processing, drying, curing, storing, roasting and brewing have been related with quality (Amorim, 1970; Blore, 1965; Gopal and D'Souza, 1977; Kamau, 1976; Northmore, 1965; Sivetz, 1963). Attempts have also been made to determine the chemical constituents of the bean and their relationship with quality (Amorim *et al.*, 1975; Anonymous, 1974; Gopalakrishna Rao and Natarajan, 1972; Shankaranarayana *et al.* 1974; Sivetz, 1963). However consistent correlation between any of the individual or set of constituents and cup quality is yet to be established.

Caffeine is an important alkaloid present in the coffee bean and responsible for the mild stimulating property of the brew. Certain ill-effects from excessive use of coffee on the human system have been attributed to caffeine and the world consumption seems to have been affected by this. To counteract this trend, chemical decaffeination has been perfected and decaffeinated coffee is popularised in the U.S. and other western countries (Sivetz, 1963). The flavour in decaffeinated coffee is however affected during the processing. A widely acceptable and natural solution to this problem would be the identification and breeding of caffeine-free or low caffeine varieties.

A number of selections combining high vegetative vigour, yield potential and resistance to leaf rust (*Hemileia vastatrix* B. and Br.) have been evolved in coffee at the Central Coffee Research Institute by adopting well known plant breeding procedures like mass selection, pure line selection, pedigree selection and backcross breeding (Vishveshwara, 1976, Srinivasan and Vishveshwara, 1980). Seed samples from all the selections have been assessed for quality. The objectives of the present study were to compare the selections with regard to some parameters of quality, compare the caffeine content of some species, hybrids and varieties and find out the relationship between some fruit and bean characters and cup quality.

## MATERIALS AND METHODS

Wet processed, sun dried and graded ('A' grade) bean samples (progeny bulk and individual plant) from various selections were sent to cup testing centres (London, Hamburg and Bangalore) for assessment of quality (raw bean appearance, roasting characteristics and cup quality) during the years 1957 to 1978. Leaf samples of 11 species, bean samples of 15 species, 7 interspecific hybrids and 58 varieties and collections of arabica were sent to Dr.C.P. Natarajan, Chairman, Discipline of Plantation Products and Flavour Technology, Central Food Technological Research Institute, Mysore, for determination of caffeine. Caffeine percentage was determined on moisture free basis by the modified ultraviolet absorption method of Smith and Rees (1963). Thirty two samples of fruits collected from different generations of a cross between *C.canephora* × *C.arabica* with backcrossing to *arabica* were studied for the following attributes: (1) weight of fruit skin, (2) time taken for natural fermentation of mucilage covering the endocarp (parchment), (3) quantity of mucilage and (4) bean size (length, breadth and thickness). Two hundred grams of sun dried beans (10–12% moisture) from each sample were sent to Cup Testing Unit, Coffee Board, Bangalore for evaluation of quality. After obtaining the cup test results, scoring indices were set up for classification of cup quality (1–poor, to 9–fine), liquor body (1–very light, to 4–good) and acidity (0–low, to 5–high). Correlation coefficients were calculated between various characters and cup quality. Characters showing significant correlation were included in a multiple linear regression analysis.

## RESULTS AND DISCUSSION

### Bean size and cup quality of selections:

The relevant data are presented in table 1. It is evident from the table that the number of samples tested per selection varied, with lowest number (2) in Sln. 1 and highest (120) in Sln.6. This may introduce some bias in comparing between selections. Nevertheless, the following points may be noted. Among the arabica selections, six (Sln.3, 3.4, 6, 7, 8 and 9) indicated medium to bold seed size and two (Sln.1 and 5), small to medium seed size. One selection (Sln.4) which consists of some Ethiopian arabica varieties, indicated a wide range for seed size (small to medium to bold). Robusta selections indicated medium to bold seed size in all the samples.

**Table 1. Bean size (Descriptive) and cup quality in some coffee selections**

| *Selection No.* | *No. of samples tested for quality* | *Bean size ('A' grade)* | *Number and percentage of samples giving f.a.q.** |
|---|---|---|---|
| **Arabica** | | | |
| Sln. 1 (S.26 line) | 2 | small to medium | 1 (50%) |
| 3 (S.795 line) | 43 | generally bold | 21 (51.16%) |
| 4 (Ethiopian arabica) | 20 | small to medium to bold | 6 (30%) |
| 3.4 (S. 1934 X Cioccie, Agaro) | 16 | medium to bold | 11 (68.75%) |
| 5 (Devamachy X S.881 line) | 27 | small to medium | 10 (37.03%) |
| 6 (274 robusta X Kents arabica line) | 120 | medium to bold | 37 (30.83%) |
| 7 (San Ramon hybrid line) | 9 | medium to bold | 4 (44.45%) |
| 8 (Hibrido-de-Timor) | 32 | generally bold | 7 (21.88%) |
| 9 (Hibrido-de-Timor crosses) | 21 | generally bold | 10 (47.62%) |
| **Robusta** | | | |
| Sln. 1 (274 robutsa) | 4 | generally bold | 1 (25%) |
| 3 (Congensis X robusta) | 14 | medium to bold | 1 (7.14%) |
| 4 (S.26 X robusta) | 11 | generally bold | 2 (18.18%) |

*f.a.q. = fair average quality

Regarding cup quality, Sln.3.4 showed the highest percentage of samples (68.75) with fair average quality (FAQ) followed by Sln.3 (51.16). Sln.8 gave the lowest percentage (21.88). The other selections fell in between these limits. The robusta selections had low percentage of samples with FAQ.

During the course of this study it was found that the bean sample from the same progeny or plant obtained different cup classification if sent to two cup testing centres or sampled during different years, pointing to the highly variable nature of quality and its method of assessment in coffee. Visual assessment for size, colour, preparation and roast was not correlated with cup quality. Similar conclusions were drawn by Awatramani *et al.* (1972) from a study of quality in three arabica selections grown at two locations and bean samples sent to two cup testing centres for four years. They however indicated a positive correlation between raw bean colour and quality.

**Caffeine content:**

Caffeine content in seeds of 15 species analysed during 1966–67 ranged from traces in *C.bengalensis* to 2.37 percent in *C.canephora* CV. S.274 (Table 2). Analysis of another set of samples from 12 species during 1969–70 gave values ranging from 0.032 percent (*C.bengalensis*) to 2.91 per cent (*C.canephora* var. Laurentii). Since the samples collected during the two years were from different plants, the differences in values basically reflect plant to plant variation for caffeine. However, some species like *aruwimiensis, racemosa, bengalensis* and *Khasiana* showed closely agreeing values over the two seasons indicating least variability for caffeine content in them. The low caffeine content of *C. bengalensis, C.arabica* var. mokka and *C. eugenioides* and the high caffeine content in *C.canephora* agree with other reports (Cramer, 1957, Carvalho *et al.*, 1965, Sylvain, 1969).

Leaf caffeine of eleven species ranged from 0.017 percent (*C.stenophylla*) to 1.20 per cent (*C.canephora* var.Laurentii). A highly significant positive correlation (.7393 **) was obtained between leaf caffeine and bean caffeine (Table 3), suggesting the ~~possibility of predicting bean caffeine~~ content from leaf caffeine content. Sylvain (1969), however, failed to obtain a significant

**Table 2. Variation in seed caffeine in some Coffea species**

| *Species* | *Caffeine content(%)* | |
|---|---|---|
| | 1966–67 | 1969–70 |
| *excelsa* | 1.15 | 1.50 |
| *liberica* | 1.00 | 1.27 |
| *aruwimiensis* | 1.07 | 1.16 |
| *Arnoldiana* | 1.11 | 1.72 |
| *canephora* var. Laurentii | 1.65 | 2.91 |
| *Dewevrei* | 2.10 | 2.70 |
| *racemosa* | 0.77 | 0.88 |
| *abeokutae* | 0.10 | 1.97 |
| *eugenioides* | 0.43 | 0.89 |
| *stenophylla* | 1.21 | 1.75 |
| *bengalensis* | trace | 0.032 |
| *travancorensis* | n.i. | 1.31 |
| *Khasiana* | 0.04 | 0.072 |
| *salvatrix* | 0.07 | n.i. |
| *canephora* (robusta) S.274 | 2.37 | n.i. |
| *canephora* | 1.98 | n.i. |
| *congensis* | 1.70 | n.i. |
| *arabica* cv. old chiks | 1.28 | n.i. |
| *arabica* cv. Kona | 1.06 | n.i. |
| *arabica* var. mokka | 0.69 | n.i. |

n.i. = not included

correlation for caffeine content between the leaves and beans in 6 arabica varieties. As pointed out by him and as is evident from the present study also, further extensive work is needed for a definite conclusion on this aspect.

**Table 3. Caffeine content in leaves and seeds of *Coffea* species**

| *Species* | *Caffeine content* (%) | |
|---|---|---|
| | *Leaf* | *Seed* |
| *excelsa* | 0.085 | 1.50 |
| *liberica* | 0.34 | 1.27 |
| *aruwimiensis* | 0.42 | 1.16 |
| *Arnoldiana* | 0.37 | 1.72 |
| *canephora* var. Laurentii | 1.20 | 2.91 |
| *Dewevrei* | 1.05 | 2.70 |
| *racemosa* | 0.041 | 0.88 |
| *abeokutae* | 0.015 | 1.97 |
| *eugenioides* | 0.031 | 0.89 |
| *stenophylla* | 0.017 | 1.75 |
| *bengalensis* | 0.073 | 0.032 |
| Correlation | 0.7393 * * | |

Among the seven interspecific hybrids analysed, caffeine content in the seed ranged from 0.84 percent in a plant of *C. excelsa* × *C.eugenioides* to 2.04 percent in a plant of *C. arabica* cv S.26 x *C.canephora* with *canephora* phenotype (Table 4). Advanced generation hybrids of *C.canephora* cv.S.274 × *C. arabica* cv. Kents with back-crossing to arabica showed caffeine contents as in arabica. Similar results were reported by Sylvain (1969) in $F_3$ progenies of a cross between *C. arabica* and *C. canephora*. Hybrids of *C. congensis* × *C. canephora* showed lower caffeine content than pure *canephora* (robusta).

**Table 4. Caffeine content in seeds of some interspecific hybrids in *Coffea***

| *Sl. No.* | *Hybrid* | *Caffeine content (%)* |
|---|---|---|
| 1. | $F_2$ of *excelsa* x *eugenioides* | |
| | Plant 1 | 0.84 |
| | Plant 2 | 1.07 |
| | Plant 3 | 1.34 |
| | Plant 4 | 1.15 |
| | Plant 5 | 1.23 |
| | Plant 6 | 1.18 |
| | Plant 7 | 1.27 |
| | Plant 8 | 1.37 |
| 2. | *congensis* x *canephora* | |
| | $F_1$ | 1.42 |
| | $F_2$ | 1.80 |
| | $BC_1(F_1xP_1)$ | 1.94 |
| | $BC_2(F_1xP_2)$ | 1.61 |
| | I gen. from $BC_2$ | 1.53 |
| 3. | $F_3$ of *arabica* cv.S.26 x *canephora* (canephora phenotype) | 2.04 |
| 4. | *canephora* cv.S.274 x *arabica* cv.Kents | |
| | $BC_2(F_1xP_2)xP_2$ | 1.09 |
| | II gen. from $BC_2$ (2383) | 1.17 |
| | II gen. from $BC_2$ (2385) | 1.22 |
| 5. | $F_2$ of Devamachy x S.881 (2269) | 1.50 |
| 6. | *Spontaneous hybrids* | |
| | Hibrido de timor | 1.24 |
| | Kawisari | 1.39 |

Among *C. arabica* varieties, caffeine content ranged from 0.69 per cent (mokka) to 2.06 per cent (sample number 6 from a collection from Kaffa province in Ethiopoia) (Table 5). Majority of the varieties and collections had caffeine content in the range of 1.2 to 1.4 percent. Collections from Kaffa province showed a wide range of variability (0.86 to 2.06 percent) for caffeine.

From the foregoing results the possibility of breeding low caffeine varieties is indicated. However, the probable effect of season on caffeine content was suggested by Sylvain (1969). Therefore further work is needed before the low caffeine lines indicated in the present study can be utilized in breeding. *C. bengalensis* and *C.Khasiana* which showed the lowest values of caffeine over both the seasons cannot be straight-away introduced into cultivation because of their low yield potential and other differences in seed size and quality. Evolving satisfactory hybrids with them would also be a long range programme.

**Relationship between cup quality and fruit and bean characters:**

Bean thickness, liquor body and acidity showed significant positive correlation with cup quality (Table 6). Liquor body and acidity were positively correlated (.6429 **). Regression analysis revealed that the three characters jointly accounted for 52 percent of the variation in cup quality (Table 7).

From the above results it can be concluded that early (16–24 hours) or late fermentation (upto 48 hours) did not affect quality. The usual time for natural fermentation is 24 to 36 hours (Anonymous, 1976). The significant positive correlation between bean thickness and quality found in the present study needs confirmation by further extensive sampling. It may be related with fat content of the bean which is known to influence quality (Cramer, 1957).

The efficiency of prediction for quality observed by taking three characters (bean thickness, liquor body and acidity) may perhaps be further improved by including other parameters like raw bean appearance, roasting characteristics and aroma. Ramunni Menon *et al.* (1973) found that visual assessment of raw coffee samples tallied with their cup quality results in 45 per cent of the cases (total samples taken 2042) only. Amorim *et al.* (1975) found that 69 percent of the variation in cup test results

**Table 5. Caffeine content in seeds of some varieties, collections and intervarietal crosses of *Coffea arabica* L.**

| *Variety/Collection/Cross* | *Plant/ sample* | *Caffeine content(%)* |
|---|---|---|
| mokka | 1 | 0.69 |
| kona | 1 | 1.09 |
| San Ramon | 1 | 1.32 |
| Geisha | 1 | 1.17 |
| S.12 Kaffa | 1 | 1.28 |
| Agaro | 1 | 1.29 |
| Cioiccie | 1 | 1.25 |
| cv. old chiks | 1 | 1.28 |
| cv. S.288 | 1 | 1.28 |
| Collections from 1964–65 FAO Expedition to Ethiopia | | |
| Shoa province | 1 | 1.82 |
| | 2 | 1.52 |
| Harar province | 1 | 1.02 |
| Sidamo province | 1 | 1.30 |
| | 2 | 1.37 |
| | 3 | 1.19 |
| | 4 | 1.35 |
| | 5 | 1.02 |
| | 6 | 1.15 |
| | 7 | 1.56 |
| | 8 | 1.28 |
| | 9 | 1.16 |
| | 10 | 1.22 |
| | 11 | 1.02 |
| Illubabor province | 1 | 1.83 |
| | 2 | 1.21 |
| | 3 | 1.84 |
| Kaffa province | 1 | 1.86 |
| | 2 | 1.88 |
| | 3 | 1.65 |
| | 4 | 1.61 |
| | 5 | 1.94 |
| | 6 | 2.06 |
| | 7 | 1.65 |
| | 8 | 1.33 |
| | 9 | 1.21 |
| | 10 | 1.11 |
| | 11 | 1.15 |

| *Variety/Collection/Cross* | | *Plant/ Sample* | *Caffeine content(%)* |
|---|---|---|---|
| | | 12 | 1.02 |
| | | 13 | 1.21 |
| | | 14 | 1.15 |
| | | 15 | 1.39 |
| | | 16 | 0.98 |
| | | 17 | 0.86 |
| | | 18 | 1.17 |
| | | 19 | 1.23 |
| | | 20 | 1.28 |
| | | 21 | 1.20 |
| | | 22 | 1.25 |
| cv. S.795 | | | |
| I. gen. progenies | 2289 | 1 | 1.27 |
| | 2299 | 1 | 1.21 |
| | 2301 | 1 | 1.32 |
| cv. S.1934 | | 1 | 1.20 |
| $F_1$ of S.1934 x Agaro | | 1 | 1.24 |
| | | 2 | 1.32 |
| | | 3 | 1.43 |
| | | 4 | 1.41 |

**Table 6. Correlation between cup quality, and some fruit and bean characters in *Coffea canephora* x *C. arabica* hybrids**

| *Sl.No.* | *Character* | *Correlation with cup quality* |
|---|---|---|
| 1. | Weight of fruit skin | —.0036 |
| 2. | Mucilage content | +.1873 |
| 3. | Duration of fermentation | +.1899 |
| 4. | Bean length | +.3100 |
| 5. | Bean breadth | +.2906 |
| 6. | Bean thickness | +.3772* |
| 7. | Liquor body | +.6335** |
| 8. | Liquor acidity | +.5358** |

* Significant at 5%
** Significant at 1%

**Table 7. Regression analysis for cup quality in *C. canephora* x *C. arabica* hybrids.**

| *Sl.No.* | *Regression function* | *Relative Efficiency* [$R^2$%] |
|---|---|---|
| 1. | Y = a + 2.37 BT* | 13.63 |
| 2. | Y = a + 0.96 Body | 40.12 |
| 3. | Y = a + 0.88 Acidity | 28.70 |
| 4. | Y = a + 2.05 BT + 0.91 Body | 49.75 |
| 5. | Y = a + 2.00 BT + 0.80 Acidity | 37.81 |
| 6. | Y = a + 0.75 Body + 0.36 Acidity | 42.94 |
| 7. | Y = a + 1.95 BT + 0.73 Body + 0.29 Acidity | 51.63 |

BT* = Bean Thickness

could be explained by linear regression on ten chemical constituents of the raw bean (total free carbohydrates, NaCl soluble proteins, phosphate buffer soluble proteins, reducing sugars, total chlorogenic acid, water soluble phenols, methanol soluble phenols, NaOH soluble proteins, hydrolyzable phenols and electrophoresis of proteins). The most important constituents in order of their significant regression coefficients were total chlorogenic acid (negative influence) and water soluble phenols (positive influence). Amorim *et al.*, (1976) found that Rio coffees (having phenolic or medicinal taste) had lower bean densities, thinner cell walls and lower cell wall/cytosol volume ratio. These results indicate the possibility of predicting quality by taking both physical and chemical characteristics of the bean.

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# BEHAVIOUR OF FLAME IONISATION DETECTOR IN THE ESTIMATION OF TRACE SOLVENT RESIDUES BY VAPOUR PHASE CHROMATOGRAPHY

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## ABSTRACT

**For greater accuracy and reproducibility it is better to use peak areas or peak height X half height width for quantitative estimations using Gas Chromatograph. They are more sensitive to the relative amounts of the standards used and also to the injector temperature. The injector temperature should be chosen such that it lies in the flat portion of the curve, when the temperature is plotted against detector response. Also as the detector response varies with the injector port temperature and with the relative amounts of the standards present, a mean detector response value should be used for greater accuracy.**

## INTRODUCTION

The use of benzene as internal standard has been recommended for the estimation of trace solvent residues in spice oleoresins(Todd, 1959 and Anonymous, 1974). This depends on the addition of one ml of toluene containing 2500 ppm of benzene to a known quantity of oleoresin followed by distillation and injection into a gas chromatograph. It is believed that the ratios (height, half height width × height and area) of the solvent (acetone, dichloroethane etc.) peak and standard benzene peak are dependent only on their concentrations and not on their actual amounts present. Relative detector response factors were found individually using the expression.

$$Rf = \frac{Ai \times Ws}{As \times Wi}$$

Where Rf is the relative response factor, Ws and Wi are masses of standard and solvents and As and Ai are peak values of the standard and solvent respectively.

During the course of analysis of several samples for trace solvent estimation, it was observed that the peak values were affected by the relative amounts of solvent present in oleoresins and also the detector response factor for acetone-benzene mixtures in toluene changed in the presence of other volatile ingredients of oleoresins. This paper describes studies on the relative detector response factors, influence of the injection port temperature on the detector response and estimation of trace solvent residues.

## MATERIAL AND METHODS

Acetone and benzene were of analytical grade and redistilled before use. Toluene free from benzene was prepared in the laboratory by repeated fractional distillations using a column and reflux arrangement. Binary mixtures of acetone in the 100–500 and 400–4000 ppm range and benzene in the 100–700 and 800–1700 ppm range were prepared in toluene by weighing appropriate quantities and diluting.

Capsicum and Turmeric oleoresins were manufactured in the main plant.

A gas Chromatograph of Chromatography and Instruments Co., Baroda was used in these studies. Chromatograph conditions were Column, UCON POLAR CHRQ-W. CELITE 545.

Oven temperature, 80°C. Detector, hydrogen flame ionisation; carrier gas, nitrogen, 30 ml/minute; compressed air, 250ml/minute; injector port temperature 85, 100, 115, 130, 145°C ± 2°C. Syringe: Hamilton. 701- NCH. with the chaney Adaption. Peak heights (I) half height width × height (II) and Area (III) were used for calculations.

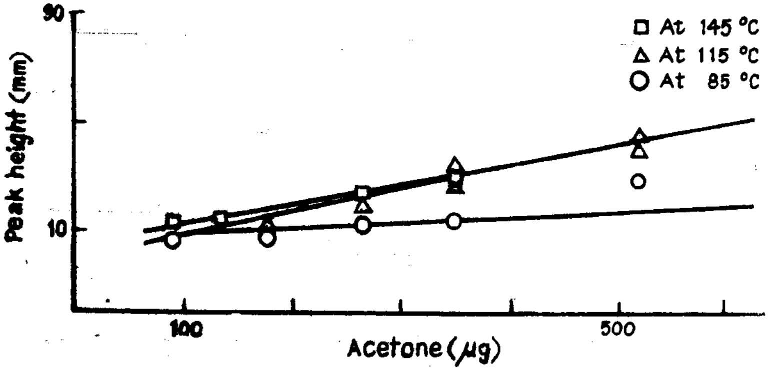
## RESULTS AND DISCUSSIONS

UCON POLAR column was chosen for this study after preliminary trials as this gave good linear values when compared to POROPAK Q column. POROPAK Q column had been reported to contain active sites which undergo alpha exchange with acetone (Barta and Gorden 1970).

### Linearity

The linear relationship of acetone concentration and peak height values at three injector temperatures are shown in fig. I. It will be seen from the figure that the slope has a maximum at an injector temperature of 115°C and more points fall in the line. The same behaviour was observed when II and III were used to check the linearity.

Fig.1 LINEARITY OF ACETONE AT THREE DIFFERENT INJECTOR TEMPERATURES



Benzene also showed a similar behaviour with respect to injector temperature. When benzene concentrations were plotted against peak height, the straight line graph obtained passed through the origin. However, when the concentrations were plotted against II or III although a straight line graph was obtained it did not pass through the origin. The straight line graph when extrapolated gave a negative intercept accounting for about 50 – 125 ppm of benzene. This emphasises the need for using absolutely benezene free toluene as a solvent when benzene is to be used as an internal standard (see fig 2) and when peak areas are used for measurement.

### Acetone-benzene relationship

When acetone concentration was plotted against ratios of acetone/benzene peak areas, the slope increased with injector temperature and best linearity was observed at 115°C (fig 3).

Fig.2 BENZENE CONCN. V/S BENZENE PEAK HEIGHT

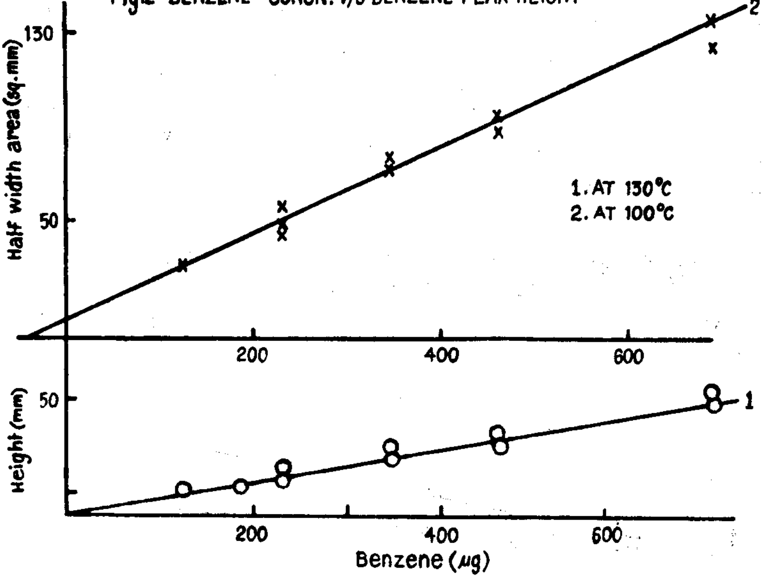
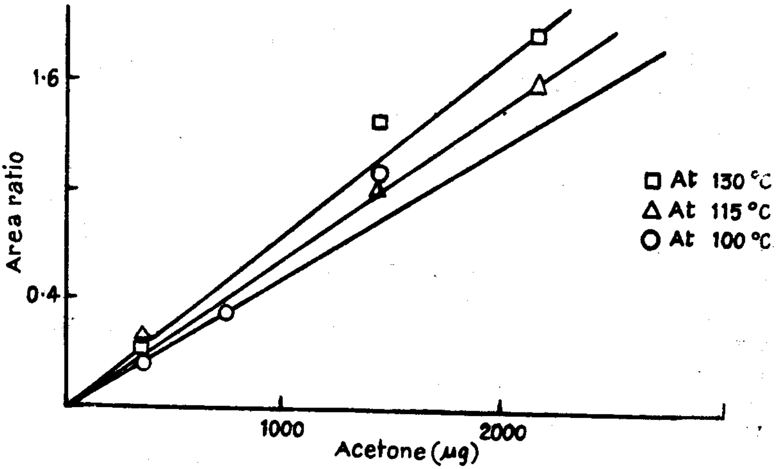
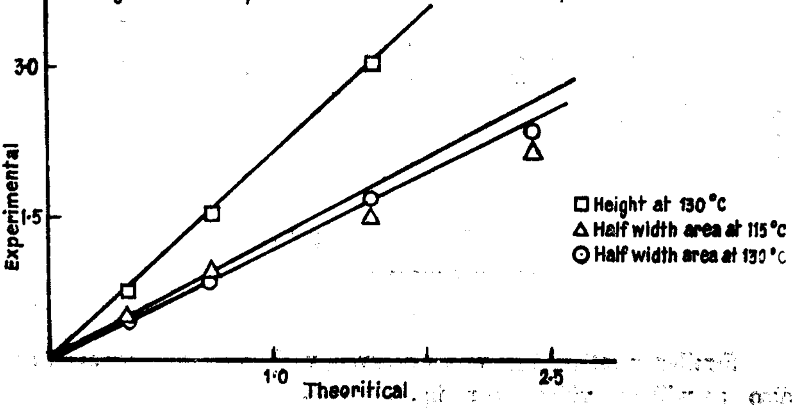


Fig.3 ACETONE CONCN. V/S ACETONE/BENZENE PEAK AREA



When theoretical ratios of acetone/benzene concentrations were plotted against their experimentally observed vlaues, al the points fell in a straight line only at 130°C. The number of points not falling in the line were more at lower temperatures (Fig. 4).

Fig.4 ACETONE/BENZENE RATIOS THEORITICAL V/S EXPERIMENTAL



When binary mixtures of acetone and benzene were injected at five different temperatures (85, 100, 115, 130 and 145°C ± 2°C) and the benzene peak heights or areas were plotted against injection temperature, there was a flat portion of the curve in the region between 100 and 130°C. It can be seen from figures 5 and 6 that above and below this temperature the values deviate. When the individual concentrations of acetone and benzene were near to each other, the flat portion of the curve became longer. Best results were obtained when height × half height width was used for finding the concentration.

Fig.5 INJECTOR TEMPERATURE V/S BENZENE PEAK HEIGHT

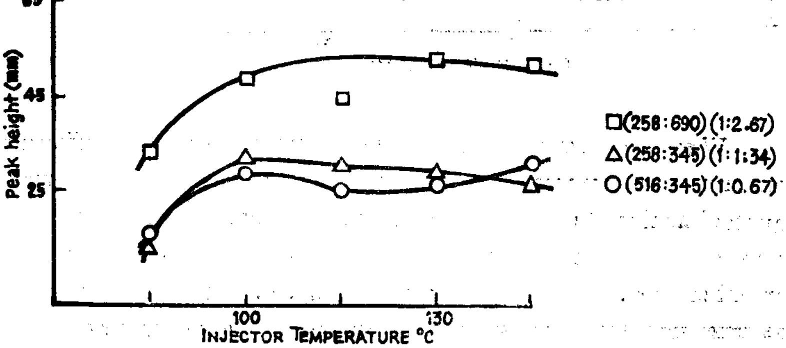
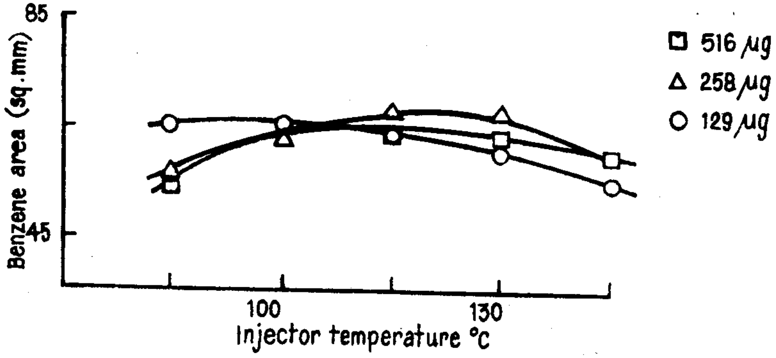
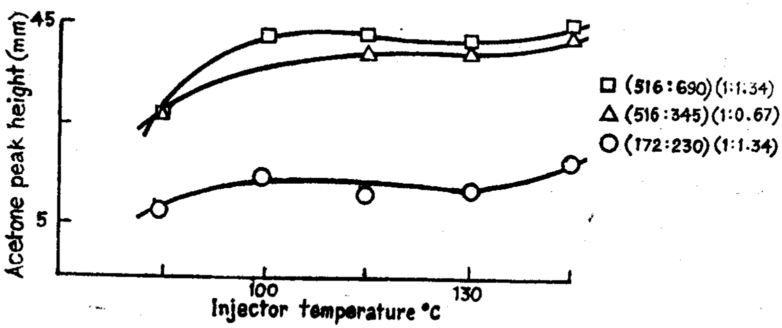


Fig.6 INJECTOR TEMPERATURE V/S BENZENE PEAK AREA



Similar relationship was observed with reference to acetone also as will be evident from fig. 7 and 8.

Fig.7 INJECTOR TEMPERATURE V/S ACETONE PEAK HEIGHT



When the acetone/benzene peak (height) ratios of different amounts, but representing the same concentration ratios were plotted against the injector temperature, again the curve runs parallel to the temperature axis in the 100–130°C range and ascends on either side. This is represented in fig. 9. This was found to be true with area also when used as one of the parameters.

Fig.8 INJECTOR TEMPERATURE V/S ACETONE PEAK AREA

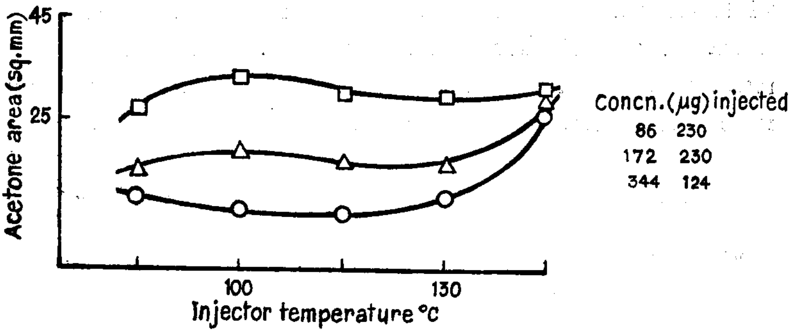
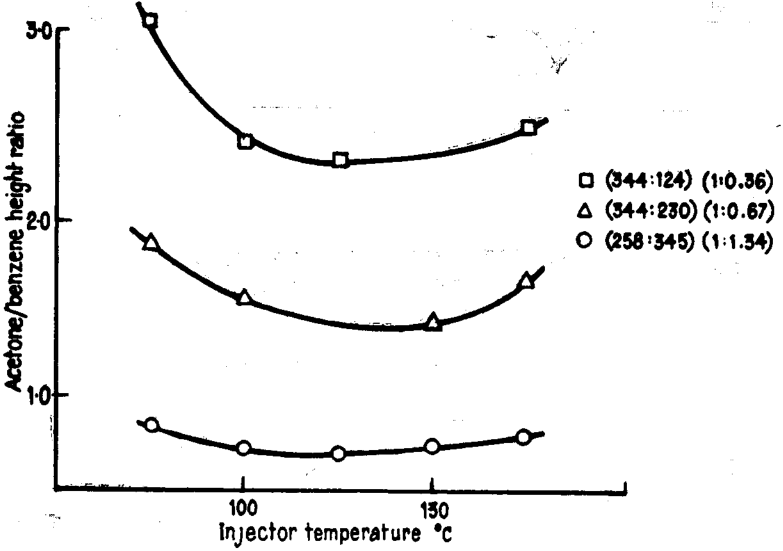


Fig.9 INJECTOR TEMPERATURE V/S ACETONE/BENZENE PEAK HEIGHTS



## Relative detector response

As it became evident that the solvent and the standard peak parameters were affected by injector temperature, the temperature effect on the relative detector response was studied. The reciprocal detector response (using peak heights) was plotted against

Table 2. The Ectophytic mycoflora in the Processed Cocoa beans

| *Mould* (*Percent*) | *Vittal* | *Puttur* | *Peechi* | *Alleppey* |
|---|---|---|---|---|
| Mould | 24.39 | 6.67 | 83.00 | 100.00 |
| Aspergillus | 10.50 | 4.50 | 52.70 | 80.00 |
| Mucor | 5.00 | 2.17 | 17.00 | 15.00 |
| Rhizopus | 2.00 | — | — | — |
| Others (No sporulation) | 6.84 | — | 13.30 | 5.00 |

Table 3. The Endophytic mycoflora in the Processed cocoa beans

| | *Vittal* | *Puttur* | *Peechi* | *Alleppey* |
|---|---|---|---|---|
| Mould Growth (Percent) | 12.00 | 0.00 | 17.85 | 36.00 |
| Aspergillus Sp. (Black) | 4.00 | 0.00 | 3.57 | 12.00 |
| Aspergillus Sp. (Brown) | 4.00 | 0.00 | 7.14 | 18.00 |
| Mucor Sp. | 4.00 | 0.00 | 7.14 | — |
| Others | — | — | — | — |
| Cut test | 1.33 | 0.00 | 4.66 | 5.33 |

**Table 4. The Quantitative Microflora in the Processed cocoa beans**

| *Sl. No.* | *Samples* | *Fungi* ($10^3$) | | *Bacteria* ($10^5$) | |
|---|---|---|---|---|---|
| | | *Surface washing* | *Maceration* | *Surface washing* | *Maceration* |
| 1 | Vittal | 49.66 | 62.00 | 29.13 | 16.00 |
| 2 | Puttur | 33.33 | 15.33 | 22.33 | 12.60 |
| 3 | Peechi | 47.33 | 55.33 | 24.20 | 14.33 |
| 4 | Alleppey | 53.66 | 58.00 | 25.86 | 18.63 |

The qualitative fungal flora and their percentage occurrence indicated the presence of 5 types of *Aspergillus* and 2 types of *Mucor* which are predominantly found in the cocoa beans(Table 5). Few non-sporulating fungi were also observed on Potato dextrose agar plates. Three isolates of *Aspergillus* were tentatively identified as A. *niger, A. flavus* and *A. fumigatus.* The *Mucor* was identified as *Mucor pusillus.* The *Aspergillus* sp was frequently occurring in the processed cocoa beans followed by *Mucor* sp. The other species of fungi observed were *Fusarium, Penicillium* and *Rhizopus.* The yeast and actinomycetes colonies were seen on the plates. The bacteria present in the beans are the three species of *Bacillus* and 2 unidentified.

The effect of mould infection on the butter fat content of processed cocoa beans is shown in Table 6. The butter fat content in check without mould infection was 56 percent. The infection of *Aspergillus* increased the butter fat content of the beans, whereas the infection by *Mucor* sp decreased the butter fat content of the beans. The free fatty acid content by mouldy beans exceeded that of sound beans as reported by Kavanagh *et al* (1970).

Cocoa is generally harvested during wet periods when atmospheric humidity is continuously high. The moisture content of the beans must not exceed 7.5 percent for the purpose of trade outside the producing country (Wood, 1979). All cocoa beans are hygroscopic but some are more hygroscopic than others (Wood, 1965). The testa (shell) and cotyledons (nib) differ in hygrosopicity and consequently the moisture content. The damage to testa (shell) will favour the development of mould inside the cocoa beans. If the moisture content is below 7.5 percent and the testa of the beans is intact, the presence of mould on the surface of the beans will not be able to affect the quality.

The *Mucor pusillus* growth was seen in three samples collected from Vittal, Peechi, and Alleppey. The mould growth is possible in the black pod (*Phytophthora palmivora*) infected cocoa pods, as the saprophytes develop after the invasion of the pathogen. The *Mucor* growth is more often observed in the black pod infected pods during the fermentation. This observation is in conformity with Rohan (1963). Beans from black pod disease (*Phytophthora*

Table 5. Qualitative fungal flora in the Processed cocoa beans

| Sl. No. | | Vittal | | Puttur | | Peechi | | Alleppey | |
|---|---|---|---|---|---|---|---|---|---|
| | | *Surface washing* | *Maceration* | *Surface washing* | *Maceration* | *Surface washing* | *Maceration* | *Surface washing* | *Maceration* |
| 1. | Aspergillus (Brown) | 19.3 | 18.0 | 11.66 | 5.00 | 13.33 | 15.3 | 14.66 | 18.3 |
| 2. | Aspergillus (Blue) | 10.3 | 15.0 | 10.00 | 3.3 | 11.66 | 8.3 | 10.3 | 12.3 |
| 3. | Aspergillus (Black) | 2.3 | 4.5 | 6.0 | 2.0 | 8.33 | 10.3 | 9.3 | 5.3 |
| 4. | Mucor | 7.3 | 2.0 | — | — | 4.0 | 8.3 | 6.0 | 8.0 |
| 5. | Others (Un identified) | 10.34 | 22.50 | 5.67 | 5.33 | 7.34 | 13.00 | 13.67 | 15.10 |

**Table 6. The effect of mould infection in the butter content of the beans**

| *Sl. No.* | *Sample* | *Butter Fat content (Percent)* |
|---|---|---|
| 1 | Control | 56.00 |
| 2 | Aspergillus (Brown) | 62.26 |
| 3 | Aspergillus (Blue) | 58.85 |
| 4 | Aspergillus (Black) | 62.26 |
| 5 | Mucor Sp. | 50.35 |

*palmivora* and charcoal pod rot (*Botryodiplodia theobromae*) affected cocoa pods will be black in colour even after fermentation.

The adoption of suitable fermentation and drying process can reduce the microbial load in the processed cocoa beans. The dried beans when rubbed with fingers should produce a *crakling* noice. The beans have to be stored in polythene bags or gunny bags lined with ploythene cover. Methyl bromide or phosphine fumigation against stored pests during storage is recommended for the control of insect infestation. The development of mould either during drying or in storage has to be prevented in the maintenance of quality of the cocoa beans.

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# TECHNOLOGY-QUALITY IMPROVEMENTS

(Session II)

*Chairman* : **Dr. C.S. Venkata Ram**

*Rapporteur* : **Dr. Laila Jacob**

# IMPROVEMENT OF THE COLOUR OF BLACK TEA BY A MODIFIED SPLIT-CTC PROCESS

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## ABSTRACT

**The split-CTC process is known to improve the colour of the infused leaf and the liquor characteristics of black tea, though it has not shown much variation in the colour of black tea. A modified split-CTC process involving two stages of fermentation and mixing reconditioning dust blended unfermented "dhool" after first stage of fermentation resulted in improved colour and appearance of black tea.**

## INTRODUCTION

South Indian tea, today, gets premium for its density, blackness and liquor qualities. It was shown in the eralier study that density and blackness of tea were associated with the technique of reconditioning in CTC tea manufacture (Stephen Thanaraj and Ramaswamy, 1980). The split-CTC process which was developed by UPASI Tea Research Institute helped in producing black teas with bright and coppery infusions, and strong and coloury liquors with more cuppage value (Ramaswamy and Lakshminarayanan, 1978). However, there is no method yet available to produce black tea which has all good qualities of density, blackness and strong, brisk and coloury liquor. Studies were continued on the split-CTC process to achieve improved black tea colour and appearance.

It was reported that the initial chlorophyll content of the leaf and the extent of production of enzymic breakdown products, such as chlorophyllide, during processing are factors which affect the desired appearance of processed black tea (Wickremasinghe, 1978). It was found (Wickremasinghe, 1966) that the formation of pheophorbide detracted from the appearance of black tea, whereas pheophytin made a positive contribution. Saijo (1970) reported that chlorophyllides and pheophorbides occured in fermented leaves and that pheophytins were formed on heating. Obviously, it was thought that the blackness of tea would be dependent on the relative proportions of pheophytins and pheophorbides contents of black tea. The present paper reports on the application of a modified split-CTC process which facilitates the conversion of chlorophyll into pheophytin during processing to produce black tea with improved leaf appearance and liquor characters.

## MATERIALS AND METHODS

### CTC Black tea manufacturing processes

In these investigations, three types of processes viz., normal-CTC, split-CTC and modified split-CTC processes were employed to produce black teas and in all of them the technique of reconditioning was essentially involved. The normal method of CTC tea manufacture involving reconditioning dusts (RC dusts) was the same as the process which has been described previously (Stephen Thanaraj and Ramaswamy, 1980). A detailed account of split-CTC process was given by Ramaswamy and Lakshminarayanan (1978). In split-CTC process, half the total number of CTC passes were given initially for the withered leaf and allowed to ferment for half the total optimum fermentation time, followed by remaining CTC passes and the fermentation to completion, before drying. Modified split-CTC process is just a combination of normal and split-CTC processes. Withered leaf was twice cut in a CTC machine without reconditioning and fermented for one third duration of the total optimum fermentation time. At this stage, a freshly cut RC dust blended withered leaf after passing twice through a CTC machine was thoroughly mixed with the fermented dhool and further processed by two more CTC passes, followed by fermentation to completion and drying.

### Analysis

By varying the periods of first ($F_1$) and second ($F_2$) stages of fermentation in modified split-CTC process, black teas were made and analyses carried out on black teas for their total colour and polyphenolic pigment contents by following the modified Roberts' method as employed by Takeo and Oosawa (1976) and Ramaswamy (1977). Samples were also sent for professional tea tasters' remarks on the colour of black tea and liquor characters.

## Seperation of pheophytin by TLC

Chlorophyll pigments from 5 g of ground black tea taken in a 25 ml quick fit conical flask was extracted with 25 ml of chloroform in dark for 4 hours. The chloroform extract was filtered through Whatman No.4 filter paper and the volume made to 25 ml with chloroform.

An aliquot of chloroform extract (0.3 ml) was spotted on 0.3 mm thick microcrystalline cellulose TLC plates and developed unidimensionally in dark using petroleum ether (b.p. 60–80°C) —acetone—n–propanol (90:10:0.45) for 30 minutes (Harborne, 1973). The plates were dried in dark and then examined both in day light and u.v. light. Grey and yellow-brown spots corresponding to pheophytins (Rf 0.8–0.93) were scraped from the plates, eluted with 100 ml of spectral grade ethanol and the optical density measured at 663 nm using spectronic–20. Similarly total chlorophyll pigments from the spotted area of an undeveloped plate were eluted with 10 ml alcohol and its optical density recorded at 663 nm. Pheophytin index was determined by calculating the ratio between the optical density of pheophytin and the optical density of total chlorophyll, both measured at 663 nm.

## RESULTS AND DISCUSSION

A scheme for manufacture of black teas by different CTC processes is given in Fig.1. Incorporation of RC dusts was done after first CTC cut in all the three processes and the quantity of RC dust addition upto 20% level was based on the information derived from earlier investigation (Stephen Thanaraj and Ramaswamy, 1980). In case of split-CTC and modified split–CTC processes, there are two stages of fermentation, namely, first stage fermentation and second stage fermentation. Black teas were made by modified split–CTC process with varying ratios between the first and second stage fermentation periods.

Fig.1 SCHEMATIC REPRESENTATION OF NORMAL SPLIT- AND MODIFIED SPLIT-CTC PROCESSES

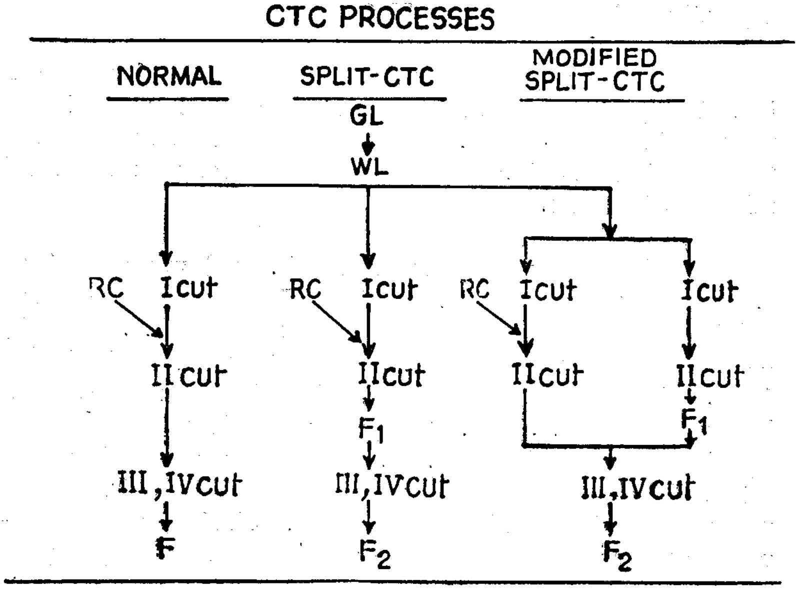

Table 1 shows the polyphenolic pigment contents of black teas made from 75% withered UPASI–15 leaf by normal–CTC, split–CTC and modified split–CTC processes. As seen from the Table 1, the modified CTC process with 15 minutes of $F_1$ and 45 minutes of $F_2$ produced black tea with improved colour of black tea and liquor characters, when compared to normal–CTC and split–CTC processes. However, other combinations of split fermentation in modified split–CTC process did not even show favourable results on blackness of tea, comparable to either normal-CTC process or split-CTC process. In order to confirm this observation, experiments were carried out with the leaf of UPASI–3 and the black teas made by modified split–CTC process, involving $F_1$ and $F_2$ in the ratio 1:3, were analysed for their polyphenolic pigments content and pheophytin index.

Table 1. Polyphenolic pigments contents of a clonal black tea made by different CTC processes

| Process | Fermentation Period (min.) F$_1$ | Fermentation Period (min.) F$_2$ | Thea-flavins % | Thea-rubigins % | High poly-merized substances % | Total colour | Relative blackness % |
|---|---|---|---|---|---|---|---|
| Normal CTC | — | — | 0.798 | 7.572 | 8.459 | 4.27 | 100 |
| Split CTC | 30 | 30 | 0.889 | 7.631 | 8.249 | 4.48 | 60 |
| Modified Split CTC | 15 | 30 | 0.919 | 7.395 | 7.912 | 4.27 | 80 |
| ,, | 15 | 45 | 0.970 | 7.708 | 8.049 | 4.41 | 140 |
| ,, | 15 | 60 | 0.832 | 7.258 | 8.249 | 4.11 | 80 |
| ,, | 30 | 30 | 0.863 | 7.231 | 7.777 | 3.89 | 80 |
| ,, | 30 | 45 | 0.906 | 7.886 | 7.912 | 4.60 | 60 |
| ,, | 30 | 60 | 0.897 | 7.395 | 8.595 | 4.24 | 40 |
| ,, | 45 | 30 | 0.807 | 7.135 | 7.504 | 3.8 | 60 |
| ,, | 45 | 45 | 0.871 | 7.408 | 7.640 | 3.95 | 40 |
| ,, | 45 | 60 | 0.820 | 7.517 | 8.322 | 4.32 | 20 |

Clonal leaf of UPASI–15 was used in these investigations.

Each value is an average of six determinations from 3 replicates.

Reconditioning was done at 20% level on green leaf basis.

TF, TR and HPS contents of RC dust were 0.65%, 6.82% and 9.55% respectively.

Table 2. Polyphenolic pigments contents of clonal black teas made by different CTC processes

| Clone | Process | Fermentation period min. | Thea-flavins % | Thea-rubigins % | High poly-merized substances % | Pheophytin index | Relative black-ness % |
|---|---|---|---|---|---|---|---|
| 75% withered UPASI-15* | Normal | 60 | 0.808 | 7.72 | 8.459 | 0.7243 | 100 |
| | Split CTC | 30 + 30 | 0.889 | 7.631 | 8.249 | 0.7215 | 60 |
| | Modified Split CTC | 15 + 45 | 0.970 | 7.708 | 8.049 | 0.79624 | 140 |
| 80% withered UPASI-3** | Normal | 40 | 1.45 | 7.89 | 8.52 | 0.7074 | 100 |
| | Split CTC | 20 + 20 | 1.48 | 8.30 | 8.75 | 0.7021 | 60 |
| | Modified Split CTC | 10 + 30 | 1.56 | 7.84 | 8.60 | 0.7459 | 120 |

Each value is an average of six determinations from three replicates.

Reconditioning at 20% level on green leaf basis.

*RC Dust contained 0.65% TF, 6.82% TR and 9.55% HPS.

**RC Dust contained 1.38% TF, 8.30% TR and 10.68% HPS.

Table 3. Tasters' report on black teas made by different CTC processes

| Process | Leaf appearance (Marks) | Infused leaf (Marks) | Liquors |  |  | Valuation (Rs/kg) |
|---|---|---|---|---|---|---|
|  |  |  | Colour (Marks) | Strength (Marks) | Quality (Marks) |  |
| Normal | 6 | 9 | 6 | 6 | 6 | 10.20 |
| Split–CTC | 6 | 9 | 7 | 7 | 7 | 10.60 |
| Modified Split–CTC | 7 | 10 | 8 | 8 | 8 | 10.80 |

Black teas were made using 80% withered leaf of UPASI–3 with 20% RC dusts.

It is evident from the results given in Table 2 that the modified split–CTC process improves the theaflavins levels in black tea as well as the blackness of tea, when compared to normal–CTC and split–CTC processes. As can be seen in Table 2 that the pheophytin index increases with increase in blackness of tea, it would seem to indicate that the pheophytin index could be used to measure the blackness of tea. Tasters' reports on valuation for black teas of UPASI–3 also indicated that the modified split–CTC process with 15 minutes of $F_1$ and 45 minutes of $F_2$ scored higher marks on valuations than normal and split-CTC processes (Table 3).

It is of interest to consider that there may be some future in the adoption of modified split–CTC process in South Indian tea factories on account of the fact that this process could improve the quality of black tea by producing not only strong, brisk and coloury liquor but also improved colour of black tea.

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# EFFECT OF SOAKING OF PERCHMENT COFFEE UNDER WATER AND SODIUM META-BISULPHITE SOLUTION ON QUALITY OF COFFEE

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## ABSTRACT

**Studies were carried out to find out the extent of improvement in coffee by post fermentation soaking in water and in 1% sodium metabisulphite solution with two arabica coffee selections.**

**Soaking of S.795 coffee processed by 'Raoeng pulper' under water and 1% sodium metabisulphite resulted in definite improvement in raw appearance of the bean. Roast characteristics of S. 795 coffee remained unaffected when soaked under water or sodium metabisulphite solution but soaking under 1% sodium metabisulphite solution had an adverse effect on liquor characteristics. In Kents where initial quality was better than in S.795, soaking either under water or under 1% sodium metabisulphite solution did not result in further enhancement of quality. The study indicated that improvement in raw appearance by soaking treatments was possible only when the initial raw appearance was poor.**

## INTRODUCTION

Quality is summative index of the characters of coffee in respect to its appearance in the raw, roast and liquor characteristics like aroma, body and acidity. Every step/operation involved in processing has a bearing on the make up of the quality.

Northmore (1965) and Northmore (1966) reported improvement in the quality of coffee in Kenya as a result of soaking under water or under sodium bisulphite solution, mainly through an improvement in the colour and quality of the raw bean. Brown Bridge (1966) found a considerable improvement in the liquor (from FAQ to good/fine) as a result of using sodium metabisulphite.

Subramanian and Aswathkumar (1968) reported a slight improvement in the quality of coffee due to soaking parchment coffee either under water or 1% sodium metabisulphite solution for 24 hours.

The effect of soaking, machine washed coffee either under water or under 1% sodium metabisulphite solution had not been studied and therefore studies were undertaken on this aspect. The effect of soaking parchment of S.795 and Kents coffee processed by using 'Raoeng' pulper in comparison to the parchment coffee of S.795 and Kents cultivars processed by alkalie treatment, under water and 1% sodium metabisulphite solution for two different durations, on the raw, roast and the liquor, is reported in this paper.

## MATERIALS AND METHODS

Parchment coffee of S.795 and Kents—two selections of *Coffea arabica* L. grown in Central Coffee Research Institute Farm was prepared and used in these studies. Mucilage was removed by using alkalie, sodium hydroxide of 10% concentration (Anonymous, 1974) in one method after pulping just ripe fruits in a two disc pulper, while in the other method demucilaging and washing was carried out in 'Raoeng' machine. Parchment coffee washed thus was soaked under water for 12 and 24 hours and under 1% sodium metabisulphite solution for 24 hrs. The treatments were as follows:

A. Alkalie wash
B. Alkalie wash + soaking under water for 12 hours
C. Alkalie wash + soaking under water for 24 hours
D. Alkalie wash + soaking under 1% sodium metabisulphite solution for 24 hours
E. Machine washed (Raoeng)
F. Machine washed + soaking under water for 12 hours
G. Machine washed + soaking under water for 24 hours
H. Machine washed + soaking under 1% sodium metabisulphite for 24 hours.

Coffee parchment after soaking for the stipulated duration was then washed and sun dried on wire bottom trays (Somaiah, 1965) and tiled floor to a final moisture content of 11 percent. The dried coffee was then hulled, garbled and graded. Samples 'A' grade coffee from these treatments were sent to Bangalore and Hamburg Cuptasting Centres for cup evaluation. The study was repeated for four years (Anon. 1972, Anon. 1973. Anon. 1974, and Anon. 1975).

Scores to test reports were awarded for every character i.e. raw, roast and liquor (cup). The combined data of four years were statistically analysed.

## RESULTS AND DISCUSSION

The data on scores awarded for the samples of 'A' grade coffee in respect of S.795 and Kents, two selections of *C. arabica* L are given in table 1. The details of scores awarded for quality of coffee in respect to raw, roast and liquor characteristics are furnished below.

**Details of scores awarded for assessment of coffee quality**

| *Raw* | | *Roast* | | *Liquor* | |
|---|---|---|---|---|---|
| Bluish | — 1 | Fine | — 1 | Fine | — 1 |
| Greyish blue | — 2 | Good | — 2 | Good | — 2 |
| Greyish green | — 3 | Fair to good | — 3 | F.A.Q. | — 3 |
| Greenish | — 4 | Fair | —4 | Falling off | — 4 |
| Brownish | — 5 | Poor | — 5 | Unclean | — 5 |

**Table. 1. Raw, roast and liquor characteristics of S.795 and Kents coffee as influenced by soaking treatments**

(Scores awarded)

(Mean of 4 seasons and two methods of drying)

| | S.795 | | | Kents | | |
|---|---|---|---|---|---|---|
| | Raw | Roast | Liquor | Raw | Roast | Liquor |
| A | 2.6 | 2.4 | 3.0 | 2.8 | 2.2 | 3.1 |
| B | 2.6 | 2.3 | 3.0 | 2.4 | 2.7 | 2.9 |
| C | 2.6 | 2.4 | 3.1 | 2.5 | 2.6 | 3.2 |
| D | 2.7 | 2.6 | 3.2 | 2.6 | 3.2 | 2.9 |
| E | 3.0 | 2.6 | 3.3 | 3.1 | 2.1 | 3.0 |
| F | 2.6 | 2.5 | 3.2 | 2.5 | 2.2 | 2.9 |
| G | 2.4 | 2.4 | 3.2 | 2.2 | 2.4 | 3.0 |
| H | 2.3 | 2.4 | 3.5 | 2.2 | 2.5 | 3.0 |
| Mean | 2.6 | 2.5 | 3.2 | 2.5 | 2.5 | 3.0 |
| Significant | * | NS | — | NS | NS | NS |
| CD 5% | 0.31 | — | 0.30 | — | — | — |
| CD 1% | — | — | — | — | — | — |

It could be seen from the data that soaking of coffee demucilaged by alkalie, either under water or sodium meta bisulphite solution did not result in the improvement of appearance of coffee, the difference among the treatments being not statistically significant. Subramanian and Aswath Kumar (1968) reported that there was an improvement in the quality of coffee due to soaking of alkalie washed coffee but the differences were significant only at 10% level.

Soaking of machine washed coffee, as seen from the data, either under water or sodium metabisulphite solution resulted in a significant improvement of the raw appearance of coffee.

Soaking coffee for longer duration under water (for 24 hrs) was better in raw quality than soaking for 12 hours. Soaking under 1% sodium metabisulphite solution for 24 hours resulted in still better improvement in raw appearance/quality than soaking under water. Northmore (1966) indicated that a 16 hour overnight soak was preferable to a shorter period during the day.

The initial colour of the raw beans in machine washed coffee in all the four years was classified as poor in majority of the cases (90%) by the both cup tasting units. The colour of the sample being greenish to greyish-greenish and coated to heavily coated. Soaking treatment as was seen from the table resulted in definite enhancement of the raw appearance where the initial quality of coffee was very low. This is in agreement with Northmore (1966) who found that the improvements due to soaking in sodium metabisulphite solutions were associated with the original colour of the bean and could be expected where this was poor. The same trend was also evident in the studies carried out by Subramanian and Aswath Kumar (1968). Roast characteristics of S.795 coffee prepared either way remained unaffected when soaked either under water or sodium metabisulphite solution. Northmore, (1966) found that the improvement in roast characteristics as a result of sodium metabisulphite soaking was not as evident as was noticed in the colour and quality of raw bean. Brownbridge (1966) observed that sodium metabisulphite soaking had little effect on the roast appearance.

Soaking of S.795 coffee processed by machine, under water resulted in slight improvement of liquor quality. The difference in the scores due to treatments were not statistically significant. Soaking under 1% sodium metabisulphite solution resulted in an increased score indicating adverse effect. But the difference in the scores was not statistically significant. Brownbridge (1966) also observed that sodium bisulphite soak had a deleterious effect when the liquor flavour of the controls was better than FAQ. The initial liquor characteristics in the present case were varying widely and inconsistant.

As could be seen from the mean scores for raw, roast and liquor characteristics, Kents coffee was slightly better than S.795 coffee in raw and liquor characteristics, while it was more or less similar in the roast. Awatramani *et al* (1973) observed that Kents coffee was superior in raw appearance while S.795 coffee was better in the cup when aggregate scores for all the three chracteristics was considered. In the present study quality of Kents coffee was not improved further by different soaking treatments.

From these studies it could be inferred that a definite enhancement could be achieved by soaking coffee of poor quality under 1% sodium metabisulphite solution. Further enhancement in quality of coffee inherently superior was not possible.

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# IMPROVEMENT OF QUALITY OF CNSL OBTAINED BY EXPELLING FROM OIL BATH ROASTED SHELLS

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## ABSTRACT

**Cashewnut shell liquid (CNSL) is an important industrial raw material. With the reduction in cashewnut processing CNSL has become relatively scarce. Additional quantities of CNSL are now extracted by expelling from the oil bath processed cashew shells. The extent of recovery in each stage has been determined. It is found that CNSL obtained in the expeller after oil bath recovery do not satisfy specification as regards toluene insolubles, ash and polymerisation time. The effect of heating, centrifugation and acid washing on the quailty of CNSL recovered by the expeller has been studied.**

## INTRODUCTION

Cashewnut shell liquid (CNSL) is an important by-product of cashewnut industry (Anonymous, 1979). When the production was high, not much importance was given to recovery of CNSL in Kerala State. Due to the advantage in shelling, it was customary to use drum roasting when no CNSL is recoverable. Because of reduction in the total quantity of cashewnuts processed, there was an encouraging rise in price of CNSL and so the extraction of available CNSL became attractive. Many processors reverted to oil bath roasting when part of the CNSL was extracted. Even the residual CNSL in the shells was found worth extracting and the use of expellers is increasing. The extent of recovery of CNSL from shells obtained after oil bath roasting and the various treatments required for improving the quality of CNSL obtained in subsequent expression have been studied.

## MATERIALS AND METHODS

Samples of shells and CNSL were procuredfrom well established cashew factories in Southern Kerala.

All methods of analysis are as described in Indian standards specifications. (Indian Standard specification for Cashewnut Shell Liquid (CNSL) IS 840, 1964).

## RESULTS AND DISCUSSION

Analysis of shells at different stages of processing are presented in Table 1. It can be seen that after the oil bath roasting considerable quantity of oil remains in the shell, which is recoverable by expelling. In fact even the expeller cake has some residual CNSL even if steaming is employed. The shells from drum roasted nuts also contain considerable CNSL. However, the oil in this case will have carbon residues due to the burning.

Examination of the analytical values and the actual figures of yield of CNSL obtained in factory will show that it was possible to calculate the approximate quantity of CNSL recoverable in various stages (Table 2). It can be seen that the quantity recoverable in expeller is nearly as much as that recovered in oil bath during roasting. There is good scope to introduce the solvent extraction for recovering the residual CNSL from expeller cake.

The Indian Standard specifications (Indian standard specification for cashewnut shell liquid (CNSL) IS 840, 1964) is given in Table 3. The specifications of most of the buyers are also more or less the same with only minor variations in some cases. While the CNSL obtained from the bath conforms to the specifications, in the case of expeller oil, it is considerably outside in the case of total ash, insolubles and polymerisation time (Table 4). A common procedure employed by the processers is to heat the sample and allow it to settle. It can be seen that heating at 180°C for a period of 2½ hours reduces the polymerisation time. Subsequent separation on standing ensures that most of the insolubles and ash go to the minor lower fraction leaving the major upper fraction improved (Table 4).

Improved results were obtained when the separation was effected by means of centrifugation (Table 5). In unheated samples gravity settling and centrifugation at low speed showed only very little improvement in insolubles and ash. At higher speeds and longer duration of centrifugation, significant improvement is obtained even without heating. The beneficial effect of centrifugation is considerably enhanced by a prior heating. The reduction of polymerization time, however, is noticed only if heating is employed. By employing heating followed by centrifugation at 2780 g for 30 minutes the values are brought down fairly close to the upper limits of the specification.

Table 1. Analysis of shells at different stages of processing

| | *Moisture* % | *CNSL* (*as in basis*) | *CNSL* (*Dry basis*)% |
|---|---|---|---|
| Raw shell | 8.4 | 38–39 | 41–42 |
| Oil bath shell | 9.0 | 28–29 | 31–32 |
| * Expeller cake | 9.6 | 16–17 | 17–18 |
| Steamed expeller cake | 9.5 | 11–12 | 13–14 |
| Drum-roast shell | 8.3 | 24–25 | 27–28 |

* Expression of oil bath Shells

Table 2. Recoverable CNSL at each stage

| | *In kg in* 100 *kg original shell* | *As % of total CNSL percent* |
|---|---|---|
| Raw shell | 38.6 | 100 |
| Oil bath | 14.8 | 38.3 |
| Expelling of (above) | 12.8 | 33.2 |
| Expeller residue | 7.5 | 19.4 |

**Table 3. Requirements for cashewnut shell liquid**

| *Sl.No.* | *Characteristic* | *Requirement* |
|---|---|---|
| i. | Specific gravity, 30/30°C | 0.950 to 0.970 |
| ii. | Viscosity at 30°C in centipoises, max | 550 |
| iii. | Moisture, percent by weight, max | 1.0 |
| iv. | Matter insoluble in toluene, percent by wt. max. | 1.0 |
| v. | Loss in wt. on heating, % by wt. max | 2.0 |
| vi. | Ash, percent by wt, max | 1.0 |
| vii. | Iodine value, min | |
| | (a) Wij's method | 250 |
| | (b) Catalytic method | 375 |
| viii. | Polymerisation | |
| | (a) Time in minutes, max | 4 |
| | (b) Viscosity at 30°C, in centipoises, min | 30 |
| | (c) Viscosity after acid washing at 30°C in centipoises, min | 200 |

**Table 4. Effect of heating & layer separation on specification**

| | | Total insolubles % | Ash % | Polymerisation time minutes |
|---|---|---|---|---|
| ISI Specification | | Max 1% | Max 1% | Max 4 |
| Oil bath CNSL | | 0.55–0.75 | 0.75–0.85 | 3 to 4 |
| Expeller oil | | 7.9 | 6.2 | 19 |
| Settling for 65 hours | Top | 7.0 | 6.2 | 19 |
| | Bottom | 7.0 | 6.0 | 14 |
| Heated to 180° in a period of 2½ hours & settling for 65 hours | Top | 3.0 | 3.6 | 8–10 |
| | Bottom | 23.0 | 15.7 | 6–7 |

Table 5. Effect of centrifugation on specification

| RPM | g | Time | Heating before centrifugation | Total insolubles % | Ash% | Polymerisation time minutes |
|---|---|---|---|---|---|---|
| 1000 | 174 | 30′ | No heating | 5.6 | 2.5 | 19′ |
| 1000 | 174 | 30′ | With heating | 3.5 | 1.8 | 6′ 20″ |
| 2000 | 696 | 15′ | No heating | 7.0 | 5.6 | 19′ |
| 2000 | 696 | 30′ | No heating | 4.9 | 2.3 | 19′ |
| 2000 | 696 | 30′ | With heating | 2.5 | 1.5 | 5′ 10″ |
| 4000 | 2780 | 15′ | No heating | 5.4 | 5.0 | 18′ |
| 4000 | 2780 | 30′ | No heating | 3.2 | 2.1 | 19′ |
| 4000 | 2780 | 30′ | With heating | 1.0 | 1.5 | 4′ 35″ |
| 6000 | 3820 | 15′ | No heating | 3.5 | 4.5 | 19′ |
| 6000 | 3820 | 30′ | No heating | 1.2 | 1.7 | 19′ |
| 6000 | 3820 | 45′ | No heating | 0.5 | 1.6 | 19′ |
| 6000 | 3820 | 60′ | No heating | 0.2 | 1.6 | 19′ |
| 8000 | 6800 | 15′ | No heating | 3.1 | 2.4 | 18′ |
| 10000 | 10650 | 15′ | No heating | 2.2 | 2.1 | 17′ |

Table 6. Effect of $H_2SO_4$ acid washing on specification

| 5% $H_2SO_4$ treatment | Heating | Total insolubles % | Ash % | Polymerisation time minutes |
|---|---|---|---|---|
| 150 c.c. in one lot | No heating | 1.4 to 1.6 | 0.36 to 0.39 | 12′ 25″ |
| 150 c.c. in one lot | With heating | 1.4 | 0.36 | 1′ 48″ |
| In two lots of 100 c.c. + 50 c.c. | No heating | 1.4 to 1.6 | 0.36 to 0.39 | 12′ |
| In three lots of 50 c.c. | No heating | 1.4 to 1.6 | 0.36 to 0.39 | 12′ 50″ |

There is a relatively sharp separation between the lower rejected phase and the upper useful phase during centrifugation. With the progressive increase of g from 174 to 2780 applied for 30 minutes the proportion of the residue also showed an increase from about 13.9% to 16.0%, with proportionate increases in the content of insolubles and ash. The separation in the gravity settling after heating is far from sharp and can be considered anywhere from 10 to 25%. In actual field operation the loss is likely to be in the neighbourhood of the upper limit. The separation of ash and insolubles also is not as satisfactory.

Washing with 5% aqueous sulphuric acid also showed substantial reduction in insolubles and ash so that these values can easily be brought down to well within the specifications (Table 6). The effect of acid wash on polymerisation time is somewhat limited. However, heating after the acid wash showed that the polyemerisation time can be reduced well below the upper limit of the specification.

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# DEVELOPMENT OF ROASTED FLAVOUR IN COCONUT

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## ABSTRACT

**The special aroma of coconut oil is liked by the people of Kerala and adjoining areas. Some of the commercial producers of good quality coconut oil impart an intense roasted smell to their product, as this aroma is particularly liked by certain sections of the consumers. Coconut oil samples with intense smell is also found to have much better keeping quality than ordinary commercial coconut oil which are very much susceptible to ketonic rancidity. It was found that such odour characteristics could be imparted to the oil by heating the disintegrated copra at 160° C for 15 minutes. Storage studies indicate that this oil has superior keeping quality compared to commercial oil.**

## INTRODUCTION

Coconut is a very important crop of Kerala, contributing about one-third of the agricultural income of the State. It is mainly grown for the oil present in the kernel of the coconut. From time immemorial, coconut oil was being used for cooking as well as for toilet purposes by the people of the area. Ordinary coconut oil is rather bland and has a very mild aroma. Commercial oils also get rancid within a few months (4 to 5 months) which affects the flavour considerably. However, some of the producers of coconut oil, market samples with a typical roasted aroma. The stability of this oil is better and it has a longer shelf-life. The process of producing this oil with intense roasted flavour is not readily available and so the conditions for producing this flavour were studied.

## MATERIALS AND METHODS

Mature coconuts were hand grated and dried in a cross flow drier at 60°–70°C, to a moisture level of less than 5%. Mechanically dried copra cut into pieces of 1 cm cubes were also used in the studies.

250 g lots of coconut gratings were heated for 15 minutes in an air oven maintained at 105°, 125°, 130°, 135°, 140°, 145°, 150°, 160°, 180°, and 200° centigrade. Coconut oil was extracted from these samples by pressing in a hydraulic press. The experiments were repeated with 1 cm cube copra pieces with a heating time of 30 minutes. In this case, only temperatures upto 160°C were tried since it was found that extensive charring took place. Oil was extracted as previously, after disintegrating the copra pieces in a waring blender. The samples of oil were subjected to storage studies for one year at room temperature (29–39°C.) in darkness.

Sensory evaluation of the samples were carried out by a panel of eight judges both before and after storage. Free fatty acid content and peroxide value of the samples were determined by standard methods. Colour using a Lovibond comparator and transmittance at 400 nm of the oil samples were determined.

## RESULTS & DISCUSSION

Preliminary studies revealed that heating coconut gratings at temperature above 120°C produced an intense, desirable roasted aroma. Intensity of flavour increased with increase in temperature but the changes were unfavourable due to charring beyond 165°C. Experiments with cut copra of approximately 1 cm cube size showed that a longer time of heating was necessary. Copra pieces developed a pleasant and intense flavour when heated for 30 minutes duration. Oil extracted from the heated sample was comparable to the best brands of the commercial, flavour enhanced oil. Sensory evaluation studies showed that all the experimental samples were nearly equal to the commercial sample (Table 1). It was also observed that oil from samples heated 130°–145°C were found to be very well acceptable. Evaluation of the samples after one year of storage indicated that only the sample heated at 160°C was comparable to the commercial sample and that the others turned slightly rancid. All heat treated samples were however superior to the unheated sample and had better keeping quality. The free fatty acid content of all heated samples were lower than that of the control sample (Table II). The peroxide value of commercial reference sample and sample heated at higher

**Table 1.** Sensory evaluation of coconut oil with flavour before and after storage for one year

Reference sample : Commercial sample with roasted smell

Score : Superior to reference sample + 1 to + 5

Inferior to reference sample — 1 to — 5

No difference 0

| | *Unheated* | | *Time of heating 30 minutes* | | | | | | | | | | | | | | | | *Fried over flm. for 6 minutes* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 105°*C* | | 125°*C* | | 130°*C* | | 135°*C* | | 140°*C* | | 145°*C* | | 150°*C* | | 160°*C* | | | |
| | *Aroma* | *Colour* | *Aroma* | *Colour* | *Aroma* | *Colour* | *Aroma* | *Colour* | *Aroma* | *Colour* | *Aroma* | *Colour* | *Aroma* | *Colour* | *Aroma* | *Colour* | *Aroma* | *Colour* | *Aroma* | *Colour* |
| Initial | −3.2 | +2.9 | −2.7 | +3.0 | −0.8 | +2.5 | −0.6 | +2.6 | −0.3 | +2.0 | −0.6 | +1.5 | −1.3 | −0.3 | −2.3 | −1.6 | −3.7 | −1.3 | −1.0 | +0.4 |
| After storage over one year | −2.9 | +0.6 | −3.4 | +0.7 | −2.0 | +0.7 | −2.9 | +0.6 | −2.1 | +0.6 | −2.3 | +0.4 | −2.8 | −0.5 | −1.7 | −1.4 | +1.2 | −2.8 | −3.0 | −0.1 |

**Table 2. Change of free fatty acid content and peroxide value of the oil samples during storage**

| Samples | Changes in ffa and peroxide value during storage | | | | | |
|---|---|---|---|---|---|---|
| | FFA(%) | Peroxide value me V of peroxide oxygen/ kg. fat. | FFA(%) | FFA (%) | FFA (%) | Peroxide value milli eqvts. of peroxide oxygen/kg. fat. |
| Unheated | 0.08 | 0 | 0.26 | 0.51 | 0.45 | 0.55 |
| Commercial reference sample | 0.13 | 0 | 0.16 | 0.17 | 0.19 | 1.16 |
| 105° | 0.10 | 0 | 0.21 | 0.29 | 0.37 | 0.54 |
| 125° | 0.08 | 0 | 0.23 | 0.30 | 0.36 | 0.43 |
| 130° | 0.08 | 0 | 0.10 | 0.25 | 0.27 | 1.03 |
| 135° | 0.08 | 0 | 0.14 | 0.14 | 0.21 | 1.16 |
| 140° | 0.08 | 0 | 0.11 | 0.13 | 0.16 | 0.91 |
| 145° | 0.08 | 0 | 0.09 | 0.14 | 0.23 | 1.12 |
| 150° | 0.10 | 0 | 0.18 | 0.16 | 0.21 | 1.58 |
| 160° | 0.10 | 0 | 0.18 | 0.20 | 0.24 | 1.14 |
| Fried | 0.08 | 0 | 0.12 | 0.18 | 0.27 | 1.57 |

Table 3. Colour and transmittance of coconut oil with roasted flavour during storage

| Sample | Colour in Lovibond units (Y + 5R) in 1″ cell | | Transmittance at 400 nm (percentage) | |
|---|---|---|---|---|
| | Fresh stage | After one year storage | Fresh stage | After one year storage |
| Unheated | 0.2 | 0.6 | Taken as reference sample | |
| Commercial reference sample | 1.0 | 2.9 | 83.5 | 83.5 |
| 105° | 0.5 | 0.8 | 96.5 | 100.0 |
| 125° | 0.7 | 1.0 | 93.0 | 100.0 |
| 130° | 0.7 | 1.5 | 92.5 | 100.0 |
| 135° | 0.8 | 2.2 | 91.5 | 98.5 |
| 140° | 0.9 | 2.0 | 89.0 | 100.0 |
| 145° | 1.1 | 1.6 | 81.0 | 92.5 |
| 150° | 3.2 | 2.4 | 56.0 | 80.0 |
| 160° | 13.1 | 6.2 | 21.0 | 46.5 |
| Fried | 1.7 | 2.4 | 79.0 | 90.0 |

temperatures were higher than that of unheated coconut oil and samples heated below 125°C. This was not, however, reflected in organoleptic evaluation and it was found that oils with a lower peroxide value were highly rancid, while the reference sample and the oils from heated copra had no rancidity inspite of a higher peroxide value. This may be due to the fact that rancidity in coconut oil is not mainly by the oxidation of unsaturated, fatty acid. $\beta$–oxidation of lower fatty acids by moulds in the presence of moisture is considered to be the reason for the rancidity (Child, 1974). Methyl-n-amyl ketone, methyl-n-heptyl ketone, methyl n-nonyl ketone and methyl-n-methtyl ketone have been identified in rancid coconut oil (Rasper, 1965).

Samples of oil obtained from heated coconut upto 140° had very light colour comparable to that of commercial sample. Heating above 140°C affects the colour and at 160°C the colour becomes too intense for commercial acceptance (Table III). Oil of lighter colour could be produced by reducing the time of heating. It was found that sample of oil obtained from copra pieces heated at 160°C for 15 minutes had optimum flavour and colour.

The better keeping quality of oil obtained from heated copra may be due to the products of non-enzymic browning reaction (Maillard's reaction). There are several literature reports about the antioxidant activity of the products of browning (Naohiko Yamaguchi and Yoshito Koyama, 1967 and Krigaya Norimasa *et al*, 1969). The exact nature of the products which exhibit the antioxidant property is not well understood.

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# REMOVAL OF COCOA BEAN ACIDITY BY IMPROVED PROCESSING

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## ABSTRACT

**Several methods of fermentation and drying were taken up to evolve a suitable technique yielding quality beans. The "maturation effect" resulted in lowering acidity. Fermentation boxes provided with side gaps for better aeration gave excellent results. Initial slow drying in artificial driers gave low acid beans though sundrying was the best method. The changes in micorflora during fermentation have been monitored. By improving processing methods it has been possible to mitigate the high acidity of locally produced cocoa beans.**

## INTRODUCTION

The cocoa bean production in India is anticipated to increase *Ca* 20,000 tons/annum by 1990. Though it should be possible that internal consumption may increase, the excess will have to be exported. The reported low quality of Indian cocoa beans especially high acidity (pH 4.6—5.0) makes it unacceptable in the world market. The cocoa bean of Malaysia also is reported to be more acidic, pH being 4.7 to 5.0 (Shepherd 1976). Defective harvesting, fermentation and drying are the main causes of acidity. Results of experiments derived to determinet he standard processing methods to overcome the problem of acidity are discussed in this paper.

## MATERIALS AND METHODS

Fully ripe pods were harvested. Damaged and diseased pods were discarded. Wooden mallet was used to break-open the pods. Fresh beans, rejecting the placenta were immediately transferred to fermentation box. The box was filled leaving 2.5 cm from the top. The beans were covered on the top with fresh banana leaves, over which one clean gunny bag was placed. The fermentation was carried out under covered space with proper drainage and aeration. Deatils of turning and other operation are given in table 1. The drying was done in hot blown electrical drier or under full sunshine.

90 ml. boiling water was added to 10 g ground sample and the pH was determined using an Elico pH meter. Fat was extracted in petroleum ether with *Ca* 40 washings.

The cocoa bean samples were collected at 24 hr intervals. Ten gram beans with pulp was transferred to 250 ml flask containing 100 ml sterile distilled water and shaken for 10 minutes. The dilution plating method was followed for enumeration of microflora. The media for yeast, acetobacter agar, tryptone and nutrient agar media were used for enumeration and isolation of yeasts, acetic acid bacteria and lactic acid bacteria respectively.

## RESULTS AND DISCUSSION

The results of processing procedures on final bean pH is summarised in Table 1. It is evident that providing sufficient aeration during fermentation and especially during later stages had beneficial effect. Temperature, moisture and aeration are important factors in fermentation processes as evaluated in our experiments. The "maturation effect" has been introduced by Liau (1976, 1978). The process involves the loss of acid from cocoa beans by keeping fermented beans warm, moist and with good air supply. Two methods are possible to create this condition viz; (i) box maturation by repeated turning (3–5 times) on 5th and 6th days to maintain a temperature around 40°C; (ii) Drier maturation by slow drying at 40°C for 4–8 hrs for first 2 days each. Eight hours drying reduced the mould growth. Among the two, the former method could be adopted due to its ease, convenience and economy.

A good quality bean with acceptable acidity level was obtained when side aeration in boxes was provided by gaps (0.5 cm) 5 cm apart. An ideal box size was 75 x 45 x 45 cm which can hold about 80 kg of wet beans. The size can be increased according

Table 1. pH values as affected by different processing methods

| No. | Fermentation | Drying | pH | Mositure % |
|---|---|---|---|---|
| 1. | Turning on 2nd and 4th days (total 7 days) | Continuous in drier | 5.2 | 4.7 |
| 2. | —do— | Dried at 50°C for first 2 days followed by continuous drying (oven maturation) | 5.6 | 8.5 |
| 3. | Turning on 2nd & 4th days. Box Maturation by turning 5 times on 5th and 6th days (Total 6 days) | Continuous oven drying | 6.2 | 5.9 |
| 4. | Box Maturation (size 75 x 45 x 45cm side ventilation) | First two days 8 hrs drying in oven followed by continuous drying. | 5.5 | 5.5 |
| 5. | —do— | Sundrying | 5.7 | 5.7 |

Table 2. Microbial changes during fermentation ($10^5$ No/g bean)

| Days | Yeast ($10^5$) | Bacteria ($10^5$) | Haemocytometer count for yeast ($10^5$) |
|---|---|---|---|
| 0 | — | — | — |
| 1 | 29.2 | 22.3 | 49.43 |
| 2 | 32.0 | 30.6 | 22.20 |
| 3 | 13.3 | 11.6 | 15.84 |
| 4 | 12.4 | 18.5 | 13.60 |
| 5 | 15.8 | 10.6 | 24.44 |
| 6 | 15.5 | 1.3 | 16.00 |

Table 3. Ripe pod to bean ratios

| No. of pods | Wt. of fresh pods (Kg) | Wt. of fresh beans (Kg) | % of Fresh beans to fresh wt. pods. | Wt. of fresh bean/pod (g) | No. of pods required to give 10 Kg beans. |
|---|---|---|---|---|---|
| 461 | 175.3 | 52.1 | 30.2 | 113.0 | 89 |
| Wt. of fermented dry beans (Kg) | % of dry bean on fresh pod Wt. | % dry bean on fresh bean wt. | No. of fresh pods required to give 1 Kg dry bean | Wt. of fresh pods required to give 1 Kg. dry beans (Kg) | Wt. fresh bean required to give 1 Kg dry bean (Kg) |
| 37.1 | 8.5 | 28.3 | 32 | 11.7 | 3.6 |

to the requirement, but it is advisable to restrict height to 60 cm. (Shamsuddin *et al* 1978). Fermenting in a larger box with gap spaces at sides and bottom yielded dried beans with good pH values, and improved quality (Shamsuddin *et al* 1978).

The pods should be ripe for proper fermentation. It is not advisable to store pods for more than 4 days after harvest. Diseased/damaged pods should be discarded. There was no significant difference among cocoa genotypes in pH values of fresh beans and pulp. The fresh bean and pulp pH ranged from 6.3—6.9 and 3.6—4.2 respectively. The fat content was 50–56% in cocoa beans.

The microbiological enumeration showed yeast to be more active in the initial stages of fermentation. The quantitative relationship has been given in Table 2. Yeasts are involved in the conversion of pulp sugars to alcohol while further conversion to acetic acid and $CO_2$ is performed by bacteria. This process occurs only late during fermentation. The yeast flora showed a reduction after 4th day of fermentation. The rod shaped acetic acid bacteria in chains were observed during later stages indicating involvement in conversion of alcohol to acetic acid.

Conversion ratios (ripe pods to bean) are presented in Table 3. These would be of help to the growers and cocoa processing units as reference material.

## ACKNOWLEDGEMENT

Grateful thanks are due to Dr. NM Nayar, Director, CPCRI, Kasaragod for initiating us to this problem and Mr. Varanasi Subraya Bhat, Chairman, CAMPCO, Puttur for help in various ways.

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# SPICE OLEORESIN WITH FRESH FLAVOUR

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## ABSTRACT

**Spices with fresh flavour are generally considered superior to dried spices. As fresh spices will be available only in growing areas and that too only in seasons, spice oleoresins are generally manufactured from dry spices. Also the high moisture content in the fresh material renders the extraction procedure inefficient and incomplete. However, considering the superiority of spices with fresh flavour, attempt was made to prepare oleoresins with fresh flavour from fresh spices. Various extraction procedures with different parameters were tried and the quality factors were assessed both by instrumental and sensory evaluation methods. The results are discussed in comparison with the standards prepared from dry spices by different methods.**

## INTRODUCTION

Spice oleoresins represent the total flavour of the spice. The essential oil contributes to the spice aroma whereas the non-volatile part constituting mainly the pungent principles, colouring matter etc. is responsible for the characteristic taste and appearance. The essential oil together with the solvent extractable non-volatile part make up the oleoresin thus depicting only the characteristic and most desirable principles of the spice in a very concentrated form.

India, a major producer of spices, earns to the tune of about 160 crores from the export of dried spices. Till recently the processing and blending for specific end uses were done in importing countries. Processing secondary valued products in the producing country itself will pave the way for better employment and foreign exchange earnings. Hence with the development of indigenous technology oleoresin industries have come up in our country in recent years and the fact that in 1978–79 India exported 123 M. tons of spice oleoresins earning 1.6 crores of foreign exchange for the country strikes an optimistic note.

In Indian cookery the flavour of fresh spices like ginger, chilli, leafy spices etc. are generally very much liked. If the fresh flavour could be incorporated in these spice oleoresins, may be that foreigners also would have appreciated the product. In recent years green pepper flavour is very much liked in Germany, France and other European countries and resulted in the export of a variety of green pepper products.

Considering the superiority of spices with fresh flavour, attempts are being made in our laboratory to prepare oleoresins with fresh flavour from spices like ginger, pepper, chilli etc.

The production of ginger in India is around 67,000 tonnes per annum out of which 12,000 tonnes worth Rs.12 crores were exported in 78–79. The rest of the ginger is consumed internally almost the whole of consumption being in the form of fresh ginger.

There are reports on trials conducted on green ginger oleoresin production by repeated hexane extraction of fresh ginger paste and also by blending of green ginger oil with the dry ginger oleoresin (Damayanthi *et al.* 1980). Ashurst *et al.* (1972) have also reported details of investigation on green ginger extraction using alcohol or warm acetone as solvent.

Various extraction procedures with different parameters were tried in the case of ginger in our laboratory and the quality factors assessed both by instrumental and sensory evaluation methods. The results are discussed in this paper.

## MATERIALS AND METHODS

Fresh ginger for our trials was acquired from the local market. (Kattakkada Variety).

Initially some experiments were carried out on the lines of Ashurst to extract green ginger directly with alcohol. For this, cleaned ginger was disintegrated in a pin mill and extracted with alcohol in the cold. The extract was freed of the solvent by distillation and the product examined for its quality.

An entirely different approach to the problem was also envisaged and ginger oleoresin was prepared by different methods as given below:

(i) Cleaned ginger was disintegrated in a pin mill and then pressed in hydraulic press or screw press at about 1500 lbs/sq. inch. Juice obtained was allowed to settle for sometime to separate out the starch and then subjected to various treatments such as solvent extraction, vacuum distillation, purging with nitrogen gas etc. all with the primary objective to trap in the constituents responsible for the characteristic fresh flavour. The residue after pressing out the juice was dried in a crossflow drier, powdered and extracted by cold percolation using ethylenedichloride as solvent. The juice extractives was then blended with calculated quantities of the residue extractives.

(ii) Fresh ginger was disintegrated in a pin mill, dried in a cross flow drier at 55–60°, powdered and extracted with ethylene dichloride by cold percolation to yield the oleoresin.

(iii) Fresh ginger was chipped into ¼" thick slices using a dicer and dried in a cross flow drier at 55–60°. The chips were ground and extracted with ethylene dichloride by cold percolation [illegible]

(iv) The whole fresh ginger was sundried, ground and extracted with ethylene dichloride by cold percolation to yield the oleoresin.

Values of chemical analysis of the above four samples are given in Table 1. Moisture was estimated by Dean and Stark method (AOAC, 12th Edn. 1975), volatile oil by Clevenger distillation (Clevenger, 1928) and gingerol content by TLC method (Nambudiri *et al.* 1975). I.R. spectra were recorded in Perkin Elmer Model 299 infra red spectrophotometer. Sensory evaluation of the four samples of oleoresin was carried out by a panel of ten judges using fresh ginger as the standard and majority opinion was taken for assessment. Results are shown in Table 2.

**Table 1. Analysis of ginger samples**

| Sample | Moisture % | Vol. oil of % v/w | Extractives % | % gingerol in extractives |
|---|---|---|---|---|
| Sundried whole | 13.0 | 1.8 | 6.7 | 26.7 |
| Chipped and dried | 12.5 | 1.6 | 5.0 | 25.9 |
| Disintegrated and dried | 9.0 | 1.1 | 5.0 | 33.5 |
| Residue after pressing(dried) | 10.5 | 1.8 | 5.1 | 31.8* |

* Residue extractives + juice extractives.

**Table 2. Sensory evaluation of oleoresin samples**

| Oleoresin sample | Flavour characteristics | Remarks |
|---|---|---|
| Sundried whole | No characteristic fresh ginger flavour | Poor |
| Chipped and dried | Characteristic fresh ginger flavour | Good |
| Disintegrated and dried | Slight flavour of fresh ginger | Satisfactory |
| Blended sample | Characteristic fresh ginger flavour | Good |

## RESULTS AND DISCUSSION

Extraction of fresh ginger with alcohol was met with some difficulties in the final stages of solvent removal. Large quantities of water extracted from the fresh material caused a steep rise in temperature resulting in serious deterioration of the oleoresin to a point where the final product had little resemblance to ginger oleoresin. Hence further attempts on these lines had to be given up.

Of all the methods tried to trap in the characteristic fresh flavour constituents present in juice, only extraction with hexane was found to give a satisfactory product with respect to yield and quality. (1.5 gms. from 2 kgs. of juice)

Regarding chemical analysis, volatile oil yields were all comparable with the exception of disintegrated sample which gave the lowest yield as expected. Whole sundried rhizomes gave the highest yield of extractives as the loss on drying is supposed to be minimum here. Whole sundried and chipped dry ginger were found to have almost the same gingerol content whereas the crushed and blended samples showed higher values. This may be explained as due to a concentration of pungent principles in the product under the conditions employed for processing or drying.

No valuable information could be obtained from the infra red spectra of the four samples of oleoresins as they were superimposable.

By sensory evaluation, chipped ginger extractives and the blended sample were judged as equally good and best comparable to fresh ginger followed by disintegrated and sundried whole ginger samples. Contrary to our expectations the blended sample though had fresh juice extractives in it was judged as not having any superior fresh flavour when compared to chipped ginger oleoresin. Both the blended oleoresin and chipped ginger oleoresin were of superior quality compared to the traditional product. Chipped ginger has also got the advantage that it takes only much lesser time for drying than the whole rhizomes thus avoiding unnecessary spoilage and contamination.

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# EFFECT OF ULTRAVIOLET RADIATION ON CTC PROCESSING OF BLACK TEA

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## ABSTRACT

**Investigations were undertaken to assess the effect of ultraviolet energy during fermentation process of black tea manufacture. Duration of UV exposure and the distance from the source during fermentation of the dhool were optimized. The rate of formation of polyphenolic pigments in clonal black teas during fermentation was enhanced by the UV treatment effecting a reduction of optimum fermentation time by 5–10 minutes. It was also observed that fungi and bacteria decreased during fermentation process and the reduction was more pronounced by the UV treatment.**

## INTRODUCTION

Spoilage of food products by microbial contamination and its prevention by suitable methods are well documented (Dack, 1956; Dutta, 1970). Proper sanitary control and bacterial cleanliness throughout the process of fermentation during black tea manufacture, are essential as the presence of bacteria imparts taint, maltiness, flatness (Harler, 1964) and other undesirable properties resulting in reduction of quality (Basu and Ullah, 1978). The microorganisms occur as contaminants during tea processing as a result of a layer of fermented juice covered on the processing machines and other equipments employed (Werkhoven, 1974). The commonly adopted practice to prevent microbial contamination is to meticulously clean the processing machines with detergents followed by repeated washings with plain water (Chakraborty and Baruah, 1971). Although several antimicrobial chemical agents are available, these cannot be employed in view of stringent food laws enforced by various countries, for fear of their residual toxic effects. In view of this, some tea producers were prompted to employ ultraviolet (UV) irradiation during fermentation, for effective microbial eradication on the basis of its known germicidal action. However, the effect of UV irradiation on the quality of the black tea, as a result of its use during fermentation, is not known. Hence, an investigation was undertaken to study the effect of UV radiation, during fermentation of CTC process, on the quality of black tea.

## MATERIALS AND METHODS

### Experimental tea manufacture

Freshly plucked clonal tea leaves were spread at the rate of 10 kg per square meter on a withering trough and allowed to wither artificially by means of warm air at 35°C for 16–18 hours to achieve 75% wither. The withered leaf was passed through a CTC machine four times to bring about adequate physical damage. Suitable portions of CTC processed leaf were allowed to ferment for the appropriate times in an UV-cabinet fermenter at 25°C and 95% relative humidity. The fermented dhool was dried in a miniature drier using hot air at 95°C to a final moisture content of 3%.

### UV cabinet fermenter

The fermenter consists of an UV–germicidal tube (3'–30 W. 'Philips', Holland make) fixed to the ceiling of a wooden cabinet (100 cm x 30 cm x 140 cm). There are four pairs of metallic frames, one below the other to hold the trays containing dhool for fermentation, each at 20 cm, 40 cm, 60 cm and 80 cm from the UV source. Trays containing dhool spread at 1 cm thickness are kept for fermentation on the frames at various distances from the UV source in such a way that UV irradiation of dhool in all the trays is effected without any hindrance. The UV–cabinet fermenter is covered with a nylon net, and water is constantly trickled over it through a perforated PVC tube to create optimum conditions of temperature (25°C) and humidity (95% RH) for fermentation inside the fermenter. A table fan was placed near the fermenter to supply fresh air to the fermenting dhool.

### Estimation of polyphenolic pigments

Theaflavins content of dhool drawn at different intervals during fermentation was estimated by following the modified Roberts' spectrophotometric method as employed by Ullah (1977).

Estimations of theaflavins (TF), thearubigins (TR) and high polymerized substances (HPS) contents of balck teas, made by varying fermentation periods, in the presence of UV, as well as in the absence of UV were carried out by following the modified Roberts' spectrophotometric method as employed by Takeo and Oosawa (1976) and Ramaswamy (1977).

### Organoleptic evaluation of black tea

Tea samples were sent to two professional tea tasters for their reports on the black tea appearance, infused leaf colour, liquor characters such as colour, strength, briskness, quality, and valuation.

### Microbial evaluation

The microorganisms present in the dhool obtained after CTC processing, before and 60 minutes after fermentation were quantified by the standard dilution plate method (Waksman, 1931). Samples of the dhool both with and without UV irradiation, were tested. Potato sucrose agar (1.5%) was used for the isolation of fungi and nutrient agar (1.5%) for bacteria. The pH of the nutrient agar was adjusted to 7.2 with 1N NaOH. Four replicates were maintained in each treatment.

## RESULTS AND DISCUSSION

The design of an UV–cabinet fermenter is given in Fig.1. The flux of UV radiation reaching the fermenting dhool kept at 20 cm, 40 cm, 60 cm and 80 cm distance from the UV source were 31.83 $mW/cm^2$, 15.92 $mW/cm^2$, 10.61 $mW/cm^2$ and 7.96 $mW/cm^2$ respectively. Since a germicidal UV–tube was used with wavelength nearer to 254 nm, it was expected that the flux could be adequate enough to cause antimicrobial effect. While Jagger (1960) reported that the entire 310–400 nm was lethal for *Escherichia coli* Himmelfarb Scott and Thayer (1970) could achieve effective killing of *Staphylococcus aureus* with exposure to fluorescent lamps at 25-100 $uW/cm^2$ in 8 hours. However, the recent review (Klein, 1978) has stated that the efficiency of 254 nm wavelength band can be from $10^2$ to $10^5$ that of 350–450 nm.

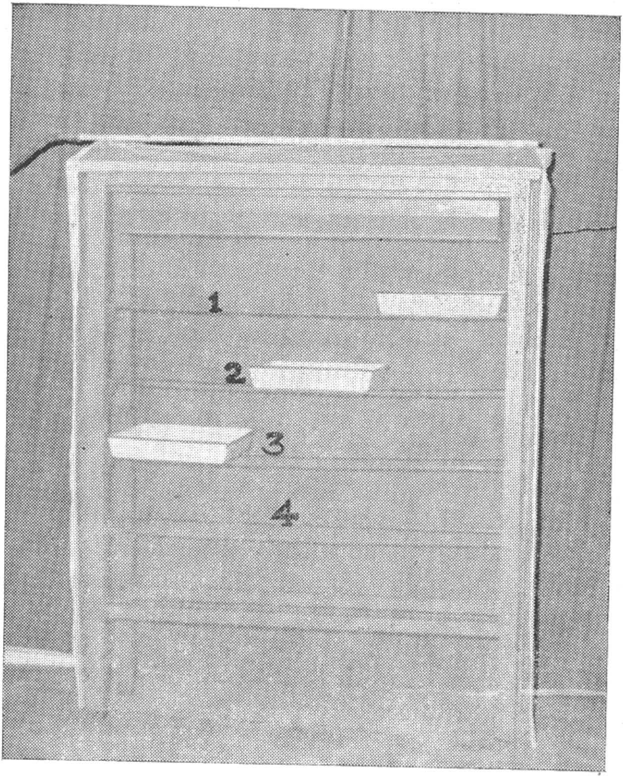

Fig. 1. The UV cabinet fermenter

The levels of theaflavins formed in dhool of the clone UPASI–3 during fermentation in relation to the distance of the UV source are presented in Fig.2. This clone exhibited maximum theaflavins formation at 45 minutes, when 75% withered leaf was CTC processed and fermented without UV exposure. The level of theaflavins formation increased considerably, when dhool was fermented in the presence of UV at a distance of 20 cm from the source and it was noticed that as the distance of UV source increased, the formation of theaflavins decreased proportionately (Fig. 2). However, between 20 cm and 40 cm of distance from the UV source, the difference in theaflavins formation was not found to be considerable enough. It was also observed that at 20 cm distance, heating up of dhool was noticed, the distance being very close to UV source. Hence, it was thought to be appropriate to fix the distance of UV source at 40 cm throughout the investigation.

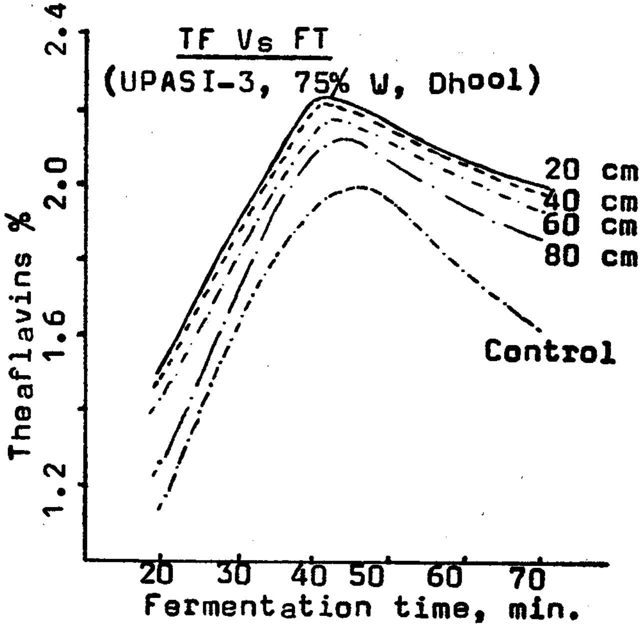

Fig. 2. Levels of theaflavins & distance from UV source

Recent work of Lakshminarayanan and Ramaswamy (1978) has shown that the theaflavins analysis could be used to assess the optimum fermentation time of CTC processed clonal leaves. Table 1 gives the effect of UV radiation on fermentation period of CTC processed clonal leaves of UPASI–3, UPASI–10, UPASI–15, UPASI–22 and TRI–2024 as determined by theaflavins analysis. It was observed that UV exposure on dhool had reduced the optimum fermentation time of these clones by 5 to 10 minutes. This may be attributed to the higher rate of theaflavins formation involving oxidative transformation of tea catechins into orthoquinones mediated by tea catechol oxidase, followed by condensation reactions. It may be supposed that UV energy could have activated the enzyme, tea catechol oxidase, by direct photo-alteration of the protein structure. It was reported (Weber, 1961) that protein containing tyrosine or tryptophan can be photoexcited by UV as evidenced by fluoresence. It appears that the radiation might affect the tertiary structure of the protein, thereby resulting in an activation of the latent tea catechol oxidase. It may also be supposed that oxidative formation of quinones leading to theaflavins and related compounds could be effected by photochemical reactions induced by UV radiations.

**Table 1. Effect of ultraviolet radiation on fermentation period**

| Clones | Optimum fermentation time (minutes) | | |
|---|---|---|---|
| | without UV | with UV* | difference |
| UPASI–3 | 45 | 38 | 7 |
| UPASI–10 | 66 | 60 | 6 |
| UPASI–15 | 48 | 43 | 5 |
| UPASI–22 | 64 | 54 | 10 |
| TRI–2024 | 34 | 29 | 5 |

* Irradiation at 40 cm from the source of UV (254 nm).

Figures 3, 4, and 5 show the levels of theaflavins, thearubigins and high polymerized substances respectively in black teas made from dhools of UPASI–3 drawn at different stages of fermentation with and without UV exposure. As far as theaflavins contents of black teas are concerned, the UV treated samples showed higher values than the untreated black tea samples, attaining a maximum level in the UV treated samples in a shorter period when compared to teas fermented under normal conditions. Formation of thearubigins and high polymerized substances, in the presence and absence of UV exposure, showed an increasing trend over the entire period of fermentation. However, the UV treatment during fermentation helped in an appreciable increase in the levels of thearubigins and high polymerized substances in black teas.

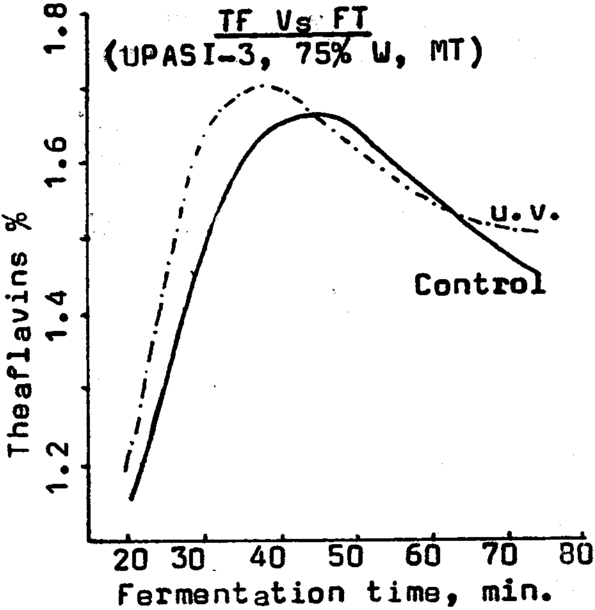

Fig. 3. Levels of theaflavins

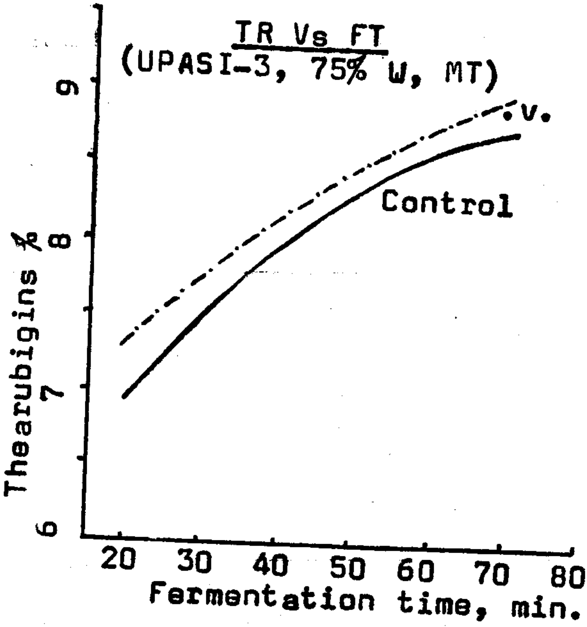

Fig. 4. Levels of thearubigins

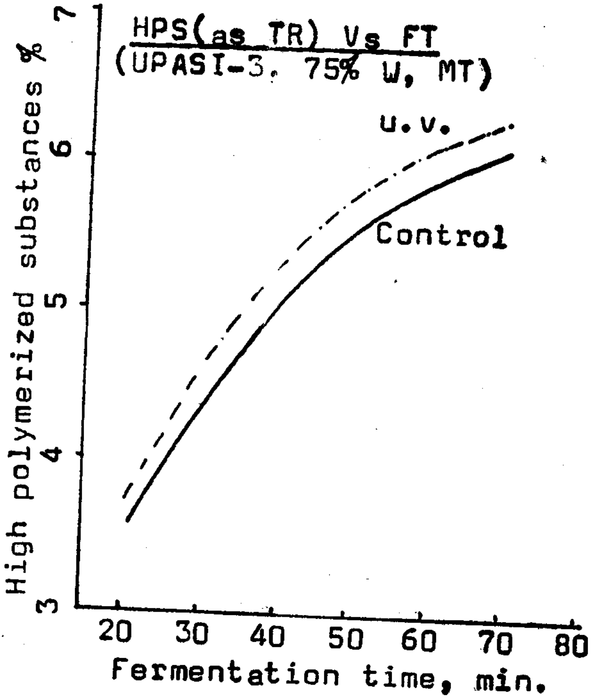

Fig. 5. Levels of high polymerised substances

Tasters' reports on valuation for black teas made after fermenting the dhool of UPASI–3 for 35 minutes with UV exposure and 45 minutes without UV exposure, indicated that UV treated samples scored higher marks on valuation than normal tea samples (Table 2).

**Table 2. Tasters' evaluation of black teas**

| Characters | Control | UV-Treated* |
|---|---|---|
| Leaf appearance, marks | 6 | 7 |
| Infused leaf colour, marks | 8 | 9 |
| Liquor colour, marks | 8 | 9 |
| Liquor strength, marks | 7 | 9 |
| Liquor briskness, marks | 7 | 8 |
| Liquor quality, marks | 7 | 8 |
| Valuation, Rs/Kg | 9.40 | 9.90 |
| Fermentation time | 40 min. | 35 min. |

* Irradiation of dhool at 40 cm from the source of UV (254 nm). Black teas were made from 75% withered UPASI–3 clonal leaves.

Microbial counts determined initially and after 60 minutes of fermentation with and without UV in the dhool of UPASI–3 are given in Table 3. The number of both fungi and bacteria decreased considerably during the process of fermentation and a further reduction of these occurred in dhool fermented under UV light. The presence of unoxidised catechins, such as, (—) *epi* gallocatechin and (—) epi gallocatechin gallate, in the dhool could have suppressed microbial growth, as these products have more antimicrobial properties than oxidized polyphenols (Bokuchava and Skobeleva, 1969; Stagg and Millin, 1975). Reduction of microbes in the dhool fermented under UV light could be due to the germicidal action of UV irradiation. However, complete inhibition of microbes could not be achieved on account of the fact that UV has very slight powers of penetration and microbes hidden behind the particles might escape its action (Frobisher, 1966).

**Table 3. Bacterial and fungal counts of dhool during fermentation**

| Fermentation period | Bacteria/g. | Fungi/g. |
|---|---|---|
| 1. 0 min. | $9.83 \times 10^6$ | $6.21 \times 10^4$ |
| 2. 60 min. | $3.52 \times 10^6$ | $3.33 \times 10^4$ |
| 3. 60 min. with ultraviolet | $2.32 \times 10^6$ | $2.29 \times 10^4$ |

Dhool from 75% withered UPASI–3 leaves.

## ACKNOWLEDGEMENT

The authors are grateful to Dr. C.S. Venkata Ram, Director of Research, UPASI and Mr. P.C. Narayan of Chandramalai Estates for their advice on the experiment. The technical assistance rendered by our colleagues, Dr. C. Kandasamy and Mr. S. Natesan is also gratefully acknowledged.

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# TECHNOLOGY OF CTC–RECONDITIONING PROCESS OF BLACK TEA MANUFACTURE IN SOUTH INDIA

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## ABSTRACT

**Addition of reconditioning dust upto 15–20% on the green leaf basis was found to increase the formation of theaflavins in clonal black teas significantly. Influence of withering and quality of reconditioning dust on the liquor characters of clonal black tea were studied. Effect of addition of reconditioning dusts on the overall grade ratio of drier-mouth tea was investigated.**

## INTRODUCTION

Incorporation of reconditioning dusts (RC dusts) at rotorvane stage to improve the density and blackness of CTC (Crush, Tear and Curl) teas is an established methodology in the context of South Indian unorthodox system of tea manufacture. However, the effect of RC dust on the formation of colouring constituents, particularly the theaflavins, in black teas has not so far been reported. Hence, attempts were made to investigate the effect of RC dust addition on the physio-chemical properties of CTC black teas.

## MATERIALS AND METHODS

### Experimental tea manufacture

Manufacture was carried out in the UPASI Tea Research Institute's mini manufacturing unit at Cinchona, Coimbatore (Dist.), South India. Freshly plucked clonal tea leaf was spread out at a rate of 10 kg per square metre on a withering trough and allowed to wither artificially by means of warm air at 35°C for varying periods to achieve different withers, ranging from 100% to 70%. The withered leaf was passed through a CTC machine four times to bring about adequate physical damage. Suitable portions of CTC processed leaf were allowed to ferment for the appropriate times in airconditioned cabinets at 25°C and 95% RH. The fermented tea was dried in a miniature drier using hot air at 95°C to a final moisture content of 3%.

### Preparation of reconditioning dust

Spills and bigger grades of teas, as obtained above 10 mesh sieve after grading the drier-mouth clonal teas, were ground in a laboratory hammer mill and the fine particles which passed through 40 mesh sieve were used as RC dust. The RC dusts collected from one of the CTC factories in Anamallais were also used in this investigation.

### CTC reconditioning process

The RC dusts at various levels were thoroughly mixed with the dhool after first CTC cut and further processed in CTC machine three times, followed by fermentation and drying.

### Grading of tea

The drier-mouth tea samples were graded by passing through 10, 18 and 24 wire mesh sieves. The weight of each fraction was determined and their percentage calculated to record the grade ratio.

### Analysis

Moisture contents of withered leaf, dhool, made tea and the RC dust were determined by the oven method prescribed by I.S.I. (1973) for the determination of dry matter content of ground black tea samples. The estimations of theaflavins (TF) contents of black teas and RC dusts were carried out by following the modified Roberts' method as employed by Takeo and Oosawa (1976) and Ramaswamy (1977). The organoleptic evaluation of tea samples was made by professional tea tasters who allotted scores for leaf appearance, infused leaf colour, and liquor characters such as colour, strength, briskness and quality.

## RESULTS AND DISCUSSION

A layout of CTC reconditioning process which is being adopted in South Indian CTC tea factories is given in Fig. 1. By this process, withered leaf containing 73% moisture, is fragmented in a shredder and then preconditioned in a rotorvane where the RC is admixed. The 'mal' is then macerated in five CTC machines in tandem, fermented for 1 hour and dried to a final moisture content of 3%. However, there is no evidence as to what should be the optimum level of RC dust that can bring about acceptable quality in CTC black tea.

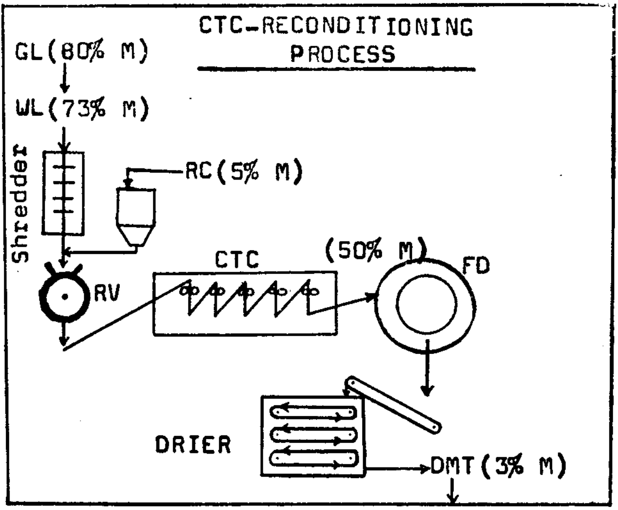
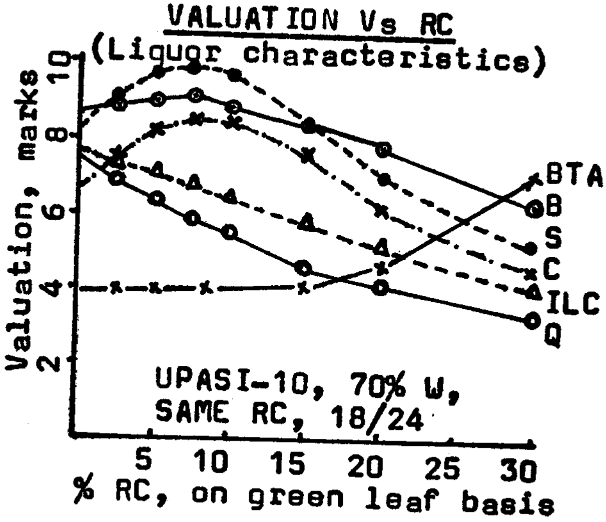


Fig. 1. CTC–Reconditioning process

Black teas were made from 75% withered leaf of UPASI–15 by CTC reconditioning process using the factory RC dusts at various levels and a grade collected between 18 and 24 mesh sieve, equivalent to pekoe fanning, was sent to professional tasters for evaluation. The factory RC dust on analysis showed 0.29% theaflavins, 5.94% thearubigins and 5.8% high polymerized substances. Fig.2 gives the effect of RC dust on the tasters' evaluation for CTC black tea appearance (BTA), infused leaf colour (ILC) and liquor characteristics such as strength (S), colour (C), briskness(B) and quality(Q). It was observed from the graph that the valuation for black tea appearance increased with the increase in level of

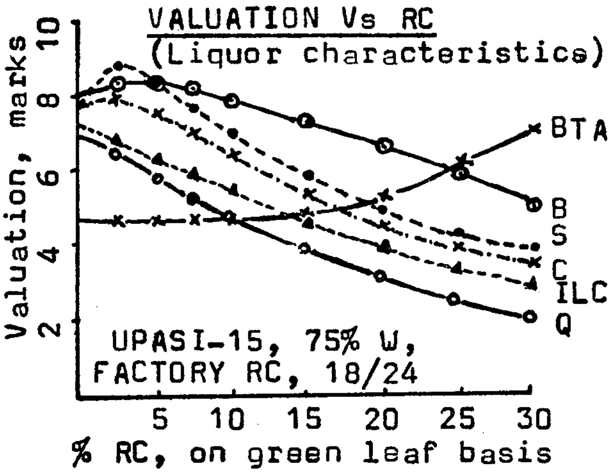
RC, while the valuation for infused leaf colour decreased gradually. As far as the colour, strength, briskness and quality of liquor are concerned, valuations for these characters showed increasing trends for black teas made by using RC dusts upto 3–5%. However, RC dust addition above 5% did not show an improvement on the liquor characters. Since theaflavins and related pigments are involved in all four characters of the liquor, it is not surprising that the quality of RC dust should have influence on the tasters' evaluation.



(Figure 2)

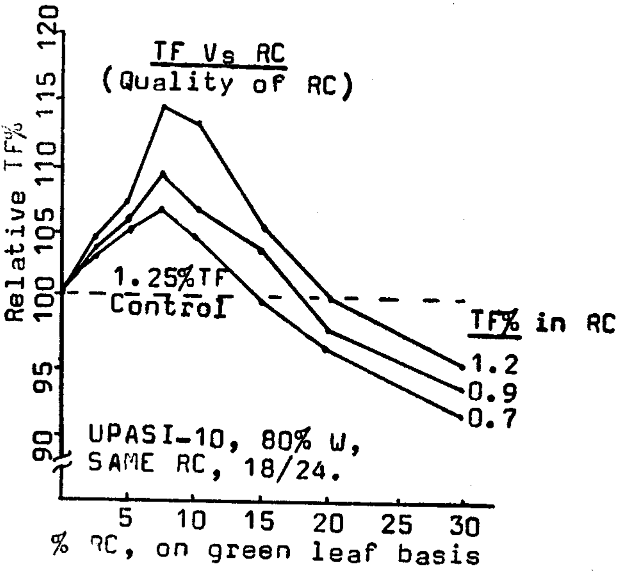
RC dusts were made from black teas of UPASI–10 and the same RC dusts were used for the preparation of black teas from 70% withered UPASI–10 leaf. Pekoe fanning grades were sent to professional tasters for evaluation. The effect of RC dust on the tasters' evaluation is presented in Fig. 3. In general, the results support the view that was stated above in respect of the black tea made from UPASI–15 using factory RC dusts (Fig. 2). Since the quality of the clonal RC is superior to the factory RC, the results indicated in Fig.3 reveal that even upto 10% of RC level, the liquor characters have received higher marks on valuation. It might be expected that the quality of made tea, as judged by tasters' evaluation, can be greatly influenced by the type of RC dust and the wither percent.

Quality is the most difficult of the liquor characters to interpret in terms of easily measurable chemical constituents. However, in late fifties Roberts (1962) tentatively outlined that theaflavins can be correlated with the quality. Hilton and Ellis (1972) have correlated the market price of Central African black teas with theaflavins content and total colour. Hence, it was thought that it would be appropriate to quantify theaflavins content of black tea while studying the effect of RC dusts on quality of CTC teas.



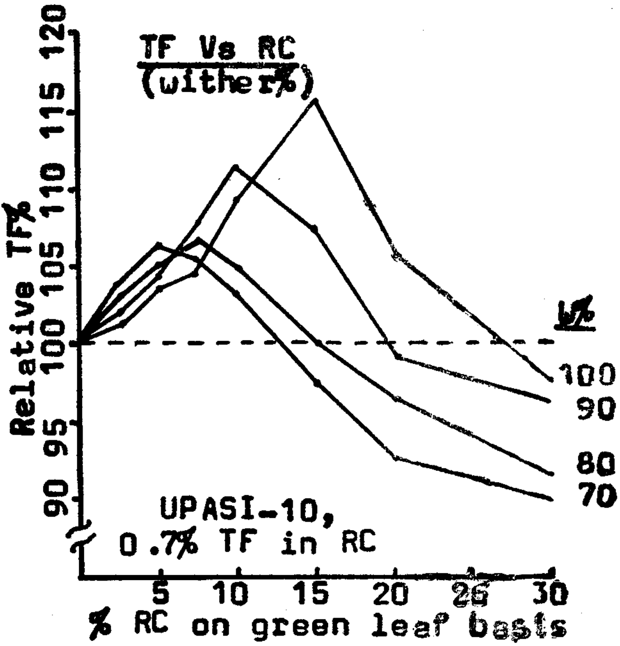
(Figure 3)

Typical results for the effect of varying levels of RC dusts on the theaflavins content of the reconditioned black tea of UPASI–10 are recorded in Fig. 4. RC dusts having different theaflavins composition were made from black teas of UPASI–10, and when these were added at different levels during CTC processing, the increase in theaflavins content of black tea over the control was found to reach a maximum at 7.5–10% level of RC dust addition. At this level of RC addition it was observed that the theaflavins content of reconditioned black tea increased with increasing concentration of theaflavins in RC dusts. It would appear that at a particular wither, the incorporation of RC dust upto certain level, depending on theaflavins content of RC dust, would help improving the level of theaflavins in black tea.



(Figure 4)

Effect of reconditioning in relation to wither percentage on theaflavins formation in made tea is presented in Fig. 5. With respect to the influence of wither on the intake of RC dusts, it is clear from the Fig.5 that, as the wither percent increases, the quantity of RC dust required to produce maximum theaflavins in made tea also increases. When black teas were made from 70% withered leaf of UPASI–10, the maximum theaflavins formation occurred at 5% RC. It appears from the results shown in Table 1 that the magnitude of theaflavins formation and the intake of RC dust during processing depend on the moisture content of the withered leaf. As the wither percent decreased, the intake of RC dust also decreased, when calculations were made on the basis of maximum theaflavins formation in the made tea as well as on the basis of moisture balance computed for 50% moisture level in dhool after reconditioning. However, incorporation of RC dusts upto 15% (on the basis of green leaf) with 80% withered leaf was found to increase the blackness of tea without affecting the liquor characteristics.



(Figure 5)

**Table 1. Intake of reconditioning dust during CTC processing in relation to withering**

| % wither | % moisture in withered leaf | % Reconditioning dust intake on green leaf basis (maximum) | |
|---|---|---|---|
| | | Moisture balance* | Theaflavin estimation |
| 100 | 80 | 66.6 | 15.0 (26) |
| 90 | 77 | 54.0 | 10.0 (20) |
| 80 | 75 | 44.4 | 7.5 (15) |
| 70 | 71 | 41.9 | 5.0 (13) |

Theaflavins in reconditioning dust is 0.7%.

Permissible limit of reconditioning dust as calculated on theaflavins estimation is given in parenthesis.

* Computed for 50% moisture in processed leaf.

It is generally experienced during CTC tea manufacture that the intake of RC dusts depends on moisture content of withered leaf, moisture content of RC dust and the capacity of the processing machine (CTC machine). The optimum intake of RC dusts can be calculated from the formula :

$$R = \frac{M_1 - M_2}{M_2 - M} \times 100$$

where R is the parts of RC dust per 100 parts of withered leaf, $M_1$ is the percent moisture in withered leaf before reconditioning, $M_2$ is the percent moisture in processed leaf after reconditioning and M is the percent moisture in RC dust. It is established that the capacity of the processing machine could be designed according to the value of $M_2$, the moisture percent in processed leaf after reconditioning.

The effect of RC addition on grade ratio of the black tea is presented in Table 2. The grades of tea collected above 10 mesh

**Table 2. Effect of addition of reconditioning dust on grade ratio of black tea**

| %Reconditioning dust | Sieve size (mesh number) | | | |
|---|---|---|---|---|
| | Above 10 | 10/18 | 18/24 | Below 24 |
| 0 | 15.7 | 19.4 | 34.6 | 30.3 |
| 5 | 13.9 | 18.6 | 36.1 | 31.4 |
| 10 | 12.2 | 16.4 | 38.3 | 33.1 |
| 15 | 9.4 | 14.3 | 40.4 | 35.9 |
| 20 | 7.3 | 12.1 | 42.6 | 38.0 |
| 30 | 5.5 | 9.6 | 44.7 | 40.2 |

Each value is an average of nine determinations from three replicates.

Black teas were made from 80% withered leaves of UPASI–10 using reconditioning dusts of the same clone.

(spills and pekoe) and those collected between 10 and 18 mesh (BOP and BOP fanning) decreased in grade ratio as the levels of RC dusts in teas increased, whereas the Pekoe dusts (collected between 18 and 24 mesh) and Fine dusts (collected below 24 mesh) showed an increasing trend in grade ratio with increasing levels of reconditioning. It is evident from the present investigation that the reconditioning in CTC process of black tea manufacture could improve the blackness of tea and the grade ratio of dust proportionately to the quantity of RC dust incorporated and that the liquor characters could be improved by reconditioning only upto 15% (on green leaf basis) with 80% withered leaf containing 75% moisture.

## ACKNOWLEDGEMENT

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# EXPERIMENTS ON SMALL SCALE FERMENTATION OF COCOA BEANS II. EFFECT OF THE DIFFERENT FACTORS FOR AERATION ON THE EXTENT OF FERMENTATION AND QUALITY OF THE CURED BEANS

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## Abstract

**Fermentation of fresh cocoa beans is known to have been influenced by a number of factors such as season, variety, quantity of the ferment, method of curing, aeration, frequency of turning etc. Various conditions which regulate the access of atmospheric air to the ferment are reported to have effects on the intensity of fermentation in larger quantities. Investigations were conducted in Kerala Agricultural University, Vellanikkara, during the rainy season of 1980 to study the individual effects in 'mini box' method of fermentation, of four factors for aeration namely, degree of insulation, turning or mixing of the beans, number of sluices in the box and quantity of beans, on the quality of cured beans.**

**Among the four insulations provided, straw (3 cm thick) in 2-layer gunny sack was found superior followed by 4-layer gunny cover. Polythene was found to be a poor insulator. Effect of season on fermentation was marked as it delayed the process by 1 to 2 days during the rainy season. But keeping the beans for more than 6 days was not desirable as it resulted in deterioration of the quality of the cured beans. Turning of the beans once daily and providing more number of sluices (10 x 10cm apart) resulted in adequate fermentation as compared to other treatments. Quantity of the ferment did not markedly influence the extent of fermentation.**

**Results from the investigations provided some general information also. Temperature build-ups in all the treatments except that involving polythene as an insulator were similar to those in commercial fermentations but with slightly lower peaks. pH of beans under fermentation tended to increase when kept for more than 6 days, but the pH of cured beans of normally fermented lots were moderate. Titrable acids (mg acetic acid/bean) ranged from 10 to 12 and were within tolerable limits. Quality assessment of cured beans by cut tests showed that treatments getting extreme insulation and/or adequate aeration gave good quality beans. It is suggested that a suitable but economical combination of these conflicting factors should be worked out.**

## INTRODUCTION

One of the basic requirements for satisfactory fermentation of cocoa beans is the maintenance of heat generated in the mass principally by the oxidative reactions in the pulp. For the production of heat, air is necessary but for the maintenance of this heat, air should be restricted to the minimum required (Quesnel and Lopez, 1975). Therefore a right balance between these two conflicting situations must be achieved which usually is not a problem in large fermentaries but is of some concern in small scale fermentation. Access of air to the ferment is influenced by different factors like the intensity of insulation, frequency of turning or mixing, number of sluices (holes) in the sweat boxes, quantity of the ferment or batch size, etc. (Rohan, 1963; Ongkheng Hoi, 1977) which either independently or in combinations can influence the extent of fermentation of cocoa beans. Information pertaining to the effect of these factors on aeration and ultimately on the extent of fermentation of small batches of cocoa beans is scant. Attempts have, therefore, been made at the College of Horticulture with an objective to elucidate the effect of four different factors influencing the level of aeration on the extent of fermentation in the mini box method developed in the Kerala Agricultural University (Kumaran *et al.* 1980) and on the quality of the cured beans.

## MATERIALS AND METHODS

Cocoa beans extracted from almost uniformly ripe pods harvested and stored for two days were used for the studies by the 'mini box' method of fermentation. Boxes having 25 cm x 20 cm x 20 cm dimensions which can hold 5 kg wet beans were used for the studies. For studying the effect of insulation, four of the boxes having sluices spaced 20cm x 10cm apart were filled with wet beans and were packed well on the second day with four insulators namely, polythene sheet (300 gauge), 4–layer gunny, straw (3 cm)-in-2-layer gunny and 2-layer gunny which was used as the control. Beans in all the boxes were turned once in 48 hours and they were kept for 6 days. Two replications were maintained. In the second study for the effect of turning, three boxes with sluices (20 x 10cm) apart and insulation with a 2-layer sacking as in the control, were filled with wet beans. They were given three frequencies of turning viz., once in 24 hours, once in 48 hrs and once in 72 hrs. All were kept for six days. Another set of the treatments were also used as a replication. Three boxes with varying number of sluices spaced 10cm x 10cm, 20 x 10cm and 20 x 20cm apart respectively were used to study the effect of aeration as influenced by sluices in the minibox. The boxes after having filled with wet beans were provided with a complete covering by a 2-layer sacking. The beans were turned once in 48 hours and they were taken out for drying on the 7th day. In the fourth experiment to study effect of quantity or batch size, three boxes having dimensions of 20 x 15 x 15cm, 25 x 20 x 20cm and 30 x 20 x 25 cm to hold 2.5 kg, 5.0kg and 7.5 kg of beans respectively with sluices spaced 20 x 10cm apart were used. Beans were filled in the boxes and fermented after providing proper insulation, turning etc. as in the 'mini box' method.

All the experiments were carried out in nearly uniform conditions prevailing in the laboratory during the months of July and August 1980 when humidity and ambient temperature in the part of the laboratory where the boxes were kept ranged from 83 to 96% and from 21°C — 34.5°C respectively. All the experiments were conducted in two groups. Effect of insulation and turning were done together followed by the other two. Temperature readings (C°) were taken daily at 8 a.m. and 4 p.m. from the centre of the ferment in each of the lots. All the treatments were kept for 6 days except in the study using different insulators wherein one set of the treatments was retained until adequate fermentation as manifested by a permanent fall in temperature, change of bean colour etc. were attained in each of the four treatments. Cotyledon pH of beans undergoing fermentation was estimated only for the first two studies by drawing samples from the centre of the ferment. But pH of cured beans was determined for all the treatments. In both cases, a standard procedure was followed (Anon 1978). Titrable acids (mg acetic acid/bean) was estimated (Ranganna, 1979). Percentage weight loss of the ferment in all the experiments was also estimated.

Properly dried beans from all the five experiments were tested for quality on the basis of the cut test for experimental grading (Wood, 1975, Anon, 1978).

## RESULTS AND DISCUSSION

Data on temperature, pH of beans, cut test, titrable acids etc. from all the experiments are given in Fig.1 (a—d) and Tables . and 2.

**a. Insulation:**

Bean temperature during fermentation rose from 28°–29°C to 43°–44.5°C (Fig.1 a) on the 4th–5th day in all the treatments except in the boxes insulated with polythene sheet in which peak temperature (40°C) was observed only on the 7th day and it continued to fluctuate between 35° and 37°C till the 12th day. In boxes insulated with straw in 2-layer gunny and 4-layer gunny, a conspicuous fall in temperature indicating adequate fermentation was observed on the 7th day while this condition was evident on the 8th day in the control which was insulated with a 2-layer gunny sacking showing that during rainy seasons minibox (control) takes 7 days for completing fermentation, perhaps due to the low atmospheric temperature. Seasonal effects on the duration of fermentation have been reported by other workers also (Hardey, 1960). Duration of fermentation however, can be limited to 6 days by providing greater insulation as in T1 and T3. This is important considering the fact that in the first two experiments, cotyledon pH crossed the generally allowable limit of 5 units when the beans were kept for more than six days. Hence it can be suggested that during rainy season, greater insulation of the mini box is necessary to facilitate adequate fermentation in six days. Howat *et al.* (1957) recommended 6 days as being sufficient for successful fermentation with turning or mixing after 2 days and 4 days. Among the insulators used, straw in 2-layer gunny was found superior followed by 4-layer gunny sacking (Table 1a, 2) while polythene was quite inferior as an insulator because of inadequate aeration. Quesnel and Lopez (1975) suggested to provide an extremely well insulated box and reduce the air supply for the production of heat in the fermenting mass. Manurung *et al.* (1976) testing the effect of sack covers and openings in cocoa minibox in East Jawa reported that among the treatments, 2 sack covers gave the best results. Kumaran *et al.* (1980) also obtained similar results in studies with small batches (1.5 and 3 kg) of beans and three types of containers, insulated with 2-layer gunny covers.

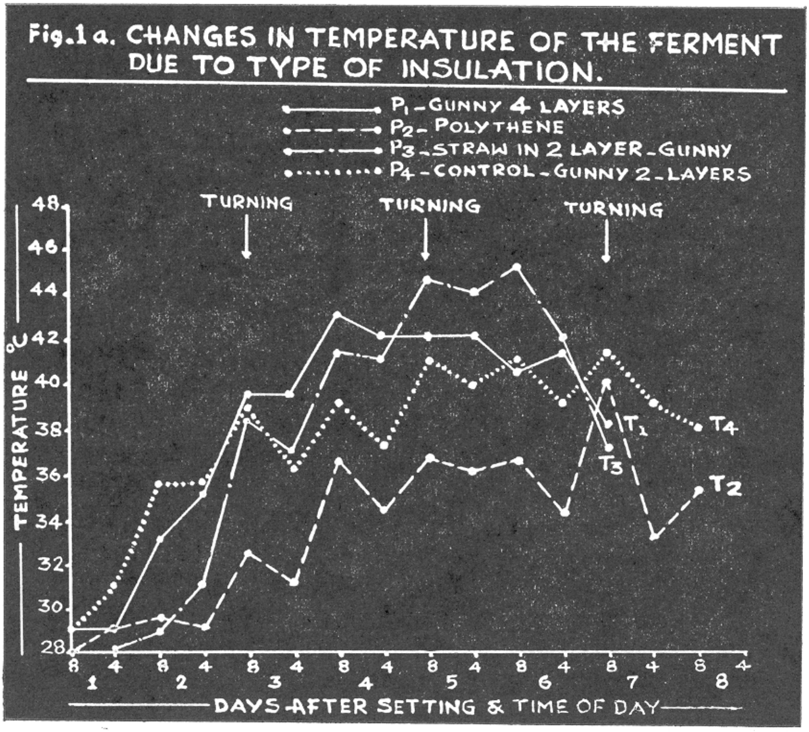


Fig.1a. CHANGES IN TEMPERATURE OF THE FERMENT DUE TO TYPE OF INSULATION.

(Figure 1a)

## b. Turning of beans

Treatment differences with respect to temperature, bean pH, titrable acids etc. (Fig. 1b, Table 1 and 2) were not marked among the three treatments tested. However, based on quality tests and temperature build-up during fermentation, daily turning was found to be superior followed by turning once in 48 hours, which could be due to greater aeration in the ferment. This is in agreement with the findings by other workers (Howay *et. al.*, 1957, Wood, 1975). Cured bean pH, however was slightly in excess (Table 1b) on the 7th day indicating a higher rate of oxidation of acid(s). From the results, it can be concluded that though daily turning is difficult and uneconomical for large quantities (Hardey, 1960) it would be advantageous for small batches of cocoa.

**Table 1(a) Variation in Cotyledon pH during fermentation of Cocoa beans for four types of insulators in 'Mini box' method**

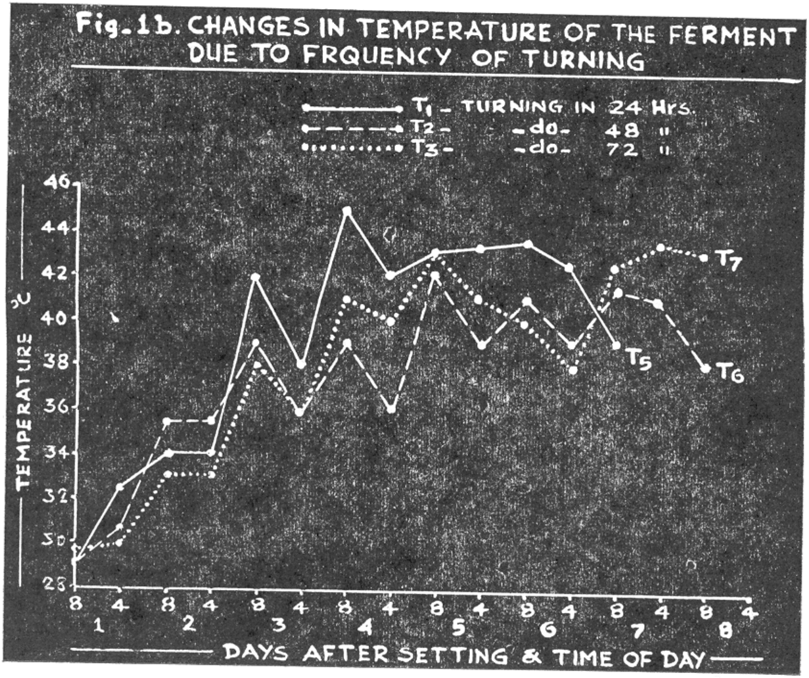
| Treatment | Daily pH reading after setting of beans | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | VII | VIII | IX | X | XI |
| 1 Gunny–4 layers | 6.45 | 6.95 | 5.05 | 4.8 | 4.2 | 4.85 | 5.68 | 6.80 | — | — | — |
| 2 Polythene sheet | 6.66 | 6.70 | 6.10 | 4.80 | 4.10 | 4.05 | 4.60 | 6.20 | 6.65 | 7.60 | 6.50 |
| 3 Straw in 2 layer Gunny | 6.63 | 6.68 | 5.93 | 5.50 | 3.10 | 4.88 | 6.30 | 7.70 | — | — | — |
| 4 Control (Gunny 2 layers) | 6.43 | 6.20 | 5.40 | 5.0 | 3.20 | 4.45 | 5.45 | 7.10 | — | — | — |

**Table 1 (b)** Variation in cotyledon pH during fermentation for three frequencies of turning in 'Mini box' method

| Treatment | Daily pH reading after setting of beans | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | VII | VIII |
| 5 turning in 24 hours | 6.40 | 6.10 | 5.70 | 5.10 | 3.30 | 4.93 | 6.30 | 6.80 |
| 6 Turning in 48 hours | 6.43 | 6.20 | 5.40 | 5.00 | 3.25 | 4.48 | 5.46 | 7.10 |
| 7 Turning in 72 hours | 6.50 | 6.30 | 5.50 | 5.20 | 3.40 | 4.60 | 6.13 | 6.90 |

**Table 2. Cut test bean pH and titrate acids of cured beans from four studies**

| Treatment | Colour classes of beans | | | | Mean percentage weight loss during curing. | Cured bean pH | Titrable acid, (mg acetic acid/beans) |
|---|---|---|---|---|---|---|---|
| | Brown | Pale purple | Deep purple | Slaty | | | |
| 1 | 2 | | | | 3 | 4 | 5 |
| A. **Insulation** | | | | | | | |
| 1. Gunny 4 layers | 36 | 42 | 22 | — | 69.0 | 5.48 | 10 |
| 2. Polythene sheet | 10 | 44 | 36 | — | 66.0 | 5.03 | 12 |
| 3. Straw in 2-layer gunny | 54 | 38 | 8 | — | 72.0 | 5.68 | 10 |
| 4. Gunny 2-layers | 22 | 52 | 26 | — | 68.0 | 5.88 | 12 |
| B. **Turning** | | | | | | | |
| 5. Turning in 24 hours | 36 | 62 | 2 | — | 68.0 | 5.94 | 10 |
| 6. Turning in 48 hours | 22 | 58 | 20 | — | 66.7 | 5.71 | 12 |
| 7. Turning in 72 hours | 26 | 44 | 30 | — | 68.0 | 5.97 | 12 |
| C. **Sluices (Holes)** | | | | | | | |
| 8. 1 hole/100 scm | 40 | 46 | 14 | — | 68.4 | 5.60 | 10 |
| 9. ,, /200 scm | 34 | 42 | 24 | — | 68.1 | 5.52 | 10 |
| 10. ,, /400 scm | 24 | 50 | 26 | — | 66.7 | 5.74 | 10 |
| D. **Quantity** | | | | | | | |
| 11. 2.5 kg | 22 | 52 | 26 | — | 67.7 | 5.80 | 10 |
| 12. 5.0 kg | 34 | 32 | 34 | — | 68.5 | 5.48 | 10 |
| 13. 7.5 kg | 32 | 38 | 30 | — | 69.0 | 5.65 | 12 |



(Figure 1b)

## c. Sluices

Among the three treatments tried, based on the production and maintenance of temperature, cured bean pH, cut test etc, (Fig. 1c, Table 1 and 2), providing sluices 10 x 10 cm (100 scm) apart in the minibox was found to be superior followed by a spacing of 20 x 10 cm (200 scm). This superiority over the inferior treatment (400 scm) can also be explained as due to the availability of adequate aeration to the ferment. Quesnel and Lopez (1975) provided slits at the bottom of the Styrotex sweat box for small scale (10 to 20 kg) fermentation to permit drainage of the sweatings and aeration. Manurung *et. al.* (1976) comparing the effect of varying number of clefts in the minibox reported that providing 3 to 5 clefts gave the best results.

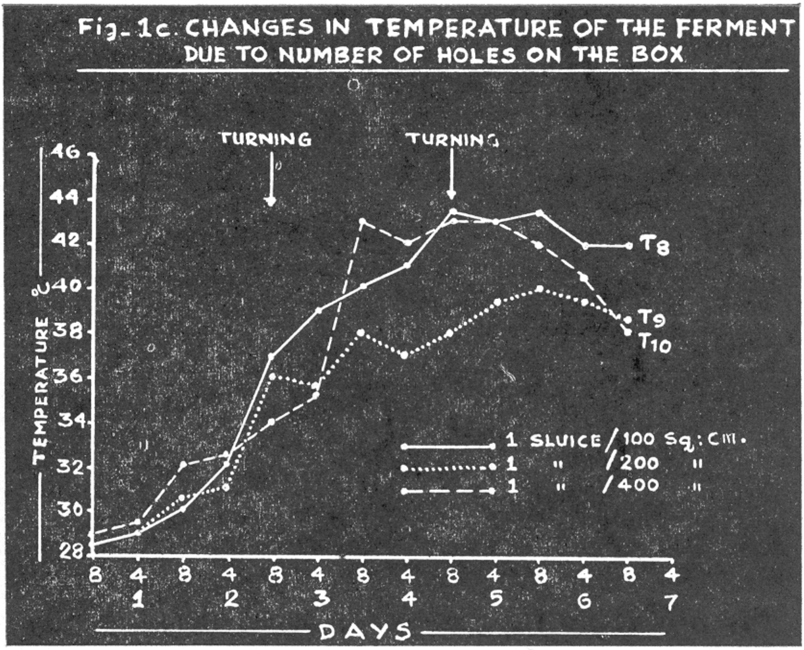


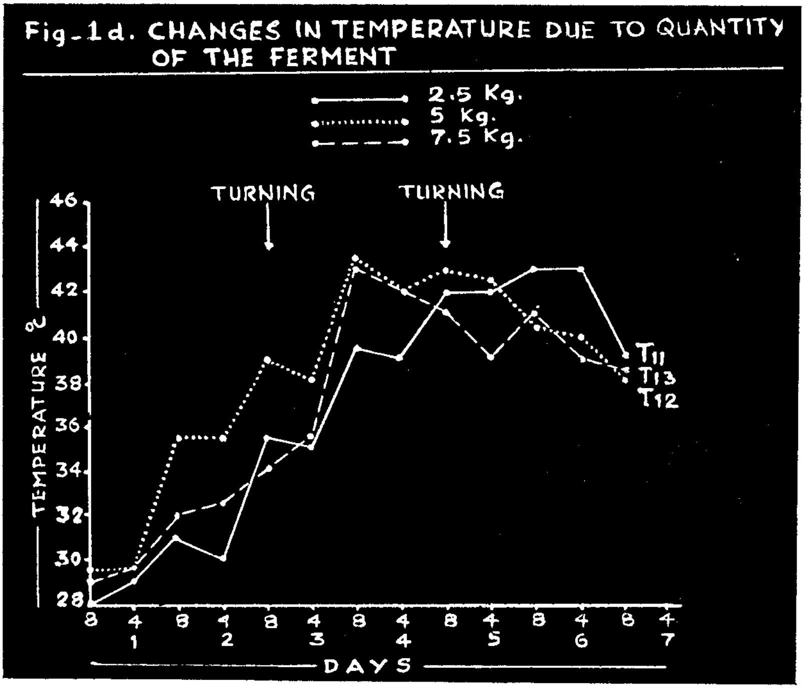
Fig. 1c. CHANGES IN TEMPERATURE OF THE FERMENT DUE TO NUMBER OF HOLES ON THE BOX

(Figure 1c)

## d. Quantity

Treatment differences in respect of the temperature build-up, pH values, cut test of cured beans etc. (Fig . 1d Table 1 and 2) were not quite marked in the three batch sizes which showed that with small quantities of the ferment, production and retension of temperature are nearly identical in wooden containers if sufficient insulation and mixing were provided as was earlier reported in this series of studies (Kumaran *et. al.* 1980). For larger quantities, however, maintenance of heat, quality of the beans etc., were reported to be in direct proportion to the batch sizes (Rohan, 1963).

Results from the different investigations also provided some additional information. The most useful index of the progress of fermentation is the temperature attained and a temperature range of 40°—50°C is necessary for most of the bio-chemical activities proceed in the cocoa beans (Hardey, 1960). Temperature build-ups in all the experiments ranged from 28°C to 45°C and the trend in its changes, except in the batches insulated with polythene sheet, agreed with those generally observed in commercial fermentations with larger quantities (Wood, 1975, Adomako *et. al.* 1979). The peak temperature, however, ranged between 45°C to 48°C and it was attained on the 3rd or the 4th day after setting. The slightly lower peak and delay in the present studies could be attributed to the small batches tested. Similar situations have also been reported by Quesnel and Lopez (1975) and Kumaran *et. al.* (1980) who noticed a comparatively low peak of temperature when small quantities of cocoa were fermented.



(Figure 1d)

pH values of the fermenting beans also revealed variations somewhat similar to those seen in commercial fermentation processes. The trends of changes were more or less identical in the two experiments studied (Table 1a and b). Bean pH decreased from

6.9 to less than 4 on the 5th day and then increased to 4.1 to 4.9 units as in commercial fermentations (Wood, 1976; Ong Kheng Hoi 1977). The considerably low pH on the 5th day is indicative of excessive production of acid(s) which can be due to a higher rate of conversion in an aerated condition of sugars in the pulp. Cured bean pH in all the treatments ranged from 5.03 (T2) to 5.97(T7). Generally, treatments getting adequate aeration showed moderately higher pH values for cured beans perhaps due to the over-oxidation of the acid(s) during curing (Chong *et. al.* 1978). Titrable acids (mg acetic acid/bean)was found to range between 10 and 12 units which was slightly less than that observed in Malaysian beans (approx. 14 units) by Chong *et. al.* (1978). It can be inferred that the beans fermented in miniboxes generally have acid(s) in tolerable limits only.

Quality assessment of the different experiments by cut test (Table 2) revealed marked differences among treatments. The percentage of brown beans was more in those treatments getting greater insulation and aeration through turning or through more number of sluices (T1, T3, T5 and T8). Incidently these were the treatments which showed higher temperature peaks and its maintenance over a longer period. The maximum percentages of brown beans in these treatments ranged from 36 to 54 but by this test, all were under-fermented. However, considering the low percentages of deep purple beans these lots can be considered to have adequately fermented subject to final organo-leptic tests (personal communication). Similar results have been reported by Adomake *et. al.* (1980) in heap and tray fermentations using larger amounts of beans. Differences in loss of weight during fermentation were not marked in all the treatments. It ranged from 66.7 percent (T–6 and T–10) to 72.0 percent (T–3) and in general, did not show any relationship with the other attributes except in the treatment T3 where weight loss was seen associated with the extent of fermentation as revealed by the temperature build-up and the percentage of brown beans.

The present investigations thus have given some general clues of the roles played by factors like insulation, mixing of the beans etc. on the degree of fermentation besides providing information on the effect of the season on the duration of fermentation.

Minibox with a compact packing by a 2-layer gunny sacking took 7 days for complete fermentation in the rainy season but it might lead to higher pH in the cured beans. Hence the boxes should be well insulated for a 6 day fermentation. Frequent mixing of the beans together with greater number of sluices provided more aeration and these in turn resulted in early build-up of temperatures and its prolonged maintenance in the ferment. From the studies reported herein, a reasonably right balance between too little aeration and too much aeration is the one that can be achieved from a thick insulation by such materials as sack which also permit some air to pass through it, and a greater frequency of mixing of the beans and sufficient number of sluices in the minibox. An appropriate combination among these diverse factors is to be identified for small quantities of beans and investigations towards this is in progress.

## ACKNOWLEDGEMENTS

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# PROCESSING CONDITIONS AND IMPROVEMENTS

(Session III)

*Chairman* : **Dr. A. G. Mathew**

*Rapporteur* : **Shri Bengali Baboo**

# EXTRACTION AND PURIFICATION OF CAFFEINE FROM TEA WASTE USING 1,1,2,2,—TETRACHLOROETHANE

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## ABSTRACT

**TCE is ideally suited for the extraction of caffeine from aqueous tea extracts in view of its low solubility in water, high recovery rate, favourable partition co-efficient and preferential extraction of caffeine leaving the other ingredients. As prolonged exposure to TCE causes headache and giddiness and long time exposure may lead to liver damage, a closed system is recommended for work. Caffeine can be purified by sublimation under atmospheric pressure.**

## INTRODUCTION

Caffeine finds use as a cardiac and respiratory stimulant and as a diuretic. Although caffeine and other purine derivatives have been synthesised very early, naturally occuring raw materials can also be economically used as a source for the extraction of caffeine. Caffeine occurs in tea, coffee, mate leaves, guarana paste and cola nuts (Anonymous, 1976). In India the tea wastes that are available in large quantities from the tea factories offer a good source for the manufacture of caffeine. This study deals with the extraction of caffeine from tea waste by hot water followed by liquid-liquid extraction using 1,1,2,2–Tetrachloroethane (TCE). Caffeine has got the maximum solubility in this solvent and the solvent also is now readily available in India.

## MATERIALS AND METHODS

The tea waste was collected from different tea factories in Tamil Nadu and Kerala. TCE (Calico Chemicals) and dichloroethane (NOCIL) were commercial solvents and used without further purification. Lime (CaO) was also a commercial sample.

For liquid-liquid extraction in the laboratory scale a separating funnel was used. For large scale preparation a rotary disc contactor (RDC) 6 ft. long provided with stator and rotors and coated with epiomite resin was used. Counter current extraction with TCE was done with both the phases moving in vertical fashion in opposite directions. The flow rate of TCE was adjusted to be about 1/5th of the rate of aqueous tea extract and one pass through the RDC was equivalent to six stage extraction as the RDC was compartmentalised.

**Extraction of Caffeine**

The laboratory experiments were performed using 100 gms. quantities of tea waste. Pilot plant studies were done in 10 Kg. quantities. Large scale extractions were done using one metric ton quantities. The tea waste was mixed with fresh lime and extracted with hot water. Three to four extractions were done and the total extract was about 4 to 5 times the weight of tea waste.

The extract was allowed to settle and the clear supernatant was extracted 4–5 times with TCE. The total quantity of TCE consumed was about one fourth the volume of the aqueous extract. TCE extracts were combined and TCE was recovered by steam distillation. During the last stages of distillation the quantity of steam let inside was raised such that the caffeine dissolved in the excess hot water formed. In other words it is crystallised *in situ.*

The experiments were modified by using different quantities of lime with tea waste; similarly the liquid–liquid extraction was also performed under different pH conditions by using 1N NaOH or HCl.

The caffeine obtained was further purified by recrystallisation with water using activated charcoal. Alternatively purification was also done by sublimation at about 160°C under normal atmospheric pressure.

## RESULTS AND DISCUSSION

1. The yield of Caffeine varied from source to source and an examination of tea wastes available from different sources gave yields ranging between 0.8 and 2.6%. Different batches of tea

waste available from the same source also gave varying yields. This may be attributed to seasonal and geographical variations. Further the yields were also affected by the method of plucking the tea leaves. If the tea waste contained stalks and more coarse materials the yields fell down.

When aqueous extractions were performed without using any lime the yields were lowered. This may be due to the fact that a part of the caffeine is present in a combined form and should be broken down under alkaline conditions for maximum recovery. When the pH was adjusted to 7,8,9 and 10 using varying quantities of lime maximum yields were obtained at pH 8 to 9 and the yield went down at higher pH. Four extractions were necessary to extract more than 90% Caffeine but the major portion was extracted in the first two extractions (Requibuddowla, *et al.* 1969).

Maintaining an alkaline condition (pH above 9.5) for a prolonged time may result in the partial decomposition of caffeine; cleavage at 1,2 and 1,6– bonds may take place to give imidazole derivatives (Kigasawa, *et al.* 1975). Thus one particular tea waste gave a yield of 2.2% caffeine at pH 7 to 8 whereas the yield was 1.6% at pH 10–11.

The yields of caffeine isolated from tea waste belonging to 3 different estates using different pH conditions for the initial four aqueous extractions are shown in Table 1.

**Table 1. Caffeine yield from aqueous tea extracts under different pH conditions**

| Source of Tea Waste | pH of aqueous Extracts | | | | Total Caffeine % |
|---|---|---|---|---|---|
| | I | II | III | IV | |
| K.K. | 5.1 | 5.3 | 8.0 | 8.9 | 1.74 |
| | 8.1 | 8.3 | 9.0 | 9.2 | 1.98 |
| | 5.2 | 5.8 | 9.0 | 9.6 | 1.64 |
| | 9.0 | 9.5 | 9.9 | 10.9 | 1.49 |
| M.S. | 7.4 | 7.6 | 8.6 | 9.1 | 1.50 |
| | 8.4 | 8.9 | 9.2 | 9.3 | 1.28 |
| | 6.9 | 7.6 | 9.1 | 10.1 | 1.50 |
| | 9.0 | 9.75 | 10.4 | 10.8 | 1.13 |
| S. | 5.7 | 6.2 | 8.5 | 9.1 | 1.86 |
| | 8.2 | 8.8 | 9.3 | 9.3 | 2.07 |
| | 5.5 | 5.8 | 9.1 | 9.8 | 1.56 |
| | 8.8 | 9.2 | 9.9 | 10.1 | 1.7 |

From 10 Kg. lots.

It may be generalised that moderate alkaline conditions in the pH range 8 to 9 gives the maximum recovery. The yields were not very much affected if the initial extractions were carried out under very mildly acidic conditions followed by moderately alkaline conditions.

The best conditions for the extraction of caffeine on a larger scale were similar to those found in small scale experiments but a longer time was required for the process. The direct recovery of caffeine from tea fluff by dissociation with super-heated steam did not appear to be a practicable process. It is impossible to obtain concentrated aqueous solutions of caffeine directly. In an exhaustive study Watson *et al.* (1923) have shown that large quantities of lead acetate were required to get caffeine directly from aqueous tea extracts and that at least 200 lbs. of water had to be evaporated for every lb. of caffeine and the losses were considerable. It is doubtful whether this method would be of any commercial value. Watson *et al.* (1923) have also found that aqueous solutions containing 1.3% of caffeine would not dissolve any caffeine further from tea waste.

In Table 2 the solubilities of caffeine in a number of solvents at different temperatures are given. Some of these solvents may be used for carrying out direct extractions on a commercial basis but here not all the caffeine is dissolved and a state of equilibrium is being set up owing to adsorption by the fluff. Caffeine has been extracted from aqueous solutions of tea waste by using 1,1-dichloroethane and 1,2-dichloroethane using horizontal countercurrent extractor. (Filipposyants *et al.* 1968; Bochorishvili *et al.* 1971). The maximum extraction was obtained using 1,1-dichloroethane at pH 6.5 at 20°C (Bochorishvili *et al.* 1971).

The distribution coefficient (Kp) of caffeine between water and different halogenated solvents has been studied (Klebanov *et al.* 1965). Kp values were found to increase with temperature but the change of pH between 1 and 5 did not influence them; between pH5 and pH7 a mild decrease of Kp was noticed. The log Kp was inversely related to the interfacial tension of the water-organic solvent system. The extraction of caffeine from aqueous solutions in columns with sieve plates has been studied using 1,1-DCE and chloroform (Plyashkevich *et. al,* 1965; 1963).

Using methylene chloride as a solvent, a bubble cap column proved to be very efficient (Bochorishvili *et al.* 1968). In our studies we found that the pH does not play a part in the extraction of caffeine from tea waste by TCE. We also found that the value of Kp was not independent of solute concentration in the range chosen for study. Longer time was needed for extraction of larger batches. The liquid-liquid extraction of caffeine using TCE under different pH conditions are shown in Table 3. Although any pH could be maintained for this extraction, it was noticed that a high alkaline pH caused an emulsion. At the same time the caffeine obtained under alkaline conditions was more white and purer than the one obtained under acidic conditions. Elimination of clouding of cooled tea extracts due to precipitation of caffeine-tannin complex may be accomplished by raising the pH (LEVIN, 1955).

**Table 2. Caffeine solubility in different solvents at different temperatures**

| Solvent | Solubility | Temp. in °C |
|---|---|---|
| Diethyl ether | 0.1 | 18 |
| Diethyl ether | 0.3 | 25 |
| Carbon tetrachloride | 0.1 | 18 |
| —do— | 0.3 | 20 |
| —do— | 0.7 | 76 |
| Toluene | 0.6 | 25 |
| Benzene | 0.9 | 18 |
| —do— | 1.2 | 25 |
| —do— | 1.2 | 30.5 |
| —do— | 5.0 | 80.1 |
| Xylene— | 1.1 | 33 |
| Trichloroethylene | 0.8 | 15 |
| Dichloroethylene | 1.8 | 15 |
| Methanol | 1.1 | 25 |
| Ethanol | 1.8 | 25 |
| Ethanol | 3.5 | 60 |
| Acetone | 2.3 | 30.5 |
| Acetic Acid | 2.5 | 22 |
| Chloroform | 11.4 | 17 |
| 90% Aqueous Pyridine | 10.0 | — |
| Pyridine | 25.6 | 20—25 |
| Tetrachloroethane | 12.3 | 30 |
| —do— | 16.1 | 60 |
| —do— | 23.5 | 97 |

Table 3. Recovery of Caffeine from TCE

| | pH | Percentage Recovery of Caffeine |
|---|---|---|
| Pure Caffeine in water | 6 | 96.4 |
| | 7 | 93.4 |
| | 8 | 94.2 |
| Aqueous extract of Tea Waste | 7 | 97.5 |
| | 7.6 | 96 |
| | 9.5 | 90 |

It is to be noted that the liquid-liquid extraction of caffeine in the water-halogenated solvent systems should be performed under mild conditions giving swirling motion and gentle stirring but vigorous shaking should be avoided to prevent emulsion formation. The Kp values of caffeine between water and TCE are about 3–4 times more than that of DCE. The fact that pH has got no influence on the extraction efficiency is understandable as caffeine cannot enolise or ionise (Cavaliert *et al.* 1954). It is interesting to note in this connection that xanthine ionises at 3,7 and 1 positions in that order. With acids caffeine may form salts which may be completely dissociated. The u.v. spectrum of caffeine remains unaltered in the pH range 2 to 14 but the spectrum is altered in the region of pH 10.

Our studies clearly indicated that TCE is an efficient solvent for the extraction of caffeine from aqueous solutions. It has a high boiling point of 146.5°C at atmospheric pressure and as such the recoveries are good. The high boiling point is not a problem as this can be easily steam-distilled. In a laboratory experiment when TCE was steam-distilled, about 9.5 ml of TCE and 18 ml of water were collected in 8 minutes with about 15 ml of water remaining in the flask. The solubility of TCE in water is negligible.

New carrier substances consisting of co-polymers of styrene have been used for extraction of caffeine by chloroform and DCE from aqueous solutions (Chmil, 1966; Chmil and Sholtenko 1964). The extraction rate under these circumstances was 2 to 2.5 times as fast as with counter current extraction. We have not extended our studies to this aspect but it can be assumed that the same relationship will hold good for TCE also.

The purification of caffeine was carried out by recrystallisation from water using activated charcoal. The temperature co-efficient of solubility of caffeine in water is very large and water is suited as an ideal solvent for recrystallisation of caffeine. Caffeine has been purified by vacuum sublimation (Janot and Chaigneau 1947). Under our experimental conditions caffeine could be sublimated at 160°C under atmospheric conditions and purified. The residue after sublimation could be further recrystallised in water to give an additional yield of caffeine.

## ACKNOWLEDGEMENT

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# A STUDY OF THE CHANGES OCCURRING IN BLACK TEAS PACKED IN PLYWOOD CHESTS WITH DIFFERENT LINING MATERIALS DURING STORAGE

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## ABSTRACT

**Orthodox broken orange pekoe and CTC red dust teas were packed in plywood chests lined with aluminium foil-tissue, 300–MXXT cellulose film, plain polyester and metallized polyester films under factory conditions of temperature and humidity, and samples were drawn for analysis and evaluation over a period of 50 weeks. The samples were analysed for moisture, theaflavins, thearubigins, high polymerized substances and total liquor colour. The organoleptic evaluation of tea samples were made by professional tea tasters who valued teas for their liquor characteristics such as colour, strength, briskness and quality. The conclusion based on results of the investigation is that 300-MXXT cellulose film and metallized polyester film can also be used as tea chest liners, in addition to aluminium foil backed with tissue paper.**

## INTRODUCTION

It is generally accepted in trade that tea packed in chest, at 3% moisture, tends to improve in quality under optimum conditions of storage by maturing (Werkhoven, 1974), but it is certain that if the tea is in storage and transit for much longer than twelve weeks or so it deteriorates. There is evidence indicating that deterioration is accelerated by high humidity and high temperature, especially the former (Stagg, 1974; Wickremasinghe and Perera, 1972). The relationship between chemical composition, acceptability, time, temperature and moisture content during storage of black tea in rigid polyethylene boxes was studied by Dougan, Glossop, Howard and Jones (1978) and more specifically it was shown that the decline in the value of tea during storage over a period of about six months was attributable to the decrease in theaflavins contents, sensory qualities and head space vapours. The rate of loss of theaflavins and sensory quality was highly dependent upon moisture content and to a small extent upon temperature, whereas changes in the composition of the head space vapours attributable to changes in the value of tea were found to be dependent upon the temperature of the storage and only to a small extent upon moisture content. However, a need was clearly seen to conduct trials under conditions more clearly related to practical conditions. The present investigation was designed to study the changes occurring in black teas packed in standard plywood chests with different lining materials during storage for a period of fifty weeks. The study of the changes occurring during storage of tea included the estimation of moisture content and analysis of theaflavins, thearubigins, high polymerized substances and total colour. Variations in organoleptic properties of samples during storage were evaluated by professional tea tasters.

## MATERIALS AND METHODS

Orthodox broken orange pekoe (BOP) and CTC red dust (RD) teas were packed in standard size plywood tea chests conforming to I.S.I. specifications (40 cm x 50 cm x 60 cm) lined with Trayophane 300–MXXT cellulose film (MXXT), Garware's plain and metallized polyester films (PPE & MPE) and the conventional lining material, aluminium foil-tissue (AFT). These trials were carried out under factory conditions by UPASI Scientific Department in Thai Mudi (orthodox) and Kallyar (CTC) factories in Anamallais during 1978–1979. At the time of packing, the moisture contents of orthodox and CTC teas were found to be 4.439% and 4.883% respectively. After packing, the chests were marked for each specific period of storage. From the date of commencement of the experiment over a period of fifty weeks, the teas were periodically opened from the tea chests, in all nine times, for analysis. Three replicates of samples were drawn, namely, from one of the top corners of the chest, middle of the chest, and a bulk after mixing. These samples were individually analysed in duplicates for moisture, theaflavins, thearubigins, high polymerized substances and total colour, and the average values were recorded. The moisture content of tea samples were determined by the oven method prescribed by I.S.I. (1972) for the determination of dry matter content of ground black tea samples. Theaflavins, thearubigins, high polymerized substances and total colour were determined by following the modified Robert's spectrophotometric method as employed by Takeo and Oosawa (1976) and Ramaswamy (1977). The organoleptic evaluation of tea samples was made by professional tea tasters who valued teas for their leaf appearance, infused leaf colour and liquor characteristics such as colour, strength, briskness and quality.

## RESULTS AND DISCUSSION

Table 1 gives the comparative properties of four tea chest liners used in the present investigation. Plain and metallized polyester films are known to possess greater mechanical properties of tensile strength, burst strength and elongation than aluminium foil and 300–MXXT cellulose films. The plain polyester film has higher water vapour transmission rate than all other lining materials used in this study. Traditionally tissue papers were used to interline the aluminium foil in tea chests, probably, because of the poor bursting strength of aluminium foil. However, 300–MXXT cellulose, metallized polyester and plain polyester films were used as such, without any tissue paper as liners, in tea chests.

Moisture pickups of orthodox–BOP and CTC–RD teas, packed in tea chests with different liners, during storage for 350 days are given in Fig. 1 and 2 respectively. From the date of commencement of the experiment over a period of fifty weeks, the respective moisture gain of the orthodox–BOP teas packed in chests lined with aluminium foil-tissue 300-MXXT cellulose film, metallized polyester film and plain polyester film were 4.371%, 3.719%, 4.199% and 4.568%. It was observed from fig. 1 that 300–MXXT cellulose film and metallized polyester films resist moisture better than plain polyester film and even aluminium foil-tissue. In case of CTC–RD teas packed in chests lined with aluminium foil-tissue, 300–MXXT cellulose film, metallized polyester film and plain polyester film, the increase in moisture contents after 350 days of storage was observed to be 3.636%, 2.733%, 3.014% and 3.955% respectively (Fig. 2). In all the cases 300–MXXT cellulose film and metallized polyester film showed better moisture barrier properties than aluminium foil-tissue and plain polyester film. A steady rise in

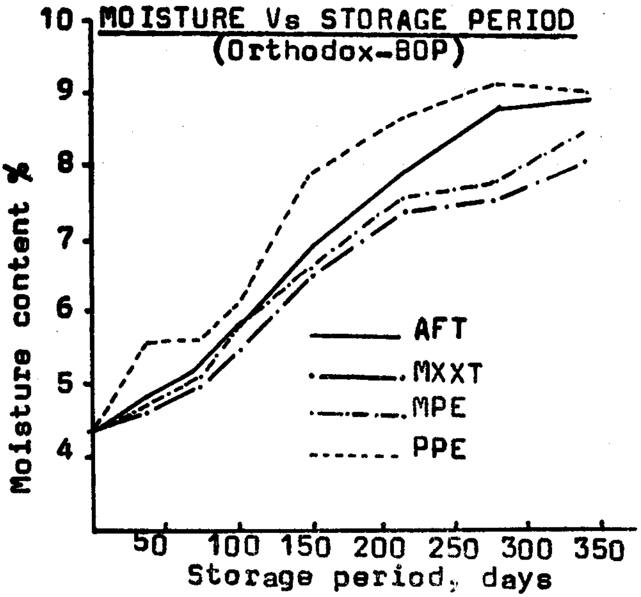
**Table 1. Comparative properties of different tea chest lining materials**

| *Properties* | *Aluminium foil* | 300 *MXXT cellophane* | *Metallized polyester* | *Plain polyester* |
|---|---|---|---|---|
| Thickness, micron | 20 | 22 | 12 | 12 |
| Tensile strength, $kg/cm^2$ | 765–1003 | 100–200* | 1750–2720 | 1750–2720 |
| Burst strength, $kg/cm^2$ | 0.95** | 2.3–3.0 | 5.0 | 5.0 |
| Elongation, % | 1.5 | 10–20 | 60–120 | 60–120 |
| MVT rate, $g/m^2/24h$ at 38°C, 90% RH | 0.1 | 10 | 2.0–3.5 | 40 |

*values given in gms/mm

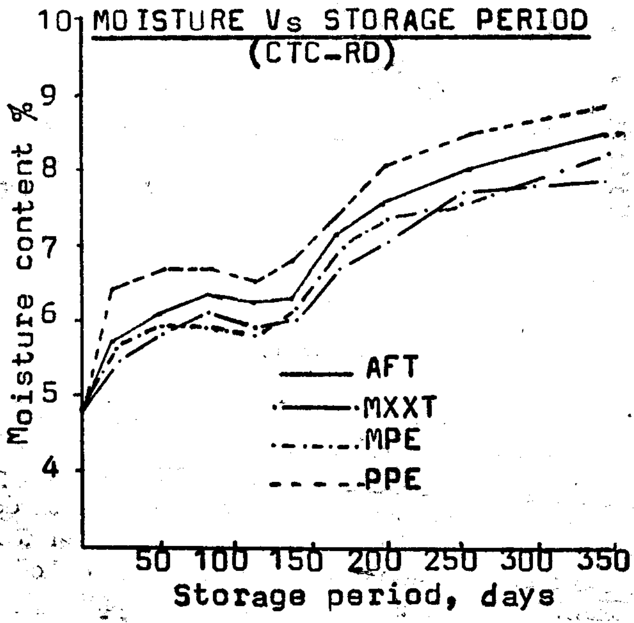
**with tissue paper

moisture pick-up by both orthodox-BOP and CTC–RD teas after 150 days of storage is attributable to the ambient high humidity conditions prevailed inside the factory warehouses during rainy season (June to September), where the chests were kept for storage trials. However, the plain polyester film did not prove to be a better tea chest lining material than aluminium foil-tissue, 300–MXXT cellulose film or metallized polyester film as far as moisture vapour transmission rate during storage was concerned.



(Figure 1)

The levels of theaflavins in orthodox-BOP and CTC–RD teas during storage are shown in Fig. 3 and 4 respectively. The theaflavins contents of both orthodox–BOP and CTC–RD teas appear to have increased upto certain period of storage and then declined differently depending upon the physical properties of tea chest liners. The increase in theaflavins contents of orthodox-BOP teas in chests lined with aluminium foil-tissue, 300 MXXT cellulose film, metallized polyester film and plain polyester film was observed respectively upto 220, 220, 175 and 75 days of storage. In case of CTC–RD teas, the theaflavins level increased upto 50 to 70 days of storage and then declined gradually. These variations could be attributed to the differences in properties of oxygen permeability and water vapour transmission rate of tea chest lining materials. As seen from Fig. 3 and 4, the teas packed in chests lined with plain polyester film showed greater loss in theaflavins content during storage than teas packed in chests lined with aluminium foil-tissue, 300–MXXT cellulose film and metallized polyester film. The results are in good agreement with those obtained by Dougan, Glossop, Howard and Jones (1978) that the rate of loss of theaflavins was affected about equally by moisture and temperature. However, it must be surmised that the tea starting with the highest level of theaflavins will always have the highest level, even after an indefinite period of storage (Fig. 3 and 4).



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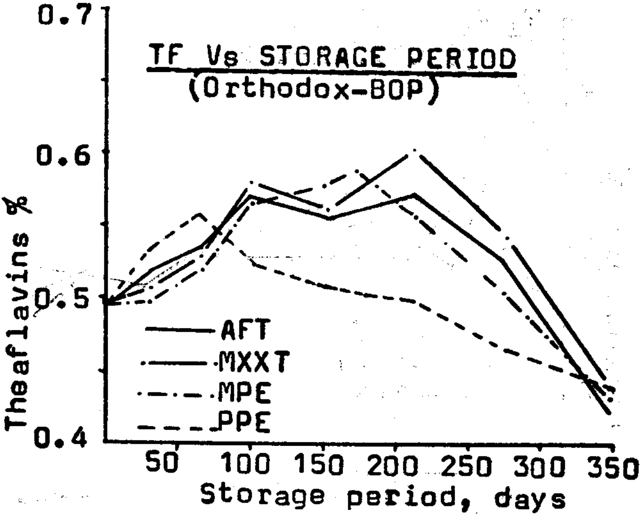
(Figure 3)



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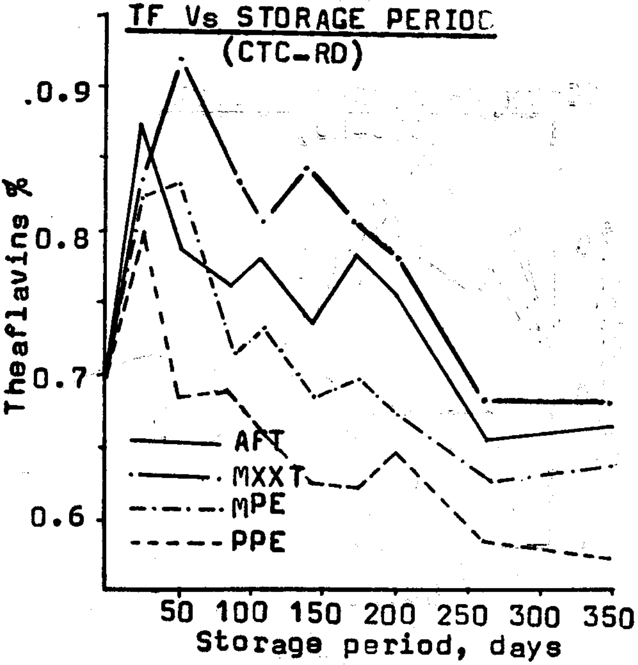

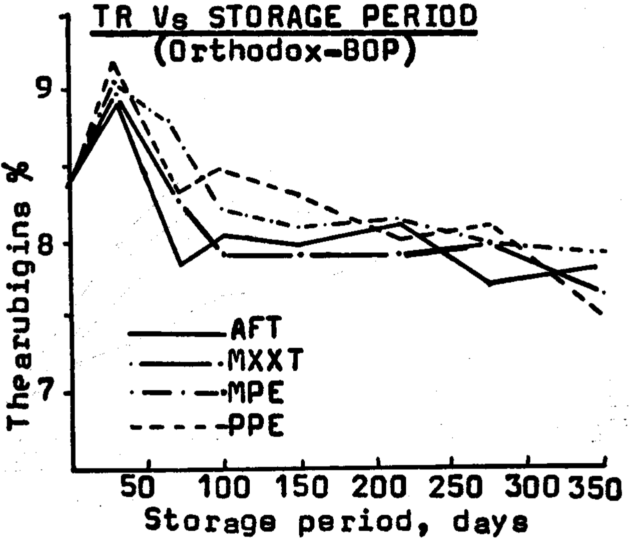

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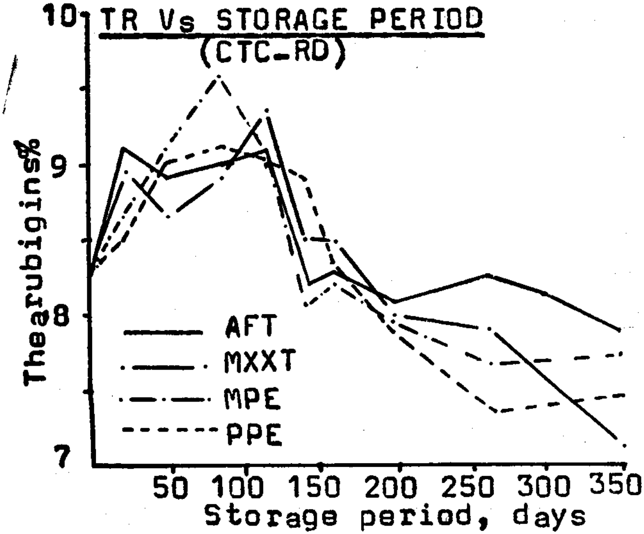
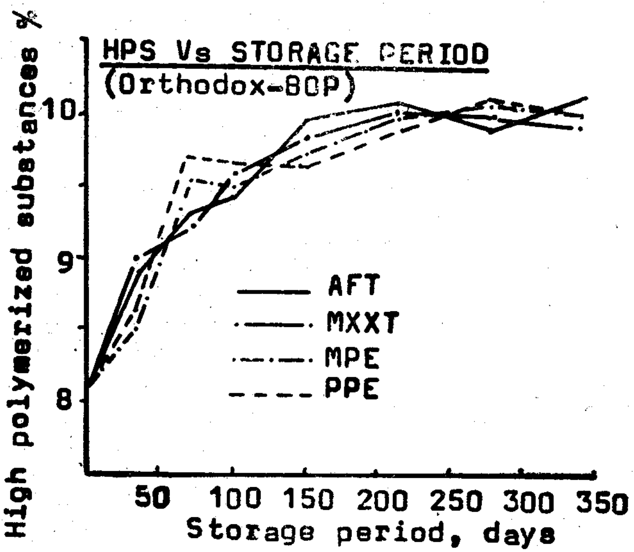


(Figure 6)

Fig. 5 and 6 show respectively the levels of thearubigins in orthodox-BOP and CTC–RD teas during storage when packed in chests lined with the four experimental lining materials. The increase in thearubigins formation in orthodox teas was shown upto 30 days, followed by a decline upto 100 days and more or less a steady level during the entire storage period of 350 days. The orthodox–BOP teas packed in chests lined with plain polyester film showed higher levels of thearubigins than those with aluminium foil-tissue, 300–MXXT cellulose film and metallized polyester film (Fig. 5). In all the cases of CTC–RD teas, the level of thearubigins increased upto 100–150 days of storage and declined thereafter. However, except the teas packed in chests lined with aluminium foil-tissue, other experimental samples contained low levels of thearubigins after 350 days of storage (Fig. 6).

The high polymerized substances contents of orthodox–BOP and CTC–RD teas as influenced by storage period are shown in Fig. 7 and 8 respectively. Both orthodox and CTC tea samples showed increasing trends in the levels of high polymerized substances throughout the period of storage for 350 days. On comparing the results shown in Fig. 3–8, it reveals that on storage, teas which show high levels of high polymerized substances contain low levels of theaflavins and thearubigins. This occurred more in cases when teas were packed in chests lined with plain polyester film than those with other expreimental lining materials. Increase in the formation of high polymerized substances may be attributed to the utilization of theaflavins and thearubigins by non-enzymic reactions taking place during storage. However, it was observed that CTC teas could undergo rapid chemical changes during storage when compared to orthodox teas.

The importance of colour in judging the quality of tea infusion and evaluation of tea liquors by spectrophotometric method were proposed by Roberts and Smith (1961, 1963). Total colour is related to the sum of theaflavins, thearubigins and high polymerized substances, and hence to strength. As seen from Fig. 9 and 10, the total colour value of both orthodox and CTC teas declined after 300 days and 100 days of storage respectively, the latter at higher rate (from 4.38 to 3.58) than the former (from 4.3 to 4.1). The decline in the value of total colour during storage over the period may be attributed to the effect of moisture and to a smaller extent, to temperature. However, the loss in total colour value of teas packed in chests lined with plain polyester film was found to be more than that with aluminium foil-tissue, 300–MXXT cellulose film and metallized polyester film after 350 days of storage. As far as total liquor colour is concerned, it is clear from the results that orthodox and CTC teas keep well on storage upto 300 days and 125 days respectively.



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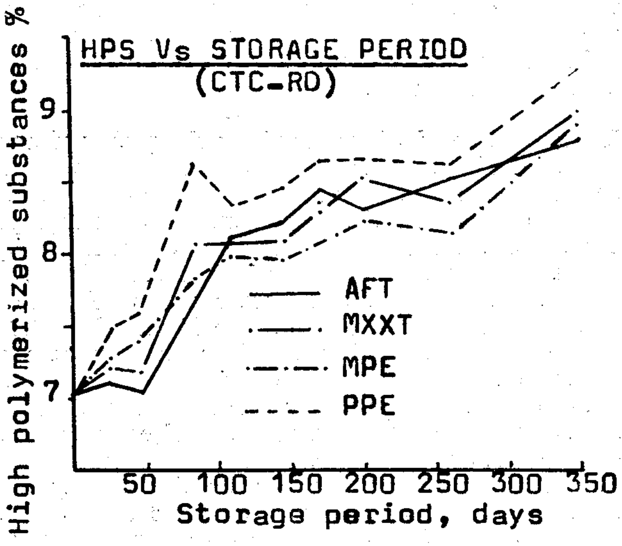

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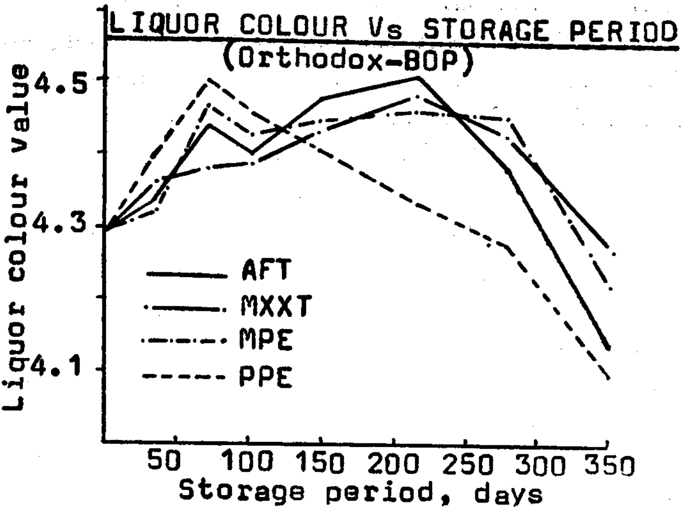

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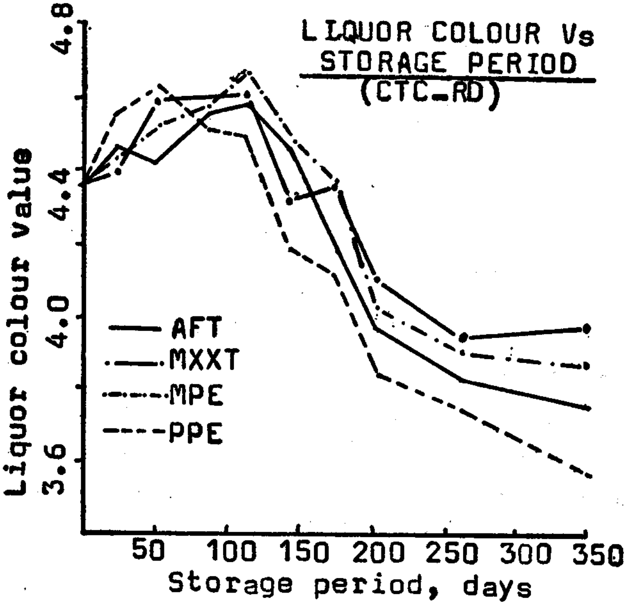

(Figure 10)

Tasters' evaluations on overall cup characters of orthodox–BOP and CTC–RD teas in relation to storage period are presented in Fig. 11 and 12. As in the case of total colour determined by spectral analysis (Fig. 9 and 10), tasters' evaluation on overall cup characters indicates that the valuations (scores) for orthodox–BOP and CTC–RD teas declined after about 250 days and 100 days of storage respectively. As far as tasters' evaluations are concerned, there is no significant difference obtained in the total scores alloted for liquors of both orthodox and CTC teas packed in chests lined with aluminium foil-tissue, 300–MXXT cellulose film and metallized polyester film. On the other hand tea chests lined with plain polyester films resulted in lowest valuations for liquor characters of orthodox–BOP and CTC–RD teas after 150 days and 50 days of storage respectively.

The conclusions arrived at in this study are (1) theaflavins and thearubigins in black teas undergo chemical changes resulting in increase of high polymerized substances during storage depending upon the oxygen and water vapour transmission rate of lining materials used in tea chests, (2) tasters' valuations on overall cup characters are in good agreement with total colour of liquor measured by spectrophotometric method, (3) orthodox teas seem to have more storage life than CTC teas and (4) 300–MXXT cellulose film and metallized polyester film can be used as tea chest liners, in addition to aluminium foil backed with tissue paper.

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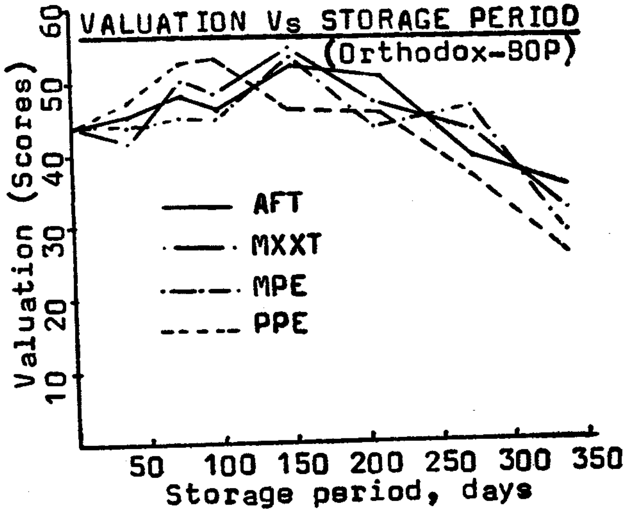

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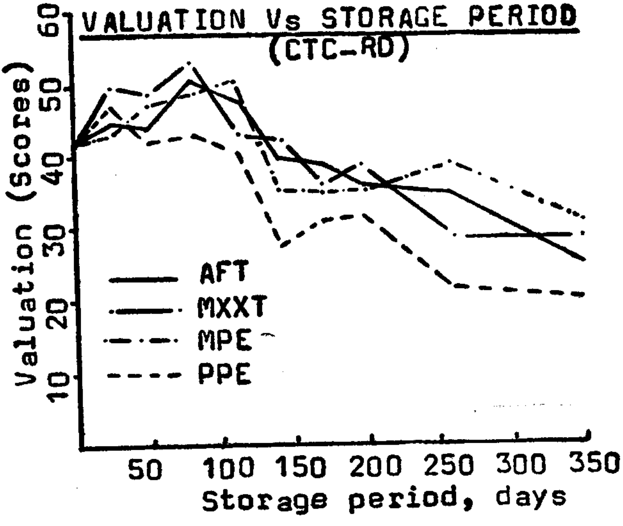

(Figure 12)

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# STUDIES ON THE CREAMING OF TEA INFUSION

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## ABSTRACT

**In the present work the creaming behavior of the tea infusion was studied. Creams obtained on chilling as well as acid precipitation were analysed for Theaflavins (TF), Thearubigins (TR), Caffeine, total polyphenols, total solids etc. Greater proportions of all the constituents were found in the cream on acid precipitation. The constituents which together form the cream were identified by paper chromatography. The effect of caffeine on the extent of creaming of the tea brew was also studied. With increasing concentration of caffeine increasing amounts of TF, TR, caffeine and total solids were precipitated out on chilling, while no cream was formed in the decaffeinated brew. The present study establishes the role of caffeine in cream formation.**

## INTRODUCTION

Cooling down of the strong infusion prepared from manufactured tea becomes turbid due to finely colloidal precipitate causing the orange red brew to change to light brown or orange suspension which ultimately leads to sediment termed as 'cream'. The extent of creaming down has been shown to have a direct relation to the amount of theaflavins (TF), thearubigins (TR) and caffeine content of the manufactured tea. The cream constituents were chemically analysed by Wickremasinghe (1966), Smith (1968) and Bhatia (1964). The major components are theaflavins, thearubigins and caffeine together with ellagic acid, gallic acid, tricetinidin, *epi* gallocatechin gattate (EGCG), *epi* catechin gallate (ECG), caffeic acid, bisflavanols A and B, chlorophyll and theobromine. A small amount of unidentified non caffeine nitrogen and ash has also been confirmed to be present in the cream.

Caffeine forms an important constituent of the infused brew responsible for the briskness of the tea liquor due to association with theaflavin. Caffeine combines with the oxidized products of polyphenols and determines the creaming behavior of tea.

The present study attempted in two parts (a) comparison of cream precipitated on chilling and on addition of 1 percent v/v sulphuric acid, and (b) effect of varying concentration of caffeine in decaffeinated brew on precipitation of tea constituents.

## MATERIALS AND METHODS

### Part I

Comparison of cream precipitated on chilling and on addition of 1 percent sulphuric acid.

(i) Preparation of brew : The tea infusion was prepared as follows—4 g tea powder was infused with 200 ml of boiling distilled water at 95°C for 10 mins. The infusion was filtered.

(ii) Total solids : Total solid content of the brew was determined by evaporating 10 ml of the sample in a porcelein dish on a water-bath and finally in an oven at 80°C to a constant weight.

(iii) Total polyphenols : Total polyphenols were estimated by ferrous tartrate method (Mitchell) and expressed as mgs of tannic acid.

(iv) Caffeine (Rutter and Stainsby, 1975) : 1 ml brew was diluted to 100 ml with distilled water. To 25 ml of the diluted brew 2 ml AR liquor ammonia was added and extracted with 25 ml chloroform for 30 sec. The chloroform layer was separated and read at 276.5 nm. The caffeine content was extrapoilated from standard graph (range 0–10$\mu$g caffeine).

(v) Creaming of tea infusion :

(a) To 50 ml fresh brew 0.5 ml AR conc. sulphuric acid was added (1 percent v/v) and kept aside for 1 hr. The suspension was centrifuged at 4000 rpm for 20 mins. and the residue was dissolved in hot water and analysed.

(b) 50 ml of the fresh brew was chilled by keeping in refrigerator at 5°C overnight. This was centrifuged in a cold centrifuge at 5000 rpm for 30 mins. The residue was dissolved in hot water and analysed.

(vi) Non-caffeine nitrogen : The total nitrogen content of the cream was estimated by Kjeldahl's method. Non caffeine nitrogen was calculated as follows.

Non-caffeine nitrogen (NCN) = Total nitrogen—Caffeine N.
Caffeine nitrogen = Caffeine/3.464

(vii) Paper chromatography : Cream obtained on centrifugation of chilled infusion was dissolved in methanol and subjected to two dimensional chromatography using Whatman paper no. 1 and irrigating solvent BAW (4:1:2.2) and acetic acid (2 percent). The chromatogram was developed with ferric-chloride–potassium ferricyanide solution by spraying.

**Part II**

Effect of varying concentration of caffeine on precipitation of brew constituents :—

A cloudy precipitate results on cooling of a strong tea brew termed as 'cream' and which indicates to the professional tea taster the strength and briskness of the tea infusion. Major components of the cream are found to be theaflavins, thearubigins and caffeine together with minor amounts of unoxidized and oxidized polyphenols. Presence of pectin has also being reported (Roberts, 1963).

A similar phenomenon is also observed when 1 percent v/v sulphuric acid is added to the brew which gives rise to copious and flocculant precipitate, can be easily filtered as against the finely dispersed suspension formed on chilling. Table 1, compares the precipitation of TF, TR, HPS, Caffeine, total solids and TPP due to chilling and on addition of 1 percent sulphuric acid in the cream formed. Along with polyphenolic constituents a small but measurable amount of non-caffeine nitrogenous constituents were also found to be precipitated which remains unidentified.

## RESULTS AND DISCUSSION

A greater amount of polyphenolic substances were found to be precipitated out by acid. The TF and TR precipitated were found to be 52 percent and 116 percent respectively higher than those precipitated on chilling. A lower ratio of TR/TF was observed in the cream which can be correlated with the brightness of the cream as compared to dull cream formed on acid precipitation. This confirms the observations made by Roberts (1963). However, a considerably lower amount of HPS fraction was observed in the acid precipitated cream which may be attributed to the change in the pH of the brew whereby only the free acids are being accounted for.

Lower amount of caffeine was observed in the acid precipitated cream which does not indicate the same proportion of TF, TR, HPS and caffeine in cream. In the case of cream obtained on chilling the proportions of TF, TR, HPS and caffeine were found to be 6 : 35 : 28 : 31 as against 17 : 67 : 17 for TF : TR : Caffeine, reported by Roberts (1963). This wide variation in TF and Caffeine, may be due to low TF content in the original brew which leads to lower ratio in the cream formed. Although the value of TR + HPS which is equivalent to TR reported by Roberts was found to be almost comparable. In the casse of acid precipitated cream the ratios were found to be 7 : 59 : 12 : 22. From Table 1 it can be observed that though there is marked increase in the TF and TR precipitated, the amount of caffeine precipitated decreased in acid precipitated cream and was almost near to that of cream obtained on chilling which can be explained as due to solubility of caffeine in 1 percent sulphuric acid. The greater proportion of each constituent precipitated due to acid as compared to chilling may probably due to lower pH and coprecipitation of other minor constituents.

Table 1. Effect of creaming down on composition

| Constituent | Normal brew | Cream formed due to Chilling | Cream formed due to 1 percent $H_2SO_4$ | Percent Precipitation Chilling | Percent Precipitation 1 percent $H_2SO_4$ |
|---|---|---|---|---|---|
| TF% | 0.96 | 0.14 | 0.216 | 14.9 | 22.5 |
| TR % | 6.47 | 0.90 | 1.95 | 13.9 | 30.14 |
| HPS % | 8.46 | 0.71 | 0.396 | 8.34 | 4.68 |
| Caffeine % | 3.53 | 0.80 | 0.725 | 22.6 | 20.57 |
| TPP % | 10.00 | 1.38 | 3.0 | 13.75 | 30.0 |
| Total solids % | 37.50 | 4.0 | 5.6 | 10.66 | 14.93 |
| NCN | 0.210 | 0.034 | 0.097 | 16.2 | 46.0 |

Total solids in the acid precipitated cream were found to be as high as 40 percent to that of cream formed on chilling. The high solid concentration of cream obtained on acid addition is due to higher phenolics and lower pH (4.0) and one can expect the precipitation of proteinaceous material is correlated with higher noncaffeine nitrogen content of cream. From the table it is evident that as high as 3 times noncaffeine nitrogen (NCN) is being precipitated out in the cream formed on acid addition. The presence of pectic substances in the cream may be another factor responsible for higher total solids.

The chromatogram was developed and compared with chromatogram obtained by Roberts (1957) for the phenolic substances of manufactured tea. In the present study the major components were found to be theaflavins, theaflavin gallates, thearubigins SI and SII fractions, caffeine and bisflavanol A. Tricetinidin and chlorophyll were also visible on the unsprayed chromatogram, tricetinidin appeared as bright pink spot while chlorophyll appeared as bright green in day light and deep red under u.v. radiation. On spraying, the minor components detected were gallic acid, ECG, EGCG, myricetin-3-glucoside, quercetin-3-glucoside, kaempferol-3-rhamnoglucoside and ellagic acid (Fig. 1). However, presence of caffeic acid was not detected as reported by Wickremasinghe (1966). A visual observation of chromatogram revealed higher concentration of theaflavin gallates and bisflavanol A along with clearly visible high intensity pink spot of tricetinidin, may be responsible for the brightness of the cream.

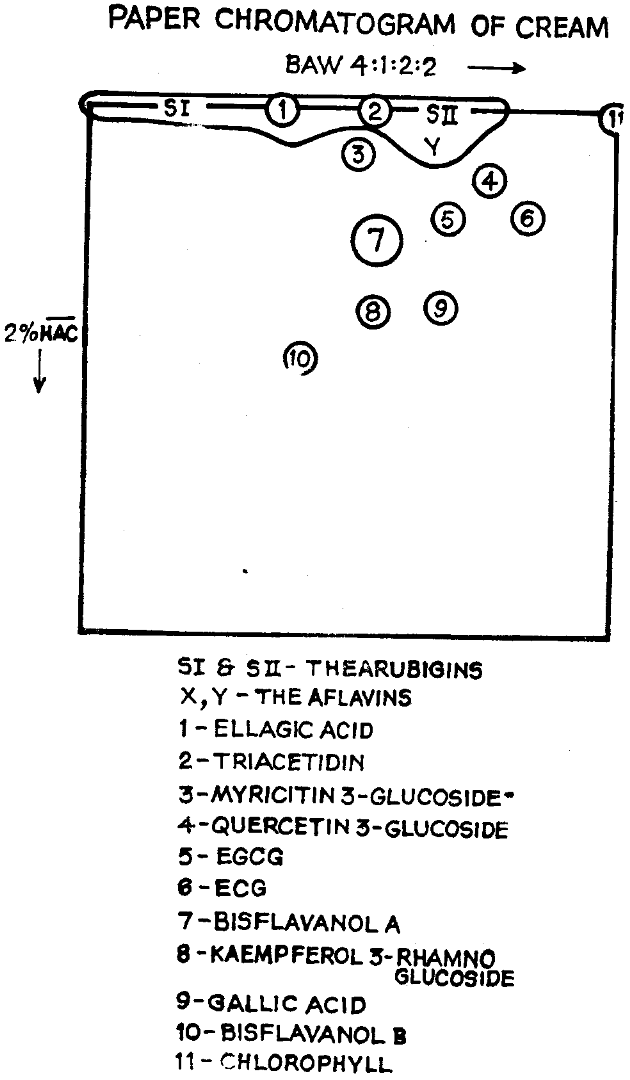

Fig. 1. Paper chromatogram of cream

(i) *Preparation of decaffeinated brew* : The tea infusion was prepared as follows : 8g tea powder was infused with 200 ml boiling distilled water at 95°C for 10 mins. and filtered. The filtrate was shaken five times with two volumes of chloroform. The chloroform from aqueous phase was removed by boiling off.

(ii) *Caffeine addition* : An aqueous solution of caffeine containing 1g/100 ml was prepared. Known volumes of caffeine solution were added (0, 0.75, 1.5, 2.5, 6.25 and 10.0 ml) to 25 ml of decaffeinated brew. The final volume was made up with distilled water to 50 ml.

(iii) *Creaming down of tea brew* : The samples prepared as above were chilled by keeping in refrigerator at 5°C overnight and centrifuged in a refrigerated centrifuge at 5000 rpm for 30 mins. to remove cream.

(iv) *Total solids :* The decaffeinated brew was analysed for total solids as discussed in part I. Similarly the cream solids were also determined.

(v) *TF, TR, TPP and Caffeine* : The supernatent liquid obtained was analysed for TF, TR, TPP, and caffeine as discussed previously.

The creaming power of strong tea brew can be correlated to the amount of caffeine and theaflavin concentration. It is observed that caffeine free brew does not yield cream. The creaming power of the manufactured tea brew can be enhanced by the addition of caffeine.

Table 2 shows the analysis of original brew which on chilling in presence of indigenous caffeine showed decrease in TSS, TPP, TF, TR and caffeine in the supernatant obtained after cream removal. The extent of TF, TR and caffeine precipitated were determined to be 35 percent, 21 percent and 23 percent respectively.

The decaffeinated brew prepared was found to contain less than 0.1 percent caffeine which on varying additions of caffeine yielded higher cream solids with increase in caffeine concentration. However, proportionate rise in the cream solids were observed at low concentrations of caffeine and found to decrease at higher concentration. The amount of solids precipitated were comparable with that of normal creaming (Table 3).

Table 2. **Normal creaming of tea infusion**

| Constituent | Fresh brew | Supernatant (cream free) | Per cent Precipitation |
|---|---|---|---|
| Total soluble solids | 249 mg | 223 mg | 10.44 |
| TPP | 86 mg | 68.25 mg | 20.63 |
| TF | 0.185 O.D. | 0.120 O.D. | 35.2 |
| TR | 0.475 O.D. | 0.375 O.D. | 21.0 |
| Caffeine | 18.25 mg | 14.0 mg | 23.3 |

Table 3. **Effect of caffeine addition to decaffeinated brew on total solid content of cream**

| Caffeine added mg | Total solids mg | Wt. of precipitate mg | percent solid precipitated |
|---|---|---|---|
| 0 | 230 | 0 | 0 |
| 7.5 | 237.5 | 10 | 4.21 |
| 15.0 | 245 | 23 | 9.38 |
| 25.0 | 255 | 30 | 11.76 |
| 62.5 | 292.5 | 51 | 17.44 |
| 100.0 | 330 | 67 | 20.33 |

A similar trend in precipitation of TF, TR and TPP was also observed (Table 4).

Table 4. **Effect of varying additions of caffeine on TF, TR and TPP**

| Caffeine added mg | TF O.D. at 380 nm | TR O.D. at 380 nm | TPP mg | Per cent TF ppted | percent TR ppted | percent TPP ppted |
|---|---|---|---|---|---|---|
| 0 | 0.158 | 0.592 | 85 | 0 | 0 | 0 |
| 7.5 | 0.140 | 0.549 | 76.9 | 11.3 | 7.25 | 9.6 |
| 15.0 | 0.120 | 0.478 | 71.3 | 24.1 | 19.3 | 16.2 |
| 25.0 | 0.095 | 0.415 | 63.8 | 39.8 | 29.9 | 25.0 |
| 62.5 | 0.062 | 0.360 | 55.0 | 60.8 | 39.8 | 35.3 |
| 100.0 | 0.042 | 0.353 | 52.5 | 73.4 | 40.4 | 38.2 |

As high as 73 percent TF was precipitated out when the caffeine concentration was used at six times to that of normal brew. TPP was found to follow TR i.e. a steady increase at lower concentration of caffeine but decreased rise in precipitation at higher concentration. A lower amount of TF was found to be precipitated as compared to normal brew but comparative values for TR, TPP and TSS were obtained.

Although the caffeine in precipitate increased with the quantity added the proportion precipitated dropped as the addition increased. However, percent caffeine in cream did not show any correlation with caffeine added as seen from the data shown in Table 5. It was observed that considerable lower proportions of caffeine was found to be precipitated out as compared to previously reported values of 31 percent (Roberts, 1963). But this fact can be explained on the basis of lower TF values in the black tea. The molar ratios in which TF and caffeine reacts to yield cream were found to be 1 : 30 and 1 : 18 in cream obtained on chilling and on acid precipitation respectively, in normal brew. While studying the cream formation on chilling using decaffeinated brew, the molar ratios of TF to caffeine were found to vary from 1 : 7 to 1 : 14. Hence no definite relationship with respect to molar concentration in which TF and caffeine react to yield cream was observed.

**Table 5. Effect of varying concentration of caffeine on the caffeine content of cream**

| Caffeine added mg | Caffeine in cream mg | percent Caffeine ppted | percent caffeine in cream by wt. |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 7.5 | 2 | 26.7 | 20.0 |
| 15.0 | 2.75 | 18.3 | 12.0 |
| 25.0 | 3.15 | 12.6 | 10.5 |
| 62.5 | 7.75 | 12.4 | 15.2 |
| 100.0 | 10.75 | 10.75 | 16.0 |

From the preceding discussion it is established that greater amount of TF, TR, TPP and total solids are precipitated out due to acid as compared to cream formed on chilling and is due to lower pH and coprecipitation of other brew constituents. A greater amount of solids and noncaffeine nitrogen are precipitated out. However, a lower amount of caffeine is found in acid precipitated cream due to the fact that caffeine is soluble in 1 percent Sulphuric acid. Paper chromatography studies revealed that the major components of cream are theaflavins, thearubigins, caffeine and bisflavanol A. Other minor constituents detected are tricetinidin, ellagic acid, gallic acid, ECG, EGCG, myricetin-3-glucoside, quercetin-3-glucoside, kaempferol-3-rhamnoglucoside, bisflavanol–B and chlorophyll.

The other study decisively proved the role of caffeine in the cream formation. No cream was formed in the absence of caffeine. However, with increasing amount of caffeine, pronounced effect on TF, TR, TPP and total solids was observed. Greater proportions of all tea constituents were found to be precipitated out with increasing amounts of caffeine. This clearly elucidates that the caffeine reacts together with theaflavins and thearubigins and yields the cream. However, no definite ratios could be established between theaflavins and caffeine, the components responsible for cream formation.

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# USE OF PROPIONIC ACID FOR THE PRESERVATION OF COCONUT KERNEL

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## ABSTRACT

**Propionic acid in three concentrations for four soaking durations was tried for preservation of fresh kernel. Concentration of 1000 ppm for 30, 45 and 60 minutes soaking time was found effective for preservation upto a minimum of 96 hours. To avoid spoilage during drying at low temperature and high humidity conditions, effects of 3 concentrations at 2 soaking durations were studied. Application of propionic acid in concentrations of 750 ppm for 30 min. and 1000 ppm for 15 and 30 min. soaking were found satisfactory for arresting the microbial activity during drying. No effect was observed on the rate of drying due to application of the chemical.**

## INTRODUCTION

Coconut is one of the main important oil seed crops in the country and it is of a special importance to Kerala where it is used for edible purposes. In India dry milling is generally practised. Dried coconut meat commonly known as copra is crushed in chekkus, rotaries or in expellers to get oil. Coconut kernel contains 45 to 50% moisture (on weight basis) which is reduced to 6% upon drying to make copra. This is generally done in open yards by exposing split kernel to the sun. Under bright sun, this operation takes about 7 days. If drying operation is prolonged, microorganisms infest the kernel/copra resulting in bad quality oil, since coconut kernel is a favourable a substrate for the growth of microorganisms. Under high humid conditions which prevail in coconut growing regions, spoilage of copra due to fungal infestation is very frequent. Uncertainty of weather conditions also affects the quality of copra produced, because copra gets infested at all levels of moisture content in inclement weather. The oil obtained from such copra may contain aflatoxins and mico-toxins (Arseculertne and De Silva, 1971, Narasimhan, 1968).

Many workers have tried different chemical dip treatments (Somatmadja and Ali, 1968; Sreemulanathan, 1979; Satyavathi, 1979, and Subramanyan *et al.* 1959) but much success could not be achieved probably because of the heavy doses of chemicals tried and their undesirable residual effect on quality of copra.

In the present investigation propionic acid is tried as an antimycotic agent for preservation of kernel. Propionic acid has been found suitable in preservation of high moisture corn (Burroughs, 1974, Jones, *et al.* 1974 and Jones, 1970) sorghum (Nelson *et al.* 1973), soybean (Stevenson and Alexander 1972), bread dough (Pintauro, 1974) and in making tortillas without affecting its quality and nutritional value. Moreover, this acid has been generally regarded as a safe food additive in Canada and USA with a tolerance limit of 2000 ppm (Pungsley, 1959).

## MATERIALS AND METHODS

Since high relative humidity (above 80%) and slight high temperature (30 to 45°C) are conducive to growth of microorganisms, the experiments were conducted in such accelerated favourable conditions for growth of microorganisms to get more feasibility of the treatment during actual sun drying. Fully matured coconuts of West Coast Tall variety were selected for study. Coconuts after husking, were split open and washed under running water. Experiments were conducted in 2 sets; one by keeping cups in single layer in well ventilated room and other in cross flow oven at 35°C. In first set, sample size of 16 cups were soaked in propionic acid solutions of 500, 750 and 1000 ppm concentrations for 15, 30, 45 and 60 min. Two control samples namely washed and unwashed were prepared. Observations for spoilage were recorded at 21, 27, 45, 51, 53, 59, 69 77, 86 and 96 hr. after the treatment. Temperature and relative humidity were also recorded during experimentation. Samples in second set were soaked in 500, 750 and 1000 ppm solution for 15 and 30 min. and then kept in cross flow oven at 35°C. The drier was operated only for six hours in a day to simulate slow and intermittent drying to create more favourable conditions for the growth of microorganisms. Treatments found successful were repeated using smaller lots of 4 cups for confirmation during high humid period from July to September.

## RESULTS AND DISCUSSION

### Preservation of kernel in a well ventilated room

Ambient conditions of temperature and humidity during the experimental period are given in Table 1. Observations on spoilage of copra are graded in different categories, as given in Table 2. Change in quality in all cups from a sample was uniform due to the application of chemical by soaking method. In control of washed cups when compared to unwashed, little more resistance to deterioration was observed upto 27 hr. After the 27 hr. both the control samples were badly infested by yellow and black fungus (*A. flavus* and *A. niger*). Infestation in all the cases followed the chain of sweating–yellowing (bacterial and fungal infestation). The discolouration or browning was also observed in cups during 45th and 53rd hr. mainly at periphery and inside where fungus infection was present. Cups treated at lower concentration showed more discolouration. For 96 hr. of storage in a well ventilated structure, the treatments of 1000 ppm for 30, 45 and 60 min. were found to be equally effective.

### Kernel subjected to 35°C temperature in a cross flow drier

The effectiveness of treatment under this condition is given by percentage of cups infested (Table 3). The treatments of 15 and 30 min. soaking in 1000 ppm solution and 30 min. soaking in 750 ppm solution were found to be effective among the other treatments, giving recovery of about 67% mould free cups as compared to 0% in case of control.

**Table 1. Ambient temperature and relative humidity during the period of experiments**

| *Temperature °C* | | | | *Relative humidity %* | | | |
|---|---|---|---|---|---|---|---|
| *Maximum* | | *Minimum* | | *Forenoon* | | *Afternoon* | |
| *Mean* | *Range* | *Mean* | *Range* | *Mean* | *Range* | *Mean* | *Range* |
| 29.37 | 25.4 – 30.50 | 23.40 | 21.8 – 25.3 | 93.00 | 83–97 | 81 | 71–95 |

**Table 2. Stage of spoilage during preservation of fresh kernel**
(*Sample size* 16 *cups*)

| *Treatment* | | *Duration of storage, hr.* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Conc ppm.* | *Soaking time min.* | 21 | 27 | 45 | 50 | 53 | 69 | 77 | 86 | 96 |
| 500 | 15 | B | B | C | C | F+++ | G+++ | — | — | — |
| 750 | 15 | B | B | C | C | F | G+++ | — | — | — |
| 1000 | 15 | A | A | C | D | E | E | F+ | G | G+ |
| 500 | 30 | B | B | C | C | C | G+ | G++ | G++ | — |
| 750 | 30 | A | A | C | B | B | C | C | G+ | G++ |
| 1000 | 30 | A | B | B | B | B | C | C | C | C |
| 500 | 45 | A | A | C | C | G+ | G+++ | — | — | — |
| 750 | 45 | A | A | C | C | C | C | G+ | G++ | G++ |
| 1000 | 45 | A | A | C | C | C | C | C | C | C |
| 500 | 60 | A | A | C | B | G | G+++ | — | — | — |
| 750 | 60 | A | A | B | B | B | F+ | F++ | G+ | G++ |
| 1000 | 60 | A | A | B | B | B | C | C | C | C |
| Unwashed Control | | D | E | G+++ | — | — | — | — | — | — |
| Washed Control | | C | E | G+++ | — | — | — | — | — | — |

A = No sweating
B = Slightly noticeable sweating
C = Sweating
D = Very high sweating
E = Sweating and yellowing (bacterial infestation)
F = Yellow fungus infestation
G = Black fungus infestation
\+ = more than 2 cups infested
++ = more than 4 cups infested
+++ = more than 6 cups infested

**Table 3. Percentage infestation during drying at 35°C in cross flow Drier**

| *Treatment* | *Infestation after 3 days* | *Infestation after 5 days* | *%mould free copra obtained* |
|---|---|---|---|
| Control | 66 | 100 | — |
| 500 x 15 | 16 | 50 | 50 |
| 750 x 15 | 5 | 50 | 50 |
| 1000 x 15 | 5 | 33 | 67 |
| 500 x 30 | — | 50 | 50 |
| 750 x 30 | — | 33 | 67 |
| 1000 x 30 | — | 33 | 67 |

Preservation of fresh kernel becomes essential by chemical treatment where drying is delayed due to uncertainty of weather conditions. If the kernel after splitting not subjected to drying, gets infested by microorganisms such as *Serratia marcessens* and *Stephylococus* (Satyavathi, 1979). This results in bad colour and sliminess of copra. The treatment of propionic acid at 1000 ppm concentration showed the inhibitary effect on microorganisms. It may be due to the hydrogen ions or due to the altered cell permeability causing growth inhibition. (Gershon and Permegiani, 1967). Toxicity of chemical applied is beyond question as concentration in the material may be in the order of 200 to 300 ppm, far below the permissible limit of 2000 ppm. The phenomenon of browning observed during 45th to 53rd h. may be due to the Maillard type of reaction in which one or more carbonyl groups (as in sugars) react with amino groups (as in aminoacids) or proteins (Gershon and Permegiani, 1967). This may also be due to rapid penetration of hyphae of *Aspergillus* species into copra meat under high humidity conditions causing discolouration and complex biochemical changes which result in high lipolytic activity and rise in FFA content. These treatments were tried under accelerated favourable conditions of temperature and relative humidity for the growth of microorganisms and found that the results were satisfactory on infestation control. This may certainly be practicable for avoiding spoilage of copra during sundrying.

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# STUDIES ON IMPROVING THE STORAGE LIFE OF COCONUT OIL

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## ABSTRACT

**Coconut oil is very susceptible to rancidity. Studies conducted on preventing rancidity in coconut oil and prolonging the shelf-life have shown that vacuum heating at 130 to 150°C for 30 minutes was beneficial. Storage studies were carried out at room temperature and accelerated conditions. Peroxide value and free fatty acid content of the samples were determined and they were also sensorily evaluated.**

**Storing the oil in brown bottles was found to improve the stability and prolong its shelf-life. Addition of antioxidants like butarylated hydroxyanisole and propyl gallate within the permissible limits showed slight beneficial effect.**

## INTRODUCTION

Coconut oil is very much susceptible to rancidity and the oil milling industry finds it difficult to market the oil within the short storage life. Rancidity development during storage is a major problem in retail packages.

Very few studies have so far been done on prevention of rancidity of commercial coconut oil. Reddy *et al.* (1978) studied the shelf-life of coconut oil in bulk in tin and found that there is a progressive increase in moisture, free fatty acid and peroxide value. The effeet of fluorescent light on oils has also been studied by Suttar *et al.* (1976). Fungus infection due to inadequate drying of coconut or rain during copra making in high humidity conditions may be one of the factors responsible for the poor quality of the extracted oil. The moisture content in coconut oil may induce hydrolytic rancidity. The effect of vacuum heating, cutting off the light and addition of antioxidants on the storage stability of commercial coconut oil are reported in this paper.

## MATERIALS AND METHODS

Commercial coconut oil obtained from an oil mill was used in these studies. Coconut oil in 500 g batch was vacuum heated at 110, 130 and 150°C for 30 minutes. The vacuum oven was allowed to attain the desired temperature and the coconut oil was placed in the hot oven and vacuum heated at the temperature needed for 30 min. at 750 mm vacuum. The unheated coconut oil was used as control. The samples were filled in 30 ml capacity test tubes and corked leaving a small head space of 0.5 cm. The corks were waxed. The test tubes were stored at room temperature in the laboratory.

In an experiment to find out the effect of light and antioxidants, one set of 12 test tubes of coconut oil were put in the cupboard and another 12 samples were kept in brown bottles. To find out the effect of antioxidants and acetic acid, the additives in the appropriate doses were dissolved in the oil and the treated oil was filled in glass stoppered test tubes (20 ml capacity) keeping a head space of 1 cm.

For storage studies in the accelerated conditions, untreated coconut oil and vacuum heated coconut oil samples were kept at 63°C ± 1°C and also subjected to air blowing (Cocks and Van Rede, 1966).

Sensory evaluation was done by a panel of trained judges. Free fatty acid was determined according to ISI (1964) and peroxide value by Wheeler's method (Cocks and Rede, 1966).

## RESULTS AND DISCUSSION

The initial values of moisture, free fatty acid (FFA), peroxide value and sensory score of untreated coconut oil and vacuum heated coconut oil are shown in Table 1. The moisture content in control sample was 0.09%, while in vacuum heated samples it was 0.04%. Thus the moisture is reduced by vacuum heating. The free fatty acid percentage was 0.67 in control and 0.65 to 0.68 in vacuum heated samples. The peroxide value was 0.24 in control and 0.37 to 0.41 in vacuum heated samples. The sensory evaluation of the samples have shown that the sample heated under vacuum at 130°C for 30 minutes had the highest preference. It had a strong pleasant flavour which was liked by the judges. The organoleptic score of this sample was 8.3 compared to 6.2 for control.

**Table 1. The initial organoleptic score of commercial coconut oil and vacuum heated oil samples**

| *Treatments* | *Moisture %* | *Free fatty acid %* | *Peroxide value* | *Total Sensory score (out of 10)* |
|---|---|---|---|---|
| Control | 0.09 | 0.67 | 0.24 | 6.2 |
| Vacuum heated at 110°C. | 0.04 | 0.65 | 0.38 | 6.5 |
| Vacuum heated at 130°C. | 0.04 | 0.67 | 0.37 | 8.3 |
| Vacuum heated at 150°C. | 0.04 | 0.68 | 0.41 | 8.0 |

The results of storage studies of coconut oil under accelerated conditions at 63°C showed that after 1 week itself the oil became bland (Table 2). But no rancidity was noticed even in control. The same trend continued for about 2 months. The vacuum heated oils were found to be slightly better than control. The free fatty acid content after nearly two months of storage at 63°C was found to be 0.60 for control and 0.55, 0.51 and 0.50 for oils heated under vacuum (750 mm) respectively at 110 , 130 and 150°C for 30 min. The corresponding peroxide values were 0.75, 0.56, 0.23 and 0.19. Thus there was a slight decrease in free fatty acid content and a reduction in the peroxide value on storage at 63°C for 2 months.

Slight change in flavour was noticed in the oil samples under air blowing for 48 h. After 76 h. of air blowing, loss in flavour and slight rancidity were noticed in control sample and in the vacuum heated sample at 110°C for 30 minutes while in the vacuum heated sample (at 130°C and 150°C)only loss in flavour was noticed. There was no perceptible rancidity. After 103 h. of air blowing, the control sample became quite rancid and the oil vacuum heated at 110°C developed slight rancidity whereas the oil vacuum heated at 130°C and 150°C for 30 min. did not have perceptible rancidity. The average sensory scores were 4,5,8 & 7. There was not much change in free fatty acid content. However, the vacuum heated samples showed lower peroxide values of 3.7, 3.5 and 3.5 compared to a peroxide value of 6.5 in control (Table 2).

**Table 2.** Changes in free fatty acid content, peroxide value and sensory quality in heat-treated coconut oil in accelerated storage conditions

| *Treatments* | *Kept in oven at 63°C for 2 months* | | | *Air blown for 103 hours* | | | |
|---|---|---|---|---|---|---|---|
| | *Free fatty acid %* | *Peroxide value* | *Sensory quality* | *Free fatty acid content %* | *Peroxide value* | *Sensory quality* | *Sensory score (Max 10)* |
| Control | 0.66 | 0.75 | Loss in typical coconut oil flavour Bland. But no off flavour or rancidity. | 0.66 | 6.5 | Quite rancid | 4 |
| Vacuum heated at 110°C for 30 min. | 0.55 | 0.56 | ,, | 0.68 | 3.7 | Slightly rancid | 5 |
| Vacuum heated at 130°C for 30 min. | 0.51 | 0.23 | ,, | 0.66 | 3.5 | Not rancid loss in flavour | 8 |
| Vacuum heated at 150°C for 30 min. | 0.50 | 0.19 | ,, | 0.68 | 3.5 | Loss in flavour | 7 |

Changes in free fatty acid content of samples stored at room temperature are shown in Table 3. There was slight reduction in free fatty acid content in vacuum heated samples compared to control on storage.

**Table 3. Changes in free fatty acid content of heat-treated coconut oil on storage at room temperature**

| Treatments | Storage period (months) 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| Control | 0.67 | 0.68 | 0.73 | 0.79 | 0.83 | 0.86 | 0.88 |
| Vacuum heated at 110°c for 30 min. | 0.65 | 0.68 | 0.73 | 0.78 | 0.81 | 0.84 | 0.88 |
| Vacuum heated at 130°c. for 30 min. | 0.67 | 0.68 | 0.73 | 0.79 | 0.81 | 0.84 | 0.84 |
| Vacuum heated at 150°c. for 30 min. | 0.68 | 0.66 | 0.73 | 0.79 | 0.80 | 0.84 | 0.83 |

The changes in peroxide value during storage are shown in Table 4. The peroxide value of samples increased up to 5 to 6 months (control 0.2 to 6.4; vacuum heated sample 0.4 to 2.2). The peroxide value of vacuum heated samples were found to be lower than control. At the end of third month the peroxide value of control sample was 6.0, whereas the vacuum heated oil samples at 110°C, 130°C and 150°C were having peroxide values of 3.3, 2.2 and 1.6 respectively. The same trend was seen at the end of six months of storage.

**Table 4. Changes in peroxide value of heat-treated coconut oil on storage at room temperature**

| Treatments | Storage period (months) 0 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Control | 0.2 | 0.8 | 6.0 | 5.7 | 6.4 | 6.0 |
| Vacuum heated at 110°C for 30 min. | 0.4 | 0.6 | 3.3 | 6.4 | 5.4 | 3.9 |
| Vacuum heated at 130°C. for 30 min. | 0.4 | 0.6 | 2.2 | 3.5 | 4.0 | 3.1 |
| Vacuum heated at 150°C for 30 min. | 0.4 | 0.6 | 1.6 | 2.4 | 2.2 | 2.0 |

The changes in sensory quality of vacuum heated oil samples and control samples during storage are reported in Table 5. Rancidity was not observed in any of the oil samples until the end of two months. Slight rancidity was noticed in control at the end of third month but not in any other samples. Rancidity was evident in the control after four months storage while the vacuum heated oil samples at 130°C and 150°C for 30 minutes were not rancid. The total organoleptic score for these samples were 8.1 and 7.6 out of 10 as compared to 5.8 for control. The vacuum heated oil at 110°C had very slight rancidity (the organoleptic score being 6.5). The same trend was seen when stored for six months

**Table 5. Changes in sensory quality* of heat-treated coconut oil on storage at room-temperature**

| *Treatments* | *Storage period (months)* 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Control | 7.5 | 7.3 | 6.8 | 5.8 | 5.3 | 4.8 |
| Vacuum heated at 110° C for 30 min. | 7.8 | 7.5 | 7.1 | 6.5 | 6.3 | 5.3 |
| Vacuum heated at 130° C for 30 min. | 8.8 | 8.5 | 8.3 | 8.1 | 7.5 | 6.3 |
| Vacuum heated at 150°C for 30 min. | 8.6 | 8.4 | 8.3 | 7.6 | 7.0 | 6.3 |

*Mean score for overall quality out of 10.

Sensory evaluation score and free fatty acid content, and sensory credit score and peroxide value were found to be correlated.

The changes in free fatty acid content of coconut oil kept in dark in brown bottles and with antioxidants during storage at room temperature are reported in Table 6. After four months' storage, the oil kept in brown bottle and in the dark had less FFA content.

The changes in peroxide value of the oil samples during storage at room temperature are given in Table 7. The samples stored in brown bottle and in darkness, were found to have low peroxide values. Antioxidants were found to have slight effect on the peroxide values.

## Table 6. Changes in free fatty acid content of coconut oil with different treatments on storage at room temperature

| | *Storage Period (Months)* | | | | |
|---|---|---|---|---|---|
| *Treatments* | 1 | 2 | 3 | 4 | 5 |
| Control | 0.24 | 0.28 | 0.30 | 0.32 | 0.34 |
| Kept in the dark | ,, | 0.27 | 0.28 | 0.31 | 0.30 |
| Kept in brown bottles | ,, | 0.25 | 0.27 | 0.29 | 0.29 |
| With Citric acid 0.01% | 0.25 | 0.27 | 0.29 | 0.31 | 0.32 |
| With propyl gallate 0.01% + Citric acid 0.01 % | ,, | 0.28 | 0.29 | 0.31 | 0.32 |
| With propyl gallate + B H A Citric acid @ 0.01 % each | ,, | 0.27 | 0.29 | 0.30 | 0.31 |
| With B H A 0.02 % + Citric acid 0.01 % | ,, | 0.28 | 0.29 | 0.30 | 0.31 |

## Table 7. Changes in peroxide value of coconut oil with different treatments on storage at room temperature

| | *Storage period (months)* | | | | |
|---|---|---|---|---|---|
| *Treatments* | 0 | 2 | 3 | 4 | 5 |
| Control | 0.1 | 3.6 | 2.7 | 2.4 | 2.2 |
| Kept in the dark | ,, | 0.3 | 0.3 | 0.4 | 0.4 |
| Kept in brown bottle | ,, | 0.2 | 0.2 | 0.3 | 0.2 |
| With citric acid 0.01 % | ,, | 1.3 | 2.7 | 2.1 | 0.9 |
| With propyl gallate 0.01 % + Citric acid 0.01 % | ,, | 0.8 | 3.4 | 1.4 | 0.8 |
| With propyl gallate + B H A + Citric Acid @ 0.01% each | ,, | 1.3 | 2.8 | 2.0 | 1.2 |
| With B H A 0.02 % + Citric acid 0.01 % | ,, | 1.0 | 2.5 | 2.3 | 0.7 |

Changes in sensory quality of coconut oil with different treatments on storage at room temperature are given in Table 8. After four months' storage, the control sample had noticeable rancidity (organoleptic score 5.8). The oil kept in brown bottle was much superior with no rancidity (organoleptic score 8.5). The oil kept in the dark was also free from rancidity with an organoleptic score of 8.0, while the oil with the addition of BHA and propyl gallate (0.01% each) and with 0.02% BHA had a score of 7.1. This trend was maintained at the end of 5 months also.

**Table 8. Changes in sensory quality* of coconut oil with different treatments on storage at room temperature**

| | *Storage period* | *(Months)* | | |
|---|---|---|---|---|
| *Treatments* | 2 | 3 | 4 | 5 |
| Control | 7.0 | 6.0 | 5.8 | 5.4 |
| Kept in the dark | 8.5 | 8.4 | 8.0 | 7.0 |
| Kept in brown bottle | 9.0 | 8.8 | 8.5 | 8.3 |
| With Citric acid 0.01 % | 7.3 | 6.2 | 6.0 | 5.6 |
| With propyl gallate 0.01 % + citric acid 0.01 % | 7.5 | 6.6 | 6.4 | 6.0 |
| With propyl gallate @ B H A + citric acid 0.01 % each | 7.8 | 7.2 | 7.1 | 6.5 |
| With B H A 0.02 % + Citric acid 0.1 % | 8.0 | 7.5 | 7.1 | 6.8 |

* Mean score for overall quality out of 10.

From the above results, it can be concluded that vacuum heating improves the keeping quality of coconut oil. Addition of antioxidants only helps to prolong the shelf-life by about a month. Storage in darkness or in brown bottles improved the keeping quality considerably and therefore avoiding exposure of oil to the light appears a must.

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# POST HARVEST TECHNOLOGY OF NUTMEG

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## ABSTRACT

**Dehydration of nutmeg seeds in a cross flow drier at 50°C as an alternative to conventional methods is practicable provided necessary precautions are taken to avoid "case hardening". Mechanical drying of mace at 50°C was found better than conventional methods. A mild blanching followed by sulphiting or a simple blanching itself helped retention of colour and general quality of mace. The characteristic scarlet colour of mace has been identified a lycopene.**

## INTRODUCTION

Nutmeg (*Myristica fragrans* Houtt) is a unique aromatic tree giving two types of valuable spices namely the nutmeg (kernel) and the mace (aril). Discovered for the first time in 1512 in Moluccas island it's cultivation later spread to other tropical regions by the effort of colonisers. Today Indonesia and Grenada are the two major producers of nutmeg contributing together 80–85% of the total world production. Nutmeg was introduced in to India by the East India company in the beginning of 19th century the cultivation of which was started in Tamil Nadu and later in Kerala and Assam. India which was importing these spices in large quantities in the past has been able to reduce the quantum of import by increasing the internal production and as on date both importing and exporting are carried on. In 1978–79 India imported 121.0 tonnes of nutmeg (value Rs. 24.9 lakhs), 3.7 tonnes of nutmeg oil (value 3.2 lakhs) and 27.5 tonnes of mace (value Rs. 5.8 lakhs). Kerala is climatically suited for its cultivation and can meet a sizeable part of the internal demand. The area of cultivation of nutmeg in Kerala in 1977–78 was estimated to be around 1517 hectares and the cultivation is expected to be more by now. Nutmeg and its by-products find varied uses in medicine, food industry, perfumery, cosmetics, etc. An updating of the conventional post harvest technology of nutmeg and mace will be called for in the immediate future. The present work is an effort in this line.

Adequate information on the chemical composition of nutmeg and mace is a prerequisite while adopting a suitabe processing technology. The nutmeg fruit has an average weight of 60 g. and consists of three main parts namely the pericarp or rind (81–82%), the seed (16–17%) and the mace (2–2.5%). The general chemical composition of the nutmeg and mace is described in literature. The proximite analyses of the fresh spices relevant to the present study was carried out in recent years. The fleshy rind usually thrown as a waste contains 1.6 to 1.7% (about 14% on dry weight basis) pectin which can be economically extracted or the rind as a whole can be used for the preparation of jam, jellies, preserves, or pickles after removal of the astringent and toxic principles. The volatile oil of nutmeg which is the main aroma principle of the spice is reported to contain nearly 50 chemical constituents. The mace oil has almost similar chemical composition. The oils of the two spices are not differentiated in trade. Myristicin, and elimicine are the hallucinogenic principles present in nutmeg and mace. Isogai *et al* (1973), Forrest *et al* (1974) and Harvey (1975) have reported the presence of several phenyl propanoids in nutmeg and mace. The natural colour as well as astringency of the nutmeg is due to presence of polyphenols (2–2.5%) of which condensed tannins and flavenoids constitute the major part. According to recent report, cyanadin accounts for approximately 76% of the toal anthocyanidin derived from nutmeg extract upon acid treatment while (–) epicatechin is present in significant amount. Polyphenols were found absent in the mature mace while procyanidin type polyphenols similar to those of nutmeg were observed in immature mace. In general nutmeg and mace have almost similar chemical characteristics. However, the latter has a finer aroma and is valued more. The present study was aimed at evolving a suitable curing, drying and packaging method for nutmeg and mace whereby the natural appearance, colour and flavour of the products are retained to maximum.

## MATERIALS AND METHODS

Raw materials procured from Trivandrum area were used for the experiments. The processing of nutmeg starts with the separation of the rind, mace and seed followed by drying. The rind of the fruit usually splits at fully ripe stage exposing the aril and the seed. The seeds after separation of mace were dried in the sun and simultaneously in an electrical cross flow drier (Kilburn India Ltd., Madras) at 65°C and 50°C by spreading in a single layer in perforated aluminium trays of 0.328 sq. m. (40.5 x 81 cm). The mace after careful separation was flattened and subjected to different treatments prior to drying. Initial study indicated that sundrying caused bleaching of the natural colour of the mace and was so discontinued. Thus the mace samples were slowly dried in the shade as well as in a cross flow drier at 50°C. The dried samples were packed in low density polythene bags immediately after drying. One set of mace samples was kept in dark condition in order to study the effect of light on colour moisture, volatile oil and colour (in case of mace) were determined in fresh and dried samples. The mace samples stored were organoleptically evaluated by a panel of judges at three months intervals. Colour of the mace was estimated as lycopene at a wave length of 503 mm by standard procedure using a Carl Zeizz Jena VSU 2P spectrophotometer. Moisture in the experimental samples of nutmeg and mace was determined by Dean and Stark distillation method, volatile oil by water distillation method using a clevenger apparatus and residual sulphurdioxide in sulphited and sulphur fumigated mace samples by modified Monier-Williams method.

Two commercial samples each of nutmeg and mace were analysed for moisture, volatile oil and colour (in case of mace samples) for comparative evaluation of quality.

## RESULTS AND DISCUSSION

Drying of a spice, without loss of its inherent quality is a delicate task involved and keeping the optimum moisture level in the dried samples is the most essential step for good keeping quality. Volatile oil content, colour and appearance are some of the major aspects to be taken care of during the curing/drying process. In this respect the conventional processing methods suffer from many disadvantages. Proximate analysis of fresh nutmeg and mace shows that the volatile oil content 15% and 20% respectively and nonvolatile ether extract (20% and 33%) respectively in fresh samples are considerably high compared to corresponding values in case of the dried spices. Obviously there is considerable loss of these ingredients during the processing and storage which need to be minimised. During the harvesting season of June-October especially in the monsoon climate of Kerala, the conventional method of sundrying for nutmeg or mace may take unduly long time leading to fungus/insect attack and deterioration of quality of the spices. In the case of mace, sundrying is not to be recommended as there is a chance for bleaching of the colour. Electrical drying was thought to be an alternative in such circumstances.

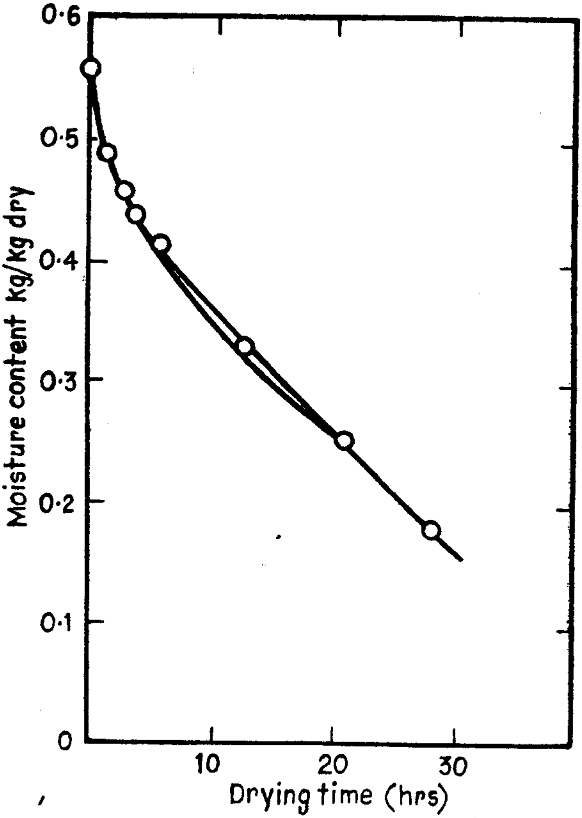
Raw nutmeg kernel at the harvesting stage is firmly attached to the outer shell and cannot be separated easily without injuring it. Hence the kernel is to be dried along with the shell which naturally takes long time. Unlike in the case of vegetables slicing of the kernels into smaller pieces for quicker dehydration cannot be recommended for two reasons; (i) loss of volatile oil during dehydration and (ii) any injury to the kernel may lead to discolouration of product because of oxidative degradation of polyphenols. The chromatographic pattern and characteristics of the anthocyanidins derived from nutmeg extract on acid treatment are given in Table 1. A preliminary drying trial to ascertain in feasibility of artificial drying of nutmeg at 65°C indicated "case hardening" which further hindered the normal drying process. Therefore the nuts were dried at 50°C in the subsequent experiments while another lot was dried in the sun for comparative study. The nuts with an initial moisture level of 36% when dried in the mechanical drier for 28 hours the moisture level came down to 9%, the drying ratio being 1.36 : 1. On the other hand the sundrying of the nuts could be completed only in 7 days where the direct sun-drying was for 18½ hours only due to bad weather condition and the moisture level dropped to 8.5% (drying ratio 1.37:1). Sundrying for nutmeg was found to be a slow but uniform process while artificial drying in a cross flow drier even at 50°C was found

**Table 1. Characteristics of anthocyanidins from the mixture of nutmeg proanthocyanidins**

| *Spot. No.* | *Colour* | *Rf* | | *Absorption peak n.m. (ethanol-hydrochloric acid)* | *Shift in peak with $AlCl_3$* | *Phenolic acid obtained on alkali fusion* | *Approximate % in the mixture* |
|---|---|---|---|---|---|---|---|
| | | *Forestal solvent. acetic acid:water: hydrochloric acid* (30:10:3) | *Formic solvent. formic-acid: hydrochloric acid: water* (52:3) | | | | |
| 1. | Pink | 0.22 | 0.06 | — | — | — | 5 |
| 2. | Pink | 0.33 | 0.13 | 535 | — | — | 6 |
| 3. | Pink | 0.50 | 0.22 | 545 | 18 | Protocatechuic acid | 56 |
| 4. | Pink with orange tint | 0.57 | 0.33 | 540 | — | — | 7 |
| 5. | Pink with orange tint | 0.70 | 0.43 | 535 | — | — | 8 |
| 6. | Pink with orange tint | 0.78 | 0.46 | 545 | 18 | Protocatechuic acid | 18 |

to suffer from the disadvantage of "case hardening." As for instance after 20 hours drying in the electrical drier, 42% of the kernels started rattling inside the shell while the rest remained without rattling. On analysis contrary to expectation the former had 11% and the latter 9.5% moisture. This anomaly is to be attributed to the "case hardening" effect. Thus unlike in the case of sundried samples the rattling sound in this case is not a criteria of complete dryness. The drying curve for nutmeg kernels dried in the electrical drier is presented in Fig. 1, which clearly indicates the unusually slow drying rate after a certain

Fig.1 DEHYDRATION OF NUTMEG SEEDS AT 50°C



(Figure 1)

period of drying. The kernels were, therefore, deshelled towards the end of the drying and further dried to a moisture level of 6 to 7% and kept well packed. Table 2 gives the comparative analysis of sundried, mechanically dried and commercial nutmeg samples. mechanically dried nuts compared well with sundried samples and were superior to commercial samples. Further studies are, however, required for standardization of the artificial drying methods for nutmeg with possible modification to the drier. While sundrying is a viable and more economic method, mechanical drying is the only alternative under unfavourable climatic conditions. Dried nutmeg kernels may be given an antifungal coating for the better storage instead of giving a lime coating as practiced by farmers. Preliminary studies with a simple antifungal coating has been found encouraging. Alternatively the properly dried seeds can be stored along with the shell for better shelflife.

Drying of mace and its storage appeared to be a more delicate process. Though mace was found practically devoid of polyphenols at the harvesting stage, its attractive scarlet colour appeared to be highly heat and light sensitive. Recent studies established its identity as lycopene, a carotenoid from chromatographic, spectral and IR data (Table 3) and the method for estimation of mace colour adopted for the present work is based on that information. Three fresh samples of mace on analysis were found to have lycopene in the range of 251 to 151 mg/100 gm while commercial mace samples were found to be very unattractive in appearance and practically devoid of lycopene. It is a known fact that lipids in improperly dried and stored foods is likely to undergo oxidation which may lead to off flavour of the product and bleaching of lycopene. Table 4 gives the different treatments applied for mace and the effect on retention of colour and volatile oil. Mechanical drying of mace normally took 5 to 6 hours to reach a moisture level of 5 to 5.5% while sundrying took 16 hours and shade drying 24 to 28 hours to reach the same moisture level. In general, mechanical drying of mace at 50°C was found to be a quick process yielding a superior product. In the present studies all the sundried and shade dried samples were found susceptible to fungus and insect attack in 2 to 3 weeks which was not so in case of mechanically dried samples. Only the machanically dried control and alkali treated samples were found to be slightly infected

**Table 2. Analysis of commercial and experimental samples of nutmeg/mace***

| | *Nutmeg* | | | | | *Mace* | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Commercial samples* | | *Experimental samples* | | | *Commercial samples* | | *Experimental samples* | | | |
| | 1 | 2 | *Raw* | *Sundried (control)* | *Mechanically dried (control)* | 1 | 2 | *Raw* | *Shade dried (control)* | *Mechanically dried (control)* | *Mechanically dried (balanced) and sulphited* |
| Moisture % | 8.0 | 9.0 | 36.0 | 7.5 | 8.5 | 10.0 | 8.0 | 40.0 | 8.8 | 7.5 | 6.0 |
| Volatile oil v/wt% | 8.1 | 8.0 | 14.7 | 11.4 | 12.8 | 12.2 | 16.4 | 20.0 | 11.0 | 11.2 | 10.7 |
| Colour as lycopene mg/100 gm | | | | | | 8.7 | 2.7 | 189.2 | 94.0 | 72.6 | 114.0 |

* The values are expressed on dry weight basis.

Table 3. Visible absorption maximum of mace pigment and lycopene isolated from tomato

| *Pigment* | *Absorption maximum (n.m.) in different solvents* | | |
|---|---|---|---|
| | *Light petroleum* | *Chloroform* | *Carbondisulphide* |
| Mace pigment | 445,471,501 | 456,483,517 | 477,505,545 |
| Lycopene from tomato: | | | |
| Observed value | 445,471,501 | 456,483,517 | 477,505,545 |
| Reported value | 446,472,505 | 456,485,520 | 477,507.548 |

$E^{1\%}_{1cm}$ at 471 nm was found to be 3280 in hexane as against a reported value of 3450 for lycopene.

**Table 4. Effect of processing on retention of colour and volatile oil in mace***

| Treatment | *Colour as lycopene mg/100gm* | | | *Volatile oil* | | *Organoleptic score*** |
|---|---|---|---|---|---|---|
| | *Shade dried* | *Mechanically dried* | *Mechanically dried and unexposed to light (after 3 months)* | *Shade dried* | *Mechinically dried* | *Mechanically dried and unexposed to light (after 3 months)* |
| 1. Control | 94.0 | 72.6 | 30.0 | 11.0 | 11.2 | 2.6 |
| 2. Steeped in 1000ppm KMS solution for 10 minutes | 110.0 | 108.0 | 34.0 | 10.6 | 10.4 | 4.2 |
| 3. Sulphur fumigated for 20 minutes (0.5 gm sulphur/0.3m$^3$) | 117.0 | 141.0 | 38.0 | 10.0 | 11.1 | 4.8 |
| 4. Steeped in 2% $Na_2CO_3$ solution for 10 minutes | 90.0 | 90.0 | 26.0 | 10.0 | 10.0 | 2.1 |
| 5. Blanched for one minute | 112.0 | 100.3 | 69.5 | 9.8 | 9.6 | 7.1 |
| 6. Blanched for one minute and steeped in 1000 ppm KMS solution for 10 minutes | 115.3 | 114.0 | 47.1 | 10.1 | 10.7 | 7.6 |

* The values are expressed on dry weight basis.

* Organoleptic score was done with respect to standard fresh dried mace which was allotted 10 marks.

with fungus after 3 months storage. A mild blanching for one minute was found to help retention of colour without much affecting the flavour of the product. Sulphur fumigation or sulphiting after a mild blanching was found to enhance colour retention and retard fungus infection.

Mace samples (mechanically dried) kept in dark condition were organoleptically evaluated by a panel of judges after 3 months storage. Control and alkali treated samples showed poor colour while blanched and sulphited mace as well as the simply blanched sample retained very good colour and flavour. Sulphur fumigated sample which had the best colour immediately after drying was found partially bleached after 3 months storage and rated poorly. The residual sulphurdioxide content in sulphur fumigated and sulphited mace samples was found to be in the range of 40 to 50 ppm. Sulphiting without blanching did not help colour retention. Blanching was felt to be the prominent factor helping retention of colour as well as protecting from fungus and insect attack. Therefore a simple blanching alone is recommended as a safe and easy method for preservation of mace. Mace samples kept protected from light after 3 month's storage were found to have slightly better colour compared to those exposed to light.

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# GLUE ADHESIVE PROPERTIES OF ARECANUT LEAF SHEATH BOARDS*

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## ABSTRACT

**3-ply arecanut leaf sheath boards were made at the laboratory with two veneers of arecanut leaf sheath and one veneer of wood under various combinations and with different glues namely starch glue (cold pressing), animal glue (cold pressing) poly vinyl acetate (Fevicol–Pidilite –cold pressing), Epoxy resin adhesive (Araldite–Ciba Geigy–cold processing) and urea formaldehyde (hot pressing). The boards were tested for their glue shear strength and water resistance in accordance with the IS specifications for tea-chest grade plywood. Areca sheath boards made with UF resin adhesive and wood veneer as core were found to have 50% more wet glue shear strength than the other areca sheath boards. Use of extenders like tamarind seed powder and deoiled sal meal up to 15% to the UF resin adhesive and the type of wood used were found to have no adverse effect on the glue shear strength of the boards. Though the areca sheath boards satisfied only 50% of the IS requirements for tea chest grade plywood, they were found to have better wet glue shear strength over the locally purchased non–ISI grade tea chest plywood.**

## INTRODUCTION

Arecanut is grown in about 1,75,000 ha in India. Each palm sheds 5–7 leaves annually and the leaves provide about 120 million $m^2$ leaf sheaths for possible economic utilisation. Earlier studies have shown that the arecanut leaf sheaths have desirable properties which permit them to be made into plyboards in combination with wood veneers, and that these could be used for making panel products such as tea chest plywood. Since a number of glues are available in the market and their prices vary widely, glue adhesive properties of arecanut leaf sheath were taken up to find out the most suitable glue for making areca leaf sheath plyboards.

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* Publication No. 199, CPCRI, Kasaragod.

## MATERIALS AND METHODS

The leaf sheaths as obtained from the farms were first processed by soaking in water to about 75% moisture and then pressed in a hot platten press under a pressure of about 4 kg/cm$^2$ and 110°C temperature for 30 min. This produced flat sheaths of 1.0–1.5 mm thickness. These were then air-dried for easy workability. The studies were carried out on five aspects, namely, 1. Type of glue; 2. Combinations of areca leaf sheaths with wood veneer; 3. Use of extenders to the glue; 4. Type of wood veneer used and 5. Comparative performance of the areca sheath plyboards with locally purchased tea chest plywood boards.

The details of the experiments are given below:

### 1. Type of glue

Arecanut leaf sheaths were made into 3–plyboards in combination with a 1.5 mm thick veneer of *Vateria indica* L. (Fam. Dipterocarpaceae) (Vellapine) wood. Five different glues, namely starch glue, animal glue, poly vinyl acetate (Fevicol Pidilite) urea formaldehyde and an epoxy resin adhesive (Araldite Ciba-Giegy) were used for the study. The glue formulations are given below:

a. *Starch glue*: Vegetable starch..100 parts by weight; Water.. 500 parts by weight. Water was boiled to 100°C and then starch was added slowly and stirred.

The boards were cold-pressed over night at room temperature under a pressure of about 4kg/cm.$^2$

b. *Animal glue*: Animal glue (Star brand) Shaw wallace: 100 parts by weight; Water..225 parts by weight; Oxalic acid as hardener — 5 parts by weight; Para formaldehyde as hardener — 10 parts by weight. The glue was allowed to soak in water for about 45 minutes. Then, the mixture was heated to 65°C, and when still hot, oxalic acid and para formaldehyde were added one after the other and stirred well.

Gluing conditions: Cold pressing over night at room temperature under a pressure of about 4 kg/cm.$^2$

c. *Polyvinyl acetate*: Fevicol.. 100 parts by weight; Water.. 200 parts by weight. Gluing conditions: Cold pressing overnight at room temperature.

d. *Urea formaldehyde:* Urea formaldehyde resin—100 parts by weight; *Ciba hardener* — 20 parts by weight.

*Gluing conditions*: Hot pressing for 7 minutes with one minute breathing at 95–100°C under a pressure of about 10–12 kg/cm.$^2$

e. *Epoxy resin:* Araldite glue formulations as laid out by the manufacturers. (Ciba-Geigy)

Gluing conditions: Cold pressing overnight at room temperature under a pressure of 4kg/cm$^2$ and at contact pressure for about 10 hours.

## 2. Combination of areca sheath with wood veneers

Three combinations were tried (Table I.). The wood veneer used was 1.5 mm thick *Vateria indica* (*Fam.* Dipterocarpaceae) (Vellapine).

**Table. 1. Combination of areca sheath boards: 3 ply.**

| *No.* | *Description* | | | *Remarks* |
|---|---|---|---|---|
| | *Ply* | *Material* | *Direction* | |
| 1. | Faces | Areca sheath and wood | Across the grain | |
| | Core | areca sheath | Along the grain | Type 1 |
| 2. | Faces | Areca sheaths both | Along the grain | |
| | Core | wood | Across the grain | Type 2 |
| 3. | Faces | Areca sheath and wood | Along the grain | |
| | Core | areca sheath | Across the grain | Type 3 |

### 3. Use of extenders to the glue

Two types of extenders namely tamarind (*Tamarindus indicus*) seed powder and de-oiled sal (*Shorea robusta* Roxb.) meal powder, were used upto a level of 15% by weight of urea formaldehyde resin to study their effect on extended resin on adhesion in 3 ply areca sheath boards. The boards comprised of areca leaf sheaths as faces and 1.5 mm thick wood veneer as core. The glue formulations and gluing conditions adopted were the same as followed for non-extended urea formaldehyde resin.

### 4. Type of wood

Three species of wood, namely *Vateria indica* Linn. (*Fam.* Dipterocarpaceae) (Vellapine); *Palaquium ellipticum* (*Fam.* Sapotaceae) (Pali); and *Mangifera indica* Linn. (*Fam.* Anacardiaceae) (Mango) were used as core veneer 1.5 mm thick for making 3 ply areca sheath boards with urea formaldehyde resin as glue, in order to study the performance of areca leaf sheaths when glued with different species of wood.

5. Comparative performance of areca sheath ply boards with commercially available tea-chest plywood boards (but not conforming to ISI standards).

Glue adhesion strength of areca sheath ply boards made with *Vateria indica* Linn. (Vellapine) wood veneer 1.5 mm thick as core and ureaformaldehyde resin as glue was compared with four brands of locally purchased tea chest plywoods.

The samples of all these studies were tested for their glue shear strength in accordance with the ISI specifications for Methods of test for plywood (General) IS:1734(1972). The water resistance of bonds made with different glues under various combinations of wood and areca sheaths was tested by seven days water soaking test as per the ISI specifications for plywood tea chests.

## RESULTS AND DISCUSSION

### Type of glue and various combinations of wood and areca sheath veneers:

The glue shear strength of areca sheath ply boards made with various glues and in various combinations of wood and areca sheath veneers were tested.

In general, the areca sheath boards did not meet fully the ISI requirements for tea chest grade plywood. The average dry glue shear strength was 45–55 kg for all the boards (Table II). There was not any remarkable difference in the dry glue shear strength among the boards with various glues and in various combinations since the failure of the boards upon the ultimate load was mostly due to the sheath fibres.

With reference to the wet glue shear strength, the failure of the boards was predominantly due to the glue used in the case of boards made with animal glue and Fevicol, while it was mainly due to the sheath fibres in the case of boards made with urea formaldehyde. The boards made with urea formaldehyde had 50% more wet glue shear strength than those made with other glues. This may be due to the better adhesion of arecanut leaf sheaths provided by urea formaldehyde than by other glues. The adhesion of areca sheath ply boards with starch glue was so poor that the boards were delaminated even before testing them. Hence starch cannot be used for preparing areca sheath ply boards.

With the three combinations of wood and areca sheath veneers tried (Table 1), the boards made with wood veneer as core showed about 50% more wet glue shear strength than the other combinations. This may be due to the better adherent properties of the sheath-wood mating surfaces than the sheath-sheath mating surfaces.

The strength properties of areca sheath ply boards showed large variations. The coefficient of variation was more than 12% in all the cases and in some cases even 38%. This may be due to the highly heterogenous nature of areca leaf sheaths.

Water resistance studies showed (Table 3) that none of the samples withstood the seven-days' water soaking test. Comparatively, the boards made with urea formaldehyde showed the best performance. Further, the boards made with wood veneer as core did not warp, while all other boards warped on soaking in water for seven days.

Table 2. Glue adhesion strength of Areca boards with various glues and different combinations*

| *Sl. No.* | *Glue used* | *Combination as in table I* | *Glue adhesion* | | | *Strength* | | |
|---|---|---|---|---|---|---|---|---|
| | | | *Dry state (kg)* | *Coefficient of variation* | *% glue failure* | *Wet (CWR) (kg)* | | |
| | | | *Range and Mean* | | | *Range and (Mean)* | *Coefficient of variation* | *% glue failure* |
| 1 | 2 | | 3 | 4 | 5 | 6 | 7 | 8 |
| 1. | Animal glue | Type 1 | 28–142<br>(146) | 29.0 | 60 | 4–26 | 30.0 | 70 |
| | | Type 2 | 42–142<br>(51) | 24.0 | 50 | 10–22<br>(12) | 24.0 | 30 |
| | | Type 3 | 39–110<br>(48) | 18.0 | 30 | 6–14<br>(9) | 11.0 | 50 |
| 2. | Fevicol | Type 1 | 48–124<br>(61) | 29.0 | 10 | 2–6<br>(4) | 14.0 | 60 |
| | | Type 2 | 46–142<br>(66) | 19.0 | 15 | 7–26<br>(11) | 19.0 | 70 |

* As per IS: 1734 — 1972

Table 2. Contd.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|
| | Type 3 | 48–114<br>(56) | 20.0 | 70 | 6–10<br>(7) | 12.0 | 60 |
| 3. Urea Formal dehyde | Type 1 | 25–132<br>(65) | 38.0 | 10 | 12–40<br>(16) | 18.0 | 20 |
| | Type 2 | 35–106<br>(58) | 31.0 | 5 | 11–35<br>(17) | 27.0 | 20 |
| | Type 3 | 45–114<br>(52) | 28.0 | 5 | 10.28<br>(13) | 24.0 | 20 |
| 4. Araldite | Type 1 | 48–88<br>(56) | 27.0 | 0 | 6–12<br>(7) | 20.0 | 30 |
| 5. Starch | Type 1 | Delaminated | | | Delaminated | | |
| 6. — | CWR Goude-Plywood | 70 | — | — | 35 | — | — |
| | ISI requirement | 55 | | | 30 | | |
| | | (Minimum individual) | | | (Minimum individual) | | |

Table 3. Water resistance properties of areca (sheath) ply boards

| *Sl. No.* | *Description* | *Observation after Seven days' water soaking test (IS: 10–1976)* |
|---|---|---|
| 1. | Animal glued boards | Delaminated after 6 days |
| 2. | Fevicol—glued boards | Delaminated after 5 days |
| 3. | Urea formaldehyde–glued boards | Slightly delaminated after 6 days and delaminated after 7 days |
| 4. | Araldite-glued boards | Delaminated after 3 days |
| 5. | Type 1 and 3 boards as in Table I | Delaminated after 3–6 days, samples warped |
| 6. | Type 2 boards as in table I | Delaminated after 6 days, samples not warped |
| 7. | Tea chest grade plywood ISI requirement | No delamination after 7 days and no warpage. |

### Use of extenders to the glue and the type of wood:

Using the extenders tamarind seed powder and deoiled sal meal powder upto 15% of the urea formaldehyde resin formulation and the species of wood used as core veneer in areca sheath boards did not adversely affect the glue shear strength of the boards (Table IV and V). The failure of the samples in both the cases was due to the sheath fibre only. Hence, the use of extenders upto 15% in the UF resin glue and the use of ordinary wood as core veneer may not affect adversely the strength of the boards. They will at the same time help to reduce the cost of production of the boards.

### Comparative performance of areca sheath ply boards with locally purchased tea chest ply wood:

The comparative performance of glue shear strength of areca sheath ply boards and four brands of locally purchased tea chest plywood was studied (Table VI). The areca sheath boards were superior to the locally purchased tea chest plywoods in their wet glue shear strength.

The studies have revealed that the areca sheath plyboards made with two veneers of areca sheaths on the faces and one veneer of an ordinary wood species like *Mangifera indica* Linn. as core and bonded with extended UF resin glue make commercially acceptable boards. These boards with an average dry and wet glue shear strength of 50 kg and 12 kg respectively do not attain the ISI specifications for tea-chest grade plywood but were superior to four brands of locally purchased tea chest plywood in wet glue shear strength. Incidentally such boards are used for the shipping of 75% of tea within the country.

These areca leaf sheath ply boards can find also many other applications particularly in packaging industry.

## ACKNOWLEDGEMENT

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**Table 4. Effect of extenders in UF resin on glue adhesion properties**

| *Sl. No.* | *Description* | *Dry Strength (kg)* | | | *Wet strength (CWR)(kg)* | | |
|---|---|---|---|---|---|---|---|
| | | *Range and (Mean)* | *Coeff. of variation* | *% glue failure* | *Range and (Mean)* | *Coeff. of variation* | *% glue failure* |
| 1. | Tamarind seed powder | 34—71<br>(53) | 15.0 | 10 | 3—22<br>(11) | 23.0 | 10 |
| 2. | De-oiled Sal meal (Extended 15% resin board) | 30—68<br>(54) | 16.0 | 10 | 4—19<br>(10) | 23.0 | 15 |
| 3. | Non extended UF resin board(control) | 37—105<br>(50) | 23.0 | 10 | 7—19<br>(14) | 21.0 | 15 |

### Table 5. Effect of type of wood used on glue adhesion properties

| | | Glue adhesion | | | Strength | | |
|---|---|---|---|---|---|---|---|
| | | *Dry/kg.* | | | *Wet (CWR) kg.* | | |
| *Sl. No.* | *Timber species used* | *Range and (Mean)* | *Coeff. of variation* | *% glue failure* | *Range and (Mean)* | *Coeff. of variation* | *% glue failure* |
| 1. | Vellapine<br>(*Veteria indica* L.) | 36—65<br>(52) | 21.0 | 15 | 6—16<br>(11) | 12.0 | 10 |
| 2. | Pali<br>(*Palaquium ellipticum*) | 41—63<br>(49) | 16.0 | 10 | 8—13<br>(11) | 12.0 | 15 |
| 3. | Mango<br>(*Mangifera indica* L.) | 35—62<br>(48) | 19.0 | 10 | 7—12<br>(9) | 14.0 | 20 |

Table 6. Comparative performance of areca sheath plyboard and commercially available tea-chest plywood.

| | | *Glue adhesion strength* | | *Wet (CWR) (kg)* | |
|---|---|---|---|---|---|
| *Sl. No.* | *Description* | *Dry (Kg) Range and Mean* | *% glue failure* | *Range and Mean* | *% glue failure* |
| 1. | Commercially available tea chest plywood | | | | |
| | Make I | 33—56<br>(52) | 90 | 1—6<br>(3) | 100 |
| | Make II | 58—77<br>(65) | 80 | Delaminated | |
| | Make III | 52—36<br>(99) | 15 | 3—5<br>(4) | 100 |
| | Make IV | 38—78<br>(59) | 85 | Delaminated | |
| 2. | Areca sheath board | 28—70<br>(51) | 15 | 8—25<br>(12) | 15 |
| 3. | ISI specifications for CWR grade plywood | 70 (Mean)<br>55 (Minimum individual) | | 35 (Mean)<br>30 (Minimum individual) | |

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# TRANSPARENT NATURAL RUBBER COMPOUNDS

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## ABSTRACT

**The paper reports the use of an indigenously available filler, Hydrated Alumina, for the production of transparent natural rubber compounds. Hydrated Alumina and imported fine particle Silica (HiSil 233) are compounded with natural rubber at 10, 20, 30, 40, 50 and 60 p.h.r. loadings and transparency and physical properties of the vulcanizates obtained are studied. Pale latex crepe normally used in transparent compounds is costly and hence use of ISNR-5 (Special) grade rubber in the production of transparent rubber compounds is evaluated by comparing transparency and vulcanizate properties of the compounds from PLC and ISNR-5 special. Formulations for some of the transparent natural rubber products like injection bottle cap which meets Indian Standard Specifications are also developed.**

## INTRODUCTION

Production of transparent rubber articles requires special attention in the choice and type of polymer and compounding ingredients. Among the various forms of natural rubber, pale latex crepe and sole crepe are generally used for this purpose. Fillers for transparent compounds should have index of refraction very close to that of the rubber matrix, as otherwise reflection and refraction of light by the filler particles shall cause opacity to the finished product. Accelerators, activators, anti-oxidants etc. used in rubber compounds also have marked influence on the transparency of the product. Zinc oxide, which is used as an activator in rubber compounds, is having very good covering power for light transmittance. Hence its use in transparent compounds was restricted to the bare minimum required for activation of the vulcanization reaction. Later works showed that addition of ammonium acetate in rubber compounds permitted the use of higher dosages of zinc oxide without affecting the transparency (Wolf and Shieber, 1960). Among the various inorganic fillers only basic magnesium carbonate and fine particle silica are used in transparent compounds. The improvement in properties of the rubber compound imparted by basic magnesium carbonate is lower compared with that of the fine particle silicas like Hi-Sil 233 or Hi-Sil 303 (Wolf, 1957).

In India mainly PLC IX is used in the production of transparent products like sport shoes, pharmaceutical items, tubings, pressure-sensitive adhesive tapes etc. Pale latex crepe is costly and its production is only about 1% of the total natural rubber produced in India (Rubber Statistical News, 1980). The introduction of modern methods of processing and technical specification for natural rubber enables the producers to process their crop into high quality raw materials required for the rubber industry. Among the different grades of Indian standard natural rubber (ISNR), ISNR 5 (Special) is the best quality with respect to the raw rubber properties and colour. ISNR 5 (Special) is less costly compared with PLC IX. Most of the fine particle silica used in transparent compounds are at present imported to this country. Hence in the present study, the performance of ISNR 5 (Special) and an indigenous filler, hydrated alumina, in the production of transparent compounds are evaluated in comparison with PLC IX and Hi–Sil 210 respectively.

## MATERIALS AND METHODS

### Selection of base formulation

For the comparative evaluation of transparency of ISNR 5 special and PLC IX compounds and that of the compounds with different loadings of hydrated alumina and Hi-Sil 210, the base formulations selected are given in Table 1. Formulation A is already reported to give best results for transparency by Ralph F. Wolf (1960). Since this formulation contained higher dosage of sulphur and MBTS, its use in pharmaceutical application may present problems. Hence formulation D which meets the requirements for transparent injection bottle caps as specified in IS 3692–1975 was also used for the evaluation. Formulation D was developed at RRII.

Table 1. Formulations tried for transparent compounds

| *Ingredients* | *A* | *D* |
|---|---|---|
| Natural rubber | 100 | 100 |
| Stearic acid | 1.0 | .. |
| Zinc oxide | 2.5 | .. |
| Ammonium acetate | 2.0 | .. |
| Zinc stearate | .. | 3.5 |
| Antioxidant SP | 1.0 | 1.0 |
| Ethylene glycol | 2.0 | 2.0 |
| Sulphur | 2.5 | 0.8 |
| ZDC | 0.25 | 0.75 |
| MBTS | 1.0 | .. |
| TMT | .. | .. |

## Raw materials for the study

PLC IX used for the study was collected from the estates of M/s. Midland Rubber and Produce Company Ltd., Alleppey and ISNR 5 (Special) from the Pilot Crumb Rubber Factory of the Rubber Board. Hydrated alumina was supplied by M/s. Marathwada Chemical Industries Pvt. Ltd., Poona and Hi-Sil 210 (Hydrated amorphous silica) by M/s. PPG Industries Inc., Chemicals Division, U.S.A.

## Experimental Procedure

For the comparison of transparency of compounds from ISNR and PLC, these were compounded as per the formulations A and D given in table 1. The compounds were then vulcanized at 150°C for the respective cure times and sample sheets of 175 X 125 X 2mm size were prepared by compression moulding. The transparency of the sheets were then evaluated. Hydrated alumina and Hi-Sil 210 were loaded at 15, 30 and 45 p.h.r. in ISNR and PLC compounds having the basic recipes A and D. These compounds were vulcanized at 150°C for the respective cure times and transparency compared. Before compounding, the fillers were incorporated in ISNR and PLC at the respective dosages and kept for one day. The compounds prepared were remilled before they were moulded. These operations were found to be helpful in enhancing the transparency of the compounds. The tensile properties of the compounds prepared were also evaluated and the results are given in tables 1 and 2.

**Table 2. Tensile Properties of Transparent Compounds**

(Formulation A)

| *Property* | *Hydrated Alumina Phr* | | | | *Hi-Sil* 210 *Loadings Phr* | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 15 | 30 | 45 | 0 | 15 | 30 | 45 |
| Modulus at 300% (Kg/Cm$^2$) | | | | | | | | |
| ISNR | 25 | 28 | 38 | 43 | 25 | 33 | 42 | 54 |
| PLC | 23 | 28 | 34 | 38 | 23 | 30 | 44 | 50 |
| Elongation at Break (%) | | | | | | | | |
| ISNR | 825 | 830 | 789 | 757 | 825 | 824 | 826 | 786 |
| PLC | 824 | 818 | 817 | 797 | 824 | 875 | 792 | 785 |
| Tensile strength (Kg/Cm$^2$) | | | | | | | | |
| ISNR | 157 | 211 | 249 | 224 | 157 | 211 | 258 | 257 |
| PLC | 186 | 209 | 237 | 234 | 186 | 218 | 250 | 241 |

## Evaluation of transparency

The transparency of the vulcanized sheets was evaluated by visual comparison and by photographic methods. In the photographic method, the clarity of a strip of black paper placed under the sheets is compared by taking photographs of the sheets with the black strip underneath. Visual comparison of transparency of the sheets was made by holding the sheets against clear light and observing the clarity of the sheets. In most cases good agreement was obtained between the two methods of assessment of transparency.

**Table 3. Tensile Properties of Transparent Compound (Formulation D)**

| *Property* | *Hydrated Alumina Loadings Phr* | | | | *Hi-Sil* 210 *Loadings Phr* | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 15 | 30 | 45 | 0 | 15 | 30 | 45 |
| Modulus at 300% (Kg/Cm$^2$) | | | | | | | | |
| ISNR | 7 | 10 | 10 | 13 | 7 | 9 | 15 | 18 |
| PLC | 8 | 7 | 11 | 10 | 8 | 8 | 11 | 16 |
| Elongation at Break(%) | | | | | | | | |
| ISNR | 1056 | .. | 984 | 909 | 1056 | 1016 | 919 | 786 |
| PLC | 1054 | 1012 | 904 | 827 | 1054 | 1032 | 933 | 856 |
| Tensile strength (KG/Cm$^2$) | | | | | | | | |
| ISNR | 60 | 88 | 99 | 98 | 60 | 99 | 113 | 92 |
| PLC | 71 | 80 | 98 | 79 | 71 | 100 | 93 | 92 |

## RESULTS AND DISCUSSION

Comparative evaluation of the transparency of compounds based on formulations A and D revealed that formulation D gives better transparency both in ISNR 5 special and PLC IX compounds. Transparency of vulcanizates from ISNR 5 special using formulations A and D was found to be comparable to that of the respective vulcanizates from PLC IX. In both ISNR and PLC compounds based on formulation D, hydrated alumina gave better transparency than the corresponding Hi-Sil 210 compounds. For hydrated alumina, 30 phr loading was found to give maximum transparency where as maximum transparency for Hi-Sil 210 compounds was noticed at 45 phr loadings. In formulation 'A' hydrated alumina produced transparency comparable to that of Hi-Sil 210 at equal loadings both in ISNR 5 special and PLC based compounds.

Evaluation of the tensile properties of the compounds from hydrated alumina and Hi-Sil 210 showed that higher modulus (300%) values were obtained for the Hi-Sil 210 compounds in all the above trials. The modulus values of the ISNR compounds were slightly better than those of the PLC compounds. In both the formulations A and D, the tensile strength of Hi-Sil 210 compounds were slightly better than that of the hydrated alumina compounds. In formulation A, ISNR gave slightly better tensile strength and in formulation D, it was comparable with that of the PLC compounds.

In the production of transparent articles, ISNR 5 special was found comparable to PLC IX. The properties of ISNR compounds were also comparable to those of the PLC IX compounds. Hydrated alumina was found to give better transparency than Hi-Sil 210 in natural rubber compounds. The tensile properties of the hydrated alumina compounds were slightly inferior to those of the Hi-Sil 210 compounds.

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# EVALUATION OF WEATHER DATA FOR DRYING AND STORAGE OF COPRA

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## ABSTRACT

**Weather data such as mean daily temperature, relative humidity, wind velocity, sunshine hours and rainfall per meteorological week at Kasaragod (HT MSL - 10.7 m 12 .30'N Latitude and 75°E Longtiude) were evaluated for predicting suitable drying period and safe storage period. Equilibrium moisture content of copra at all meteorological weeks was determined. The time required for drying was calculated per week from the energy associated with ambient air. The copra can be dried from 40th week to 20th week within 8 days. Drying can be achieved within 6 days if dried during 13th to 19th week. Drying can be achieved even during 40th to 48th week and 21st to 22nd week if solar cabinet drier is used, because during this period precipitation over 25 mm/week is expected. During the predicted suitable drying period solar radiation available is in the order of 5000 k Cal/m /day and hence drying process can be accelerated by trapping this energy by use of solar drier. Copra can be stored safely in well ventilated storage structures except in 25th to 39th week, relative humidity being below 80%. If proper ventilation is not maintained it may deteriorate even from 22nd week. From 22nd to 41st week the relative humidity ranges between 80–90% and equilibrium moisture content of copra above 4% which attracts fungus *Penicillium frequentas.* To avoid this, supplemental heat aeration (5°C above ambient) or use of industrial dessicants may be practised in storage structure.**

## INTRODUCTION

Copra is the dried kernel of coconut. Good quality copra shall has a moisture content of around 6%. The initial moisture content of kernel being 45–50% (w.b.), sundrying is usually practised and mechanical drying is opted only when indispensible. The time required for sundrying mainly depends on ambient air conditions. It takes about 5–7 days if drying is carried out on bright sunny days. If drying is slow as in humid weather the spoilage by microbial infection is more pronounced. If after cutting open the nut, the drying is delayed, even by few hours spoilage sets in affecting the quality of oil (Grimwood, 1974).

India produces about 5800 million nuts per year and copra production is about 327000 tonnes (Nair and Mathan, 1971). The energy needed for preparing the above quantity of copra would be about 176580 x $10^6$KCal. Fortunately, being in tropics there is plentiful supply of solar energy by diffusion as well as radiation. So it is upto processors to use the naturally available energy to the fullest extent.

Coconut kernel is an excellent substrate for the growth of fungi and bacteria. The infestation can occur at all levels of moisture content, unless proper preventive measures are not adopted. Copra was observed to be infested even at 4 percent moisture content when humid condition above 85% relative humidity prevail (Henderson, 1952).

This shows that both the drying and storage of copra are closely related to ambient conditions. Knowledge of prevailing ambient conditions at any given time of the year will enable to pre assess the moisture content upto which copra can be dried, the time required for drying and the extent of supplimental aeration needed for safe storage. Such information will help in appropriate drying and storage systems, design and planning.

## MATERIAL AND METHODS

Weather data for 11 years (1969–1979) viz. temperature, relative humidity, wind velocity, sunshine hours and rainfall were collected from the agricultural meteorological observatory at CPCRI Kasaragod situated 10.7 m above mean sea level, 12.5°N latitude and 75°E longitude. The average values of all these parameters over 11 years were calculated for every meterological work. The material constants C and N in Henderson's Equation (Equation No. 1) for equilibrium moisture curve were calculated from the data after Brustillos and Banzon (1949) (Table 1).

$$1 - RH = C - CTMe^{n} \quad - (1)$$

where,

RH = relative humidity indecinal

Me = equilibrium moisture content percent, dry basis

T = absolute temperature in °K, C and N are material constants

**Table 1. Equilibrium Moisture Content of Copra at Room Temperature (30° + 3.5°C) (After Brustillos and Banzon, 1949).**

| RH | EMC |
|---|---|
| 10 | 0.32 |
| 20 | 0.65 |
| 25 | 0.80 |
| 30 | 0.96 |
| 35 | 1.10 |
| 40 | 1.30 |
| 45 | 1.55 |
| 50 | 1.80 |
| 55 | 2.05 |
| 60 | 2.31 |
| 65 | 2.61 |
| 70 | 2.96 |
| 75 | 3.32 |
| 80 | 3.73 |
| 85 | 4.30 |

| | |
|---|---|
| Values of C and N for Copra | $C = 1.22 \times 10^{-3}$<br>$N = 1.10$ |

Equilibrium moisture content values of copra for every met week were calculated from mean temperature and relative humidity values by equation 1. The drying day degree were calculated equal to wet bulb depression at known mean temperature and relative humidity values (Perry, 1950). The energy available with ambient air which could be used for drying at 100% efficiency was calculated by following equation.

$$E = S.W.Cp.\ Q.DD \quad \text{—(2)}$$

where

E = energy in $KCal/m^2/day$

S = no. of sunshine hrs. per day

W = wind velocity in m/hr

Cp = Specific heat of ambient air

Q = density of air from humid volume at corresponding mean temperature

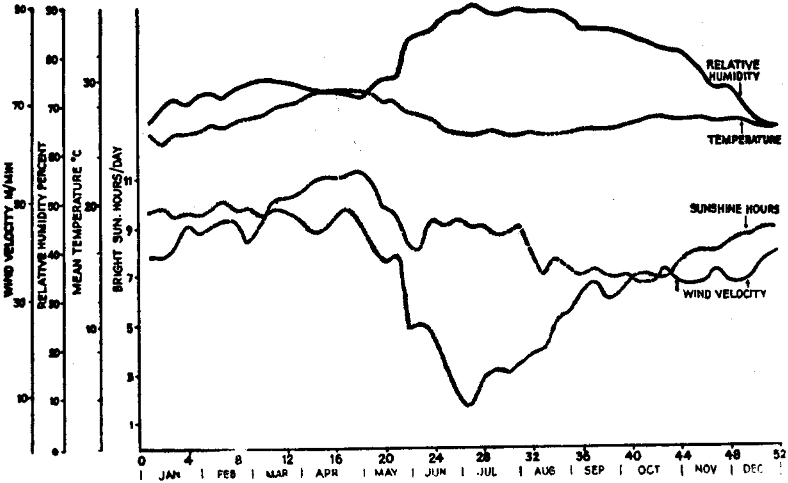
DD = No. of drying day degree/day

The copra is generally spread in a single layer at about 70–80 cups/$m^2$ yielding about 6 kg of copra. The moisture thus to be removed will be 6 x 0.9 = 5.4 kg. Considering energy required for vapourization as 600 KCal/kg of water, the total energy required for drying will be 600 x 3.4 = 3240 KCal. The time required for drying was calculated by assuming the heat utilization efficiency of natural drying at 1.75%. The energy available from solar radiation which was calculated from the average global radiation at Kasaragod which is in the order of 570 KCal/$m^2$/day.

## RESULTS AND DISCUSSION

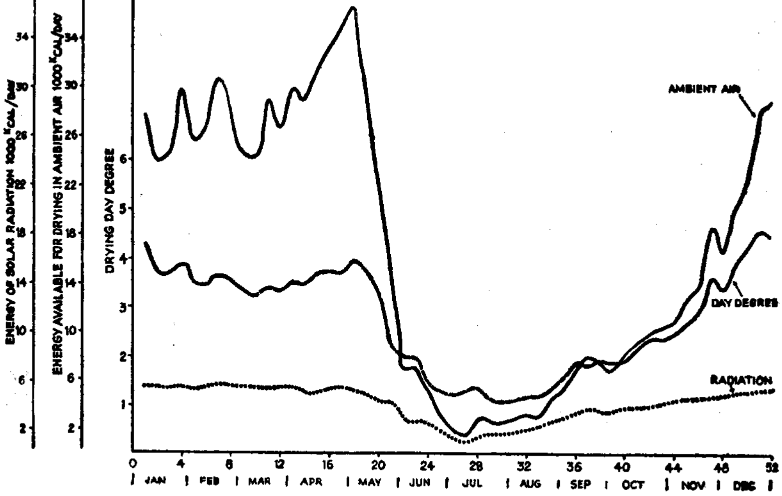
Fig. 1 shows the variation of mean temperature, relative humidity wind velocity and sunshine hours at different meteorological weeks. Fig. 2 shows variation of drying day degrees per day and energy associated with ambient air/day for drying and energy available from solar radiation/day. Fig. 3 shows the variation in equilibrium moisture content of copra, number of days required for drying and rainfall/week. The best suited period for drying and safe storage period are also marked on Fig. 3. Every point on the graph is average of 11 years.

WEEKLY VARIATION OF MEAN AMBIENT TEMPERATURE, RELATIVE HUMIDITY, SUNSHINE HOURS AND WIND VELOSITY BASED ON DAILY MEANS OF 1969-'79

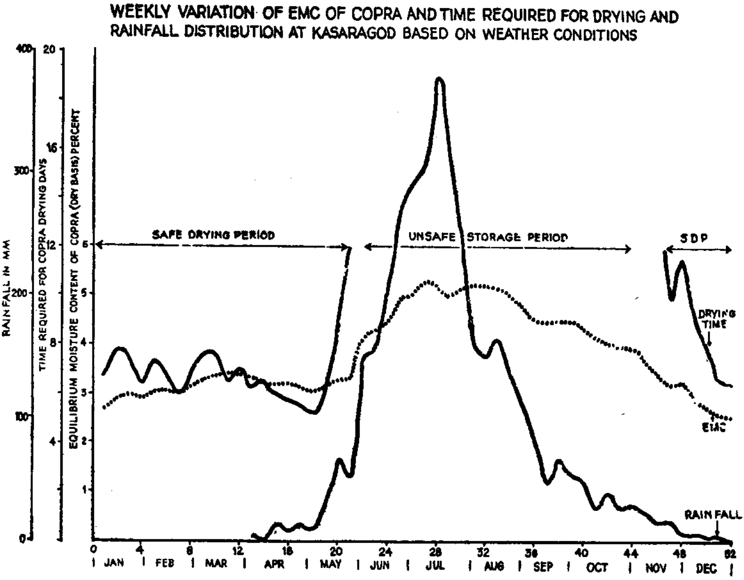


(Figure 1)

WEEKLY VARIATION OF DRYING DAY DEGREES/DAY, ENERGY FOR DRYING, WITH AMBIENT AIR, AND ENERGY AVAILABLE FROM SOLAR RADIATION AT KASARAGOD



(Figure 2)



(Figure 3)

## Variation of weather parameters with line

*Temperature*: The mean temperature was obtained by the average of daily maximum and minimum temperature. The higher values above 28°C occur during 14th to 22nd week (April and May) and lower values of about 26°C prevail during 27th to 35th week (July, August). The average daily temperature over 52 weeks is 26.6°C. Drying under these conditions, being low temperature will not have any adverse effect on quality of copra.

*Relative humidity:* The higher values above 85% occur during 23rd to 29th week (June to September) and lower values below 70% occur during 49th to 5th week (December to January). The average relative humidity for 52 weeks is 78%.

December and January having relative humidity below 70% are most suited for hot air drying from drying efficiency point of view.

*Wind Velocity:* The higher values above 50 m/min occur from 13th to 19th week (last week of March to first week of May) which directly helps in quicker drying. The lower values below 35 m/min are observed during 40th to 50th week (October, November and first fortnight of December). The average wind velocity is 41m/min are observed during 40th to 50th week. The wind velocity throughout the year is well above the required value in thin layer drying.

*Sunshine hours:* The bright sunshine hours above 9.5 occur during 1st to 11th week (January to mid March) and sunshine hours less than 3.5 occur from 25th to 31st (from second week of June and July). The no. of sunshine hours are lower during cloudy weather in rainy months which reduces the availability of energy from solar radiation. The average sunshine hours per day at Kasaragod are 7.2 hr/day.

*Rainfall:* From 22nd to 35th week (last week of May to August) this place receives rainfall above 100 mm/week. It results in increase in vapour content of the air, hence reduction in drying ability of the ambient air. Clear dry weeks are 1st to 9th (January-February). Peak rainfall is in 24th week (second week of June). Rainfall above 25 mm/week is also received during 19th to 22nd week and 36th to 44th week (May, September and October).

## Equilibrium Moisture content of copra

The material constant C and N for copra are $1.22 \times 10^{-3}$ and 1.10 respectively. The equilibrium moisture content values calculated by putting the values of C, N, T and RH in equation 1 remained below 6% throughout the year. This indicates the possibility of drying copra upto desired level even only by aeration. It also indicates the moisture level which well dried copra would attain if stored for long duration. The average value of equilibrium moisture content is 3.8%. This value is observed to be increased beyond 4% mainly due to the effect of relative humidity of the ambient air, i.e. when the relative humidity is above 80% in 23rd to 44th week (June to October).

## Energy associated with ambient air for drying

The higher energy values of above 30,000 Kcal/m$^2$/day occur during 13th to 19th week (first week of March, April and first week of May) resulting in the drying of copra within 6 days. The lower energy values occur during 27th to 44th (July to October) i.e. more than 20 days for drying. The energy associated with ambient air is function of five factors given in equation no. 2. Out of them wind velocity, drying day degrees and no. of sunshine hours are most prominent factors. More energy available during 11th to 19th week (March second week to first week of May) is due to higher wind velocity and no. of sunshine hrs and energy during 49th to 5th week (December and January) is the function of higher drying day degrees and no. of sunshine hours.

## Energy available from solar radiation

About 8 months, there is plentiful supply of solar radiation. The energy available is above 4000 Kcal/m$^2$/day from 40th to 21st week (October to third week of May). This helps in quickening the drying process along with the energy associated with ambient air for drying. This is function of no. of bright sunshine hours per day and offers the scope for the use of solar driers. The lower value of solar radiation occur during 23rd to 35th week (June to August). Average solar radiation for 52 weeks is about 4100 Kcal/m$^2$/day.

## Effect of weather on drying of copra

The peak harvest season of coconut which comes in March offers advantage in use of most effective time for drying in the year i.e. 13th to 19th week (last week of March to first week of May). The time required for drying is only 6 days to obtain good quality copra, as shorter the drying period results in better quality copra. The drying should not be practised from June to September because of heavy rainfall and high humidity in the air. Artificial drying during the period also will not be much economical due to less moisture carrying capacity of the air. Suitable drying period for copra under the sun is from 49th to 20th week (December to second week of May) where copra can be dried within 9 days. Bright sunshine hours and wind velocity which are conducive to drying are observed to increase from December to May. During December and January drying is quicker due to higher day degrees i.e. above 4. This period is also best suited for mechanical drying due to lower relative humidity of ambient air (about 70%). Quiker drying is also achieved during 13th to 19th week due to higher value of wind velocity i.e. above 55 m/min. The drying time of about 18 to 20 days is required during 40th to 48th and 21st and 22nd week (October, November and Second fort night of May) which can be reduced to 10 to 12 days by utilizing radient energy with the help of solar drier. During this period light showers are also received which makes sundrying without solar drier little risky. Solar driers used for drying copra in combination to open drying throughout the suitable period (October to May) will help in quicker drying of copra.

**Table 2. Weather Data at Kasaragod**

(average of 11 years)

| *Met week* | *Mean Temp.%°C* | *Relative humidity%* | *Sunshine hours* | *Wind velocity m/min* | *Rainfall mm/week* |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 5 |
| 1 | 25.7 | 66 | 9.6 | 38.5 | — |
| 2 | 24.5 | 69 | 9.8 | 38.3 | — |
| 3 | 25.5 | 71 | 9.4 | 40 | — |
| 4 | 25.7 | 69 | 9.6 | 45 | — |
| 5 | 25.7 | 72 | 9.5 | 43.3 | — |
| 6 | 26.3 | 72 | 9.7 | 45 | — |
| 7 | 26.1 | 71 | 10.1 | 46.7 | — |
| 8 | 16.5 | 73 | 9.7 | 47.7 | — |
| 9 | 26.8 | 74 | 9.8 | 41.7 | — |
| 10 | 27.0 | 75 | 9.4 | 45 | 1.25 |
| 11 | 2.6 | 75 | 9.7 | 50 | — |
| 12 | 27.9 | 75 | 9.6 | 48.3 | 0.3 |
| 13 | 28.1 | 74 | 9.4 | 51.7 | 4.6 |
| 14 | 28.7 | 73 | 8.8 | 53.3 | 0.22 |
| 15 | 28.9 | 73 | 8.8 | 55 | 13.6 |
| 16 | 28.9 | 73 | 9.3 | 55 | 7.9 |
| 17 | 29.1 | 72 | 9.7 | 55 | 13.5 |
| 18 | 29.0 | 71 | 9.2 | 56.7 | 8.9 |
| 19 | 28.9 | 73 | 8.5 | 55 | 31.3 |

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
| 20 | 28.2 | 75 | 7.5 | 48.3 | 66 |
| 21 | 28.2 | 75 | 7.9 | 48.3 | 50 |
| 22 | 27.2 | 83 | 4.8 | 41.7 | 151.1 |
| 23 | 27.0 | 84 | 5.1 | 40.0 | 156.7 |
| 24 | 26.6 | 85 | 4.8 | 46.7 | 201.2 |
| 25 | 25.8 | 88 | 3.5 | 45.0 | 274.3 |
| 26 | 25.7 | 88 | 2.2 | 46.7 | 232.9 |
| 27 | 25.4 | 90 | 1.6 | 45.0 | 305.9 |
| 28 | 25.5 | 89 | 2.9 | 45 | 380 |
| 29 | 25.8 | 88 | 3.3 | 34.3 | 255.3 |
| 30 | 25.3 | 89 | 3.0 | 43.3 | 253.3 |
| 31 | 25.5 | 89 | 3.3 | 45.5 | 156.4 |
| 32 | 25.6 | 89 | 3.9 | 40 | 150.6 |
| 33 | 25.4 | 89 | 4.0 | 35 | 166.7 |
| 34 | 25.5 | 89 | 5.2 | 38.3 | 137.8 |
| 35 | 25.5 | 87 | 5.5 | 36.7 | 11.34 |
| 36 | 25.9 | 85 | 6.2 | 35 | 86.1 |
| 37 | 26 | 85 | 6.8 | 36 | 46.1 |
| 38 | 25.9 | 85 | 6.0 | 35 | 68.6 |
| 39 | 26.2 | 85 | 6.1 | 35 | 55.8 |
| 40 | 26.3 | 84 | 6.8 | 33.3 | 27.7 |
| 41 | 26.5 | 83 | 7.1 | 33.3 | 38.9 |
| 42 | 26.8 | 82 | 6.9 | 36.7 | 29.3 |
| 43 | 26.7 | 81 | 6.9 | 33.3 | 32.4 |
| 44 | 26.6 | 81 | 7.6 | 33.3 | 24.9 |
| 45 | 26.7 | 70 | 7.9 | 33.3 | 16.5 |
| 46 | 26.9 | 76 | 8.1 | 36.7 | 18.2 |
| 47 | 26.6 | 73 | 8.0 | 33.3 | 7.85 |
| 48 | 26.5 | 74 | 8.3 | 33.3 | 7.85 |
| 49 | 26.7 | 70 | 8.7 | 33.3 | 7.04 |
| 50 | 26.4 | 68 | 8.7 | 35.0 | 5.12 |
| 51 | 26.2 | 65 | 9.1 | 38.3 | 3.63 |
| 52 | 26.1 | 65 | 9.0 | 40.0 | 0.63 |
| Average | 26.6 | 78 | 7.2 | 41 | 69.49 |

## Table 3. Evaluation of Weather Parameters

| *Met week* | *Drying day degrees* | *Energy associated with and air KCal/day* | *Solar radiaion KCal/day* | *Equilibrium moisture content% of copra* | *No. of days required for drying* |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | 4.3 | 28000 | 5500 | 2.68 | 6.6 |
| 2 | 3.7 | 24000 | 5600 | 2.90 | 7.8 |
| 3 | 3.7 | 24000 | 5400 | 3.04 | 7.6 |
| 4 | 3.9 | 30000 | 5500 | 2.89 | 6.3 |
| 5 | 3.5 | 25000 | 54000 | 3.12 | 7.3 |
| 6 | 3.5 | 27000 | 5500 | 3.11 | 6.9 |
| 7 | 3.7 | 31000 | 5800 | 3.03 | 6.0 |
| 8 | 3.5 | 28000 | 5500 | 3.19 | 6.6 |
| 9 | 3.4 | 25000 | 5600 | 3.27 | 7.6 |
| 10 | 3.2 | 24000 | 5400 | 3.36 | 7.7 |
| 11 | 3.4 | 29000 | 5500 | 3.35 | 6.5 |
| 12 | 3.3 | 37000 | 5500 | 3.35 | 6.9 |
| 14 | 3.5 | 29000 | 5000 | 3.17 | 6.5 |
| 15 | 3.7 | 31000 | 5000 | 3.17 | 5.9 |
| 16 | 3.7 | 33000 | 5300 | 3.17 | 5.6 |
| 17 | 3.7 | 34000 | 5500 | 3.08 | 5.4 |
| 18 | 4.0 | 36000 | 5300 | 3.00 | 5.1 |
| 19 | 3.7 | 30000 | 4900 | 3.17 | 6.1 |
| 20 | 3.4 | 22000 | 4300 | 3.26 | 8.6 |
| 21 | 2.2 | 15000 | 4500 | 3.26 | 12.6 |
| 22 | 2.0 | 7000 | 2700 | 41.9 | 26 |
| 23 | 2.0 | 7000 | 2900 | 4.32 | 25.5 |
| 24 | 1.4 | 6000 | 2700 | 4.47 | 33.3 |
| 25 | 1.3 | 4000 | 2000 | 4.96 | 51 |
| 26 | 1.2 | 2000 | 1300 | 4.96 | 35 |
| 27 | 1.3 | 2000 | 9000 | 5.35 | 120 |
| 28 | 1.4 | 3000 | 1700 | 5.15 | 62 |
| 29 | 1.1 | 3000 | 1900 | 4.96 | 66 |
| 30 | 1.1 | 3000 | 1700 | 5.15 | 75 |

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
| 31 | 1.1 | 3000 | 1900 | 5.15 | 64 |
| 32 | 1.2 | 3000 | 2200 | 5.15 | 56 |
| 33 | 1.2 | 3000 | 2200 | 5.15 | 62 |
| 34 | 1.3 | 5000 | 1000 | 4.79 | 35 |
| 35 | 1.5 | 5000 | 3310 | 4.79 | 45 |
| 36 | 1.9 | 7000 | 3500 | 4.48 | 25 |
| 37 | 1.8 | 8000 | 3900 | 4.48 | 23 |
| 38 | 1.9 | 7000 | 3500 | 4.48 | 26 |
| 39 | 1.8 | 7000 | 3900 | 4.47 | 27 |
| 40 | 1.9 | 8000 | 3000 | 4.33 | 23 |
| 41 | 2.1 | 9000 | 4000 | 4.20 | 21 |
| 42 | 2.4 | 10000 | 4400 | 4.07 | 19 |
| 43 | 2.3 | 10000 | 4000 | 3.96 | 18 |
| 44 | 2.4 | 11000 | 4300 | 30.9 | 17 |
| 45 | 2.7 | 13000 | 4500 | 3.74 | 14.6 |
| 46 | 2.9 | 15000 | 4600 | 3.95 | 13 |
| 47 | 3.6 | 19000 | 4600 | 3.19 | 9.9 |
| 48 | 3.3 | 16000 | 4700 | 3.27 | 11.5 |
| 49 | 3.9 | 20000 | 5000 | 2.95 | 9.3 |
| 50 | 4.2 | 29000 | 5000 | 2.81 | 8.2 |
| 51 | 4.6 | 28000 | 9200 | 2.61 | 6.6 |
| 52 | 4.5 | 28000 | 5100 | 2.61 | 6.5 |
| Average | 2.73 | 17000 | 4100 | 3.8 | |

## Effect of weather on storage of copra

Copra can be stored well except from 22nd to 44th week (last week of May to October), the relative humidity during this period being above 80%. The storage can be safe during October if structure is well ventilated. But in well ventialted structures also copra can not be stored during 23rd to 39th week (June to September) unless and otherwise some measures are adopted to reduce the relative humidity of the air inside the structure. The relative humidity above 85% during this period in combination with equilibrium moisture above 4% creates favourable condition for the infection by fungus *Penicillium frequentas*. This can be avoided by use of industrial dessicants or by frequent aeration with supplimental hot air in the storage structures.

## ACKNOWLEDGEMENT

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# ARECANUT LEAF SHEATH–RAW MATERIAL FOR PRODUCT DEVELOPMENT

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## ABSTRACT

**In India arecanut is grown in about 1,75,000 ha. Arecanut palms shed about 1000 million leaf sheaths every year. These are not put to any active economic uses now. They are used to small extent for making head caps for agricultural workers, containers for toddy, packing sheets for fish etc. and as an inferior fuel. However, they provide as much as about 120 million square metres of veneer like flats. Hence to see if economic uses could be developed for this material, its mechanical properties were studied. The length of sheaths measured 75–85 cm and breadth 15–40 cm. The thickness varied 3.0–8.5 mm at the centre and 1.0–2.0 mm at the edges. The sheaths exhibited much flexibility at a moisture content of about 75% which permitted it to be moulded to any form. At 15% moisture content, they absorbed 13–14% moisture in 24 hours at 38°C and 90% RH. The sheaths showed a moderate tensile strength of 195 kg/cm2 along the grain direction and 25 kg/cm2 across the grain direction. The bursting strength of the sheaths was about two–thirds of the strength of card board of 4 mm thickness.**

**The study of mechanical properties indicates that arecanut leaf sheaths can be used for making plyboards, tea-chests, packing cases, office bags, file boards, decorative veneer panels, throwaway cups and plates, etc. The significance of this material is discussed in the light of the relevant shortage of soft wood in India.**

## INTRODUCTION

Arecanut (*Areca catechu* L.) is grown in India in about 175000 ha. The arecanut palms shed about 1000 million leaf sheaths every year making available about 120 million square metres of total effective area of flat sheaths for possible economic utilisation. These are not put to any active economic uses now. They are now used to a small extent for making head caps for agricultural workers, containers for toddy, packing sheets for fish etc. and

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mostly as an inferior fuel. If we can develop an active economic use for arecanut leaf sheath it will help to supplement the arecanut grower's income. Studies on developing industrial uses for arecanut leaf sheath was initiated in 1975. First the mechanical properties of the sheath was taken up, with a view to exploring the probabilities of this product for putting it into various uses. The results are presented here.

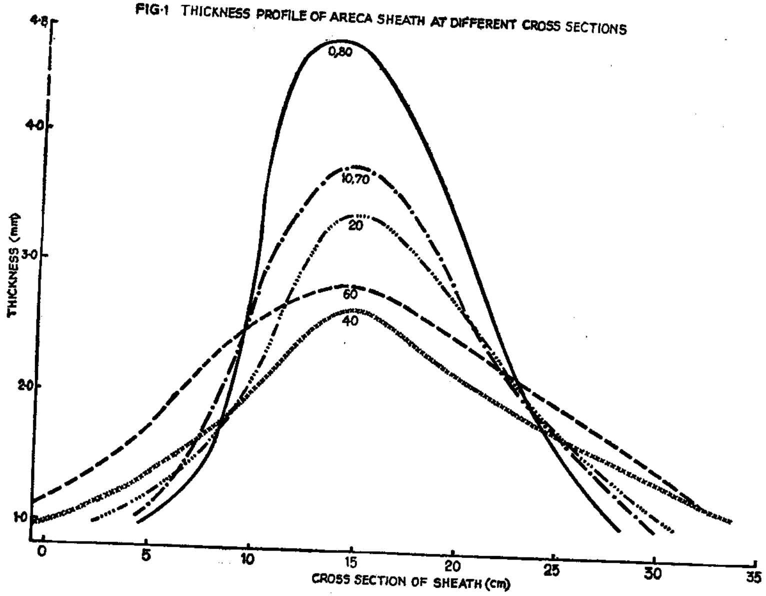
## Mechanical properties of the sheath

The sheath measures 75–85 cm long and 35–40 cm wide at the centre and 15–20 cm wide at the stalk end. The sheath of an adult palm shows a concavity, but this is less prominent in those of the younger palms. The sheath is heterogenous in structure, composition and even appearance and this creates problems as well as widens the scope for product development. The outer surface of the sheath is greenish or brown, waxy and tough while inner surface is creamy in colour and has a glossy membrane.

1. *Thickness:* The thickness is highly variable. The value at various cross sections of the sheath is given in Fig. 1. The sheath is thicker at the centre and it slopes down towards the two edges. The thickness at the centre ranges from 3.0–8.5 mm with an average of 5.0 mm. Towards the edges the sheath becomes thinner with an average thickness of 1.0 mm. Along the length alos, the thickness slopes down from the ends towards the middle portion of the sheaths. The thickness at the middle portion is 2.4–3.0 mm which is comparatively even. From these, it was assessed that 10 cm length from both the ends along the grain direction and 5 cm from the edges across the grain direction may have to be removed to obtain a comparatively homogenous piece of flat of size 60 cm x 20 cm for effective use.

2. *Weight:* The effective surface area of the sheath weighs about 200–250 gm at 12% moisture content.

3. *Moisture content:* The moisture content of a freshly fallen sheath is about 55–60%. The sheath dries down to 30–40% after drying under shade for 2 days. The moisture content is reduced to about 14% after drying under shade for 6–7 days.


FIG·1 THICKNESS PROFILE OF ARECA SHEATH AT DIFFERENT CROSS SECTIONS

(Figure 1)

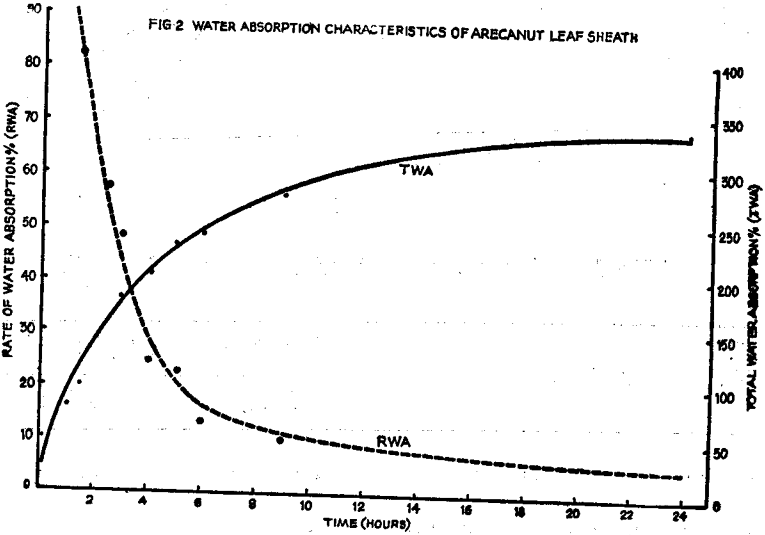
**Table 1. Moisture content of arecanut leaf sheath**

| *Sl. No.* | *Description* | *Moisture content % wet basis* | |
|---|---|---|---|
| | | *Range* | *Mean* |
| 1. | Freshly fallen sheath | 55.0—60.0 | 58.0 |
| 2. | Sheath after 2 days drying under shade | 30.0—40.0 | 37.2 |
| 3. | Sheath after 6–7 days drying under shade | 11.0—16.0 | 14.0 |

The moisture absorption of the sheath at 15% moisture content over a period of 24 hr at 38°C and 90% RH was 13–14%. For comparision, the moisture absorption of 2mm cardboard at

5% moisture content was 11%. The sheath provided enough flexibility above 75% moisture contents to permit it to be moulded to any form.

4. *Water absorption characteristics :* When soaked in water for 24hr, the moisture content of the sheath increased from 14% to 340% (Fig. 2). Of this, 23% was absorbed in the first hour, 17% in the second hour, 15% in the third hour, 9% in the fourth hour, 5% in the fifth hour and 3% in the sixth hour. At the same time the water absoprtion of 1mm thick card board was 169% after 24 hr from a moisture content of 7%. Two thirds of the water was absored in 1½ hours, and 80% of the water was abosrbed by the end of 2½ hours.



(Figure 2)

5. *Tensile strength*: Tensile strength of a material is the maximum resistance of the material when subjected to a stretching load without tearing.

The tensile strength of the sheath was studied in accordance with the IS Specifications for Methods of Test for Thermo-setting resin bonded laminated Sheets. The tensile strength of the sheath (Table 2) was 195 kg/cm$^2$ along the grain direction and injector temperature in fig. 10. It will be seen that all the points are more or less in a flat line. However, when the half height width × height is plotted instead of peak heights (fig. 11) the curve is linear only at 10° above and below 115°C. The values deviate much at 85°C and 145°C. The deviation became more when the acetone-benzene concentration was in the range of 1:3.

Fig.10 INJECTOR TEMPERATURE V/S RECIPROCAL DETECTOR RESPONSE (Height)

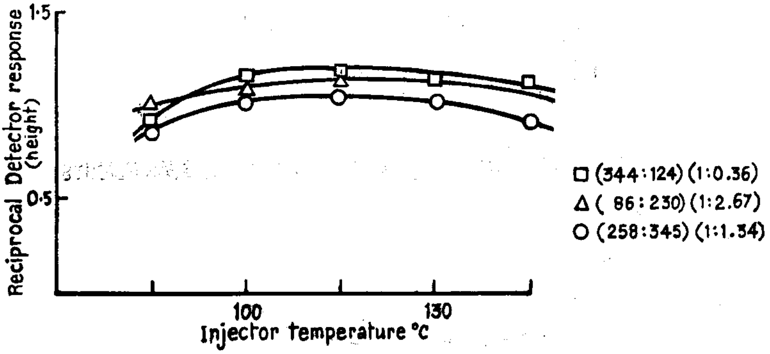
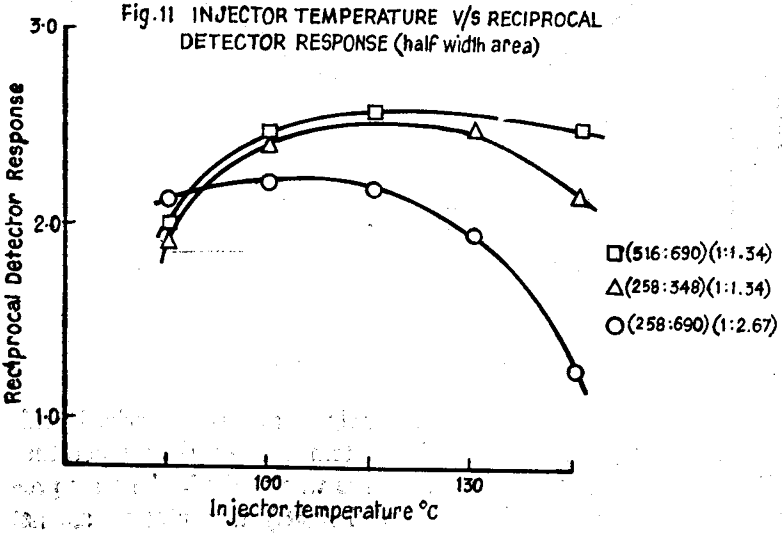


Fig.11 INJECTOR TEMPERATURE V/S RECIPROCAL DETECTOR RESPONSE (half width area)



It became clear from these studies that for more reproducible results the optimum injector temperature should be around 115°C. This temperature is close to the boiling point of toluene which is used as a solvent to dissolve acetone and benzene mixture. Although the toluene peak goes off the scale and apparently does not play any role in the estimations, it seems to be necessary that toluene should also be completely volatalised. Obviously the sensitivity and the reproducibility depended on the partial vapour pressures of all the components present in the system. The difference observed in the relative detector response values appeared to be correlated with the nonideality of the gas-liquid partition equilibria as the benzene standard contains only carbon and hydrogen, whereas acetone contains oxygen in addition. The preliminary results of experiments devised to study the use of compounds of similar chemical type, which elute close to the solvent estimated, as internal standard have revealed that methyl ethyl ketone could be advantageously used as an internal standard for the estimation of acetone.

## Estimation of solvent residues in spice oleoresins

During the course of estimation of residual acetone in turmeric oleoresin and dichloroethane in capsicum oleoresin, it was observed that the absolute area of the benzene standard peak, in general increased when the solvent peak was small. This will be seen from fig. 12 where the ppm of acetone present in turmeric oleoresin was plotted against benzene peak area corresponding to about 40 ppm. Similar results were observed with capsicum oleoresin when the ratio of solvent (dichloroethane) to standard (benzene) peak areas were plotted against benzene peak areas (fig 13). When DCE/benzene peak ratio becomes small the value of the benzene peak area is larger. This may be due to the fact that the other volatile ingredients present in the oleoresin contributed to the nonideality and affect the partial vapour pressures of acetone and benzene.

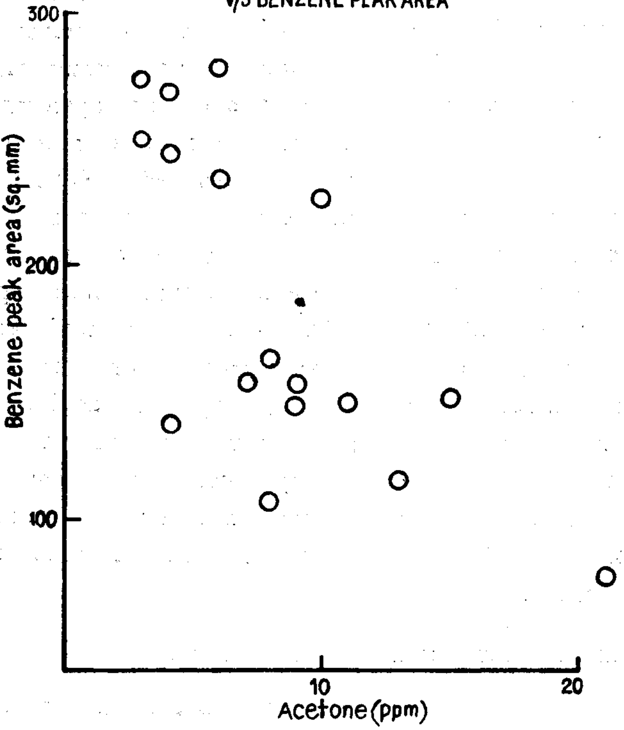
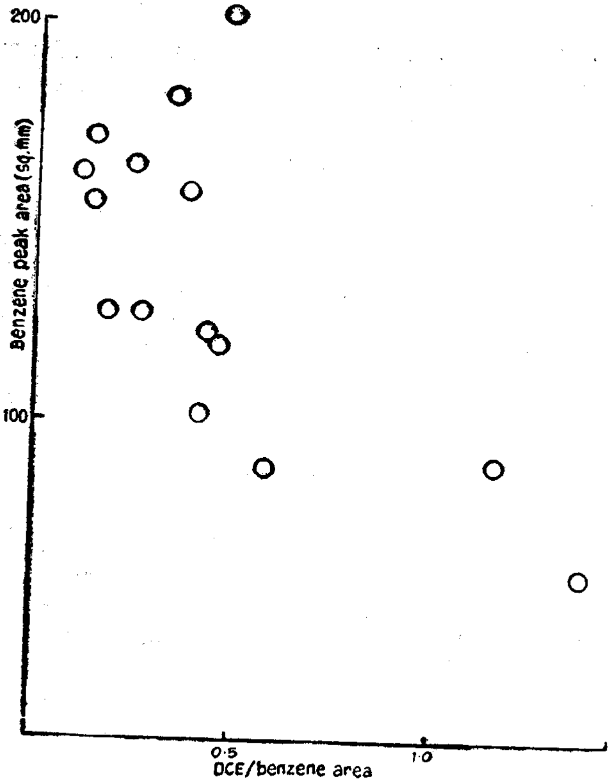


Fig.12 ACETONE IN TURMERIC OLEORESIN V/S BENZENE PEAK AREA

## Plate number

Assuming that the sensitivity of the detector may be related to the latent heat of vapourisation of the solvents, the plate numbers were calculated using the formula $16\left(\frac{x}{y}\right)^2$ where x is the height and y is the width of the peaks. A linear relationship of increase in the number of plates with increase of injector port temperature could not be obtained as was observed, using thermal conductivity detector (Pollard and Hardy, 1955). The plate number increased with increase of injector temperature only in a few cases and in majority of cases it reached a maximum at 115°C in these experiments.

Fig.13 DCE/BENZENE AREA V/S BENZENE AREA IN CAPSICUM OLEORESIN



## ACKNOWLEDGEMENT

The authors are thankful to Dr. V. Kalyanaraman for helpful suggestions.

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# MICROFLORA ASSOCIATED IN THE PROCESSED COCOA BEANS

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## ABSTRACT

**The quantitative and qualitative enumeration of microflora associated with the processed cocoa beans were investigated. Among the fungal flora (moulds) the species of *Aspergillus* and *Mucor* were predominant. More attention was given on moulds, since it is considered to tell upon the quality of cocoa beans, as it affects the flavour of the manufactured cocoa products. Further the infection of moulds on the butter fat content of the beans were studied. This suggests that, the packing and moisture content of the beans were important in the storage of the cocoa beans.**

## INTRODUCTION

Cocoa is being grown as one of the important plantation crops in our country. It is mainly grown as a mixed crop in coconut and arecanut gardens. The increase in area under cocoa cultivation has increased the production of cocoa in our country. Since the demand for the internal consumption of cocoa products is less, the surplus produce has to be exported. Some countries have adopted the Iternational Cocoa Standard which comprise the "Model ordience and code of practice" (Wood, 1979). Cocoa of marketable quality is required to be free from smoky beans. Further it is required to be reasonably free from living insects, broken beans and pieces of shell. In addition, cocoa is graded on the basis of limits to its content of particular defects viz. mouldy beans, slaty beans, germinated beans and flat beans. Mould has been described as worst defect of cocoa beans, as it affects the flavour. It is possible to detect the mould off-flavour in the samples with as little as 4 percent mouldy beans. The other effects of moulds are (i) It increases the free fatty acid content of the cocoa butter (Kavanagh *et al*, 1970; Guenot *et al*, 1977) (ii) The growth of some moulds may produce mycotoxins (Feuell, 1966). Moulds can develop in the beans during the process of fermentation or drying or during storage. Several types of moulds are reported in the processed cocoa beans by many workers (Broadbent, 1967; Broadbent and Oyeniran, 1967; and Oyeniran, 1972). Apart from mould, yeast, bacteria and actionomycetes were also reported in the beans (Lopez and Quesnel, 1973). In the present investigation, the authors report the presence of ectophytic and endophytic microorganisms associated with the processed cocoa beans.

## MATERIALS AND METHODS

Sample collection—The processed cocoa bean samples were collected from two places in Karnataka, namely (i) C.P.C.R.I. Vittal with improved method of processing. (ii) CAMPCO processing unit, Puttur. The two samples of processed beans collected from Kerala, represents Trichur Distirct, (C.P.C.R.I. Peechi), and Alleppey District. The samples were collected in Polythene bags and stored before use.

### pH and moisture content of the beans

Twenty g. of cocoa beans were taken and ground to powder using mortar and pestle and 50 ml. of hot water was added to it. The pH was then determined.

Ten g. of cocoa bean samples crushed roughly with the help of mortar and pestle were dried in an oven regulated at 103 ± 2°C for 16 hrs and percentage moisture was calculated. (Anon, 1967).

Smoke contamination—100 g of whole cocoa bean was soaked in 33 ml of ethyl alcohol (96 percent) for 5 minutes with constant agitation. Then the ethanol was poured out, filtered and the resulting yellow coloured compound was assessed both visually and spectrophotometrically. (Alvim, 1975).

### Ectophytic mycoflora

The fungi associated on the surface of processed cocoa beans were studied by blotter technique. For each sample 50 beans were placed on moist blotting paper kept in sterile petridishes. The plates were incubated at room temperature (32±2°C). The fungal growths on the bean surface were examined after 5 days.

The purified cultures were maintained on Potato Dextrose Agar (PDA) slants for identification. The percentage occurrence of mould was calculated.

### Endophytic micoflora

The studies on the presence of endophytic fungi were carried out by removing the testa of the beans after surface sterilization in 0.1% $HgCl_2$ solution for 3 minutes and washed 4 times in sterile water. Then each bean was cut longitudinally by using sterile scalpel into 2 halves and plated on Potato Dextrose Agar (PDA). The petridishes were incubated at room temperature (32 ±2°C). The observations on fungal growth were taken after 5 days. The purified cultures were maintained for identification.

### Quantitative microflora

### Beans surface washing method

Ten g. of cocoa beans were transferred to 250 ml. flask containing 100 ml. of sterile water and shaken for 10 minutes. The serial dilution plating method was followed for the enumeration of microflora. Nutrient Agar (NA) and NA + 15% been extract agar media were used for the bacterial flora estimation. The fungal propagules were estimated using Potato Dextrose Agar and PDA + 15% bean extract agar media. The plates were incubated under laboratory condition to count bacteria after 48 hrs. and fungi after 72 hrs. The frequently occurring bacteria and fungi were isolated for identification.

The surface washed beans were repeatedly passed through several changes of sterile water. Then the beans were placed on the petridish containing PDA medium to find out the mycelial form of fungi present on the surface of the beans.

### Bean maceration method

Ten g. of cocoa beans were macerated and dilution plating method was followed to count the microorganisms inhabiting on the surface and inside the beans. The method followed was same as explained for the surface washing.

## Qualitative microflora

The bacterial and fungal colonies were purified and transferred to slants for identification. The percentage occurrence of fungi were calculated. The fungal colonies were tentatively identified upto generic level. The bacterial colonies were subjected to morphological, physiological and biochemical tests to group them to genus level.

## The effect of mould infection on the butter fat content of beans

Three species of *Aspergillus* and a species of *Mucor* were inoculated separately into the cocoa beans by pin prick method. The beans were placed in petridish with moist blotting paper for 5 days. 3 g of powdered beans were used for the estimation of butter fat using solvent petroleum ether (40–60°C) in a soxhlet extraction apparatus for 10 hrs. The solvent was evaporated in an oven at 105°C and dried to constant weight. The increase in weight of the flask was the butter fat content of the beans. The cocoa bean with out mould infection was used as check.

## Results and Discussion

The data pertaining to the general analysis of the processed cocoa bean samples for pH, moisture content and smoke contamination are presented in Table 1. The pH of the cocoa bean samples varied between 4.9 and 5.7 and a pH increase was noted in the Vittal sample. The moisture content of the cocoa beans ranged from 5.4 percent to 6.8 percent. No smoke contamination was detected in the samples since the drying of beans was done in an electric oven/sun drying.

The moisture content of the beans and atmospheric humidity are important in the storage of the beans. The moisture content of the beans should be between 6 and 7 percent. When the moisture percent exceeded 8, the mould growth occurs on the beans (Wilbaux, 1965). The relative humidity during storage should not exceed 80 percent. Checking the humidity is essential not only at the port of embarkment but also when the beans are brought from the farmer or during storage.

Table 1. Description of four samples, determination of pH, moisture and Smoke contamination of Processed cocoa beans

| Sl. No. | Sample collected | Fermentation method | Drying method | pH | Moisture | Smoke contamination | |
|---|---|---|---|---|---|---|---|
| | | | | | | Visual | Spectrophotometer |
| 1 | CPCRI Vittal | Improved Box method with 2nd & 4th day turning "Maturation." in the 5th & 6th day of fermentation. | Electric Oven | 5.2—5.7 | 5.8 | + | 0.05 |
| 2 | CAMPCO Puttur | Box fermentation with 2nd & 4th day turning | Electric Oven | 4.9—5.2 | 5.4 | + | 0.06 |
| 3 | CPCRI Peechi | Heap method of fermentation, turning 2nd and 4th day | Electric Oven | 4.9—5.1 | 6.0 | + | 0.09 |
| 4 | Alleppey | Heap fermentation, turning 2nd and 4th day | Sun drying | 5.0 | 6.8 | + | 0.07 |

The analysis of the beans for the ectophytic mycoflora. The maximum mould growth was observed on the beans collected from Alleppey district (100 percent) and the least being in the samples collected from Puttur (6.67 percent). The mould growth in Peechi samples was 83 percent and that of Vittal was 24.39 percent. The mould growth observed on the surface of the beans are 5 species of *Aspergillus,* 2 species of *Mucor,* one species of *Rhizopus* and a few non sporulating fungi. The frequency of mould occurrence in four samples were calculated (Table 2). The *Aspergillus* sp. was observed in more number, followed by *Mucor* sp.

The occurrence of endophytic mycoflora is presented in Table 3. The bean samples collected from Puttur did not show the presence of fungi inside the beans whereas the other three samples indicated the presence of mould in the beans. The mould growth was observed more in the sample collected from Alleppy (36 percent).

In the Vittal sample the internal fungal growth observed was up to the extent of 12 percent. The mould growth inside the beans are tentatively identified as two species of *Aspergillus* and a species of *Mucor.* The percentage occurrence of mould indicated the presence of *Aspergillus* sp in more numbers followed by *Mucor* sp. Similar observation was reported by the earlier workers (Broadbent, 1968 and Oyeniran, 1972). The maximum mouldy beans allowed as per the cut test followed in the international market, is 3 percent for Grade I and 4 percent for Grade II. Twenty eight mould species have been isolated from the commercial cocoa in Nigeria (Broadbent, 1968 and Oyeniran, 1972). The growth of mould in cocoa beans produced mycotoxin (Feuell, 1966).

The dilution plating method for the quantitative enumeration of fungal and bacterial flora are presented in Table 4. The use of cocoa bean extract in the medium has no influence on the counts of fungi and bacteria. The surface washing and bean maceration method has decreased the total bacterial counts considerably in all the samples. Among the four samples used, the cocoa beans collected from Puttur showed least count both for fungi and bacteria.

25 kg/cm$^2$ across the grain direction. The tensile strength of the sheath across the grain direction was only one-eighth of the strength along the grain direction as the sheath fibres are oriented in one direction only. The capability of the material to retain its tensile strength after repeated wetting and drying is an interesting characteristic of the sheath which will help in wet moulding of the sheath.

**Table 2. Properties of Arecanut Leaf Sheath**

| *Sl. No.* | *Description* | | *Average strength* |
|---|---|---|---|
| **I.** | **Tensile Strength:** | | |
| 1. | Fresh sheath : | Along the grain | 195.0 kg/cm$^2$ |
| | | Across the grain | 25.0 kg/cm$^2$ |
| 2. | Sheaths after repeated wetting and drying: | | |
| | | Along the grain | 192.0 kg/cm$^2$ |
| | | Across the grain | 24.5 kg/cm$^2$ |
| 3. | 3–ply Areca sheath board. | | 220 kg/cm$^2$ |
| 4. | 3–plywood—4mm thick | | 500 kg/cm$^2$ |
| **II.** | **Bursting Strength :** | | |
| 1. | Arecanut leaf sheath | | 70.5 kg/cm$^2$ per cm thickness |
| 2. | Card board 4 mm thick | | 110.7 kg/cm$^2$ per cm thickness |

6. *Bursting strength* : The bursting strength of the sheath (Table 2) was determined in accordance with the IS Specifications for Methods of Test for paper and allied products. The bursting strength of the sheath was about 70.5 kg/cm$^2$ per cm thickness while that of cardboard of 4 mm thickness was 110.7 kg/cm2 per cm thickness.

**Vendible products that can be made out of arecanut leaf sheath:**

The results of the studies have given some ideas on the uses to which the sheath could be put to use. For most purposes the sheath is flattened under pressure of about 4 kg/cm$^2$ and temperature of 110°C in a hot press.

1. *Arecanut leaf sheath plyboards:*

The moderate tensile strength and the flat surface of the sheath make it a suitable material for plyboard manufacture. Since the sheaths are weak across the grain direction, they have to be strengthened by interposing one ply of wood veneer between two plies of sheaths and gluing them together to make 3-ply boards. Such boards may be used for making tea-chests for internal movement of tea and packing cases for shipping medicines, etc. The total production of plywood in India was about 40 million sq. metres in 1973. Of this, about one-third is used for tea-chests manufacture. And out of this 77% is produced by small scale and cottage industries. Even if arecanut leaf sheath boards are used to meet 50% of the tea-chest plywood requirements, they would save about 3 million square metres of plywood, resulting in a saving of about 12000 cubic metres of timber. This is considered to be a significant gain in view of the increasing scarcity of timber in India.

2. *File boards:* The moderate bursting strength of the sheath has been used with advantage for making file boards and brief cases. The file boards made by gluing together three layers of arecanut leaf sheath have been put to test use in the University of Kerala and the CPCRI and have bean found to give satisfactory results.

3. *Decorative veneer panels and picture mounts:*

Aesthetically attractive and imaginative novelties can be made from arecanut leaf sheaths taking advantge of the natural colour and grain variations of the surface. For this, the sheath surface, given a finish in the varnish or French polish, makes a beautiful picture mount or a decorative panel. The dark and white faces of the outer and inner surfaces of the sheath have been exploited to prepare decorative panels of wooden almirahs and teapoys.

4. *House chappals:*

The easy yielding or pliability of the sheath and its ability to absorb the moisture in the form of sweat suggest its usefulness as a cheap substitute for leather sole-tops in house chappals and cheap summer-wear chappals especially in the drier regions of India.

5. *Throw-away plates and cups:*

Throw-away plates and cups can be moulded from wet sheaths, then dried and used. Such plates and cups are already being produced in atleast two small-scale units in South Karnataka.

6. *Gin washers:*

Gin washers made out of arecanut leaf sheaths were used for making the cotton ginning rolls. But test trials showed that their performance was not satisfactory as they generated heat faster and produced higher trash in lint with slightly reduced yarn strength and lower production as compared to the chrome-leather gin washers used at present.

7. *Other uses:*

Brief cases, hand bags, spectacle cases, tea or coffee trays and many other products have been prepared out of arecanut leaf sheaths.

## Conclusion:

The foregoing studies have amply shown the good possibilities of utilising arecanut leaf sheaths for preparing economic products. The best possibilities have been opened up in the manufacture of areca plyboards for making tea-chests and other packing cases, decorative panels, file boards, suit cases and throw-away plates. Economic utilisation of the sheath will help the areca farmer to supplement his income by sale of areca leaf sheaths, increase rural employment, and most importantly, help save scarce timber resources of India.

## ACKNOWLEDGEMENTS

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# ARTIFICIAL DRYING OF CARDAMOM

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## ABSTRACT

**The dried green cardamom capsules of the plant *Elettaria cardamomum* Maton have a greater demand in West Asian market. India is the principal exporter of cardamom and earns more than 50 crores annually. The alleppey green cardamom accounts 90 to 95% of export and is preferred for its superior quality. The freshly picked capsules contain about 80% moisture and this has to be dried 8 to 9% for trade or for storing. Conventionally, green cardamom is produced in flue type driers. A forced hot air circulatd drier was found to give satisfactory results. Flushing of hot humid air, though slightly costlier, was found to result in better green colour. Based on these with other governing factors such as optimum temperature and bed thickness, a drier capable of drying 120 kg was fabricated and tested in field conditions.**

## INTRODUCTION

India produces approximately Rs. 80 crores worth of dried cardamom capsules. Bulk of this amounting to Rs. 50 crores is exported. In export market, the green colour of the dried capsule is very important. While in Indian market bleached cardamoms are common, West Asia market in particular prefer dried Alleppey green cardamoms. Sun drying which degrades the chlorophyll cannot be employed for green coloured products.

Freshly harvested capsules contain 80% moisture and this has to be dried to 8 to 9%. Conventionally green cardamom is produced in flue pipe drying rooms or "stoves" as they are known. Kerala State's almost the entire produce is converted into green cardamom.

In Karnataka, only in Coorg District green cardamom is mainly produced. There in addition to flue pipe drying chambers, electrically operated cross flow cabinet driers are also being used.

The paper describes the studies conducted in developing a through flow drier for the production of green cardamom.

## MATERIALS AND METHODS

The cardamom capsules used in experiments for cabinet drier carried out in Trivandrum were obtained from an estate in Nelliampathy. The studies to standardize bed thickness in a bin drier were done in Mysore and the capsules were procured from an estate in Mercara. For the preliminary studies with improved through flow drier were done in Trivandrum with cardamom obtained from an estate near Nagercoil and for the field studies at Myladumpara, the locally harvested capsules were used.

Moisture determination was as per Dean & Stark method (A.S.T.A. 1960). Alkali treatment was carried as per the method recommended by Natarajan *et al.* (1967).

## RESULTS AND DISCUSSION

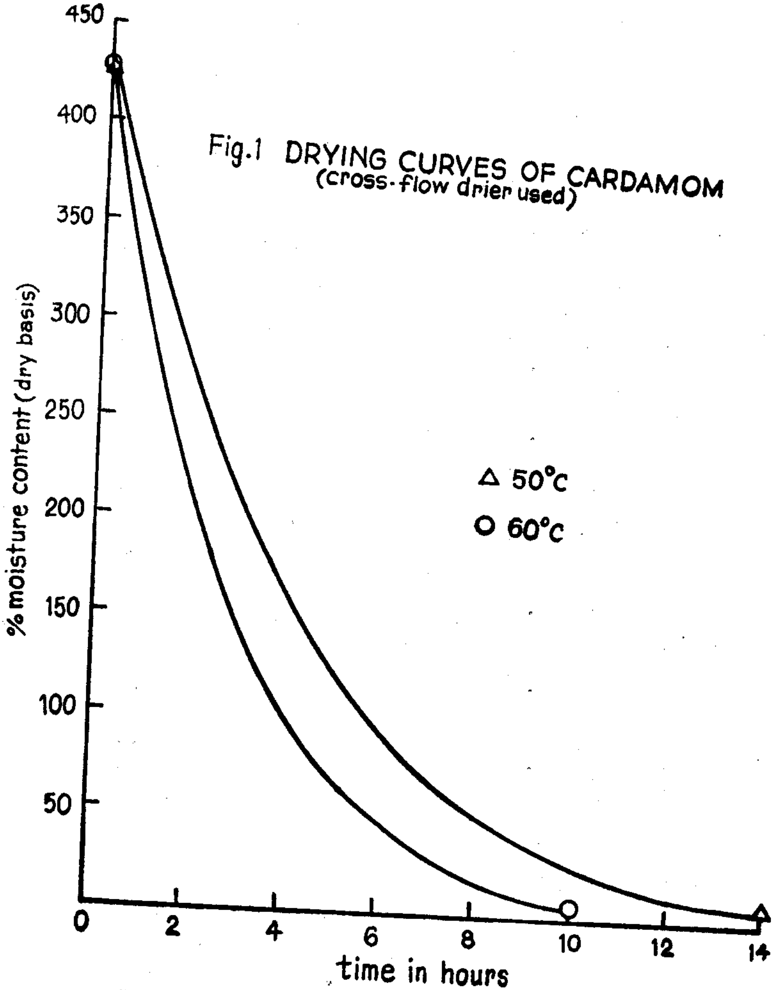
Initial drying trials were carried out with a cabinet drier. Trays of 82 x 41 cm size were loaded with 2.5 Kg of fresh capsules. Comparison of drying at 50°C and 60°C is presented in Table 1. The results confirmed that drying at 50°C give a slightly superior product as far as colour was concerned. At higher temperature, there is a tendency for the green colour to fade because of greater destruction of chlorophyll. However, the drying rate, as could be expected was higher at 60°C than at 50°C (Fig. 1). Drying time was about 10 hrs. in the case of 60°C and 14 hours in the case of 50°C. Alkali treated capsules gave a better green colour. It was also noticed that a more efficient drying was obtained when trays had a sieve bottom (Table 2). In trays without perforation in the bottom, drying took longer time and was nonuniform.

While surveying the drying chambers available, it has been observed that wherever good arrangement for flushing out the hot humid air was made, the resultant colour invariably was good. Thus, providing ventillators, or better still exhaust fans, gives a more satisfactory drying condition and therefore more resultant green colour while curing cardamom in a flue pipe 'stove.'

Table 1. Drying of fresh cardamom capsules in cross-flow drier

| *Temperature °C* | *Treatment* | *Initial weight (kg)* | *Loss of weight (kg) after drying for* | | | | | | | | *Moisture %* | | *Remarks on dried products* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | *1 hr* | *2 hr* | *3 hr.* | *4 hr.* | *6 hr.* | *10 hr.* | *12hr.* | *14hr.* | *Initial* | *Final* | |
| 50°C | Alkali treated | 2.5 | 0.37 | 0.66 | 1.05 | 1.26 | 1.63 | 1.89 | 1.95 | 1.96 | 81.0 | 8.0 | Very good green |
| | Control | 2.5 | 0.40 | 0.60 | 1.04 | 1.27 | 1.61 | 1.89 | 1.94 | 1.96 | 81.0 | 8.0 | slightly faded green |
| 60°C | Alkali | 2.5 | 0.60 | 1.15 | 1.31 | 1.72 | 1.88 | 1.99 | .. | .. | 81.0 | 6.0 | Good green |
| | Control | 2.5 | 0.58 | 1.00 | 1.36 | 1.63 | 1.84 | 2.00 | .. | .. | 81.0 | 6.0 | Slightly faded green |

Note : Fresh cardamom capsules were obtained from Nelliampathy during Aug. 1976.
Treatment : Steeping in 2% sodium carbonate solution for 10 minutes.



(Figure 1)

The possibility of using this advantage in a forced draught drier was attempted by using a through flow drier. It was generally noted that a good colour is obtained by using through flow as the hot air carrying the humidity from the capsules are not allowed to come in contact with the chlorophyll containing plant product and is flushed out.

**Table 2. Drying of Cardamom with cross-flow drier at 60°C**

| *Tray No.* | *Initial Wt.(Kg.)* | *Initial moisture contents %* | *% loss of moisture* | | | *Remarks* |
|---|---|---|---|---|---|---|
| | | | *1 hour* | *5½ hours* | *7½ hours* | |
| 1. | 1.0 | 84.0 | 28.0 | 78.0 | 79.0 | Drying was fairly uniform |
| 2. | 2.0 | 84.0 | 27.8 | 77.5 | 78.3 | –do– |
| 3. | 3.0 | 84.0 | 20.2 | 78.0 | 78.3 | –do– |
| 4. | 4.0 | 84.0 | 22.3 | 77.5 | 78.3 | –do– |
| 5. | 1.0 | 84.0 | 24.5 | 76.6 | 78.3 | –do– |
| 6. | 2.0 | 84.0 | 29.5 | 78.0 | 79.0 | –do– |
| 7. | 3.0 | 84.0 | 25.7 | 78.0 | 79.0 | –do– |
| 8. | 4.0 | 84.0 | 19.8 | 78.0 | 79.0 | –do– |
| 9. | 1.0 | 84.0 | 20.0 | 62.5 | Drying was slow and non uniform | Drying was unsatisfactory |
| 10. | 2.0 | 84.0 | 10.0 | 52.0 | | |
| 11 | 3.0 | 84.0 | 6.7 | 38.0 | | |
| 12. | 4.0 | 84.0 | 10.0 | 50.0 | | |
| 13. | 1.0 | 84.0 | 20.0 | 64.5 | | |
| 14. | 2.0 | 84.0 | 10.0 | 54.5 | | |
| 15. | 3.0 | 84.0 | 6.7 | 42.0 | | |
| 16. | 4.0 | 84.0 | 10.0 | 50.5 | | |

*Note :* Trays 1 to 8 are perforated with stainless steel sieve mesh
Trays 5 to 6 are alkali treated sample
Trays 9 to 16 without perforation/sieve mesh.

Table 3. Drying of Cardamom in bin drier

| Bed thickness (cm) | Fresh wt. of Cardamom (kg) | Initial moisture content % | Total drying time | Final bed thickness (cm) | Dried weight (kg) | Final mositure content % |
|---|---|---|---|---|---|---|
| 7.5 | 8.5 | 84.0 | 5½ | 2.5 | 1.496 | 8.5 |
| 15 | 16.5 | 84.0 | 6½ | 5.0 | 2.965 | 8.5 |
| 20 | 20.0 | 84.0 | 10 | 6.0 | 3.750 | 9.5 |
| 25 | 25.0 | 84.0 | 11 | 7.5 | 4.535 | 8.0 |

*Note :* The drying was uniform and the products were good green colour.
Inlet tem. 60–61°C.
In 25 cm bed thickness the temperature raising to the top was slow and the cardamom at the top appeared fresh even after 5 to 6 hours drying.

Table 4. Field trials on drying of cardamom with the cardamom drier

| Initial wt. (kg.) | Bed thickness (cm) | | Period of drying (hrs.) | Temp. C° | Final wt. (kg) | Moisture (dried product) % | Drying ratio | Quality of product |
|---|---|---|---|---|---|---|---|---|
| | Initial (before drying) | Final (after drying) | | | | | | |
| 25 | 7.5 | 2.3 | 15½ | 55–60 | 7.0 | 9.5 | 3.5:1 | Faded to dull green Burnt appearance. More shrinkage & less aroma. |
| 10 | 3.0 | 1.0 | 34 | 40–45 | 2.45 | 10.0 | 4.09:1 | Fresh green appearance-good |
| 10 | 3.0 | 1.0 | 10 | 50 | 2.6 | 10.0 | 3.84:1 | –do– |
| 10 | 6.0 | 2.0 | 20 | 50 | 2.56 | 9.8 | 3.90:1 | –do– |
| 60<br>(Single drying chamber) | 17.0 | 6.1 | 22 | 50 | 16.4 | 9.5 | 3.56:1 | –do– |
| 120<br>(both drying chamber used) | 17.0 | 6.1 | 22 | 50 | 32.3 | 9.5 | 3.70:1 | –do– |

Table 3 representes the results of experiments carried out to determine the maximum bed thickness that can be allowed in *through-flow drying. From the results of drying trials,* colour and quality assessment it was concluded that green cardamom can be dried in a bin drier up to a bed thickness of 20 cms with a drying temperature of 50 to 60°C.

On the basis of above results a design of a prototype through flow drier was made and the drier was fabricated with the help of CFTRI, Engineering Section (Fig. 2). The drier consists of a centrifugal blower, electrical furnace, ducting with arrangements to distribute the flow of hot air uniformly and a drying chamber where 120 Kg fresh cardamom capsules can be loaded to a bed thickness of 20 cms. The air velocity was 60 cms/sec and the drying temperature was thermostatically controlled. The hot air carrying the humidity was not allowed to recycle.

Field studies were carried out in an estate in Myladumpara in Idukki District. The results were presented in table 4. With 120 Kg fresh capsules with the temperature adjusted at 50°C, the drying time taken was 22 hours. The dried capsule has been found to be acceptable to the trade in superior green colour, flavour and appearance.

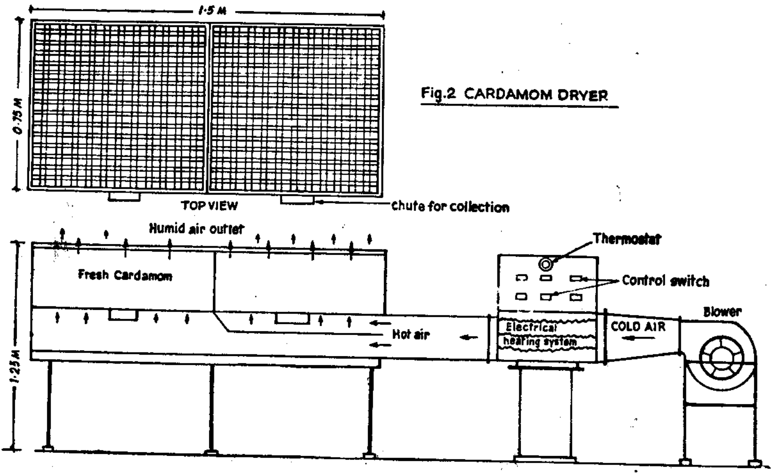


Fig.2 CARDAMOM DRYER

(Figure 2)

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# DRYING OF RUBBER

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## ABSTRACT

**The paper describes various drying equipments used in processing different forms of rubber like sheet, crepe and block rubbers. The fuels used are firewood, oil and electricity. An analysis of the fuel efficiency of various systems is given. Experience on indigenously developed electrically heated crumb rubber drier of the Rubber Board is described. The advantages and disadvantages and the economics of electrical heating vis-a-vis other forms of energy are also given. The paper also proposes further studies on the utilisation of renewable energy sources for drying rubber.**

## INTRODUCTION

The crop collected from rubber plantation consists of latex (containing 30 to 40% dry rubber) and the various forms of field coagulum grades (like cuplump, shell scrap and tree lace). Normally the ratio of latex to field coagulum grades is 80 : 20 on a dry basis. Latex is processed into sheet (Ribbed Smoked Sheet-RSS, or Air Dried Sheets-ADS), Pale Latex Crepe (PLC) or Block Rubber and Latex concentrate. The field coagulum grades are processed to either estate brown crepe (EBC) or block rubber. Excepting latex concentrate, processing of all other forms of rubber involves drying operation. The types of drying equipment used depends on the form of rubber. In making ribbed smoked sheets (RMA grades) the drying is carried out in an atmosphere of smoke produced by controlled combustion of firewood. The cresotic substances present in the smoke prevents mould growth and acts as anti-oxidants for the rubber. For drying of all other forms of rubber hot air is used, the temperature depending on the type of rubber. The type of equipment used depends on the drying characteristics of the rubber.

## Drying Characteristics

A plot of water content of rubber vs. drying time shows that drying takes place in two stages, firstly a rapid reduction in moisture content which is a constant rate period followed by a falling rate period. During drying the heat required for varpourisation of moisture is transferred from the medium (hot air) to the rubber mostly by convection. During the constant rate period-drying takes place by diffusion of vapour from the saturated surface of the rubber across a stagnant air film into the environment. Moisture movement within the rubber is rapid enough to maintain a saturated condition at the surface and the rate of drying is controlled by the rate of heat transfer to the evaporating surface. The rate of mass transfer balances the rate of heat transfer and temperature of the saturated surface remains constant and it is equal to the wet bulb temperature when heat transfer is solely by convection.

Initiation of falling rate indicates that movement of water from the interior to the surface has become a controlling factor. This becomes more and more important since the moisture content of the particle decreases with time. In early stages of falling rate period, part of the surface may remain saturated (where evaporation rate is decided by the external factors) while at the remaining surface, the internal moisture movement determines the rate of evaporation. This could be considered as the first falling rate period. In the second falling rate period, the rate of drying is solely controlled by the internal moisture movement and this is a diffusion cntrolled mechanism.

The critical moisture content, depends on the size and surface to volume ratio of the rubber being dried. The drying rate during the constant rate period depends on

1. temperature and humidity of air
2. size and surface to volume ratio of the material
3. the air velocity and
4. bed height in case of crumbs under through circulation drying.

The drying time for falling rate period depends

1. particle size and
2. temperature

Since the rate of heat transfer to the material should balance the rate of mass transfer, the maximisation of drying rate in each stage is decided by the highest temperature and time the material can stand without affecting the technological properties, which is mainly decided by the size and surface to volume ratio of the material. It has also been observed that very high drying rates during the early stages will lead to the drying of the surface resulting in movement of moisture to the surface difficult.

The drying characteristics of various forms of rubber are given below: (Gale, 1960, Sethu 1968, Tharmalingam 1977)

| | *Characteristics* | *Sheet* | *Crumbs* | *Lace* |
|---|---|---|---|---|
| 1. | Initial moisture content, % | 40–60 | 40–50 | 7–12 |
| 2. | Drying temp., °C | 60 | 100 | 34 |
| 3. | Drying time, average | 3–5 days | 3–5 hours | 6 days |
| 4. | Critical moisture content, % | 15 | 10 | 3 |
| 5. | Falling rate period, % of total drying time | 85–95 | 90 | 85 |

The different types of drying equipment used for various forms of rubber are described below:

**Ribbed Smoked Sheets**

The drying device commonly used is smoke house. Several modifications were tried in the past to improve the efficiency of smoke houses and quality of sheet. The types now in use are the conventional types and the RRIM tunnel type (Graham, 1964).

Rubber sheets are prepared in about 1/8" thickness and each weighs about 500 grams. The drying time is normally 4 days. The temperature of the chamber is increased from 45°C at the inlet point to 65°C at the exit point.

In conventional type, smoke house sheets are hung in four layers on barottes at a centre distance of about 3½". There is a furnace on one side outside the chamber and the gas is admitted to the bottom of the chamber through a tunnel. Temperature at the bottom i.e. near the fuel outlet is 45°C and at the top about 65°C. There is a chimney at the top with a baffle arrangement. The furnace is designed for controlled combustion of firewood. The temperature is regulated by adjusting the air inlet and the chimney opening. The wet sheets are loaded in the lowest layer and everyday the sheets are reversed and moved to the next layer. These type of smoke houses are available in capacities ranging from 20 to 200 kg/day. These are generally recommended for small holders, because of less capital cost.

In the tunnel type smoke houses, the sheets are loaded on trucks moving on rails inside a tunnel. The furnace is near one end of the tunnel and feeding of trucks is from the opposite end. These are available in four sizes 1100, 2200, 3300, 4400. The type 1100 holds 4 trucks and 2200 holds 8 trucks. The figures represent capacity in lbs/day of dry rubber.

The furnace is designed to minimise heat and prevent spark and as entering the tunnel. The door is designed to regulate the air inlet to control combustion. The flue line runs along the full length of the tunnel opening below each truck at its centre. The openings of the outlets are set in each type to get to required temperature. Chimneys are provided along the length at suitable positions to prevent direct escape of smoke from flue outlets. The temperature at inlet is 57°C which increases to 63°C at the outlet (furnace end). Each truck carries 500–600 kg. drc of sheets depending on coagulation and machining conditions. Trucks have baffles at the bottom to keep the drippings off the truck and the floor sloping towards the sides collects the drippings and taken out through a drain. A ceiling is also provided to prevent condensation of smoke resulting in dripping of tar on to the sheets. These type of smoke houses are generally recommended for estates.

Among small holders with production of 10 kg/day or less, it is a common practice to dry the sheets initially for a few days in direct sun followed by a few days in the kitchen chimney.

## EBC/PLC

The drying temperature recommended for EBC is 32–34°C and PLC 32°C. Generally the practice is to dry at room temperature and drying time varies from 7 to 20 days in the case of EBC and 8 to 15 days in the case of PLC, depending upon the climatic conditions. The thickness ranges from 1 to 3 mm for EBC and that for PLC from 0.9 to 1 mm. The drying sheds are generally built for single or two tier loading of crepe. Roof exractors or vents are provided to give good air circulation. The crepe is hung 3 m high at about 4 to 5 inch centre distance (Morris 1964).

In certain cases to achieve a better control on drying and drying time, hot air by electric heating or oil firing is admitted to the drying house (Tharmalingam, 1977). Hot water is also used by circulating through pipes inside to drying house to increase the ambient temperature. This will help in reducing drying time, and in providing uniform drying and better colour for PLC.

## Block Rubber

Processing of natural rubber into block forms is a relatively recent development which is popular among the leading natural rubber producing countries for more than a decade now. Currently about 35% of the world supplies of natural rubber is in this form. In India production of block rubber started in 1973, and it is expected to grow considerably in the coming years.

In block rubber processing, the latex coagulum or field coagulum grades after a series of washing/cleaning/sheering operations is finally reduced in size by communition in hammer mill or extruder or shredder. The particles of rubber are then dried and baled into blocks.

The size reduction results in an enormous increase in the surface area which helps in reducing the drying time by having a higher drying temperature, compared to the other forms of rubber already described. The drying temperature is in the range 100–120°C and the drying time is 3½ to 5 hrs.

All the dryers employ "deep bed through circulation drying" (Sethu 1967–68). The driers generally are:–

1. Batch or chamber with semicontinuous movement of trolleys.
2. Continuous or semicontinuous movement of drier with single or double layer arrangement within a drier chamber.
3. Continuous apron drier.

For generating hot air, all the leading NR producing countries use oil firing either direct or indirect. In the indirect firing, tubular exchangers, steam pipes or high temperature oil (HTO) pipes are used. In direct fired heaters, the drier will have a single unit or multiples of such units for different stages.

The drier will have different zones where temperatures and air velocities will be different to cater to the drying characteristics. A portion of the air from the wet end is vented out to prevent humidity build up. The remaining portion of air is recirculated after heating.

The performance of the drier will depend on the velocity and quantity of air in various zones. The various zones require good air seals to prevent bypassing or leakage of air. The following are some of the recent developments in drier design towards improvement of the efficiency.

1. Development of spring loaded stainless steel seals against rubber seals used in the past which require regular replacement.
2. Use of high performance centrifugal fans in place of axial flow fans. This has resulted in increasing the discharge pressures of air.
3. Development of chain-pusher mechanism situated outside the tunnel. This has eliminated the need of chains running inside the tunnel, the inspection and maintenance of which is tedious.
4. By-passing of air between zones across baffles in continuous driers have been overcome by intermittent actuation of the chain mechanism as against continuous movement of chains.

Under the conditions in Kerala, it was considered appropriate to develop driers based on electrical heating and at the Rubber

Board such a drier was developed. Under the H.T. Tariff Rates of the Kerala State Electricity Board, unit cost of electricity depends on the quantum of energy consumed and unit cost decrease with increasing energy consumption. Hence the economics of electric heating vis-a-vis oil firing will largely depend on capacity utilisation of the plant. Since electricity is a must for other machinery of the plant, the total cost of power and fuel is the key factor to be taken into account. A comparison of the cost is given in Table 1.

Energy is becoming costlier day by day and hence systems have to be designed for maximum utilisation of energy. The energy utilisation factor (Kg of rubber dried per 1000 K Cals) for various forms of driers are given in Table 2. It could be seen that drying at higher temperatures help in reducing energy requirement. The higher energy requirement for drying at lower temperature is mainly due to higher heat losses, heating of large volumes of air and longer drying time.

A comparison of cost of various types of drying equipment is given in Table 3.

## Future developments

Solar energy could be utilised for drying rubber. Solar hot air collectors are reported to produce hot air of upto 80°C and these can be used for drying sheet or crepe rubber. In the case of block rubber the system can be combined with electrical heating which can take care of fluctuations of temperature. The disadvantage with the system is that there is no storage facility. This would be overcome by using the collector for heating water which could then be used for drying PLC or sheet.

Biogas could be produced and utilised for generating hot air. The processing of rubber produces effluents which require treatment before discharge to public waterways. Of late it has been reported that water hyacinth can be grown in the anaerobic treatment ponds to assist BOD reduction. The growth of the weed is estimated at about 500 kg/ha/day. Anaerobic decomposition of water hyacinth by methane producing bacteria produces biogas containing 70% methane and 30% carbon dioxide, with a calorific value of about 5250 K Cals/Cu. M. (Yaduraju 1979).

Table 1. Comparison of total power and fuel cost for 10 TPD block rubber factory with electric/oil fired drier

| | *Factory with Electric Drier* | | | *Factory with Oil Fried Drier* | | |
|---|---|---|---|---|---|---|
| 1. Monthly production, (Tonnes) | 250 (Three shift) | 167 (Two shift) | 84 (Single shift) | 250 (Three shift) | 167 (Two shift) | 84 (Single shift) |
| 2. Power, Kwh per tonne | | | | | | |
| (a) Milling | 140 | 140 | 140 | 140 | 140 | 140 |
| (b) Others | 50 | 50 | 50 | 50 | 50 | 50 |
| 3. Fuel for drier Kwh/Tonne for Electric **or** litres per tonne for oil fired* * | 410 | 410 | 410 | 50 | 50 | 50 |
| 4. Unit cost of electricity, ps/kWh* | 25 | 33 | 56 | 39 | 54 | 96 |
| 5. Cost of power, Rs. per tonne | 48 | 62 | 104 | 74 | 101 | 183 |
| 6. Cost of fuel, Rs. per tonne | 105 | 136 | 229 | 128 | 128 | 128 |
| 7. Total cost of power and fuel | 153 | 198 | 333 | 202 | 229 | 311 |

*Note:* * Based on the current tariff rates of KSEB.

** Cost of High Speed Diesel Oil — Rs.2/55 per litre.

Table 2. Typical energy utilisation factors for different driers

| *Type of rubber* | *Fuel* | *Drying temp°C* | *Drying time* | *Fuel requirement per tonne of dry rubber* | *Kg. of rubber dried per 1000 KCals of energy* |
|---|---|---|---|---|---|
| RSS | Firewood | 57–63 | 4 days | 800 kg | 0.60 |
| ADS | High Speed Diesel Oil | 57–63 | 4 days | 79 litres | 1.32 |
| PLC | High Speed Diesel Oil | 32–34 | 6 days | 81 litres | 1.29 |
| PLC | Electricity | 32–34 | 6 days | 702 Kwh | 1.66 |
| Block Rubber | High Speed Diesel Oil | 100–120 | 3½—5 hrs | 50 litres | 2.09 |
| Block Rubber | Electricity | 100–120 | 3½—5 hrs | 410 Kwh | 2.84 |

**Table 3. Estimated cost of various drying equipment**

| *Type of rubber* | *Drying equipment* | *capacity* | *Normal drying time* | *Area requirement* | *Estimated cost* Rs. |
|---|---|---|---|---|---|
| RSS | Smoke house (Type RRIM–2200) | 1000 Kg/day | 4 days | 72 sq.m. | 1,80,000 |
| ADS | Drying tunnel (Electrically heated) | 1000 Kg/day | 4 days | 72 sq.m. | 1,70,000 |
| PLC | Drying shed (Room temp.drying) | 1000 Kg/day | 8 days | 400 sq.m. | 2,40,000 |
| PLC | Drying shed (Electrically heated) | 1000 Kg/day | 6 days | 300 sq.m. | 2,00,000 |
| EBC | Drying shed (Room temp.drying) | 1000 Kg/day | 10 days | 143 sq.m. | 86,000 |
| Block rubber | Electric drier | 200 kg/hr | 5 hrs | 40 sq.m. | 3,50,000 |

*Note:* Smoke house at Rs.1000/– per sq.m.
Drying shed at Rs.600/– per sq.m.
(December 1980)

Each kg. of water hyacinth on a dry basis can produce about 370 litres of biogas. This requires further large scale trials to find out the potential as an energy source. If found successful, this would be of great value in effluent treatment and also as fuel for drier.

## ACKNOWLEDGEMENT

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# A NOTE ON A SMALL-SCALE COCOA DRIER

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## ABSTRACT

**A cocoa drier working with ordinary electric bulbs was made and tested. The set up consisted of a wooden box of internal dimensions 90 cm x 60 cm with three racks spaced at 15 cm. Source of heat consisted of six bulbs two each of 100w, 60w and 40w. The bulbs were fixed in various positions and the temperature in the different parts of the box was studied. The temperature within the box remained more or less uniform irrespective of the positions of the bulbs. With all the six bulbs on, the temperature stabilised at about 54–55°C in two hours. With two each of 100w and 60w bulbs only, the maximum temperature was nearly the same but stabilisation took a little more time. With only two 100w bulbs, the temperature attained was only between 40 and 45°C. When a 750w heater was used as the source of heat, the temperature within the drier was well over 100°C in about 2 hours. The temperature** ***variation was also highly conspicuous. About 4 kg of wet cocoa beans*** **were test-dried spreading them in half of the middle tray at 2–bean thickness with bulbs as the source of heat. It was found to dry in less than 24 hours when all the six bulbs were kept on.**

## INTRODUCTION

Fermented cocoa beans are to be dried immediately after the fermentation period and the maximum permissible time lag is reported to be 12 hours between cessation of fermentation and drying of beans. Drying of cocoa in most of the cocoa producing countries is done in the open sun. Sundrying also is found to yield beans of best quality. Sun drying of cocoa is not usually possible during the monsoon months in South India and therefore artificial drying has to be resorted to temperature beyond 60°C that could be attainable normally in artificial driers are generally considered undesirable as they lead to detectable acidity.

The performance of drier employing electric bulbs for drying cocoa was evaluated in the present study and the results are reported.

## MATERIALS AND METHODS

A wooden box with internal dimensions of 90 x 60 x 60 cm and with three racks spaced at 15 cm was made. Ten holes of 1 cm diameter were provided at the rear top to act as air outlet. Separate air inlet holes were not provided to start with. Ordinary electric bulbs formed the source of heat. The number, capacity and positions of the bulbs were standardised by measuring temperature at various positions within the box by setting thermometers in the four corners of the three racks. Similar measurements were also made after providing 10 additional air inlet holes at the front base. Temperature measurements were also made with a 750 W heater used as the source of heat.

## RESULTS AND DISCUSSION

### Standardisation of the number and capacity of bulbs

A temperature of 54 – 57°C was attained in 2 hours. With two 100 w bulbs fixed on the sides of the box below the bottom tray, two 60 w bulbs below the middle tray and two 40 w bulbs below the top tray. The variation in temperature between the four positions in a tray was slight and hence these values were pooled and averaged out. There was slight variation only in temperature at the three trays. Data on the temperature changes in the different trays are presented in Fig. 1.

The temperature range at the end of the 2 hours period with two 100 w and two 60 w bulbs switched on only (the positions of the bulbs being the same as in the previous set) was from 54 to 56°C. The temperatures attained were much lower (42 to 46°C) when only the two 100 w bulbs were switched on.. Evaluation of this temperature range was eliminated for this range was much lower than the one adopted generally.(Fig. 2).

### Standardisation of the position of bulbs

The following two positions of the bulbs were tested.

(i) Two 100 w bulbs below the bottom rack, the two 60 w bulbs below the middle rack and the two 40 w bulbs below the top rack (when used).

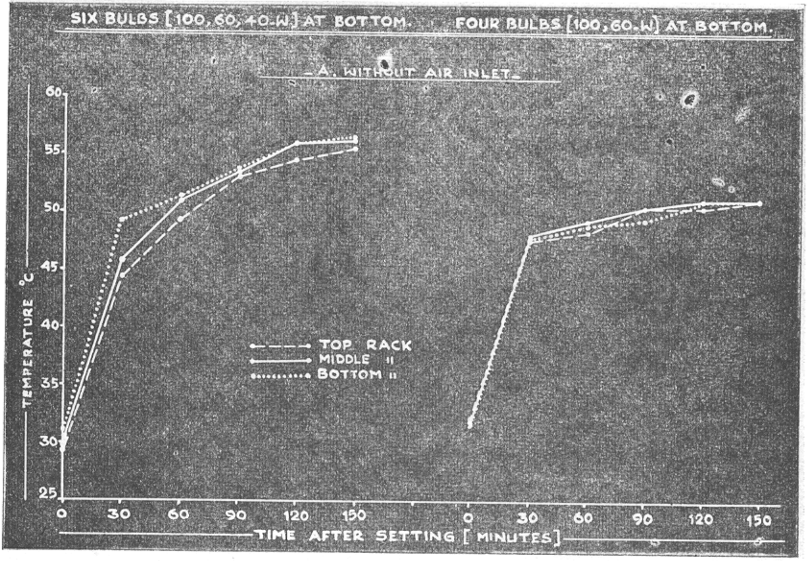

Fig. 1. Temperature changes on different trays

(ii) All the bulbs at bottom.

These two positions of bulbs were tested with four and 6 bulbs switched on. When all the bulbs were at the bottom, maximum temperature of the drier ranged from 55.5 to 56.5°C as against 51.5°C only with four bulbs switched on. These figures were comparable to the set with bulbs at different positions when six bulbs were used. With four bulbs, temperatures were slightly lower than when the bulbs were at the bottom (Fig. 3).

As the set with all the bulbs at the bottom had the advantage of being more convenient and as the differences in temperatures were not appreciable, combination of bulbs at different positions was not tested further.

**Provision of additional air inlet**

In the earlier tests, holes for air-inlet were not given and entry of air was only through the joints. Provision for additional air entry was given by making 10 holes of 1 cm diameter at the front

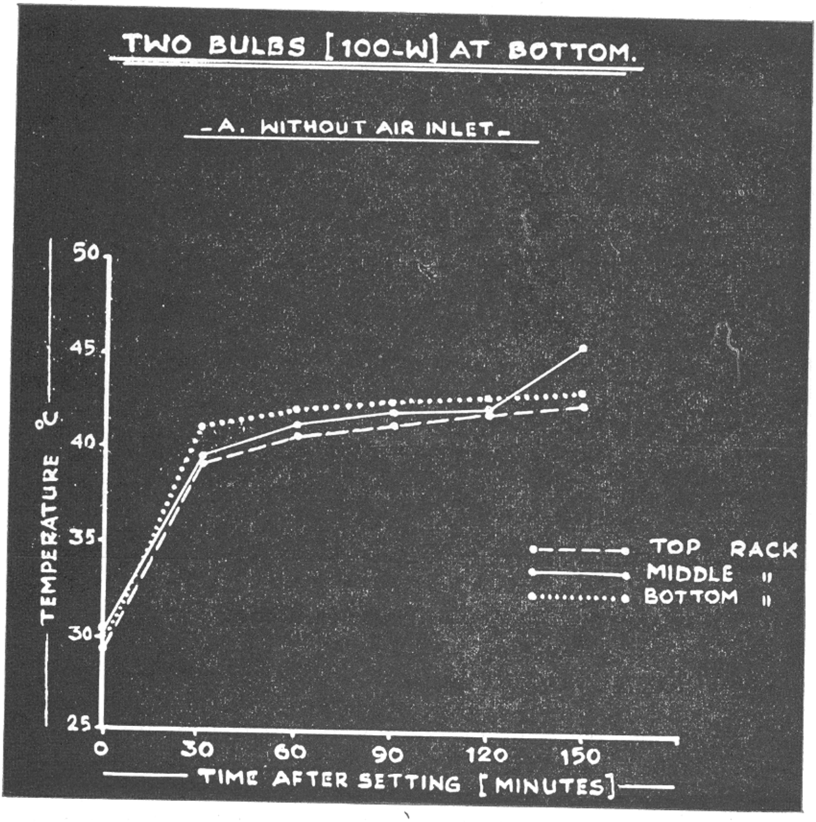

Fig. 2. Effect of 2 bulbs on temperature

bottom of the box. Temperatures in the box with four and six bulbs were studied. With additional air inlet holes, the maxmum temperature dropped by about, 1°C with six bulbs switched on and by 2.5 to 4.5°C with four bulbs switched on. Data on the temperature at various positions of the box are given in Fig. 4.

## Alternative sources of heat

A 750 w electric heater was used as the source of heat instead of the bulbs. While with the bulbs, temperature was more or less uniform inside the box, wide fluctuations in temperatures between the various positions were noticed when the heater was

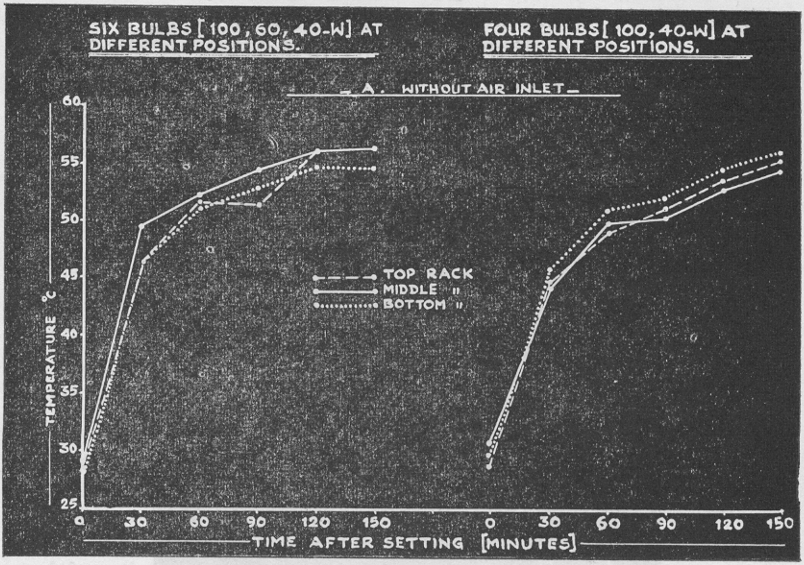

Fig. 3. Effect of position of bulbs on temperature

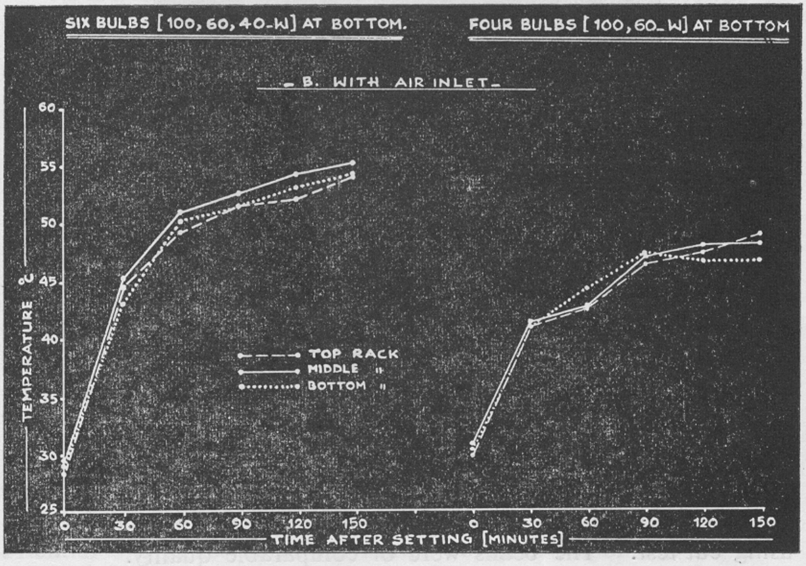

Fig. 4. Effect of additional air inlet on temperature

installed. More so the temperatures rose fast beyond 60°C within a short period of 30 minutes and at the end of 2 hours, it was over 100°C. Assessment of the suitability of a heater as a source of heat was discontinued due to unsuitable initial high temperatures which also fluctuated widely (Fig. 5).

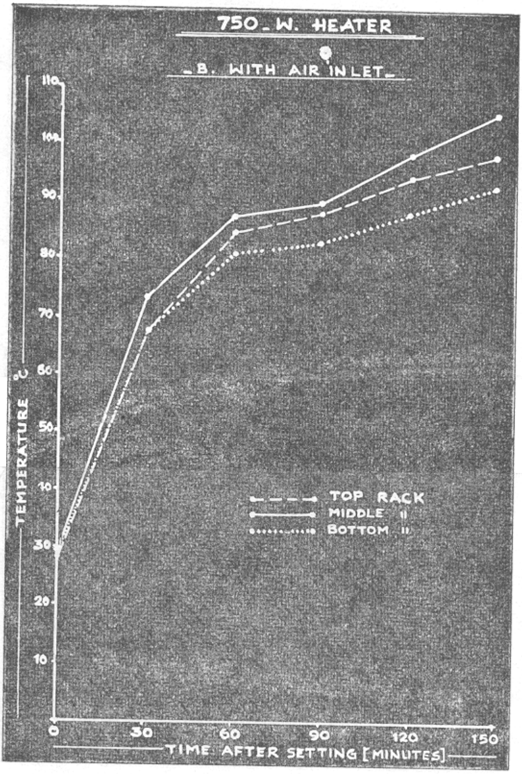

Fig. 5. Temperature changes in heater drying

## Test-drying of fermented beans

Drying of 25 kg fermented beans that were loaded in the drier at two-bean thickness took about 48–72 hours. The quality of beans dried in the drier was compared with the sundried lot using cut-test. The beans were of comparable quality.

# THERMAL PROCESSING OF TEA

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## ABSTRACT

**Thermal processing is an important step in food processing operations which helps in arresting enzymic reactions, dehydration, reduction in moisture levels etc. and it brings about a number of physical and chemical changes in the food materials. In conventional black tea processing operations, firing is an important step which arrests the enzymic oxidation reactions and dehydrates to give the characteristic black pigmentation to the finished product.**

**Bokuchava and her group of Russian workers have reduced the fermentation time and firing time to half and this was followed by thermal treatment at moderate temperatures (50–70°C) at different intervals of time. Some of the parameters like catechin, essential oil contents etc. have been evaluated but the accessible literature gives incomplete information.**

**In the present investigation, similar experiments have been carried out in a laboratory scale and various quality parameters like % TF, % TR, TF/TR ratios, creaming power, creaming index and total tannins have been evaluated and compared with respect to control samples and factory made samples. The thermally processed teas show good quality parameters.**

## INTRODUCTION

Black tea of commerce is a product of a number of biochemical transformations of the tea flush. The catechins, gallocatechins and their galloylated derivatives undergo oxidative transformations catalysed by the endogenous polyphenol oxidase enzyme to yield theaflavins, the orange red pigments responsible for the briskness and thearubigins, the reddish brown pigments responsible for the body and strength of the tea infusions. These biochemical reactions are also accompanied by the formation of volatile carbonyl compounds from aroma precursors like proteins, amino acids, sugars, carotenoids etc. These in conjunction with the natural essential oils of tea form the aroma complex responsible for the characteristic flavour of tea.

The conventional process of black tea manufacture involves a number of steps like withering, rolling, fermentation, firing and grading stages. In the modern black tea manufacture, the slow and time consuming process of rolling has been replaced by CTC and rotorvane machines resulting in enhanced fermentation and increased throughput. The crucial steps in tea manufacture are fermentation and firing.

Theaflavins and thearubigins, the beneficial polyphenolic pigments are formed at optimum concentrations after the fermentation proceeds to optimum time. The beneficial factors formed are arrested at that level by the firing operations. Firing not only helps in arresting the fermentation reactions but also helps in the formation of newer aroma components by thermal degradation of carotenes, sugars, etc. Hence firing is a critical step in the tea manufacturing operations.

In the conventional process, firing is carried out in ovens at a temperature of about 100°C. Trays carrying fermented leaves move from the top of the firing oven to the bottom reducing the content of the leaves to the desired level. The operational energy costs are very high.

Although the conventional tea manufacturing steps have been universally adopted by most of the tea factories, the classical process suffers from number of obvious disadvantages.

1. About 20–25% of the tea leaf tissues remain undistorted during rolling (Bokuchava and Skobeleva, 1980) precluding them from taking part in biochemical transformations and thus it cannot produce good yields of high quality tea.
2. During the polyphenol oxidase mediated fermentation reactions, the oxidative processes are rapid and uncontrolled. The rate of oxidation is not uniform thus resulting in high losses of catechins and tannins.
3. During firing operations, about 70–80% of the essential oils are lost, thus weakening that part of the aroma complex.
4. Manufactured tea ages rapidly with significant loss of its quality in a few months, slow ripening to improve the taste and aroma is not possible.

5. Greater care has to be exercised during firing to avoid case hardening and stewing phenomena leading to poor storage characteristics of manufactured teas.

Since the classical process fails in complete utilisation of the components of green tea flush and retention of its positive characteristics a new technology has been developed at the Bakh Institute of Biochemistry, U.S.S.R. Academy of Sciences by Bokuchava and coworkers (1957) involving thermal treatment of the underfermented teas. This method has shown a greater promise overcoming some of the drawbacks listed earlier for the conventional manufacturing processes. Transformations of catechins into theaflavins and thearubigins and amino acids into carbonyl compounds during the course of oxidative fermentation reactions hitherto considered to be purely enzymatic have now been recognised as due to nonenzymatic, thermochemical processes. This results in tannin oxidation resulting in red and brown pigments but without the production of insoluble tannin-protein complexes. Flavour development also depends upon the biochemical reactions but to a certain extent on nonenzymic process of the thermochemical type.

According to the new technology, the withered tea leaf is subjected to rolling, the extent of which is determined by the quality of tea leaves and season. After rolling, firing is performed in a single step process to ensure a residual moisture content of 6–9% for fine fractions and 7–10% for coarse fractions in contrast to 3–4% achieved in the conventional processing. Then the underfermented tea is treated thermally in a special chamber at 50–65°C for 2–3 h. in the case of fine fractions and 3–5 h. for larger fractions to reduce the moisture content to 4–6%. This tea is sorted and packed (Bokuchava, 1957).

It is a common practice in Assam, Darjeeling and Coonoor that tea is heated to 70°C and packed while hot to improve the flavour. A similar practice has been followed in China also. It is interesting to note that in tropical climates underfermented tea is subjected to a slow thermal treatment in a factory or storehouse at ambient temperatures that reach upto 40°C (Bokuchava and Popov, 1958).

Thermally treated teas showed a good increase in the yields of highest and first grade teas to the extent of 75 to 80% compared to 50–60% in the classical manufacturing processes. The conventional procedure decreased both the total soluble and dialysable tannins whereas the latter category only was affected by the thermal treatment. Thermal processing also decreased those tannin components which form the tannin-protein complexes vis-a-vis the conventional process. Thermal treatment also led to significant increases in extractives, tannins, catechins, vitamin P, essential oil content and individual amino acids (Bokuchava, 1980). According to Bokuchava and Oragrebidge (1966), thermally processed teas contained 50–70 mg of catechins per gram of tea compared to traces in conventionally manufactured black teas thus promoting the health giving properties of tea (Bokuchava, 1980). This treatment also eliminated the harsh taste and grassy odour of the underfermented teas possibly due to isomerisation and epimerisation of catechins, degradation of chlorophyll and synthesis of aldehydes and essential oils (Bokuchava, 1980).

Bokuchava, *et al.* (1966) compared the storage characteristics of thermally treated tea with normal black tea at room temperature and 60–62% RH over 5 years and were found to give better organoleptic properties for the former.

Though a lot of research and developmental work had been carried out on thermal processing of tea in Russia, the application of this new technology to tea processing operations in India has been hampered by inadequate knowledge of the technical methodology due to difficult access to technical literature. This paper deals with the findings of the effect of thermal processing at different temperatures and different intervals of time on the quality of teas distorted by legg cut method as well as quality of black teas made by conventional means. A number of parameters like theaflavins and thearubigins contents, TF/TR ratio, creaming power, creaming index and total tannin values which are important characteristics of made tea quality are studied for thermally treated teas at different temperatures.

## MATERIALS AND METHODS

### Preparation of thermal tea samples

The withered tea leaves obtained from a mid elevation tea estate in Nilgiris (Woodbriar Estate) were cut by legg cut method and the optimum fermentation time to reach a maximum theaflavins content was estimated to be 1 h. and 30 min. using a method developed by Ullah (1977). The leaves were cut by legg cut method and allowed to ferment for half the fermentation time (45 min.) and subjected to firing for half the firing time (30 min.), in laboratory tea drier at 100°C. Small quantity of sample was preserved for comparison purposes, and the rest was subjected to thermal treatment at two different temperatures viz., 60°C and 75°C (4 h, 5 h. and 5½ h. respectively). A control sample of black tea was prepared by fermenting for 1 h. and 30 min. and firing at 105°C for 2 h. A factory made black tea sample made from the same estate was also used for comparison purposes.

A batch of black tea obtained from Coorg was thermal processed for 5 h. at 80°C and the black tea from the same estate was used as control for comparison.

### Assessment of fermentation

500 g. withered tea leaves were cut by a legg cutter. This was spread uniformly on an enamel tray to ½" thickness and allowed to ferment for 45 min. 5 g. of fermenting leaf was infused with 100 ml. of boiling water for 1 min. with constant stirring and filtered through cotton wool; 5 ml of the filtrate was pipetted out into 5 ml of anhydrous di-sodium hydrogen phosphate solution (1% W/V) taken in a separating funnel. The mixture was extracted by shaking with 10 ml of ethyl acetate for 1 minute. The lower aqueous layer was drained off and 2 ml of extra ethyl acetate was added to the extract. (The extract was then transferred to a test tube and the colour intensity was judged visually by viewing vertically through the column of the liquid against a

white background). The optical density of the extract was measured in a colorimeter at 460 nm using water as blank. The experiment was repeated at intervals of 10 min. during fermentation. The highest optical density of the extract corresponds to the maximum theaflavins formation, and this determines the optimum fermentation time.

## Moisture

10 g. of tea leaves were weighed accurately into a petri dish. Kept in an oven at 105°C for 6 h. Dried to a constant weight. The loss in weight was reported as moisture content.

Total soluble solids were estimated by AOAC method (A.O.A.C. 1945 a).

Tannins were estimated by Lowenthal's method (A.O.A.C., 1945b).

Creaming power was estimated by Smith's method (Smith, 1968).

Creaming index was estimated according to Robert's method (Roberts, 1963).

Theaflavins and Thearubigins were estimated according to Roberts and Smith method (Roberts and Smith, 1961).

## RESULTS AND DISCUSSION

The withered tea leaves which were distorted by a legg cut method were assessed for their fermentation characteristics by the method of Ullah (1977) and the optimum fermentation time corresponding to the maximum amount of theaflavins formation and optimum amount of thearubigins formation was found to be 1h. and 30 min. Hence to arrest the enzyme mediated polyphenol oxidation reactions the half fermentation time (45 min.) was chosen and the leaves were fired for half of the normal firing time employed in factories. Then the leaves were thermally processed at 60°C and 75°C for 4, 5 and 5½h respectively. Table 1 represents typical values of the chemical quality parameters of these teas.

**Table 1. Chemical parameters of thermal processed teas at different temperatures**

| Parameters | *Control (half fermented for 45 min. half fixed for 30 min.)* | *Thermal processing at 60°C* | | | *Thermal processing at 75°C* | | | *Black tea prepared in laboratory* | *Black tea from factory* |
|---|---|---|---|---|---|---|---|---|---|
| | | 4 h. | 5 h. | 5½ h. | 4 h. | 5 h. | 5½ h. | | |
| 1. Moisture, % | 42.87 | 5.313 | 4.480 | 3.602 | 4.50 | 3.331 | 3.310 | 4.032 | 8.635 |
| 2. Metal soluble solids, % | 38.4 | 40.5 | 37.2 | 24.75 | 38.6 | 41.1 | 38.89 | 30.77 | 31.75 |
| 3. Creaming power, % | 8.521 | 10.217 | 13.218 | 13.497 | 11.348 | 12.866 | 15.918 | 12.358 | 10.903 |
| 4. Creaming Index (ml)* | 70.4 | 70.9 | 70.9 | 69.50 | 71.2 | 70.9 | 71.2 | 71.30 | 69.40 |
| 5. Tannin, % | 6.972 | 22.66 | 19.17 | 17.43 | 20.92 | 19.17 | 12.20 | 11.974 | 12.049 |
| 6. Theaflavins (TF), % | 0.1631 | 0.2081 | 0.321 | 0.2891 | 0.2137 | 0.3775 | 0.303 | 80.1686 | 0.0731 |
| Thearubigins (TR), % | 13.379 | 21.233 | 16.697 | 18.815 | 20.651 | 17.285 | 21.304 | 18.8502 | 16.2557 |
| Thearubigins (380 nm/460 nm) | 3.826 | 5.493 | 1.862 | 2.004 | 2.836 | 2.18 | 2.929 | 3.4907 | 3.5977 |
| Theaflavins/ Thearubigins | 0.893 | 0.612 | 3.826 | 6.614 | 1.072 | 1.83 | 0.923 | 0.7163 | 0.4517 |

* Creaming index is always expressed as 'X' ml of 0.1M $KMnO_4$/gm of tea.

The moisture content of the thermally processed teas showed a decline with increasing intervals of time. Low values of 3.6 and 3.3 were observed for thermally processed teas at 60°C and 70°C respectively for a period of 5½h.

The total soluble solids with an initial value of 38% shows an increase upto 40.5% and 41.1% within 4 h. and 5 h. of thermal processing at the two respective temperatures and definitely shows a declining trend in soluble extractives after longer durations of processing.

According to Smith (1968) the creaming power is an alternative to the creaming index values of Roberts. Good creaming power values represent a good ability to cream down as well as the correct balance of percentage theaflavins and percentage thearubigins and also an optimum E 380/E 460 ratio of thearubigins. These properties are valued by the tea tasters as a measure of good quality teas. The creaming power in the present experiment increases from 8.5 for control to 13.5 and 15.9 for thermal processed teas for 5 h. at the two respective temperatures. These values are better than the corresponding values for black tea and hence a desirable factor for quality.

It has been observed by Roberts (1963) that theaflavins and thearubigins couple with caffeine to form tea cream. Capacity of the tea infusions to cream down is considered to reflect the quality. It has been found that with increasing fermentation time the the ratio of thearubigins to theaflavins increases and there is a progressive decrease in the amount of theaflavins combined with caffeine to form cream. The increasing ratio of thearubigins to theaflavins is directly correlated with increasing cream index as the fermentation time increases and the increased cream index values bear a highly significant negative correlation with the tea tasters' score for briskness. The cream index values for thermal teas reach an optimum value of 70.9 and 71.2 within 5 and 5½ h. of processing at the two respective temperatures. These values compare well with those for factory made black tea.

The total polyphenol content shows a high value for thermal teas processed for 4 h. at the two respective temperatures than for longer durations. The values are higher than those for the corresponding control and factory made black tea samples. This is in line with the earlier observations of Bokuchava (1980) that the total available polyphenols are more for thermally processed teas and there is no tannin loss in this new method campared to conventional methods.

The percentage theaflavins in the tea infusions is always associated with a good scrore for briskness by professional tea tasters. It can be seen from Table 1 that half fermented control sample and thermally processed samples are having higher theaflavin values compared to the corresponding values of black teas. This is in line with the earlier observations that prolonged fermentation in black tea converts some of the theaflavins into thearubigins, thus affecting the briskness of the tea infusions. Theaflavin values for thermal teas reach an optimum within 5 h. and then decrease at the respective temperatures. The thearubigins values of thermal processed teas increase upto 4 h. and then shows a decrease. This may be due to a progressive thermal decomposition reactions of thearubigins. An optimum TF–TR balance was obtained at 5 h. for thermal processed teas at the temperature ranges studied. The percentage theaflavins values seem to attain optimum values within 5 h. of thermal processing at both the temperatures studied.

The E 380/460 ratio for thearubigins are low for thermally processed teas upto 5 h. time indicating deeper colour of the infusion in comparison with the factory made black tea samples, and hence they are desirable. Quality evaluation (Table 2) indicates the degree of acceptability of the products.

**Table 2. Organoleptic evaluation of thermal processed teas**

| *Samples* | *Organoleptic evaluation* |
|---|---|
| Control (Half fermented for 45 min. and half fired for 30 min.) | Greenish yellow colour, much of bitterness, raw and greenish odour of green tea. |
| **Thermal processing at 60°C** | |
| 4 h. | Good colour, light body, slight bitterness, no characteristic tea taste. |
| 5 h. | good colour, light body, pleasant characteristic tea flavour, acceptable. |
| 5½h. | slighly darker colour, mild strength with very little astringency. |

Table 2 (contd.)

| *Samples* | *Organoleptic evaluation* |
|---|---|
| **Thermal processing at 75°C** | |
| 4 h. | dark liquor, with little characteristics of tea, no bitterness observed. |
| 5 h. | darker liquor, light body, pleasant flavour, acceptable. |
| 5½ h. | darker liquor, light body, no bitterness, foreign taste. |
| **Black tea prepared in laboratory** | Slightly darker colour, characteristic tea taste, acceptable. |
| **Black tea from factory** | light body, bitterness, characteristic tea taste, acceptable. |

### Thermal processing of factory made black tea

Thermal processing of factory made black tea was also carried out to study the effect of thermal treatment on the already finished product. The results are tabulated in Table 3. From these data, it can be seen that the total soluble solid content and the creaming power increase and creaming index shows an optimum value in line with the observations of the earlier workers. The thermally processed teas also show a higher percentage of theaflavins and an optimum percentage of thearubigins. The E 380/460 values for theaflavins favours the thermal processed teas whereas the corresponding TR values favour the factory made black tea.

It is interesting to note that though the chemical parameters signify good tea characteristics for thermally processed teas, it is not concomittantly reflected in the organoleptic evaluations of these tea infusions.

Besides the obvious advantages of higher throughput and reduced energy costs, the data obtained during the course of this investigation show that the tea characteristics like TF, TR values and their ratios, creaming power, creaming index and total tannins are enhanced by thermal treatment. The nutritive and pharmacological properties of tea are claimed to have been conserved

**Table 3. Chemical parameters of factory made black tea after thermal processing**

| *Parameters* | *Black tea from factory* | *Thermal processed black tea at 80°C for 5 h.* |
|---|---|---|
| 1. Moisture, % | 5.9685 | — |
| 2. Total soluble solids, % | 40.3 | 44.8 |
| 3. Creaming power, % | 15.7505 | 19.678 |
| 4. Creaming index*, ml | 70.5 | 58.3 |
| 5. Tannin, % | — | 24.402 |
| 6. Theaflavin—Thearubigin | | |
| Theaflavins % | 0.0939 | 0.15336 |
| Thearubigins, % | 15.9891 | 15.3786 |
| Thearubigins (380 nm/460 nm) | 3.2467 | 3.9295 |
| Theaflavins/Thearubigins | 0.823 | 0.8107 |

* Creaming index is always expressed as 'X' ml of 0.1 M $KMnO_4$/gm of tea

because of the retention of the catechins and the losses in aroma and vitamin constituents are restricted to minimum as evidenced by Russian workers. More detailed investigations are required to translate these laboratory scale experiements into a technological feasibility.

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# MOTORISED MECHANICAL AIDS TO PRUNE/SKIFF TEA (*CAMELLIA* L. spp)

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## Abstract

**An investigation was carried out to examine the feasibility of applying two models of motorised mechanical pruning aids in tea culture. The model KPE 700 was found to be effective to skiff bushes at 85 cm and above and was also found to be very useful for cutting lanes for plucking and spraying. In the former operation this machine will pay back its price by operating in 16.4 ha. Additionally, this model emerged as an effective and economic substitute for the manual chopping of prunings for spreading in fields.**

**The second model, KFS 1200, was found to be useful for skiffing at 75 cm and above and would repay its price by skiffing about 28.5 ha of tea.**

**In the context of increasing labour wages and frequent resort to light cut across and skiffing of tea in South India, a case was made out for the use of the two motorised mechanical pruning aids in tea culture.**

## Introduction

Pruning is an essential operation in tea, carried out once in 4 to 8 years depending upon the altitude at which the crop is grown, so as to keep the bushes in perpetual vegetative phase and at a manageable height for harvesting the foliage crop. Normally in South India, pruning of tea is undertaken during April to May and August to September, the two peak periods of utmost demand on labour requirement for various cultural operations in tea estates. Often, due to the shortage of labour, pruning continues into very wet months leading to delayed recovery. Also, with the increasing labour wages and fixed tasks the cost of the operation is escalating continually. Mechanisation of at least such operations as pruning, where there is a possibility, will help in overcoming the labour shortage and the entailing problems. Excepting in Japan, there is very little work done in this direction in the various tea growing regions of the world; Japan has developed some machines for pruning and skiffing. The performance and applicability of two motorised pruning/skiffing machines designed by M/s. Kobayashi Corporation and marketed by M/s. New Century Corporation, Tokyo, Japan, were investigated at the UPASI Tea Research Institute, Chinchona.

## MATERIALS AND METHODS

Two models of motorised pruning machines, model KPE, 700 and model KFS 1200, were tested for their operational efficiency to skiff/prune 6–year old clonal tea.

(a) *Model KPE* 700*:* This machine is 5.0 kg in weight, fitted with 2 cycle KT–12 engine on one side and is operated by one man; length of the pruning blade is 78 cm. The maximum power obtaining by the machine is 1.0 ps/6500 r.p.m.

(b) *Model KFS* 1200*:* This machine is 14.8 kg in weight, with a pruning blade of 120 cm long and has to be held by one man at each end and operated; the engine is of 2 cycle G3C type, with a maximum power of 1.5 ps/7500 r.p.m.

One litre of petrol runs each machine for 80 minutes.

The price of the first model is Rs. 5,000/– and the second Rs. 8,500/– and the life of the machines is taken as 1,000 h. for the purpose of calculating depreciation.

Model KPE 700 was found to be ineffective and inoperable below 75 cm of the bush height from ground level; it was tested to skiff tea at (i) 75 to 80 cm and (ii) 85 to 90 cm from the ground. The machine was also tested to cut the side branches of tea rows to form plucking and spraying lanes in tea fields. Model KFS 1200 was not effective below 65 cm and hence tried to cut across/skiff tea at (i) 65 to 75 cm and (ii) 75 to 80 cm. Traditional, manually cut across/skiffed bushes at different heights mentioned were maintained for the purpose of comparison. There were 30 bushes under each treatment.

## RESULTS AND DISCUSSION

(i) *Model KPE 700:* The operational efficiency of this machine is given in table 1.

**Table 1. Operational efficiency of the model KPE 700**

| *Ht. of skiff* | *Time taken to skiff 30 bushes* | *No. of bushes skiffed in one hr.* | *Time required to skiff 1 ha* | *Petrol consumption/ha. litres* |
|---|---|---|---|---|
| 75-80 cm | 2 min 7 sec | 850 | 12 hr | 9 |
| 85–90 cm | 1 min 25 sec | 1270 | 8 hr | 6 |

This model, when applied to skiff below 85 cm was found to damage the bark and resulted in jagged cuts. However, at 85 cm and above the machine has done a neat skiffing and is acceptable for light skiffing and also, to cut the plucking and spraying lanes. Recovery of the bushes from skiffing by this machine was camparable to that of manual skiffing.

Cost of skiffing one hectare at 85 to 90 cm with the model KPE 700 :

| | | *Rs. P.* |
|---|---|---|
| Wages of 2 workers @ Rs. 10/– per worker (time required – 8 hr.) | : | 20.00 |
| Cost of 6 l petrol @ Rs. 5/– per l | : | 30.00 |
| Depreciation for 8 hr. @ Rs. 5/– per hour | : | 40.00 |
| Contingencies | : | 5.00 |
| Total | : | 95.00 |

Cost of manual skiffing of 1 ha at 85–90 cm:

| | | |
|---|---|---|
| Wages of 40 workers @ Rs. 10/– (10,000 bushes at 250 bushes per worker) | : | 400.00 |
| Savings | : | 305.00 |

At a saving of Rs. 305/– per hectare, the machine pays for itself by pruning 16.4 ha of tea.

Cost of cutting lanes in alternate rows with KPE 700 in one hectare, for plucking and spraying :

| | | *Rs. P.* |
|---|---|---|
| Wage of 1 worker @ Rs. 10/–<br>(time required 4 hr. 20 min.) | : | 10.00 |
| Cost ot 3.2 1 petrol @ Rs. 5/– per 1. | : | 16.00 |
| Depreciation for 4 hr 20 min.<br>Rs. 5/– per hr. | : | 21.70 |
| Contingencies | : | 5.00 |
| Total | : | 52.70 |

Cost of cutting lanes manually:

| | | |
|---|---|---|
| Wages of 7.5 workers @ Rs. 10/– per worker | : | 75.00 |

At a saving of Rs. 22.30 per hectare, for cutting lanes, the machine pays back its price by operating in 224 ha.

In addition to its application for skiffing at 85 cm and above and cutting lanes, this model could be very effectively used to substitute chopping of the prunings to spread out in the field. A good job of chopping the prunings, manually, costs about Rs. 350/– per ha. Instead of employing labour to chop the prunings, this machine could be first applied to stiff the bushes at 85 cm or above, before actually resorting to a deeper and routine prune; the choppings thus obtained could be spread in the fields. Thus, an amount of Rs. 255/– could be saved on the chopping of prunings, which is an essential operation in tea after pruning.

(ii) *Model KFS* 1200*:* The operational efficiency of this model is given in table 2.

**Table 2. Operational efficiency of the model KFS 1200**

| *Ht. of skiff* | *Time taken to skiff 30 bushes* | *No. of bushes skiffed in 1 hr.* | *Time required to skiff 1 ha* | *Petrol consumption/ha litres* |
|---|---|---|---|---|
| 65–75 cm | 2 min. 34 sec. | 700 | 14 hr. 18 min | 10.7 |
| 75–80 cm | 2 min. 8 sec. | 844 | 12 hr. | 9.0 |

The bark was damaged, too many branches were split and the cuts were not neat when this machine was used to skiff the bushes below 75 cm from the ground level. It's performance at and above 75 cm from the ground was good and acceptable and the recovery from skiffing was comparable to that of manual skiffing.

Cost of skiffing one hectare at 75–80 cm with the model KFS 1200:

| | | Rs. P. |
|---|---|---|
| Wages of 5 workers @ Rs. 10/– per worker (2 shifts at 2 workers per shift) | : | 50.00 |
| Cost 9 l petrol @ Rs. 5/– per l | : | 45.00 |
| Depreciation for 12 hr. @ Rs. 8.50 per hr. | : | 102.00 |
| Contingencies | : | 5.00 |
| Total | : | 202.00 |

Cost of manual skiffing of 1 ha at 75–80 cm:

| | | Rs. P. |
|---|---|---|
| Wages of 50 workers @ Rs. 10/– (10,000 bushes at 200 bushes per worker) | : | 500.00 |
| Savings | : | 298.00 |

At a saving of Rs. 298/– per hectare this machine pays for itself by skiffing 28.5 ha.

With the increasing resort to the lighter forms of pruning like cut across and skiffing in tea in South India and, in the context of shortage of labour and escalating wages, these two mechanical pruning aids appear to have a positive place in tea culture in near future, if not immediately.

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# INDIGENOUS APPLICATOR FOR LIQUID FERTILIZERS

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## ABSTRACT

**The paper describes a simple applicator, developed by M/s. Indo-custom Fertilizers and Farm Services P. Ltd. with the help of Hassan Engineering College, for manuring with liquid fertilizers. The applicator is easy to carry in the Hilly terrain and the liquid fertilizer is fed to the injecting gun from a polythene tank which is carried on the back and fixed in position by shoulder belts. The liquid fertilizer is sucked initially by creating a partial vacuum in the position-cylinder assembly, with a consequent supply by the differential hydraulic pressure head and then injected into the soil through a nozzle by applying hydraulic pressure on the liquid by the piston. With this applicator, the fertilizer can be injected at the optimum depth. The volume of liquid injected per stroke can be changed by suitable adjustment of the caliberation locking clip. The results of experiments conducted to test the efficiency of fertilizers applied to soil by the applicator, as compared to traditional methods of broadcasting, broadcasting and dibbling in, or placement, showed their equal effectiveness in manuring of tea. Further developments required in the design and the choice of components are also discussed based on certain practical problems faced in the field.**

## INTRODUCTION

Liquid fertilizer is defined as the aqueous solution containing nutrients in the dissolved and/or suspended phase with no or low vapour pressure. The main advantages of liquid fertilizer formulations described by Hojer Pedersen (1972), Viswanathan (1979) and Veeraraghavan (1979) are (i) the energy requirements for production are far less than the solid fertilizer complexes, (ii) the solids which have poor physical conditions like nitrophosphates could be used, (iii) their composition is more homogenous and are free from caking and hygroscopicity, (iv) they lend themselves for incorporation of micronutrients, pesticides and herbicides whenever necessary and feasible, (v) they are agronomically as efficient as solid fertilizers, and (vi) under certain circumstances such as dry weather periods they are slightly superior to solid fertilizers mainly arising from the better distribution of nutrients achieved in the soil and from the consequent less injury to the seedling roots.

In Denmark, ammonia injection accounts for 45% of N consumption (Ansiaux, 1974). In U.S.A., the consumption of liquid fertilizers went up from 0.5 million tonnes in 1955 to about 13.63 million tonnes in 1976 registering an average growth rate of about 15% per annum (Veeraraghavan 1979) and this speaks of the gaining popularity of the liquid fertilizers. In our country, the limiting factor is the lack of technological advances in the transportation, handling and distribution of these fertilizers as well as in the development of suitable appliactors. As early as 1957 a simple equipment for ammonia injection, which could be mounted on bullock cart or hand pulled wheeled chassis, was developed by Mysore Agricultural College (Govinda Rajan and Venkata Rao 1957). However there was no follow up work, probably due to lack of suitable tanks for filling ammonia. The general awakening on this subject could be evidenced by the fact that one full session was spent on liquid fertilizer in a recent group discussion organised by the Fertilizer Association of India (Logistics of Fertilizer distribution—A group discussion, October 1979, Madras). In tea, which is grown in hilly terrain, the applicator developed for hooking to tractors or bullock carts could not be used. This paper deals with the simple applicator developed by M/s. Indo Customs Private Limited, Mahe with the help of Hassan Engineering College for applying liquid fertilizer into the soil under pressure which prevents clogging of nozzles.

## MATERIALS AND METHODS

The working of the applicator and the experiments carried out with it are described below :

*Principle :* This device works on the mechanism that the liquid fertilizer from the tank is sucked initially by creating a partial vacuum in the piston-cylinder assembly, with a consequent supply by differential hydraulic pressure head and gravity flow, and then injected into the soil through a nozzle by applying hydraulic pressure on the liquid by the piston.

*Description :* The injecting gun (Fig. 1) consists of mainly tank, spring loaded injecting foot rest, reciprocative pump, injecting lance and nozzle. The tank, made of plastic, is about 20 l capacity and is light and corrosion resistant. It has adjustable shoulder straps for convenient mounting over the shoulder. The lid of the tank, coupled with a valve to allow air in and a long strainer, is leak proof and air tight. The injector is about 1 m height, including that of injector lance and nozzle of about 0.21 m, and weighs about 5 kg. The indispensable part of the applicator is the pump in which the piston moves up and down. The plunger tube of the piston, connected with the strainer of the

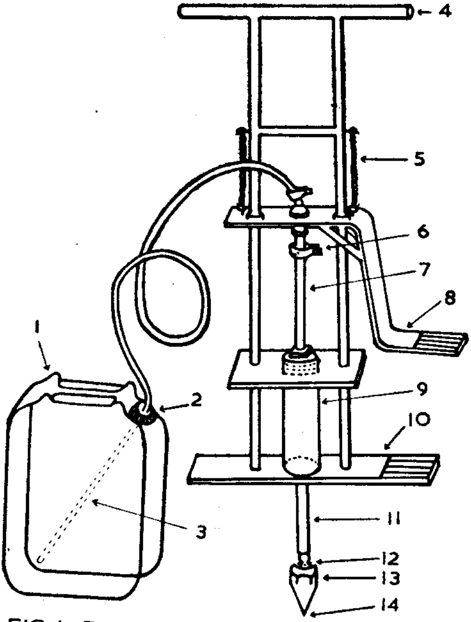

FIG.1. FERTILIZER APPLICATOR

(Figure 1)

1. Tank
2. Lid with valve
3. Strainer
4. Handle
5. Spring
6. Calibration locking clip
7. Plunger tube
8. Injection foot rest-spring loaded
9. Piston pump assembly
10. Thrust foot rest-fixed
11. Lance (Extension tube)
12. Feed nozzle
13. Nozzle head
14. Pointed nozzle top

tank through plastic or nylon tubing, is fixed firmly with the movable spring loaded injection foot rest assembly. The plunger cup is fitted with a moulded rubber and a rubber washer to function as a piston and a ball valve to prevent back flow during the pressure stroke of the pump. This is a positive displacement plunger pump having a provision for displacing a definite volume of liquid in each stroke. The plunger tube, also, carries a strong movable metal clip, the position of which determines the height of displacement in the pump. In other words, it serves for the purpose of ejecting out a constant volume of the solution from the pump. The lance, replaceable type, from the piston pump is connected to the male nozzle of the injector. The top portion of the nozzle above the feeding holes, is fitted with a spring loaded ball valve (Fig. 2) which opens when hydraulic pressure is applied from the pump.

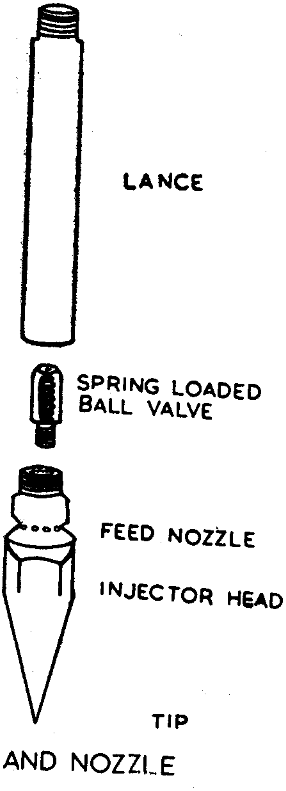

FIG.2. LANCE AND NOZZLE

(Figure 2)

*Operation :* This is a manually operated injecting gun suitable for liquid fertilizer application at the desired depth level into the soil. The tank, containing the liquid fertilizer, can be fitted over the shoulder by properly fixing the shoulder belts. The hand carried injecting gun, weighing about 5 kg, is then inserted into the soil near the plant at an angle. If the field is a hilly terrain, injecting above the plant within the drip circle seems suitable. Since this applicator is fairly heavy, it pierces into the soil with great ease like a "crow bar", to the desired depth. When the soil is hard and dry, the lance may not reach its full depth, and therefore, under these conditions, the desired depth can be achieved by pressing the thrust footrest against the soil till it touches the soil surface. Once the lance and the nozzle reaches the desired depth level, it is ready for injecting the liquid fertilizer. While starting the pump, lance and rubber tubing are filled with air and, therefore, this is released by pressing and releasing the spring loaded injecting foot rest with right or left leg. Every downward stroke (pressure stroke) of the pump releases part of air, and the return stroke creates a partial vacuum in the pump. This is achieved by the two valves, one at the nozzle opens only during the pressure stroke and the other at the plunger cup opens during the return stroke. The return stroke does not require any effort as it is automatically done by the spring action. Successive operation for a few times create vacuum in the pump sufficient enough to draw liquid from the tank to the pump. Afterwards, the flow of liquid from the tank is mainly by differential hydraulic pressure head/gravity flow. The liquid in the pump ready for injection can then be injected by pressing down the injecting footrest. During this pressure stroke, hydraulic pressure is developed on the liquid and the valve in the nozzle is opened, as a result of which the fertilizer solution is ejected from the nozzle to the soil. This operation is repeated to make two or more injections per plant as desired and continued.

Two other facilities of the gun are (i) the liquid fertilizer can be injected at any desired depth level by suitably replacing the lance of required length (ii) the voume of liquid required to be injected per stroke can be achieved by suitably adjusting the position of the calibration locking clip.

*Field experiments*: Two field experiments, one each in young and mature tea were carried out to test the efficiency of liquid fertilizers. The flux of available nutrients and nitrogen fractions following the application was also studied by the methods discussed by Ranganathan (1977, 1978). Details on the cost of application and other difficulties faced in the field on the use of applicator were also gathered.

## RESULTS AND DISCUSSION

### Agronomic efficiency of liquid fertilizers

*Young tea*: In Young tea, the injection of liquid fertilizers, NPK and NK, was found to be as efficient as application of solid fertilizers according to the present recommended practices, i.e., P to be placed as rock phosphate once a year and NK 40:60 mixture to be broadcast 5 to 6 times in a year (Ranganathan 1979).

The yield levels attained and the growth measurements of collar recorded in young tea under different methods of application are given in table 1.

The attainment of yield levels and thickening of collar of young tea under different treatments suggest that the injection of NPK or NK liquid fertilizer is agronomically as efficient as solid fertilizers applied according to the recommended practices.

*Mature tea:* In mature tea, the liquid fertilizer was tried in the post-monsoon period of 1977 in the fourth year field of clone UPASI–9 (B/6/61), 1963 planted. The flux of available nutrients in the soil for 70 days following the application are shown in table 2.

From table 2, it could be seen that there are practically no differences in the trends of fluctuation of available NPK contents between liquid NK fertilizer based on aqueous ammonia and solid fertilizers based on sulphate of ammonia and urea. Theoretically, there is a likelihood of more leaching of potassium with liquid ammonia based formulations; but this did not happen in the experiment conducted, probably due to the extreme acidity of tea soils.

**Table 1. Efficiency of liquid fertilizer application in young tea**

Clone : UPASI–10 (B/6/62)
Date of planting : July 1977
Spacing : 150 cm x 75 x cm 75 cm N :P :K
Fertilizers applied : 1st year : 120:90:90 in 4 splits
2nd year : 240:90:180 in 5 splits
3rd year : 300:80:225 in 6 splits

| *Treatment* | *Made Tea kg/ha* | | | *Average girth (cm) at the end of* | | |
|---|---|---|---|---|---|---|
| | *Second year* | *Third year* | *Total* | *First year* | *Second year* | *Third year* |
| NPK Liquid Injection | 201a | 974a | 1175 | 0.81a | 1.83a | 3.63a |
| NK: Liquid injection + P: Placement | 196a | 906a | 1102 | 0.01b | 1.99a | 3.689 |
| NK: Broadcast + P: Placement | 205a | 969a | 1174 | 0.82a | 1.91a | 3.66a |
| C.D. at P — 0.05 | 29 | 108 | | 0.03 | 0.18 | 0.24 |

**Table 2. Fluctuations in soil available nutrient (ppm) status**

Date of starting : 2nd September 1977

Fertilizer application : 60:30 N:$K_2O$ kg/ha

| *Treatments* | *Before application* | | | *0–7 days* | | | *8–23 days* | | | *24–39 days* | | | *40–70 days* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *N* | *P* | *K* | *N* | *P* | *K* | *N* | *P* | *K* | *N* | *P* | *K* | *N* | *P* | *K* |
| Ammonium sulphate | 18 | 13 | 35 | 23 | 7 | 88 | 20 | 6 | 85 | 20 | 3 | 105 | 13 | 5 | 91 |
| Urea | 15 | 63 | 55 | 24 | 7 | 78 | 13 | 3 | 70 | 20 | 5 | 85 | 10 | 19 | 84 |
| Liquid fertilizer* | 16 | 13 | 50 | 20 | 2 | 80 | 10 | 5 | 70 | 18 | 12 | 108 | 28 | 5 | 98 |
| Control (No N) | 13 | 11 | 65 | 16 | 2 | 95 | 11 | 4 | 75 | 17 | 12 | 110 | 12 | 6 | 90 |
| Cumulative rainfall in cm | – | | | 17.4 | | | 29.2 | | | 53.0 | | | 95.7 | | |

* aqueous ammonia based.

The fluctuations observed in nitrogen fractions are shown in Table 3.

Liquid fertilizer based on aqueous ammonia is able to maintain nitrogen availability on similar pattern as observed with solid fertilizers based on sulphate of ammonia and urea. Only nitrate content was lower in liquid fertilizer plots than that compared to sulphate of ammonia and urea plots. After a spell of continuous wet conditions for 24 days, there was a tendency for nitrite to accumulate in the soil. Even under these conditions, the nitrite accumulation was considerably lower with liquid ammonia formulation and sulphate of ammonia than with urea.

The comparative leaf analysis and yield data are given in Table 4.

Practically, the differences between treatments, as far as yield data are concerned, are not statistically significant. However, the liquid ammonia formulation is less efficient than the other sources in wet period; but it is slightly superior to others in the dry period. The increase in dry weather crop may be due to better distribution of fertilizer in the lower horizon of soil profile which are moist and hence are explored by the roots during that period. Such an advantage due to the injection of liquid fertilizers on dry spring seasons was observed in Danish experiments (Hoger Pedersen 1972). A better utilization of potassium when applied as NK liquid fertilizers is indicated by the results of leaf analysis.

The experimental results described above prove the agronomically equal effectiveness of liquid fertilizers injected to soil compared to traditional solid fertilizer mixtures. Several such reports on other crops have also been published time and again (Patel 1976, Ghosh 1959, Hoger Pedersen 1972).

*Survey data:* The four groups of estates have experimented with liquid fertilizers on large acreage ranging from 20 to 100 ha. All of them were satisfied with the agronomic efficiency of liquid fertilizers and also agreed on its usefulness for giving one more additional fertilizer application in November/December. They also expressed the feasibility of using liquid fertilizers on a much larger scale provided that the leakage problem discussed elsewhere in this paper is solved satisfactorily.

**Table 3. Fluctuations in different nitrogen fractions (ppm) in soil following fertilizer application**

Date of starting : 2nd September, 1977

Fertilizer application : 60:30 N:$K_2O$ kg/ha

| *Treatments* | *Before application* | | | 0–7 *days* | | | 8–23 *days* | | | 24–39 *days* | | | 40–70 *days* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $NH_4^+$ | $NO_3^-$ | $NO_2^-$ | $NH_4^+$ | $NO_3^-$ | $NO_2^-$ | $NH_4^+$ | $NO_3^-$ | $NO_2^-$ | $NH_4^+$ | $NO_3^-$ | $NO_2^+$ | $NH_4^-$ | $NO_3^-$ | $NO_2^-$ |
| Ammonium Sulphate | 14 | 4 | 0.02 | 19 | 4 | 0.06 | 11 | 9 | 0.04 | 16 | 4 | 0.14 | 6 | 7 | 0.09 |
| Urea | 11 | 4 | 0.03 | 24 | 4 | 0.08 | 8 | 5 | 0.02 | 13 | 7 | 0.24 | 5 | 5 | 0.15 |
| Liquid fertilizer* | 13 | 3 | 0.06 | 17 | 3 | 0.02 | 6 | 4 | 0.02 | 13 | 5 | 0.12 | 23 | 5 | 0.10 |
| Control (No N) | 10 | 3 | 0.06 | 13 | 3 | 0.04 | 7 | 4 | 0.02 | 12 | 5 | 0.12 | 7 | 5 | 0.14 |
| Cumulative rainfall in cm. | | — | | | 17.4 | | | 29.2 | | | 53.0 | | | 59.7 | |

* aqueous ammonia based.

**Table 4. Yield data and leaf composition of mature tea**

Data of starting : 2nd September, 1977
Fertilizer application : 60:30 N:$K_2O$ kg/ha

| *Treatment* | *Made tea kg/ha* | | | *percent yield* | | | *Average leaf composition for the period Sept/March (as %)* | | | *Moisture* |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Sept–Dec.* | *Jan–March* | *Total* | *Sept–Dec.* | *Jan–March* | *Total* | *N* | *P* | *K* | |
| Ammonium sulphate | 1956b | 792b | 2748b | 100b | 100b | 100b | 4.25 | 0.67 | 1.95 | 78.3 |
| Urea | 1868ab | 785b | 2653b | 95ab | 99b | 97b | 4.23 | 0.68 | 1.90 | 78.3 |
| Liquid fertilizer* | 1780ab | 810b | 2590b | 91ab | 102b | 94b | 4.02 | 0.70 | 2.05 | 78.0 |
| Control (No N) | 1439a | 619a | 2058a | 74a | 78a | 75a | 3.85 | 0.74 | 2.02 | 77.8 |
| C.D. at P = 0.05 | 487 | 145 | 458 | 25 | 18 | 17 | — | — | — | — |

* aqueous ammonia based.

*Cost of application:* The normal task for application of fertilizers in tea fields is about 2 to 3 labourers/ha for broadcasting, 4 to 6 labourers/ha for broadcasting and dibbling in and 8 to 10 labourers for placing the fertilizer at 15–25 cm depth in crow-bar holes. The operation of injecting fertilizers with the applicator under study requires about 5 to 6 labourers/ha, which is in between broadcasting and placement methods of solid fertilizer application. In young tea, where one placement application for P and 4 to 6 broadcast and dibbling in applications for NK fertilizers are recommended, there is practically no increase in cost of application. But in mature tea, where only broadcasting of NK fertilizers is recommended, there may be an increase in cost of application to the tune of Rs.30/– to 50/– per application. However, the cost of fertilizers will be very much lower when liquid ammonia, which is the cheapest form of nitrogen, is used. Assuming the unit weight of nitrogen in liquid ammonia to be around Rs.2/– per kg, the saving for a NK 60:30 mixture would be around Rs.238/– compared to sulphate of ammonia based mixture and Rs. 50/– to urea based mixture. Additionally, as the energy requirements for liquid fertilizer manufacture is very much lower than that for solid fertilizers, there could be a substantial saving in cost when direct manufacture of large quantities of liquid formulations are undertaken in the country which will more than offset the increase in cost of application.

One more advantage in tea with the liquid fertilizers is that one more application of fertilizers can be given after November/ December in south-west monsoon zones and two more applications one in January/February and another July/August in north-east monsoon zones.

*Operational problems:* There is no difficulty in injecting the liquid fertilizer into the soil and there is no clogging of nozzles. However, it is found to be difficult to carry the tank through 3rd or 4th year fields, but this could be managed to some extent by cutting plucking lanes. The major problem is the leakage. Any leak in the tank or in the lance is harmful in as much as the ammonia which comes in contact with the skin causes rashes and burns. This could be overcome to some extent by supplying with overcoats and hand gloves, but if the leak is appreciable these precautionary measures may fail. The best thing is to improve the construction materials for leak proof joints. Secondly, leaks occur in the pump part when the washers wear out or the pistons and other metal parts are corroded by the use of acidic or alkaline fertilizers. It is reported that at 20 and 40°C, even the steel is corroded at a rate of 0.015 to 0.05 g/m$^2$/hr in liquid NP and NPK fertilizers. The presence of nitrite ions reduces the corrosion to 0.001 g/m$^2$/hr (*Soils and Fert.* Abstract : **38**(7), Abstract No. 2095 (1975)), but this will not solve the problem as nitrite is phytotoxic. Therefore, the choice of materials for making different components of pump part is quite essential. With leaks, lot of ammonia escapes which chokes the whole area within a short time. This is one of the major complaints made by the estates who have used and tested the liquid fertilizers on field scale. Another problem encountered in high elevation estates is the precipitation/crystalization of fertilizers on long storage due to low temperature. Anti-precipitant/anticoagulant chemicals should, therefore, be added to keep them in solution/suspension. One other modification contemplated to overcome this problem is to have two compartments separately in the tank for N and K and two pumps, instead of one, which will alternatively operate and inject N and K separately in two strokes at the same point. The problems which are faced in the field only are discussed and other problems pertaining to transport, handling and distribution are left to the fertilizer industry which is more competent to solve them.

## ACKNOWLEDGEMENTS

Our thanks are to M/s. Indo Customs Private Limited, Mahe for making available the applicator and liquid fertilizer formulations for our tests. Our thanks are also due to estate managers, who had done large scale field tests, for their free discussions with us on their experience with the use of liquid fertilizers.

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# A MANUALLY OPERATED ARECANUT HUSKER

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## ABSTRACT

**An arecanut husker to husk dry arecanuts has been developed. The operation of husker is done by leg and feeding of nuts by hand. The husker performs the function of loosening the husk which is easily peeled off by hand. An unskilled labourer in a day (8 hours) can make about 40 kg husked nuts.**

## INTRODUCTION

Arecanut, one of the important commercial crops of South India plays a prominent role in the religious, social and cultural life of people. It is cultivated in 1.93 lakh ha. distributed over South and North Eastern India and accounts to about two-thirds of world arecanut production. The total production is estimated to be 1.66 lakh tones, of which two-third is processed as ripe nuts and about one-third as tender nuts. The two processes are illustrated in Fig. 1. While the husking of nuts is done immediately after harvest in the case of tender nut processing, the same is done after drying in the case of ripe nut processing. The husking of dry nuts is presently carried out by skilled persons with the help of a country tool (Fig. 2). The turnout varies from 40 to 100 kg. per day (8 hours) depending on the efficiency of the skilled labourer. In other words, the present method of husking operation is highly skilled and prone to injuries. The device described here can be used by an unskilled labourer for husking dry nuts.

The dried arecanut of commercially grown varieties is generally oval or oblong in shape. The portion of husk above the nut (chali) and towards peduncle is the most soft portion the of husk in the nut. The weakest point in the husk lies just above the nut (chali) towards peduncle. If a husking tool is used at this point it will require least force for husking.

TENDER NUT
↓
Dehusking — GREEN HUSK
↓
IMMATURE NUT Whole nut
↓
Slicing
↓
Boiling
↓
Colouring
↓
Drying

RIPE NUT
↓
Drying
↓
Dehusking → DRY HUSK
↓
Dry Nut
↓
Grading
↓
Storage
↓
Cutting/Slicing

Fig. 1. Flow diagram of arecanut processing.

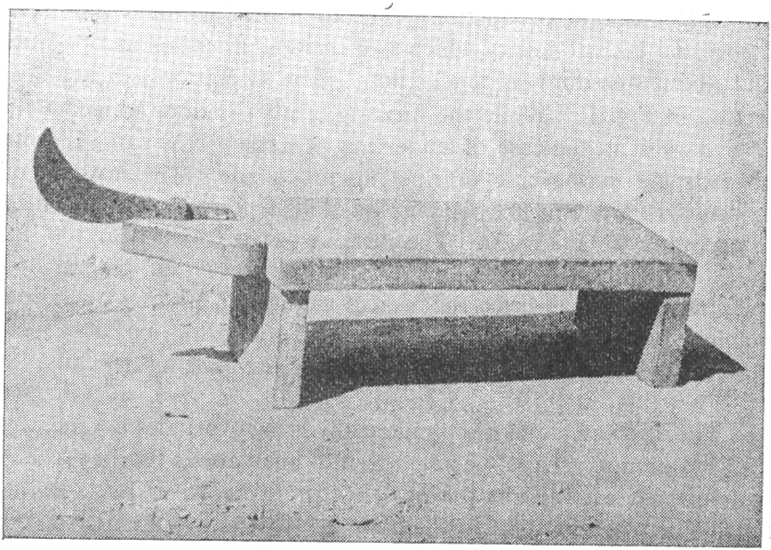


Fig. 2. Country husking tool

The cross section of tender nut and dried nut are shown in Fig. 3.

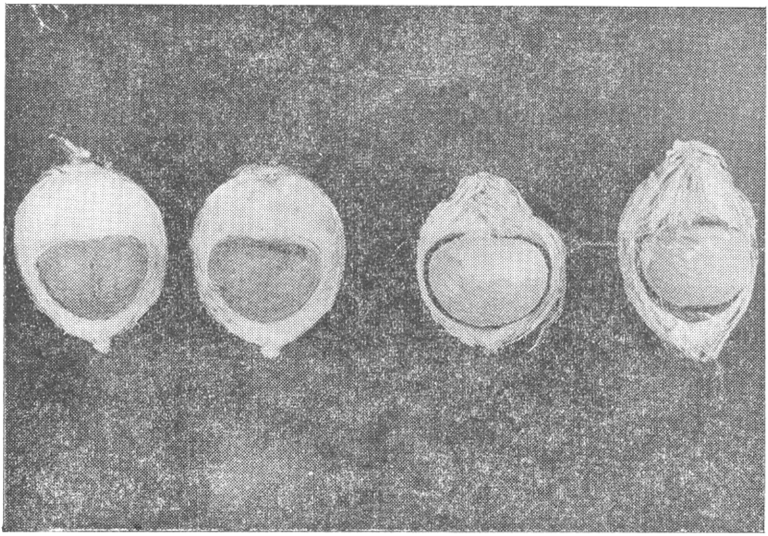


Fig. 3. Cross section of tender and dried arecanuts

## Work done

No published work on the development of a husker for dry arecanuts is available excepting two patents taken on arecanut husking/shelling machine (Patent No. 92C(I)3 Oct. 1973 and personal communication). However, the patented machinery on arecanut husking/shelling is not in use or available in the market.

## The design

In India most of the arecanut growers have small holdings. An average land holder having 1 ha. under cultivation with intensive management practices may harvest abouut 2,000 kg. of arecanut per annum. The machine which does not need mechanical or electrical power is designed for use even by such a small areca growers.

There can be two types of mechanisms for husking arecanut viz. (1) a mechanism by which the husk is loosened by way of rubbing and crushing or (2) the husk is made to split into two halves. In the present design the first mechanism was considered and made use of with a veiw to increase out turn.

## Components of the model

Each component of the areca husker is discussed here.

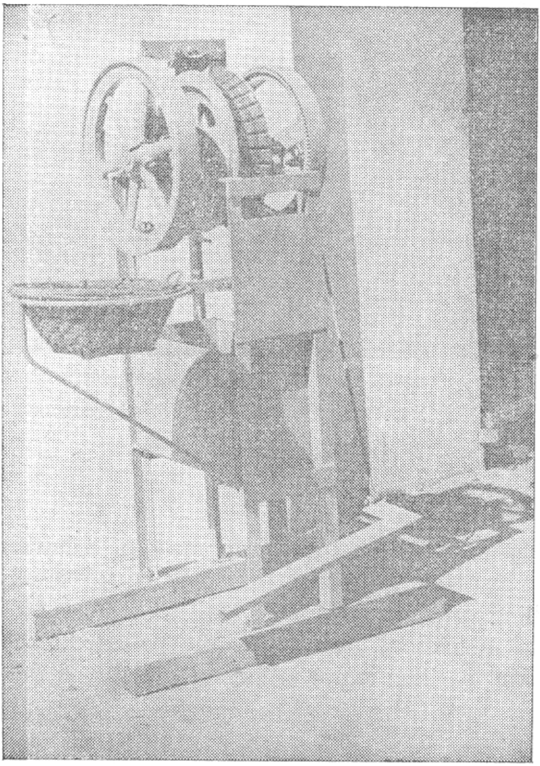
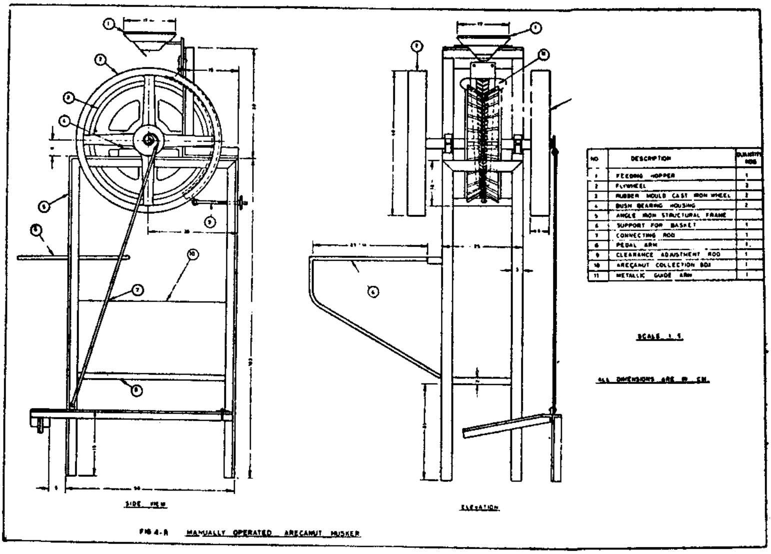


Fig. 4a. Arecanut husker

### *Pedal mechanism*

The pedal mechanism has been adopted to run the husker as a source of power, for the convenience of the operator. Moderate operations results in an opproximate speed of 125 rpm.



| NO | DESCRIPTION | QUANTITY NOS |
|---|---|---|
| 1 | FEEDING HOPPER | 1 |
| 2 | FLYWHEEL | 2 |
| 3 | RUBBER MOULD CAST IRON WHEEL | 2 |
| 4 | BUSH BEARING HOUSING | 2 |
| 5 | ANGLE IRON STRUCTURAL FRAME | |
| 6 | SUPPORT FOR BASKET | 1 |
| 7 | CONNECTING ROD | 1 |
| 8 | PEDAL ARM | 1. |
| 9 | CLEARANCE ADJUSTMENT ROD | 1 |
| 10 | ARECANUT COLLECTION BOX | 1 |
| 11 | METALLIC GUIDE ARM | 1 |

Fig. 4b. Components of arecanut husker

*Fly wheels*

Two fly-wheels each of 45 cm diameter and 25 kg. weight are employed in the husker and are mounted on the main shaft. The wheels keep the machine and main shaft balanced and store adequate energy for husking the nut when fed. With this operation the husker becomes easy and smooth.

*Rubber-mould cast iron wheels*

Two cast iron wheels of 35 cm diameter and 5 cm. width at periphery are rubber moulded with 2cm. thick rubber. The rubber mould reduces scratching and breaking of nuts and helps in easy operation of husker.

*Metallic guide arms*

The metallic guide arms which help in crushing and shearing of the nut husk is fixed in the back half of rubber-mould cast iron wheels. The arm is provided with hard steel teeth both sides join in a sharp edge in the centre. The angled teeth and sharp edge in the centre makes the crushing and shearing action more effective. The arm is attached to a clearance adjustment rod for use with various sizes of nuts. The rod is spring loaded which provides minor adjustments of clearance while nut is passing through the metallic arm and cast iron rubber-mould wheels.

*The Grader*

The nuts vary in size (length 4.0 to 6.3 cm. and width 2.2 to 4.3 cm.) as shown in Table–1. To avoid breakage and scratching of nuts (chali) the clearnace between metallic guide arm and rubber-mould cast iron wheels is adjusted for small range of size. Grading of unhusked nuts is done by this grader (Fig. 5) by allowing the nuts to fall from higher end. The nuts that fall are grouped in three different sizes of 2.2 to 4.0, 4.1 to 5.0 and 5.1 to 7.5 cm.

**Table 1. Size of dry arecanuts (sample size 100 nuts)**

| *Dimension* | *Range* | *Mean* |
|---|---|---|
| Length | 4.0 to 6.3 cm. | 5.1 cm. |
| Width | 2.2 to 4.3 cm. | 3.2 cm. |

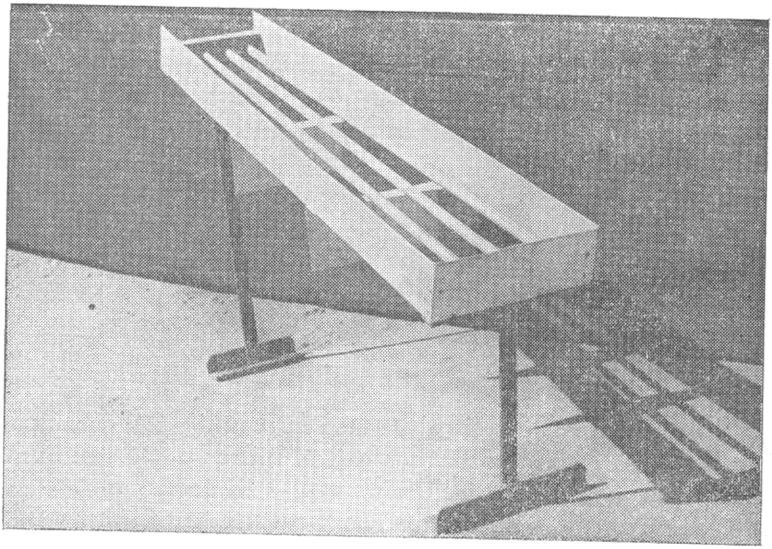


Fig. 5. Arecanut grader

## Operation

The husker works by operation of pedal mechanism which rotates the fly wheels towards metallic guide-arm. When the wheels pick up momentum (in about 5 seconds) the feeding of unhusked nuts start. The operator takes the nuts from basket by the left hand and exchanges it to right hand and then feeds into the feeding hopper. The nuts are fed one after the other only after the earlier one has came out. The operator thus could feed approximately 8 kg. of nuts in about 20 minutes. The loosened husk of nuts from the collection box could then be peeled off by hand while resting. Peeling of the husk of the above 8 kg. nuts take about 20 minutes during which process the operator gets also some rest. Only 80% nuts could thus be peeled in the first attempt. The balance of 20% nuts are fed again with the next set of nuts as it would other wise be difficult for hand pealing.

By employing two persons, operation of the husker and peeling could be done faster and simultaneous for the advantage.

## RESULTS AND DISCUSSION

Test trials were conducted with the husker with one and two persons separately for 6 hours of daily operation. The data is presented in Table 2. It is seen from this table that the time required for grading 100 kg. unhusked arecanut by a single person is about 60 minutes and that for two persons it is only 40 minutes. Similarly one man operating the husker for 6 hours could husk 41 kg of husked nuts whereas the out turn increased to 92 kg with two persons, working for the same period. Again, one man in a day (6 hrs.) could completely husk (grading and husking) on an average 36 kg. (husked nuts) where as two could husk 87 kg. It is seen that if two persons work jointly the operation becomes faster and less tiring.

At the end of operation 5% nuts were found to be broken ones, of which about, 4% were infested nuts called Patcha or Dagi Patcha (Table–3).

The husker when operated normally runs at a speed of 125 rpm. during the actual operation. This safe and simple machine for husking arecanut could also be motorised, if necessary.

**Table 2. Observations on testing of the dehusker**

| *No. of persons* | *Time required for grading 100 kg. un husked* | *Out put per day (6 hrs.) (husking operation only Kg.* | *Out put per day (6 hrs.) (grading and husking) Kgs.* | *Average* |
|---|---|---|---|---|
| One | 60 min. | 40 | 35 | 36 |
| One | 60 min | 42 | 37 | |
| Two | 40 min. | 90 | 84 | 87 |
| Two | 40 min. | 94 | 90 | |

**Table 3. Percent breakage of nuts (random sample size) 100 unhusked nuts**

| *Sample* | *Broken (infested nuts)* | *Broken (good nuts)* |
|---|---|---|
| I | 4 | 1 |
| II | 5 | 1 |
| III | 3 | 2 |

## ACKNOWLEDGEMENTS

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# CARBONATED BOTTLED TEA BEVERAGE

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## ABSTRACT

**Technological methods have been evolved to avoid creaming down problem in tea brew. A ready-to-serve beverage based on tea has been formulated using black tea brew, flavouring agents, sugar, preservatives and carbon-dioxide. Storage trial for 10 months in a refrigerator (at 8–10°C), incubator (at 37°C) and shelf (at room temperature, 20–25°C)was carried out to find out the shelflife of the product. The product did not show any significant change in taste, colour, flavour, $CO_2$ volume, brix and pH even after storage for 10 months at any of the above temperature regimes.**

## CARBONATED BOTTLE TEA BEVERAGE

Tea is a pleasant and mildly stimulating beverage because of its excellent flavour and healthful effects on the human body due to its nutritional and therapeutic value (Stagg and Millin, 1975). Besides black tea, there are three other types of tea, namely, green, oolong and instant teas which are commercially available. Black Teas are available in the form of tea bags as well. Popularity gained by instant teas soluble in cold water is much more than that of hot water soluble instant teas, because it is iced tea which is the real basis for the success of instant teas in some Western countries (Wickremasinghe, 1978). However, ready-to-serve tea beverages in bottles are not commercially available to consumers unlike some of the popular fruit as well as cola based nonalcoholic carbonated beverages.

To prepare carbonated tea beverages, certain technological problems have got to be overcome. The major problems that are considered vital during bottling of tea brew are of two types, namely, "cream" formation and flavour retention (Natarajan, *et al.* 1975 and Ramaswamy, 1976). While attempting to overcome the problem of creaming down in tea brew, flavour retention was not easily possible. Keeping these points in view, efforts were made to evolve technological improvements to avoid creaming down problems in tea brew at the same time developing a ready to serve beverage based on various tea containing flavours.

The methodology adopted for the stabilization of the tea brew is kept confidential in view of trade interests.

The carbonated tea beverage is composed of stabilized tea brew, a sweetening, agent, acid, flavour, preservative and carbondioxide. To make this beverage appealing and refreshing, the ingredients used were of superior quality at propr concentrations.

The use of sucrose in the production of bottled tea is of great concern from the point of view of its nutritional as well as beverage-stabilizing properties. To make low-calorie tea-based cola type beverage, artificial sweetening agents like cyclamate, saccharin and their blends can also be used. It has been reported that tea can be sweetened to the conventional sweetness level, achieving good sweetness quality with fructose-saccharin and xylitol-saccharin mixtures (Hyvonen et al. 1978a and 1978b).

In this study it was found that pineapple, ginger, cardamom and cola flavours had better compatibility with the stabilised tea brew than the other flavouring agents tried.

Since tea has high antimicrobial effect related to the bactericidal and bacteriostatic effects of catechins (Bokuchava and Skobeleva, 1969), it was considered essential to inhibit the growth of yeasts and moulds, if any, with the help of sorbic acid (Sand, 1977). However, the Prevention of Food Adulteration Act (No. 37 of 1954) has permitted the use of only sulphur dioxide or benzoic acid as preservatives in sweetened ready-to-serve beverages and hence sorbic acid may have to be replaced by benzoic acid.

The beverage was prepared by the premix process wherein measured amounts of the formulated tea brew were placed in sterilized bottles, carbonated and then hermatically sealed with crown corks.

Storage trial for ten months in a refrigerator (8 – 10°C), incubator (37°C) and shelf (20–25°C) did not show any appreciable change in taste, colour, flavour, total solids and pH, as determined by standard procedures.

The carbonated bottled tea beverage developed by UPASI has a great consumer acceptability and it was reported on very favourably by all those who tasted it blind. It is now in the stage of test marketing for full commercial exploitation.

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# MARKETING AND DEVELOPMENT

## (Session V)

*Chairman* : **S.S. Meenakshi Sundaram**

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# DEVELOPMENT OF CASHEW DURING SIXTH PLAN

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## ABSTRACT

**Against the processing capacity of about 5 lakh metric tonnes of raw nuts in the organised sector of the cashew industry, the present production of rawnuts is estimated at about 1.8 lakh metric tonnes. In recent years the maximum quantity of exports of cashew kernels in any one year was little over 66000 metric tonnes. In order to maintain this level of exports and to meet the internal requirement of about 10000 metric tonnes of cashew kernels we may require about 3 lakh metric tonnes of raw nuts. Thus the gap of 1.2 lakh metric tonnes is sought to be bridged immediately.**

**The VI Plan proposals have been drawn up with the dual objective of achieving the production target of 3 lakh metric tonnes by the end of the Plan period and with the long term objective of achieving self-sufficiency with an annual production of 5 lakh metric tonnes of raw nuts by the mid 90s.**

## INTRODUCTION

The total production of raw cashewnut in India during 1979–'80 has been estimated at 1.28 lakh M.T. as can be seen from table-I. The table shows an increasing trend till 1976–77 when the country had a record production of 1.82 lakh tonnes. Since then the production has decreased. In 1977–78 the country's production was 1.43 lakh tonnes which further came down to 1.29 lakh tonnes in 1978–'79 and 1.28 lakh tonnes in 1979–'80. India is the largest exporter of cashew kernels. There was a period when India could contribute to the world market over 95% of the total world requirement of cashew kernels, the percentage of which was slightly but steadily gliding down and India's share of exports has come down to below 50% now.

All along, our industry was depending on the imported nuts mainly from East African countries. The higher exports in the earlier years were facilitated because of import of rawnut in sufficient quantities from countries like Tanzania, Mozambique and

Table 1. Area and Production of Cashewnut in India—1974–75 to 1979–80

*A — Area* *P — Production*

| | 1974—75 | | 1975—76 | | 1976—77 | | 1977—78 | | 1978—79 | | 1979—80 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | P | A | P | A | P | A | P | A | P | A | P |
| Andhra Pradesh | 31300 | 12800 | 31000 | 12600 | 32400 | 12500 | 31113 | 9400 | 38211 | 7600 | 38211 | 7600 |
| Kerala | 108220 | 117890 | 109187 | 119211 | 118139 | 129020 | 122735 | 92151 | 149135 | 84586 | 147278 | 83902 |
| Karnataka | 34236 | 14290 | 35658 | 15249 | 36534 | 15175 | 35975 | 15666 | 38925 | 12107 | 38925 | 12107 |
| Maharashtra | 33452 | 4216 | 33452 | 4214 | 30024 | 4258 | 30024 | 4258 | 30024 | 4258 | 30024 | 4258 |
| Orissa | 13390 | 3912 | 13390 | 3912 | 13390 | 3906 | 13638 | 4027 | 13710 | 4343 | 38830 | 320 |
| Tamil Nadu | 91780 | 8700 | 96760 | 10480 | 92360 | 10150 | 92090 | 10240 | 91780 | 9960 | 94770 | 10410 |
| Goa | 32517 | 6500 | 32476 | 7019 | 39317 | 6500 | 39300 | 6500 | 41600 | 6118 | 41600 | 6118 |
| Pondicherry | 319 | 158 | 320 | 138 | 322 | 166 | 329 | 205 | 343 | 205 | 363 | 217 |
| Tripura | 555 | 2 | 565 | 2 | 565 | 8 | 565 | 6 | 565 | 14 | 951 | 49 |
| West Bengal | 4600 | 10 | 4600 | 10 | 4600 | 10 | 4600 | 190 | 3498 | 221 | 6698 | 2807 |
| TOTAL : | 350369 | 168478 | 357448 | 173006 | 367651 | 181693 | 370369 | 142643 | 398791 | 129412 | 437650 | 127788 |

Kenya. As these countries have themselves started processing their produce, our main supply source began drying up. Added to these was the considerable fall in global production of rawnut. India used to import more than 1.5 lakh tonnes in Sixties and early Seventies. India could import a maximum quantity of 1.98 lakh M.T. in the year 1972–'73. This year the import is not likely to exceed 15,000 M.T. In recent years the maximum quantity of export of cashew kernels in any one year was a little over 66,000 M.T. In order to maintain at least this level of export as well as to meet the internal requirement which is roughly estimated at 10,000 M.T. of kernels, we may require about 3 lakh M.T. of rawnuts even though the processing capacity in the organised sector is of the order of about 4.5 lakh tonnes.

The efforts made in the past did increase the area under cashew but did not reflect significantly on production due to various reasons. A large percentage of older trees have become outlived and had been heavily damaged by pest attack especially by stem-borer. Felling of many bearing trees have also contributed to lesser production. The area expansion programmes implemented during the earlier Plan periods are yet to bear economic yield.

Our immediate objective, therefore, is to achieve a production target of 3 lakh M.T. Accordingly, the following programmes have been proposed for cashew development during the Sixth Five Year Plan for implementation as centrally sponsored schemes in all the important cashew growing states.

### Scheme for laying out demonstration plots for improved practices in growers' orchards

This is a continuing scheme. The scheme has the objective to educate and convince the growers about the need for scientific management practices for cashew trees. This objective is to be achieved by laying out a series of demonstration plots in growers' orchards and in such places, all the management practices such as fertilising the trees with recommended doses of fertilisers and timely prophylactic plant protection measures will be adopted with a view to prove that such practices would help increase productivity. Each plot will be of the size of 2 acres consisting of 160 trees above 10 years old. Subsidy will be provided at the rate of

Rs.500/- per plot per annum for a continuous period of 3 years. 4200 plots would be brought under this scheme.

### Scheme for improvement of cashew by vegetative propagation

This is also a continuing scheme and it intends to improve the newly raised seedling cashew plantation by adopting techniques of vegetative propagation such as insitu budding or grafting so as to convert them into trees of merit in respect of yield and quality. An area of 18,050 ha. are to be covered under this scheme over a period of 5 years.

### Scheme for establishment of progeny orchards for cashew

This is also a continuing scheme. The objective of this scheme is to establish clonal orchards of cashew raised from superior seeds evolved at the research stations and high yielding trees of merit located in private orchards in the country to serve as nucleus for large scale multiplication of propagation material for future plantations and thus it would serve as an adjunct to the scheme for improvement of cashew by vegetative propagation. 690 ha would be brought under the scheme.

### Scheme for adoption of prophylactic plant protection measures on cashew

This is a new scheme proposed for implementation during the Sixth Plan period with an objective of controlling the pest attack and to quickly increase the productivity of the existing plantations. 65,000 ha. in the Districts of Cannanore, Calicut and Malappuram in Kerala and 15,000 ha. in the Districts of South and North Kanara in Karnataka would be covered every year commencing from 1981–'82. As an incentive to take up the timely spraying programme, it is proposed that 50% of the cost of plant protection chemicals and operational expenses required for two rounds of spraying would be provided as subsidy.

### Scheme for statistical survey for area and production of cashew

This is also a new scheme proposed to be implemented during the Sixth Plan period. As no reliable statistics of area and production of cashew are available and as the Directorate of Economics

& Statistics is also not in a position to provide the same, it is therefore very necessary that correct statistics are collected. Three rounds of survey have been proposed to be conducted from 1981–82 to 1983–84 in all the cashew growing States except Kerala. The present system of collecting statistics with effect from 1977–78 under 'Timely Reporting Scheme' of Kerala seems to be satisfactory.

### Scheme for subsidised plantation of cashew for area expansion

This is also a continuing scheme. However, this is joint programme with the World Bank aided multi-state Cashew Project in the 4 states of Kerala, Karnataka, Andhra Pradesh and Orissa during the Sixth Plan period. It is proposed to bring new areas of 78,800 ha. during the period of 5 years in all the important cashew growing states in the country, out of which 53,775 ha. will be under the World Bank Project. Under this programme, it is proposed to provide a subsidy of Rs. 500 per ha. in departmental areas (Corporate Sector) to be disbursed in two years at the rate of Rs.300 and Rs. 200 respectively. In private areas, Rs.900 per ha. are proposed as subsidy payable in 3 equal annual instalments. The subsidy for individual farmers would be restricted to a maximum of 4 ha. for new cashew planting. The yearwise and Statewise Phasing of the programme has been shown in table–2.

Under the World Bank Project, 500 ha. under corporate sector and 2500 ha. under private sector in Karnataka, 2000 ha. under private sector in Andhra Pradesh and 2500 ha. under corporate sector in Orissa would also be covered under the programme of improvement. Thus a total of 7500 ha. would be improved during the Plan period.

Experience of the Soil Conservation Department of Orissa has shown that cashew once established will stabilise the sand dune land and thrive on it. There is an one kilometre strip of shifting sand dune land running about 150 kilometres with an area of about 15,000 ha. along the Orissa coast. Under the World Bank Aided Project, a pilot scheme covering an area of 500 ha. will be planted with cashew by the Soil Conservation Department of Orissa on this sand dune land during the Plan period. The success of the pilot scheme would encourage planting cashew in the entire area afterwards.

Table 2. Subsidised area expansion programme in Sixth Plan

| | 80–81<br>1 | 81–82<br>2 | 82–83<br>3 | 83–84<br>4 | 84–85<br>5 | Total |
|---|---|---|---|---|---|---|
| (A) *With World Bank assistance* | | | | | | |
| New Plantation | | | | | | |
| Small holders | | | | | | |
| Kerala | 1000 | 2000 | 3000 | 3000 | 1000 | 10000 |
| Karnataka | 375 | 1500 | 2250 | 2250 | 1125 | 7500 |
| Andhra Pradesh | 400 | 1600 | 2400 | 2400 | 1200 | 8000 |
| Orissa | 250 | 1000 | 1500 | 1500 | 750 | 5000 |
| Sub total | 2025 | 6100 | 9150 | 9150 | 4075 | 30500 |
| State Corporations | | | | | | |
| Kerala | 100 | 450 | 700 | 700 | 325 | 2275 |
| Karnataka | 125 | 500 | 750 | 750 | 375 | 2500 |
| Andhra Pradesh | 400 | 1600 | 2400 | 2400 | 1200 | 8000 |
| Orissa | 525 | 2100 | 3150 | 3150 | 1575 | 10500 |
| Subtotal | 1150 | 4650 | 7000 | 7000 | 3475 | 23275 |
| Total | 3175 | 10750 | 16150 | 16150 | 7550 | 53775 |
| (B) *Without World Bank assistance:* | | | | | | |
| Small holders | | | | | | |
| Tamil Nadu | 1300 | 1500 | 1500 | — | — | 4300 |
| Maharashtra | 500 | 500 | 1000 | — | — | 2000 |
| Goa | 1000 | 1200 | 1300 | — | — | 3500 |
| Sub-total | 2800 | 3200 | 3800 | — | — | 9800 |

**Table 2. (contd.)**

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| State Corporations | | | | | | |
| Kerala | 100 | 100 | 200 | — | — | 400 |
| Karnataka | 175 | 200 | 225 | — | — | 600 |
| Andhra Pradesh | 1100 | 900 | 600 | — | — | 2600 |
| Orissa | 3475 | 2900 | 3850 | — | — | 10225 |
| West Bengal | 200 | 300 | 400 | — | — | 900 |
| Goa | 100 | 200 | 200 | — | — | 500 |
| Sub-total | 5150 | 4600 | 5475 | — | — | 15225 |
| Total | 7950 | 7800 | 9245 | — | — | 25025 |
| **Grand Total :** | 11125 | 18550 | 25425 | 16150 | 7550 | 78800 |

In the Kerala Small Holder Project area, the poor condition of feeder roads is a constraint to cashew development. Thirty two roads having a total length of 250 kilometres have been identified, out of which about 200 kilometres would be improved with the assistance of World Bank during the Plan period.

Research on cashew would also be strengthened under I.C.A.R.

A study on cashew industry will be undertaken. This study would review the status of the industry, examine cashew institutes and policies, establish costs and returns of rawnut production, processing, kernel exports or local sales and would propose changes of policy or institutional arrangements, if necessary.

The implementation of the above schemes during the Sixth Plan period and the benefits of the schemes implemented during the earlier Plans are expected to increase the production of rawnuts in the country to the level of 3 lakh M.T. in the nineties.

# PEPPER MARKETING: PROBLEMS AND PROSPECTS

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## ABSTRACT

**Black pepper is an important item in our agricultural exports. However, in recent years, India yielded her virtual monopoly position to Brazil, Malaysia and Indonesia in both the fields of production and export of pepper. The direction of Indian pepper trade has also undergone dramatic change to a considerable extent in these years. While our exports to the USA have declined substantially, the exports to the USSR and other centrally planned countries have gone up following bilateral trade agreements. A critical appraisal of current problems of pepper trade in India forms the basis of a number of proposals for tackling the issues.**

## INTRODUCTION

Pepper (*Piper nigrum*) is one of the most ancient crops cultivated in India. It was the chief spice in the world during the Middle Ages and the commercial importance of this commodity in those days can be imagined from the gravity of the fact that it created a necessity for the search for a sea route to India. Till the beginning of the 19th century, Indian pepper had a pride of place in the world market. Later on, the countries like Indonesia, Malaysia and Thailand appeared in the scene of international trade as suppliers of black pepper and as a consequence India lost her monopoly position in this respect. During 1935–39 the average world production of peepper stood at 84 thousand tonnes and Indonesia accounted for 58.3 thousand tonnes (69.4%) followed by India with an average production of 15thousand tonnes (17.8%). However on account of large scale destruction of the pepper plantations in Indonesia, Borneo and Sarawak (as a part of the second world war devastations), India regained near monopoly in this commodity for quite a few years immediately following the second world war. During 1947-49, the world pepper production was around 39 thousand tonnes and India's share worked out at 80 percent. But through the post-war drives, Indonesia and other pepper producing countries improved the conditions of their plantations and forged ahead as the leading producers of pepper.

India's pepper production as percentage of world production declined from 80 percent in 1947–49 to 50 percent in 1950–51, to 47.5 percent in 1960–61 and to 25.6 percent in 1965–66. Between 1970 and 1976, India produced on an average 27 thousand tonnes of pepper per annum which then accounted for 24 percent of world production of about 112 thousand tonnes. Indonesia, Malaysia and Brazil accounted for 23.8, 29 and 16.5 percent respectively of the world production during the same period (Table 1).

Current world production of pepper is estimated to be around 140 thousand tonnes and the production level for India is around 28 thousand tonnes. In other words, India now produces only one-fifth of the world pepper. It is most striking to observe that the production of pepper in Brazil went up from a mere level of 300 tonnes in 1950–52 to about 50 thousand tonnes in 1979–80. Today, Brazil ranks first in the world production, placing Malaysia, Indonesia and India in lower orders.

## Exports

India's relative share in world trade of pepper came down from near monopoly stage in late 40s to 64 percent in 1950–51, to 42.5 percent in 1960–61 and to 37.1 percent in 1965–66. Between 1970 and 1976 the export of pepper from India further declined to 24.9 percent. The shares of other major producing countries namely, Malaysia, Indonesia and Brazil for the above period were in the order of 32, 20.6, 16.9 percent, respectively (Table 2).

Though India has failed to obtain an appreciable share of the world pepper trade, the volume of world export of this spice has gone up from 25 thousand tonnes in 1950 to 40 thousand tonnes in 1960, to 70 thousand tonnes in 1965, and around 90 thousand tonnes in 1975. The export figure for the world pepper stood around 105 thousand tonnes in 1978 while the corresponding figure for India was as low as 15 thousand tonnes. During the same year, Brazil exported double the quantity of Indian export and emerged out as the biggest supplier of pepper in the world market.

**Table 1. World production of pepper during 1970–'76 ('000 Tonnes)**

| *Country* | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | *Av. of* 70–76 | % |
|---|---|---|---|---|---|---|---|---|---|
| India | 25.0 | 26.0 | 26.0 | 26.2 | 28.7 | 28.2 | 28.8 | 27.0 | 24.0 |
| Indonesia | 17.2 | 24.3 | 31.0 | 28.5 | 27.5 | 30.5 | 26.9 | 26.6 | 23.8 |
| Malaysia | 25.9 | 28.4 | 27.3 | 23.8 | 29.7 | 41.4 | 37.1 | 29.1 | 26.0 |
| Brazil | 14.3 | 13.5 | 14.5 | 14.5 | 18.0 | 26.0 | 28.0 | 18.4 | 16.5 |
| Madagascar | 4.4 | 4.4 | 5.8 | 4.8 | 4.9 | 5.0 | 5.0 | 4.9 | 4.4 |
| Other Countries | 16.0 | 17.3 | 2.0 | 3.0 | 0.6 | 1.5 | 0.7 | 5.9 | 5.3 |
| World | 102.8 | 113.9 | 106.6 | 100.8 | 109.4 | 122.6 | 126.5 | 111.8 | 100.0 |

Table 2. World export of pepper during 1970–'76 ('000 Tonnes)

| *Country* | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | *Av. of* 70–76 | % |
|---|---|---|---|---|---|---|---|---|---|
| India | 22.3 | 18.0 | 19.2 | 28.1 | 28.9 | 24.6 | 17.9 | 22.7 | 24.9 |
| Indonesia | 2.6 | 22.9 | 24.9 | 25.6 | 16.0 | 15.2 | 24.2 | 28.8 | 20.6 |
| Malaysia | 25.9 | 28.4 | 27.3 | 23.8 | 29.7 | 31.4 | 37.1 | 29.1 | 32.0 |
| Brazil | 9.0 | 17.3 | 14.3 | 13.8 | 15.5 | 17.9 | 20.0 | 15.4 | 16.9 |
| Madagascar | 3.8 | 3.1 | 5.5 | 5.0 | 4.9 | 4.5 | 4.5 | 4.5 | 4.9 |
| Other Countries | 1.7 | 0.2 | 0.1 | 1.7 | 0.4 | 0.1 | 0.0 | 0.6 | 0.7 |
| World | 65.3 | 89.9 | 91.3 | 98.0 | 95.3 | 93.7 | 103.7 | 91.0 | 100.0 |

*Source : Pepper Community.*

During the last 30 years, the production of Indian pepper varied between 21 and 32 thousand tonnes, whereas the volume of Indian exports in pepper fluctuated between 12 and 31 thousand tonnes (Table 3).

**Table 3. India: production and export of pepper ('000 tonnes)**

| *Year* | *Production* | *Export* | *Export as % of production* |
|---|---|---|---|
| 1950–51 | 21 | 16 | 76.19 |
| 1955–56 | 28 | 13 | 46.43 |
| 1960–61 | 28 | 17 | 60.71 |
| 1965–66 | 23 | 26 | 113.04 |
| 1970–71 | 26 | 18 | 69.23 |
| 1971–72 | 26 | 19 | 73.08 |
| 1972–73 | 26 | 20 | 76.92 |
| 1973–74 | 26 | 31 | 119.23 |
| 1974–75 | 28 | 26 | 92.86 |
| 1975–76 | 28 | 24 | 85.71 |
| 1976–77 | 32 | 20 | 62.50 |
| 1977–78 | 32 | 25 | 78.13 |
| 1978–79 | 26 | 15 | 57.69 |

## Utilization and demand

Pepper is an indispensable ingredient of sauces, soups, pickles and other food preparations in the household sector. In the developed countries pepper is extensively used by the food processing industries and in particular by the meat sectors. In India, besides its use as an important spice, pepper is one of the chief ingredient in most Ayurvedic drug preparations. As a carminative, pepper owes its properties to three important constituents namely, volatile oil, a resin and an alkaloid 'piperine.' These three constituents are present both in the skin or pericarp and in the hard coated seeds which it encloses.

Indian pepper, commonly known as 'Malabar peppr' is considered to be the best in the world for its excellent aroma, flavour and pungency. Tellichery pepper possesses the characteristic 'boldness,' in addition to all the properties of Malabar pepper. Historically, the sausage makers of Italy have been some of the major customers of Tellicherry pepper.

Indonesian black pepper, otherwise known as 'Lampong pepper' (the name goes with the producing district) compares with Malabar in pungency and flavour. But unlike Malabar, the berries of Lampong pepper are small and thin shelled and are suitable for machine decortication. Moreover, ground black pepper of Lampong is relatively light in colour. However, Indonesia's 'Muntok pepper' goes into white pepper production and this type has its characteristic aroma and relatively mild flavour.

'Sarawak pepper' of Malaysia is also mild in flavour, low in volatile oil content and very light coloured in appearance. The bulk of the Sarawak pepper goes into white pepper production. Europe and commonwealth nations are the traditional customers of this pepper.

Brazilian black pepper possesses characteristic appearance and relatively smooth surface. While the outer skin of this type of berry is black, the centre of the berry is very white, causing a sharp black and white contrast in the appearance of the ground pepper. So far as it's flavour is concerned, Brazilian black pepper is graded as inferior to Tellicherry, Malabar and Lampong varieties. Brazil also produces some quantity of white pepper, but this type is less pungent than Muntok white pepper of Indonesia.

Madagascar, eventhough a small producer of pepper in the world produces and supplies a major portion of green pepper available in the world market. Among the major producing countries

India leads in respect of supply of pepper oleoresin and oil. Recently, dehydrated green pepper was introduced into the world market by India and it is a most appropriate step to penetrate into the western sophisticated market. India, as well as other major producers of pepper are now attempting to directly enter into the retail outlets of the major importing countries through the ground pepper supply in consumer packs.

USA is by far the largest pepper importing country in the world. Nearly one-fourths of the total world trade in pepper is directed to that country. Among the other pepper importing countries, the important buyers are USSR, Federal Republic of Germany (West Germany), France, Japan, UK, Italy, Morocco, and Canada. During 1970–78, USA imported on an average 25 thousand tonnes of pepper (both black and white) per year, while USSR, West Germany and France imported 9.4, 8.1 and 5.5 thousand tonnes, respectively. The volume of import in respect of Japan, UK, Italy, Morocco and Canada for the above period were in the range of 2.3 and 4.6 thousand tonnes a year (Table 4).

**Table 4. Average annual import of pepper by major importing countries during 1970-78 ('000 tonnes)**

| *Rank* | *Country* | *Vol.* | *Rank* | *Country* | *Vol.* |
|---|---|---|---|---|---|
| 1 | U.S.A. | 25.2 | 9 | Canada | 2.3 |
| 2 | USSR | 9.4 | 10 | Poland | 1.8 |
| 3 | W. Germany | 8.1 | 11 | Netherland | 1.4 |
| 4 | France | 5.5 | 12 | Argentina | 1.4 |
| 5 | Japan | 4.6 | 13 | Yugoslavia | 1.3 |
| 6 | UK | 3.8 | 14 | Spain | 1.2 |
| 7 | Italy | 3.2 | 15 | Australia | 1·1 |
| 8 | Morocco | 2.6 | 16 | Belgium | 1.0 |

The per capita consumption of pepper for the countries such as Federal Republic of Germany, Switzerland, USA, France, Denmark, Canada and Hungary comes between 100 and 131 gms per annum. For countries like Austria, Netherlands, Sweden, Australia, Poland, Italy and UK, the per capita consumption of pepper varies between 51 and 97 gms. (Table 5).

**Table 5. Per capita consumption of pepper in major importing countries in 1975**

| *Rank* | *Country* | *gms* | *Rank* | *Country* | *gms* |
|---|---|---|---|---|---|
| 1 | W. Germany | 131 | 9 | Sweden | 90 |
| 2 | Switzerland | 121 | 10 | Australia | 82 |
| 3 | U.S.A. | 117 | 11 | Poland | 62 |
| 4 | France | 107 | 12 | Italy | 58 |
| 5 | Denmark | 102 | 13 | UK | 51 |
| 6 | Canada | 100 | 14 | Spain | 36 |
| 7 | Hungary | 100 | 15 | USSR | 32 |
| 8 | Austria | 97 | 15 | Yugoslavia | 32 |
| 9 | Netherlands | 94 | 16 | Japan | 28 |

The trade statistics reveal that in 40s and 50s the main destination for Indian pepper was the USA followed by the UK and West European countries. From 60s, the exports of Indian pepper to these countries tended to decline as a result of bilateral trade agreements with the USSR and socialist countries of Eastern Europe such as Poland, Czechoslovakia, and Yugoslavia. By 1961–62 the export of Indian pepper to American zone came down to 45.8 percent and to UK and ECM countries to 13.6 percent of the total Indian pepper exports. In subsequent years the rate of decline of Indian pepper to the USA and West European countries

Table 6. Import of pepper from India by major pepper importing countries during 1973–'74—1977–'78 (Tonnes)

| *Country* | 1973/74 | 1974/75 | 1975/76 | 1976/77 | 1977/78 | *Av. for 5 years* | *% Total* |
|---|---|---|---|---|---|---|---|
| USSR | 9412 | 7541 | 10244 | 8390 | 9473 | 9012 | 35.40 |
| U S A | 7736 | 6074 | 3756 | 1481 | 5119 | 4833 | 10.01 |
| Canada | 1417 | 1471 | 1254 | 715 | 1013 | 1174 | 4.6 |
| Italy | 2321 | 1048 | 1284 | 1135 | 1057 | 1369 | 5.4 |
| Czechoslovakia | 891 | 1580 | 888 | 930 | 1252 | 1108 | 4.4 |
| Yugoslavia | 1519 | 332 | 421 | 1807 | 905 | 997 | 3.9 |
| Poland | 795 | 2759 | 1617 | 1404 | 781 | 1471 | 5.81 |
| Rumania | 65 | 1291 | 1199 | 842 | 879 | 855 | 3.31 |
| Hungary | 1110 | 738 | 350 | 650 | 200 | 610 | 2.40 |
| Sudan | 143 | 47 | 58 | 158 | 62 | 94 | 0.4 |
| Other countries including UAR | 6239 | 3460 | 3155 | 3015 | 3818 | 3937 | 15.4 |
| TOTAL | 31648 | 26341 | 24226 | 20527 | 24559 | 25460 | 100.0 |

was of the significant order. In the year 1966–68, the American zone accounted for only 10.5 percent of the total exports of Indian pepper, whereas the East European countries accounted for 72.3 percent of the same. Between 1973–74 and 1977–78, the USSR accounted for 35.46 percent followed by USA accounting for 19 percent of total pepper exports from India (Table 6). However, during 1979–80 the Soviet Union alone imported nearly 50 percent of India's total pepper export of 20 thousand tonnes. Pepper shipped to the USSR and East European nations is delivered against payment in rupees and commands a premium.

India's share in the total import of pepper by the individual importing countries was analysed and it was observed that in recent years India meets about 88 percent of total pepper requirement of the USSR, 100 per cent of Poland, 80 percent of Czechoslovakia, 60 percent of Yugoslavia and nearly 42 percent of Hungary. The supplies to the traditional pepper buyers in general and the USA in particular have declined partly due to lack of exportable surplus left over after meeting the obligatory demand of East European countries and partly because of the stiff competition in international markets from other major pepper producing countries. During 1971 to 1977 India's share in the total imports of the USA, UK and Japan constituted as 15.75, 2.93 and 1.96 percent, respectively (Table 7).

Another possible reason for India's failure to capture West European market is the growing demand for white pepper in the household sector in these countries. White pepper in these days accounts for 60 to 70 percent of the total annual imports of pepper into the West European markets. The production as well as export of white pepper so far as India is concerned, is negligible. As previously mentioned, Indonesia, Malaysia and to some extent Brazil produce white pepper in bulk quantities for exports to the industrially developed countries. Although the flavour of white pepper from Brazil is not considered to be on par with that of Malaysian (Sarawak) and Indonesian (Muntok) white pepper, several importers tend to prefer Brazilian white pepper on account of its clean appearance and uniform size.

**Table 7. Import of pepper by major importing countries and India's share in the total import of those countries (Tonnes)**

| *Country* | *Period* | *Av. annual import* | *Av. annual import from India* | *India's share in %* |
|---|---|---|---|---|
| USA | 1971 to 1977 | 25674 | 4043 | 15.75 |
| Canada | –do– | 2297 | 1169 | 50.89 |
| Japan | –do– | 3579 | 70 | 1.96 |
| UK | –do– | 3307 | 97 | 2.93 |
| Italy | –do– | 3272 | 1236 | 37.78 |
| Norway | –do– | 282 | 34 | 12.06 |
| Denmark | –do– | 581 | 15 | 2.58 |
| Spain | –do– | 1208 | 54 | 4.47 |
| Switzerland | 1972 to 1977 | 730 | 19 | 2.60 |
| USSR | 1971–1977 | 9365 | 8254 | 88.14 |
| Poland | 1973 to 1975 | 1428 | 1428 | 100.00 |
| Yugoslavia | 1974 to 1977 | 1391 | 831 | 59.74 |
| Hungary | 1973 to 1977 | 1953 | 816 | 41.78 |
| Czechoslovakia | 1975 | 1250 | 1000 | 80.00 |
| Newzealand | 1973 to 1976 | 202 | 10 | 4.95 |
| Saudi-Arabia | 1971 to 1976 | 888 | 149 | 16.78 |
| Kuwait | 1973 to 1975 | 136 | 50 | 36.76 |
| Iran | 1972 to 1977 | 714 | 121 | 16.95 |

Madagascar, is the chief supplier for green pepper to France, Switzerland and other West European countries. India and Brazil supply relatively small quantities of green pepper in brine to the western world. However, the food processing industries of the UK and the USA are rapidly moving towards pepper oleoresins. Though India and other pepper producing countries are attempting to grab sizeable portion of the oleoresin market of the advanced countries they are subject to stiff competition from the well established flavour houses of those countries, namely the USA and the UK, with their superior technology and marketing skills. Again, the consumption pattern of the developed as well as developing countries is fast changing and the major producers and exporters of pepper are expected to be more vigilant in this regard.

### Price trend

The price of pepper has been fluctuating very widely in the world market from year to year. As a result of this the production and trade in pepper are quite uncertain. The price of Indian pepper soared to unheard heights during early 50s due to an unprecedented demand and the crop was found to become exceedingly profitable for Indian producers and traders. In the year 1950–51, the export earnings from pepper was Rs. 20.4 crores which accounted for 3.4 percent of the total export earnings for the country from all the commodities during that year. The unit value of exported pepper for 1950–51 was Rs. 12,750 per tonne. This suddenly came down to Rs. 3,615 in the year 1955–56 affecting the export-earnings to a very great extent. The export value for Indian pepper for 1955–56 came down to Rs. 4.7 crores and it's share to the total export earnings for the country also got reduced to 0.8 percent, although the export earnings from all commodities in that year remained almost at the 1950–51 level. While the total export earnings for the country is moving in an upward trend, the share of pepper as percentage to the total export value is declining. In 1978–79, it reached 0.5 percent. During the year 1977–78, the export value from Indian pepper reached a record high of Rs. 49 crores, largely for the highest unit value realisation (Rs. 19,600/tonne) coupled with a fairly good size of export (25 thousand tonnes). The unit value of Indian pepper is falling from 1978–79 due to stiff competition from other producers (Table 8 and 9).

### Table 8. India: unit value of exported pepper

| | | *Rs./Tonne* |
|---|---|---|
| 1950–51 | .. | 12,750 |
| 1955–56 | .. | 3,615 |
| 1960–61 | .. | 5,000 |
| 1965–66 | .. | 4,269 |
| 1970–71 | .. | 8,444 |
| 1975–76 | .. | 14,083 |
| 1976–77 | .. | 19,100 |
| 1977–78 | .. | 19,600 |
| 1978–79 | .. | 18,667 |
| 1979–80 | .. | 15,952 |

### Table 9. Export earnings from pepper in relation to all commodities (Rs. in crores)

| *Year* | *Export earnings from* | | *Share of pepper (%)* |
|---|---|---|---|
| | *All commodities* | *Pepper* | |
| 1950–51 | 600.64 | 20.4 | 3.4 |
| 1955–56 | 599.32 | 4.7 | 0.8 |
| 1960–61 | 660.22 | 8.5 | 1.3 |
| 1965–66 | 805.64 | 11.1 | 1.4 |
| 1970–71 | 1,535.16 | 15.2 | 1.0 |
| 1975–76 | 4,042.81 | 33.8 | 0.8 |
| 1976–77 | 5,173.23 | 38.2 | 0.7 |
| 1977–78 | 5,375.08 | 49.0 | 0.9 |
| 1978–79 | 5,725.00 | 28.0 | 0.5 |
| 1979–80 | 5,999.00 | 33.5 | 0.6 |

The index of f.o.b. with 1970–71 as base has been moving in an irregular fashion reflecting the uncertainty in the international trade. However, barring 1971–72 and 1972–73 the f.o.b. for Indian pepper is noticed to be higher than 1970–71 level. Since 1974–75, the f.o.b. has been more than doubled indicating a better prospect for the years to come (Table 10).

**Table 10. The index of f.o.b.**

| *Indian Pepper* | *f. o. b.* | *Indice* |
|---|---|---|
| | *Rs./Qtl'.* | *Base:* 1970-71 |
| 1968–69 | 514 | 60.6 |
| 1969–70 | 872 | 85.5 |
| 1970–71 | 849 | 100.0 |
| 1971–72 | 770 | 90.6 |
| 1972–73 | 717 | 84.4 |
| 1973–74 | 933 | 109.8 |
| 1974–75 | 1809 | 212.9 |
| 1975–76 | 1899 | 223.5 |
| 1976–77 | 1863 | 219.3 |
| 1977–78 | 1998 | 235.2 |
| 1978–79 | 1833 | 215.7 |

The annual wholesale prices of pepper in Calicut market move hand in hand with the f.o.b. for pepper. In other words, there exists a high and positive correlation between wholesale price and f.o.b. of pepper. The difference between wholesale price and f.o.b. comes within a range of Rs. 200 and Rs. 400 per quintal of pepper (Table 10 and 11).

Table 11. Annual wholesale prices of pepper (nadan) in Calicut market

| *Year* | *Rs/Qtl* | *Index No.* |
|---|---|---|
| 1970–71 | 638 | 100 |
| 1971–72 | 596 | 93 |
| 1972–73 | 530 | 83 |
| 1973–74 | 696 | 109 |
| 1974–75 | 1046 | 164 |
| 1975–76 | 1141 | 179 |
| 1976–77 | 1512 | 237 |
| 1977–78 | 1661 | 260 |
| 1978–79 | 1640 | 257 |
| 1979–80 | 1436 | 225 |

The average monthly wholesale prices of black pepper in Calicut and Cochin markets remain low during February to May. This is obviously due to post-harvest glut in the wholesale markets. However, due to its inherent nature of production and supply the percentage deviations from the annual mean are not high. The deviations are found to be ± 6 percent (Table 12 & 13).

The prices of pepper in London market reveal that Malabar black pepper fetches higher price as compared to Sarawak black pepper. In case of New York market both Malabar pepper and Lampong pepper realise more or less same prices (Table 14).

Pepper extractors generally favour Malabar and Lampong black pepper for their superior chemical compositions. Though Malabar pepper has an edge over all other pepper so far as quality is concerned, the importers are becoming more and more price conscious these days. While during 1979–80 the Indian black pepper price was quoted at about Rs. 15,500 per tonne, Indonesian and Malaysian black pepper were available for Rs. 12,000 to 13,500. Thus, the high price of Indian pepper has denied it substantial access to US, UK and other Western markets.

**Table 12. Average monthly wholesale prices of pepper in Calicut and Cochin markets**

(*Rs./Qtl.*)

| *Year* | *April* | *May* | *June* | *July* | *Aug.* | *Sept.* | *Oct.* | *Nov.* | *Dec.* | *Jan.* | *Feb.* | *March* | *Average* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Calicut Market—Wynadan Variety** | | | | | | | | | | | | | |
| 1974–75 | 1025 | 1105 | 1137 | 1094 | 1095 | 1059 | 1047 | 1102 | 1094 | 1079 | 1015 | 1023 | 1073 |
| 75–76 | 1087 | 1106 | 1145 | 1161 | 1132 | 1175 | 1260 | 1300 | 1219 | 1132 | 1139 | 1230 | 1173 |
| 76–77 | 1364 | 1364 | 1516 | 1571 | 1545 | 1579 | 1689 | 1800 | 1620 | 1650 | 1606 | 1694 | 1579 |
| 77–78 | 1770 | 1781 | 1802 | 1803 | 1669 | 1745 | 1706 | 1710 | 1793 | 1800 | 1625 | 1610 | 1734 |
| 78–79 | 1787 | 1750 | 1783 | 1784 | 1739 | 1756 | 1767 | 1775 | 1725 | 1563 | 1453 | 1482 | 1699 |
| 79–80 | 1461 | 1461 | 1492 | 1629 | 1584 | 1575 | 1585 | 1561 | 1506 | 1463 | 1349 | 1325 | 1499 |
| Average | 1416 | 1428 | 1481 | 1507 | 1461 | 1481 | 1501 | 1541 | 1493 | 1472 | 1365 | 1394 | 1460 |
| **Cochin Market—Garbled** | | | | | | | | | | | | | |
| 1974–75 | 1039 | 1134 | 1159 | 1114 | 1123 | 1078 | 1068 | 1121 | 1099 | 1125 | 1080 | 1047 | 1099 |
| 75–76 | 1092 | 1090 | 1135 | 1165 | 1151 | 1180 | 1277 | 1315 | 1282 | 1195 | 1176 | 1236 | 1191 |
| 76–77 | 1379 | 1369 | 1490 | 1551 | 1548 | 1556 | 1591 | 1765 | 1607 | 1713 | 1706 | 1761 | 1586 |
| 77–78 | 1812 | 1822 | 1832 | 1831 | 1720 | 1740 | 1685 | 1679 | 1720 | 1714 | 1649 | 1625 | 1737 |
| 78–79 | 1749 | 1714 | 1765 | 1789 | 1732 | 1735 | 1774 | 1751 | 1655 | 1550 | 1529 | 1497 | 1687 |
| 79–80 | 1469 | 1466 | 1485 | 1573 | 1545 | 1545 | 1554 | 1527 | 1466 | 1460 | 1400 | 1356 | 1487 |
| Average | 1423 | 1432 | 1478 | 1504 | 1470 | 1472 | 1492 | 1526 | 1473 | 1460 | 1423 | 1454 | 1465 |

Table 13. Deviations from annual means (1974–75 to 1979–80) of wholesale prices of pepper in Calicut and Cochin market

| Month | Calicut market | | Cochin market | |
|---|---|---|---|---|
| | Deviation | % Deviation | Deviation | % Deviation |
| April | –44 | –3.01 | –42 | –2.87 |
| May | –32 | –2.19 | –33 | –2.25 |
| June | 21 | 1.44 | 13 | 0.89 |
| July | 47 | 3.22 | 39 | 2.66 |
| August | 1 | 0.07 | 5 | 0.34 |
| September | 21 | 1.44 | 7 | 0.48 |
| October | 41 | 2.81 | 27 | 1.84 |
| November | 81 | 5.55 | 61 | 4.16 |
| December | 33 | 2.26 | 8 | 0.55 |
| January | 12 | 0.82 | –5 | –0.34 |
| February | –95 | –6.51 | –42 | –2.87 |
| March | –66 | –4.52 | –11 | –0.75 |

Table 14. Average annual prices of pepper in London and New York markets (Rs/Qtl)

| | London market | | | New York market | |
|---|---|---|---|---|---|
| | Malabar | Sarawak pepper | | Malabar | Lampong |
| | Black | Black | white | Black | Black |
| 1970–71 | 968 | 673 | 776 | 946 | 946 |
| 71–72 | 923 | 650 | 858 | 832 | 784 |
| 72–73 | 738 | 590 | 865 | 878 | 809 |
| 73–74 | 1115 | 1043 | 1609 | 1069 | 1067 |
| 74–75 | 1542 | 1316 | 1692 | 1517 | 1516 |
| 75–76 | 1608 | 1283 | 1641 | 1713 | 1667 |
| 76–77 | 1999 | 1807 | 2107 | 1920 | 1880 |
| 77–78 | 2060 | 2021 | 2578 | 2167 | 2177 |
| 78–79 | NA | 1877 | 2952 | 1691 | 1740 |
| 79–80 | NA | 1817 | 2488 | 1732 | 1732 |

While Brazil, which started its pepper plantation only in 1920s, now exports pepper to some 40 countries in the world; India's destination is about one-half of that figure. In other words, India is dependent on fewer markets than her counterparts in pepper production.

India faces stiff competiton in the international pepper trade as prices are ruling high in this country. The main factor associated with the high price of Indian pepper is its low productivity. The average productivity of pepper per hectare in the year 1978 for the major producing countries is as follows:

| | | |
|---|---|---|
| India | .. | 233 kg |
| Indonesia | .. | 641 kg |
| Malaysia | .. | 3455 kg |
| Brazil | .. | 3333 kg |

Our productivity is very low mainly due to poor management and low yielding potential of Indian pepper gardens. Indian pepper plantations are also subject to serious attack of Phytophthora disease. Immediate attention should therefore, be focussed on rejuvenation of old plantations by replanting with high yielding and disease resistant varieties. Supervised credit systems should be followed simultaneously in order to facilitate the adoption of package of practices by the small and marginal producers of pepper.

India also needs reorganisation of pepper marketing. Distress sale of the produce by the growers should be avoided by appropriate institutional measures. Moreover, as the uncertainty of prices of pepper is great in India, schemes to ensure price stabilisation could be suitably look into. Since the prospect for world trade in white pepper is very bright and encouraging, serious efforts should be made to increase the production of white pepper in India. It may be mentioned here that white pepper fetches 30 to 50 percent higher price than black pepper. Similarly, green pepper in brine has a greater export potential. As a measure to reduce demand uncertainty the alternate uses of pepper in potential areas such as pharmaceutical and pesticidal industries need greater emphasis. For reasons of cost there is now an upward demand trend towards pepper oleoresin and oil in US and UK and it would be most desirable for India to establish suitable link and collaboration with the domestic flavour houses as well as leading importers and distributors of those countries to obtain a sizeable market for the processed products.

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# MARKETING OF GINGER IN INDIA WITH REFERENCE TO WORLD TRADE

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## ABSTRACT

**An attempt has veen made to highlight the broad aspects of marketing such as supply, demand and price trends of ginger. India continues to be the leading producer and exporter of ginger in the world for the past several years. The produce is exported to a large number of countries. The main ports of shipment are Cochin and Bombay. The destinations in order of importance of the trade are Middle East, UK and other Western Europe, USA and Canada, East Asia and Eastern Europe. In the world trade of ginger, India faces competition from relatively very small producers such as Jamaica, Sierra Leone, Nigeria and Fiji Islands. During the last decade, the prices of ginger have been fluctuating violently. Effort must continue to reduce the uncertainties on prices, production and export of ginger.**

## PRODUCTION AND SUPPLY

Ginger has been cultivated in India from very ancient times and has been an important commodity of commerce since early middle ages. The ginger of commerce is the rhizome or the underground modified stem of the plant *Zingiber officinale* Roscoe of the zingiberaceae family. It is cultivated over the greater part of the tropical and sub-tropical regions of the world. India alone accounts for 50 percent of the total world production of 134 thousand tonnes of dry ginger (Table 1).

Table 1. Country-wise estimated production of dry ginger in respect of some of the top ranking ginger producing countries during 1978.

| *Country* | *Production* | % |
|---|---|---|
| India | 67.17 | 50.12 |
| Taiwan–China | 17.80 | 13.28 |
| Japan | 13.10 | 9.78 |
| Sri Lanka | 5.20 | 3.88 |
| Australia | 2.00 | 1.49 |
| Sierra Leone | 1.00 | 0.75 |
| Mauritius | 1.00 | 0.75 |
| Jamaica | 0.90 | 0.67 |
| Nigeria | 0.60 | 0.45 |
| Hawai | 0.40 | 0.30 |
| Fiji | 0.20 | 0.15 |
| Other Countries Including China, Malaysia and Thailand | 24.63 | 18.38 |
| Total | 134.00 | 100.00 |

Though the estimates on the production of ginger of China, Thailand and Malaysia are not available; those countries also grow ginger on a fairly large scale. Other important countries in respect of ginger production are Taiwan (13.28%), Japan (9.78%), Sri Lanka (3.88%), and Australia (1.49%) (Table 1). However, barring India, Taiwan and Malaysia none of the major ginger producing countries figure in the world trade of ginger as their domestic market demands are greater than their domestic production. On the other hand, relatively very small ginger producing countries like Jamaica, Sierra Leone, Nigeria and Fiji Islands find place in the international trade of ginger due to several favourable factors of trade (Table 2).

Table 2. World export of ginger ( '000 tonnes)

| *Exporting Country* | 1971 | 1972 | 1973 | 1974 | 1975 | *Average of* 71–75 | % |
|---|---|---|---|---|---|---|---|
| India | 6.75 | 6.05 | 5.08 | 4.68 | 4.79 | 5.47 | 31.2 |
| Taiwan | — | 4.90 | 4.56 | 6.62 | 6.70 | 4.56 | 26.0 |
| Malaysia | 2.10 | 2.70 | 2.90 | 3.10 | — | 2.16 | 12.3 |
| Nigeria | 2.30 | 2.08 | 1.14 | 0.63 | 0.66 | 1.36 | 7.7 |
| Fiji | 0.70 | 0.73 | 1.20 | 1.20 | 1.40 | 1.05 | 6.0 |
| Sierra Leone | 0.60 | 0.49 | 0.35 | 0.21 | 0.15 | 0.36 | 2.1 |
| Jamaica | 0.30 | 0.35 | 0.48 | 0.34 | 0.29 | 0.35 | 2.0 |
| China | 0.10 | 0.20 | 0.10 | 0.10 | — | 0.10 | 0.6 |
| Sri Lanka | — | — | 0.12 | 0.40 | — | 0.10 | 0.6 |
| Singapore | — | 2.70 | 3.90 | 3.50 | — | 2.02 | 11.5 |
| Total | 12.85 | 20.20 | 19.93 | 20.78 | 13.99 | 17.55 | 100.0 |

Between the period 1971 and 1975, the average annual world export of ginger was in the order of 17.5 thousand tonnes and India ranked first among the exporting countries in the world ginger trade accounting for 31.2 per cent of the total export. Taiwan and Malaysia constituted 26.0 percent and 12.3 percent respectively, during the above period in the international trade of ginger. The share of Fiji Island on this account was 6.0 percent, where as it was 7.7 percent in the case of Nigeria, 2.1 percent for Sierra Leone and 2.0 percent for Jamaica. The year to year variations in the export figures are very much pronounced and no single exporting country is found to be free from the problems of fluctuating trade in ginger (Table 2).

The world production of ginger has significantly increased *from nearly* 33 thousand tonnes in 1960 to 134 thousand tonnes in 1978. Similarly, India's ginger production has gone up from 17 thousand tonnes in 1960 to 67.2 thousand tonnes in 1978 (Table 3). It shows that the world production as well as India's production during 19 years have registered an increase of around 300 percent. As regards the exports of ginger, the world exports rose from 6.8

thousand tonnes in 1960 to 19.2 thousand tonnes in 1978 and the rise in India's export figure was from 4.1 thousand tonnes to 11.8 thousand tonnes during the same period. In other words, the volume-wise ginger exports of both the world and India have gone up by around 185 percent during 1960–78. However, while the proportion of the world export to the world production declined from 20.7 percent in 1960 to 14.3 percent in 1978, the proportion of India's export to India's production remained almost same around 50 percent during 1960 and 1978. Moreover, the proportion of India's export to the world export in those two points of time remained constant at 61 percent (Table 3). Though India is the largest supplier of dry ginger in the world market, the exports from Taiwan in some years have exceeded India's export (Table 2). Owing to production uncertainties in the home front and price uncertainties in the world market, the export of India's ginger over the period of years have been erratic.

**Table 3. Ginger: important indicators of change**

| | | 1960 | 1978* |
|---|---|---|---|
| 1. | World production ('000 t) | 32.9 | 134.0 |
| 2. | World export ('000 t) | 6.8 | 19.2 |
| 3. | 2 as % of 1 | 20.7 | 14.3 |
| 4. | India's production ('000 t) | 17.0 | 67.2 |
| 5. | 4 as % of 1 | 51.4 | 50.0 |
| 6. | India's export ('000 t) | 4.1 | 11.8 |
| 7. | 6 as % of 2 | 61.2 | 61.6 |

*Provisional estimates

The exports of ginger from India takes place mainly through the ports of Cochin and Bombay. During the period 1975–76 to 1977–78, on an average 3417 tonnes (53.9%) of dry ginger were shipped to overseas countries from Cochin port and another 2913 tonnes (45.9%) were shipped from Bombay port. In addition to these, a small quantity (5.5 tonnes) was exported from Madras, Tuticorin, Calicut and Calcutta ports (Table 4). While the major bulk of the exported ginger from India continues to be the product of Kerala, Calicut and Alleppey ports have lost their importance in the matter of export of ginger.

Table 4. Port-wise exports of ginger from India (tonnes)

| *Sl. No.* | *Port* | 1975–76 | 1976–77 | 1977–78 | *Total* | *Average of 3 years* | % |
|---|---|---|---|---|---|---|---|
| 1. | Cochin | 2637 | 1682 | 5933 | 10,252 | 3417.33 | 53.93 |
| 2. | Bombay | 2146 | 2771 | 3822 | 8,739 | 2913.00 | 45.98 |
| 3. | Calicut | 0.4 | 0.8 | 0.1 | 1.3 | 0.43 | 0.01 |
| 4. | Tuticorin | 0.3 | 0.6 | 0.4 | 4.9 | 1.63 | 0.03 |
| 5. | Madras | 0.2 | 0.6 | 0.5 | 8.5 | 2.83 | 0.04 |
| 6. | Calcutta | — | — | 0.2 | 2.0 | 0.67 | 0.01 |
|  | Total | — | — | — | — | 6355.9 | 100.00 |

The important overseas destinations of Indian ginger are Middle East Countries, USA, Canada, UK and East Asian Countries. To zone-wise export figures for Indian ginger indicates that the Middle East countries account for 60 to 80 percent of the total export from India (Table 5). Further, the distribution of Indian ginger exports between 1973–74 and 1977–78 reveals that nearly 29 percent of total exports from India was directed towards Saudi Arabia, 20 percent towards Yemens (both Democratic Republic and Arab Republic), 7 percent towards Kuwait, 9 percent towards USA and 4 percent towards UK (Table 6).

**Table 5. Zonewise exports of ginger from India (percent)**

| *Year* | *Eastern Europe* | *UK & other European countries* | *middle East* | *East Asia* | *Africa* | *America* | *Australia & Oceania* |
|---|---|---|---|---|---|---|---|
| 1960–61 | — | 9.5 | 62.7 | 9.1 | 6.0 | 10.00 | 2.7 |
| 1965–66 | 2.7 | 2.5 | 78.9 | 6.4 | 2.9 | 5.5 | 1.1 |
| 1970–71 | 7.0 | 0.6 | 86.1 | 2.0 | 1.6 | 1.8 | 1.0 |
| 1975–76 | 3.4 | 7.0 | 79.7 | 2.06 | 1.0 | 5.6 | 1.2 |
| 1977–78 | 2.5 | 12.4 | 59.7 | 11.0 | 1.6 | 12.0 | 0.8 |

Source: D.G.C.I. & S.

**Table 6. Country-wise import of ginger from India (tonnes)**

| *Country* | 1973–74 | 1974–75 | 1975–76 | 1976–77 | 1977–78 | *Average of 5 yrs.* | % |
|---|---|---|---|---|---|---|---|
| Saudi Arabia | 1299 | 1511 | 1966 | 1000 | 2539 | 1663.0 | 28.90 |
| Yemen D. Rep. | 759 | 263 | 588 | 806 | 321 | 547.4 | 9.51 |
| Yemen A. Rep. | 367 | 308 | 431 | 671 | 1131 | 581.6 | 10.11 |
| USA | 660 | 527 | 192 | 152 | 1092 | 524.6 | 9.12 |
| Netherlands | 144 | 76 | 126 | 50 | 139 | 107.0 | 1.86 |
| Morocco | 225 | 449 | 200 | 50 | 150 | 214.8 | 3.73 |
| USSR | 70 | 200 | 95 | 65 | 184 | 122.8 | 2.13 |
| Kuwait | 92 | 94 | 257 | 515 | 370 | 265.6 | 6.62 |
| Singapore | 98 | 47 | 46 | 30 | 567 | 157.6 | 2.74 |
| Iran | 59 | 48 | 2 | 96 | 281 | 97.2 | 1.69 |
| UK | 308 | 359 | 152 | 48 | 388 | 251.0 | 4.36 |
| Others | 1002 | 799 | 731 | 978 | 2600 | 1222.0 | 21.23 |
| Total | 5083 | 4681 | 4786 | 4461 | 9762 | 5754.6 | 100.00 |

## UTILISATION AND DEMAND

Ginger has numerous applications in the food, beverage and pharmaceutical industries. In India it is largely used as a spice in cookery as well as in ayurvedic medicine preparations. Another popular form in which fresh ginger is consumed in India and other Asian countries is sliced and salted ginger pickle. Ginger, preserved in brine is most popular in Japan. In the Middle East countries like Saudi-Arabia and Democratic Yemen, ginger is used mainly in the preparation of ginger coffee. Drinking ginger coffee is a deep-rooted social custom in many parts in the Middle East zone. Again in some of the traditional cardamom coffee drinking areas of this region, ginger is gradually replacing cardamom as a substitute for flavouring coffee. In the USA, Canada, UK and other Western countries, ginger is widely used in baking industry, meat seasoning industry and soft drink manufacturing industry, besides cookery. The beverage industries namely ginger-ale manufacturing units in the USA and ginger-beer manufacturing units in the UK absorb substantial quantities of high quality ginger available in the world market.

The functionally significant components of ginger are primarily its aroma and secondarily its pungency. Volatile oil present in ginger imparts a special aroma to it, while its pungent taste is due to the presence of a resin, found dissolved in the oil.

In the trade circle, the quality of dry ginger is decided by the factors like plumpness of rhizomes, fibre content, presence of mildew, colour, size and appearance, weight of rhizomes, method of preparation and cleanliness, besides moisture content, ash content, aroma and pungency. Indian ginger contains about 3.5 percent volatile oil; which is a favourable factor for the international trade of ginger. However, barring Kerala ginger, the gingers produced in other states of India have no export potential because of their higher fibre and moisture content. While the low quality Indian gingers are widely used for internal consumption, the bulk of Kerala gingers find entry into the export market due to their superior qualities. Calicut ginger and Cochin ginger (the trade names go with the places of production) have good demand in the world market for their lemon like aroma and flavour, in addition to the other quality attributes like low fibre and moisture content. Moreover, Calicut ginger depicts its characteristic red colour and boldness. In recent years, Kerala alone produces about 28 thousand tonnes of dry ginger per annum and nearly 35 to 43 percent of Kerala's production moves every year for export.

Market surveys reveal that there is definite preference for Indian bleached gingers in Middle East and Far East countries. Similarly, Indian unbleached gingers are preferred by the beverage industries of the USA, Canada and UK. However, the demands for Jamaican ginger, Sierra Leone ginger, Nigerian ginger and Fiji ginger are rapidly growing in the Western countries and as a result of this, India is gradually yielding its place of trade importance in many of the important ginger importing countries such as the USA, Canada, UK, West Germany and France.

The trade figures for the importing countries show that during 1974 to 1978, the average annual imports of ginger for the USA, Canada, UK, West Germany and Netherlands were in the order of 7260, 1448, 2960, 873 and 376 tonnes. The proportion of Indian ginger to the total imported gingers for the above countries come as 16 percent for the US, 16.5 percent for Canada, 10.7 percent for UK, 14.8 percent for West Germany and 21.9 percent for Netherlands. India's position in other European markets is more or less the same (Table 7). It is evident from the above facts that India's trade performance in ginger is far from satisfactory, considering her size of production.

India accounted for four-fifth of the Saudi-Arabian ginger imports between 1972 and 1976 because of the Saudi's distinct preference for Indian gingers. In the same context, India still remains the chief source of quality ginger for the Middle East due to obvious reason. However, the demand for the Indian ginger from the USSR, Poland and some other centrally planned East European countries can be seen in a different context as these countries import major portion of their ginger requirements from India under the bilateral trade agreement. Therefore, India's trade in ginger is not subject to open market competition in respect of a few countries like USSR and Poland.

**Table 7. Import of ginger by major importing countries and India's share in the total import of those countries**

| *Countries* | 1974 | 1975 | 1976 | 1977 | 1978 | *Av. for 1974–78* | *Av. Import from India 1974–78* | *Col.8 as % of Col.7* |
|---|---|---|---|---|---|---|---|---|
| U.S.A. | 6907 | 6052 | 8277 | 7224 | 7839 | 7260 | 1161 | 16.0 |
| Canada | 1032 | 1177 | 1644 | 1463 | 1925 | 1448 | 239 | 16.5 |
| U.K. | 2369 | 2916 | 3091 | 3383 | 3039 | 2960 | 316 | 10.7 |
| W. Germany | 866 | 723 | 891 | 883 | 1002 | 873 | 129 | 14.8 |
| Netherlands | 339 | 365 | 371 | 319 | 486 | 376 | 82 | 21.9 |
| Sweden | 94 | 112 | 123 | 119 | 128 | 115 | 35 | 30.0 |
| France | 99 | 95 | 151 | 160 | 232 | 147 | 16 | 11.1 |
| Denmark | 34 | 25 | 37 | 39 | 49 | 37 | 7 | 17.4 |
| Spain | 10 | 9 | 12 | 20 | 21 | 14 | 3 | 23.6 |
| Newzealand | 87 | 62 | 52 | 62 | — | 53 | 34 | 63.9 |
| USSR | 170 | 130 | 120 | 99 | 225 | 149 | 149 | 100.0 |
| Morocco | 280 | 501 | 378 | 398 | 533 | 418 | 240 | 57.3 |
| Japan* | 719 | 1099 | 6459 | 8516 | 5338 | 4426 | 148 | 3.4 |
|  | **72/73** | **73/74** | **74/75** | **75/76** | **76/77** | *Av. for* **72/76** |  |  |
| Iran | 205 | 131 | 197 | 289 | 92 | 183 | 61 | 33.2 |
|  | **1972** | **1973** | **1974** | **1975** | **1976** | *Av. for* **72/76** |  |  |
| Saudi Arabia | 2050 | 1581 | 1626 | 1529 | 1805 | 1718 | 1389 | 80.8 |

*Including fresh ginger

Table 8. Export of ginger oil and oleoresin from India during 1978–1979

| *Commodity* | *Unit* | *U.S.* | *U.K.* | *France* | *West Germany* | *Hol-land* | *Aust ralia* | *Other count-ries* | *Total* |
|---|---|---|---|---|---|---|---|---|---|
| *Ginger oil* | Tonnes | 3.45 | 0.65 | 2.23 | 0.30 | 0.47 | 0.40 | 0.16 | 7.66 |
| | Rs. million | 2.14 | 0.41 | 1.43 | 0.19 | 0.31 | 0.26 | 1.02 | 4.87 |
| | % of value | 44.1 | 8.4 | 29.4 | 4.0 | 6.5 | 5.3 | 2.3 | 100.00 |
| *Ginger Oleoresin* | Tonnes | 5.31 | .. | .. | 1.30 | .. | 0.25 | 0.32 | 7.18 |
| | Rs. million | 0.95 | .. | .. | 0.35 | .. | 0.05 | 0.10 | 1.45 |
| | % of value | 65.2 | .. | .. | 24.4 | .. | 3.4 | 7.0 | 100.0 |

Market trends in major importing countries indicate that the future demand outlook for dry ginger is promising. The compound growth rates of import of ginger per annum for some of the importing countries have been estimated on the basis of 1971–78 figures and they are as follows:

| | | | |
|---|---|---|---|
| U.S.A. | 6.76% | U.K. | 8.74% |
| Canada | 15.32% | France | 17.72% |
| Japan | 49.15% | W. Germany | 5.94% |

However, according to a survey of the world market the world ginger imports can be expected to continue to grow at a rate of 3 percent a year during the next few years.

Apart from the encouraging prospects of ginger demand, the demand for its products like ginger oil and oleoresins is building up day by day. It is a matter of happiness that India is in a very good position in the spices processing industry eventhough there are certain constraints in this line. In the year 1978–79, India supplied 7.7 tonnes of ginger oil and another 7.2 tonnes of ginger oleoresins to the world market. The main buyers of ginger oil were the US and France, whereas the main customers of ginger oleoresins were the US and West Germany (Table 8).

### Price trend

The wholesale prices of dry ginger in Calicut and Cochin markets suddenly came down by 59 percent in 1971–72 and further declined by another 7 percent in 1972–73 from the 1970–71 level. Then they slowly started rising, but remained sufficiently below the 1970–71 level upto 1975–76. Again, in 1976–77 and the subsequent year the wholesale prices of ginger registered a rise by more than 60 percent over the 1970–71 level and then declined. The 1979–80 price was found to be 44 percent below the 1970–71 price (Table 9).

**Table 9. Average annual wholesale prices of ginger in Calicut and Cochin markets (Rs./Qtl.)**

| *Year* | *Calicut Market* | | *Cochin Market* | |
|---|---|---|---|---|
| | *Dry* | *Index No.* | *Unbleached* | *Index No.* |
| 1970–71 | 832 | 100.0 | 850 | 100.0 |
| 1971–72 | 355 | 42.7 | 362 | 42.6 |
| 1972–73 | 290 | 34.8 | 304 | 35.8 |
| 1973–74 | 426 | 51.2 | 436 | 51.3 |
| 1974–75 | 613 | 73.7 | 662 | 77.9 |
| 1975–76 | 725 | 87.1 | 734 | 86.4 |
| 1976–77 | 1345 | 161.6 | 1377 | 162.0 |
| 1977–78 | 1368 | 164.4 | 1384 | 162.8 |
| 1978–79 | 965 | 116.0 | 985 | 115.9 |
| 1979–80 | 469 | 56.4 | 476 | 56.0 |

Index no. base : 1970—71.

The wholesale prices of Indian ginger being dependent upon the world market, particularly the Arabian demand, the period of high prices of ginger in Calicut and Cochin markets obviously coincides with the peak period of export. Again, since both Calicut and Cochin markets have close trade connections with each other, the prices of ginger in these markets more almost together (Tables 9, 10 and 11).

Table 10. Average monthly wholesale prices of ginger in Calicut and Cochin markets (Rs./Qtl.)

| *Year* | *April* | *May* | *June* | *July* | *Aug.* | *Sept.* | *Oct.* | *Nov.* | *Dec.* | *Jan.* | *Feb.* | *March.* | *Average* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Calicut market—Dry Ginger* | | | | | | | | |
| 1974–75 | 594 | 665 | 691 | 606 | 595 | 600 | 595 | 587 | 590 | 635 | 619 | 575 | 613 |
| 1975–76 | 612 | 635 | 614 | 619 | 642 | 806 | 865 | 875 | 862 | 720 | 681 | 772 | 725 |
| 1976–77 | 1010 | 1112 | 1331 | 1505 | 1475 | 1595 | 1662 | 1537 | 1200 | 1106 | 1169 | 1469 | 1345 |
| 1977–78 | 1585 | 1581 | 1544 | 1535 | 1494 | 1537 | 1419 | 1250 | 1170 | 1150 | 1081 | 1067 | 1368 |
| 1978–79 | 1275 | 1331 | 1275 | 1206 | 1094 | 985 | 969 | 912 | 745 | 650 | 581 | 555 | 965 |
| 1979–80 | 523 | 494 | 470 | 414 | 479 | 490 | 486 | 461 | 445 | 454 | 435 | 414 | 469 |
| Average | 933 | 970 | 987 | 947 | 963 | 1002 | 999 | 937 | 836 | 786 | 761 | 809 | 914 |
| | | | | | *Cochin market—Unbleached* | | | | | | | | |
| 1974–75 | 639 | 711 | 719 | 669 | 689 | 675 | 671 | 653 | 646 | 660 | 612 | 597 | 662 |
| 1975–76 | 630 | 647 | 625 | 627 | 657 | 822 | 875 | 937 | 806 | 725 | 697 | 764 | 734 |
| 1976–77 | 1020 | 1115 | 1400 | 1540 | 1506 | 1690 | 1700 | 1560 | 1160 | 1144 | 1208 | 1481 | 1377 |
| 1977–78 | 1615 | 1594 | 1581 | 1580 | 1512 | 1560 | 1406 | 1212 | 1170 | 1150 | 1125 | 1108 | 1384 |
| 1978–79 | 1275 | 1362 | 1362 | 1194 | 1125 | 990 | 1019 | 875 | 825 | 660 | 594 | 585 | 985 |
| 1979–80 | 563 | 494 | 494 | 500 | 479 | 504 | 495 | 464 | 470 | 483 | 461 | 435 | 476 |
| Average | 957 | 987 | 987 | 1018 | 995 | 1040 | 1028 | 950 | 847 | 804 | 783 | 828 | 936 |

**Table 11. Deviations from annual means (1974–75 to 1979–80) of wholesale prices of ginger in Calicut and Cochin markets**

| | *Calicut Market* | | *Cochin Market* | |
|---|---|---|---|---|
| *Month* | *Deviation* | *%Deviation* | *Deviation* | *%Deviation* |
| April | 19 | 2.08 | 21 | 2.24 |
| May | 56 | 6.13 | 51 | 5.42 |
| June | 73 | 7.99 | 51 | 5.45 |
| July | 33 | 3.61 | 82 | 8.76 |
| August | 49 | 5.36 | 59 | 6.30 |
| September | 88 | 9.63 | 104 | 11.11 |
| October | 85 | 9.30 | 92 | 9.83 |
| November | 23 | 2.52 | 14 | 1.50 |
| December | –78 | –8.53 | –89 | –9.51 |
| January | –128 | –14.00 | –132 | –14.10 |
| February | –153 | –16.74 | –153 | –16.35 |
| March | –105 | –11.49 | –108 | –11.54 |

The average monthly wholesale prices of dry ginger in these markets remain low from December to February. From March onwards the prices begin to rise reaching the maximum in September-October. The prices remain above the annual mean during April to November (Table 10). The percentage deviations from the annual mean (based on the price data given in table 10) were worked out and it was found that the deviations are in the range of (–) 16 percent to (+) 11 per cent (Table 11). Ginger, like any other agricultural commodities, is subject to seasonal price variations and in this case also the observations are true to the expectations, the postharvest prices being low and the preharvest prices being high.

Though we have observed that the wholesale prices of Indian ginger are highly fluctuating like the exports of dry ginger between years, the export values of Indian ginger are seen to more steadily upward. This is due to significant rise in the unit value of ginger year after year. Per kilogram unit value of ginger has gone up from Rs. 1.57 in 1960–61 to Rs. 8.27 in 1970–71 and Rs. 10.88 in 1978–79, (nearly 600 percent increase during 19 years) resulting a substantial boost to export earnings (Table 12).

**Table 12. Export of ginger from India**

| *Year* | *Export* ('000 t) | *Value* ('000 Rs). | *Unit value* (*Rs./Kg.*) | *Indices* *E(Q)* | *E(V)* | *U(V)* |
|---|---|---|---|---|---|---|
| 1960–61 | 5.6 | 8732 | 1.57 | 100 | 100 | 100 |
| 1965–66 | 3.9 | 13249 | 3.32 | 70 | 152 | 211 |
| 1970–71 | 3.2 | 26094 | 8.27 | 57 | 299 | 527 |
| 1975–76 | 4.8 | 41049 | 8.58 | 86 | 470 | 546 |
| 1978–79 | 11.8 | 128361 | 10.88 | 211 | 1470 | 693 |

The spices as a whole are also maintaining an upward trend in the aggregate export earnings for India. However, the export values for ginger constitute 5.6 to 9.6 percent of the total spices export earnings for the country (Table 13).

**Table 13. Share of ginger in total spices export from India (Value in Rs. '000)**

| *Year* | *Total spices export value* | *Export value for ginger* | % |
|---|---|---|---|
| 1974–75 | 625924 | 35127 | 5.61 |
| 1975–76 | 727250 | 41049 | 5.64 |
| 1976–77 | 759871 | 58432 | 7.68 |
| 1977–78 | 1418850 | 136899 | 9.65 |
| 1978–79 | 1609048 | 128361 | 7.98 |

Source : D.G.C.I. & S.

The prices of gingers in the world markets also vary according to their qualities. A comparative study of average annual prices of four different qualities of ginger representing four major exporting countries reveals that Indian ginger (known as Cochin ginger in London market) fetches the lowest price, while the Jamaican ginger fetches the highest in London. Prices of Sierra Leone ginger by and large move in between, whereas Nigerian ginger in some years receives higher prices and in some other years fetches lower prices than Indian ginger. Similarly in the New York market Chinese ginger fetches higher prices than Indian ginger (Table 14).

Jamaican ginger is generally considered to be the best in quality in the World on account of its delicate aroma, flavour and very low fibre content. Its attractive appearance coupled with cleanliness places it in a most advantageous position in the area of competition. This ginger is extensively used in the USA for manufacture of ginger-ale. Unbleached Jamaican ginger also stands today in a monopoly situation before the pharmaceutical units of United Kingdom. Household sector finds it as an excellent ginger for table purpose.

Similarly, Sierra Leone ginger, known as African ginger has pungent and somewhat camphoraceous flavour and it contains more essential oil than other types. This ginger is considered to be a good all-purpose ginger and is preferred by the meat processing/seasoning industries of the West. Though Nigerian ginger is considered to be of inferior quality as per the chemical parameters, it resembles the Jamaican type in physical appearance. As its low quality gets compensated by its relatively low price, Nigerian ginger finds acceptance in wide markets in the western world. In case of Indian ginger fibre and moisture contents are relatively higher than that of Jamaican and Sierra Leone types. Also, the oleoresin content of Indian varieties is low. The curing of Indian ginger is not as good as in the case of other competitive types. Thus India fetches lower price in the world market compared to Jamaica, Sierra Leone and sometimes Nigeria.

The food industries and the household sector in most parts of the world are the main source of demand for ginger and there is a definite trend towards an increased use of this spice in certain

**Table 14. Average annual prices of ginger in London and Newyork markets (Rs./Qtl.)**

| Year | *London Market* | | | | *New York Market* | |
|---|---|---|---|---|---|---|
| | *Cochin ginger* | *Jamaican No. 3* | *Nigerian split* | *Sierra Leone ginger* | *Cochin ginger* | *Chinese peeled whole* |
| 1970–71 | 1012 | 1917 | 509 | 983 | N/A | N/A |
| 1971–72 | 535 | 1745 | 389 | 664 | NA | NA |
| 1972–73 | 396 | 1374 | 396 | 512 | ,, | ,, |
| 1973–74 | 649 | 1662 | 756 | 964 | ,, | ,, |
| 1974–75 | 925 | 1656 | 1026 | NAF | ,, | ,, |
| 1975–76 | 976 | 1390 | 799 | 1223 | ,, | ,, |
| 1976–77 | 1610 | 1652 | 1067 | 1073 | 1504 | ,, |
| 1977–78 | 1705 | 2350 | 1767 | 2004 | 1858 | 176 |
| 1978–79 | 1333 | NA | 1859 | 2024 | 1502 | 2345 |
| 1979–80 | 767 | 6216 | 1824 | 2047 | 804 | 1696 |

quarters. India's trade expansion however, largely depends upon the improvement of qaulity of ginger. The main strategy in this direction should be the evolution of cultivars with the desired characters such as low fibre, low moisture, high oleoresin, high pungency and buff colour. At the same time, the existing methods of processing and storage need substantial change, so that the appearance of ginger could be very attractive as well as more resistant to mould and insect (particularly scale) infestation.

There is a noticeable fluctuation in our export of ginger and this is largely due to demand uncertainty. This uncertainty of overseas demand for ginger seriously affect the wholesale prices of ginger in the home markets which further leads to the production uncertainty. Export promotion measures should be vigorously pursued in the potential areas as a remedial measure to reduce fluctuations in demand, prices and production. A suitable agency should also coordinate planned production and marketing of ginger in India. Apart from its export potential, it is a labour intensive crop and primarily an important crop of the weaker section of the country. Therefore, ginger production and marketing need greater attention in coming days.

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# INTER DISTRICT VARIATIONS IN THE PRICES OF COCONUTS, COPRA AND COCONUT OIL IN KERALA

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## ABSTRACT

**The variations in the wholesale prices of coconuts, copra and coconut oil in Kerala, from 1958 onwards were studied. While the inter-district variations in the price of copra and coconut oil remained more or less steady over the years, the variations in the prices of coconuts was found to increase with increase in prices. The possible reasons for this phenomena are discussed.**

## INTRODUCTION

The coconut crop occupies a pride of place in the economy of Kerala State. About one-third of the cropped area in the State is under coconut and no other crop is grown in such a large extent. There are about 2.5 million coconut holdings in the state and according to a survey conducted during the 60s, the cultivating households were selling about 75% of the total production in the form of raw nut itself, while about 15% were used for home consumption (Anonymous, 1966, 1967). Consumption of coconut oil in the State is of the order of 60,000 tons, of which about 50,000 tons is for edible purposes (Thampan and Pankajakshan, 1976). It is used in almost every household in the State, for culinary purposes and or toiletary purposes. In view of the above, the fluctuation in the prices received by the cultivator for the raw produce and those paid by the consumer for the end product are watched with interest by many in the State. In this paper, an attempt has been made to examine the interdistrict variations in the wholesale prices of coconut (with husk), copra and coconut oil.

Coconut is a traditional crop of Kerala. During 1978–79, over 3000 million nuts were produced in the State from about 6.8 lakh ha. Except in the two interior districts of Idukki and Palghat, in all the other districts, about 50,000 to 1,00,000 ha. are under coconuts. The maximum area under coconut is in Calicut district, closely followed by Cannanore and Quilon districts. In the case of production also, the same pattern is noticed (Table—1). Productivity is highest in Trichur distirict. In Calicut, Ernakulam and Alleppey districts also, it is higher than the state average. Availability of coconuts was the highest in Calicut district, with 249 nuts, per capita, followed by Cannanore district. In the remaining districts, except in Idukki and Palghat, it fell within the range of 125 to 148 nuts.

**Table 1. Production, productivity and availability of coconuts in Kerala State**

| *District* | *Area* ('000 *ha*) | *Production* (*Million nuts*) | *Productivity* (*nuts/ha*) | *Availability* (*nuts, per capita*) |
|---|---|---|---|---|
| Trivandrum | 75.8 | 320 | 4221 | 146 |
| Quilon | 87.6 | 357 | 4077 | 148 |
| Alleppey | 59.4 | 283 | 4768 | 133 |
| Kottayam | 51.3 | 192 | 3743 | 1295 |
| Idukki | 14.3 | 40 | 2806 | 52 |
| Ernakulam | 57.3 | 276 | 4816 | 128 |
| Trichur | 49.6 | 311 | 6265 | 146 |
| Palghat | 18.9 | 62 | 3274 | 37 |
| Malappuram | 65.6 | 266 | 4054 | 143 |
| Calicut | 99.4 | 524 | 5270 | 249 |
| Cannanore | 94.3 | 422 | 4477 | 178 |
| State | 673.5 | 3053 | 4533 | 143 |

Alleppey, Cochin and Calicut are among the important markets for coconuts and coconut products in Kerala, and Bombay is an important market for coconut oil outside the State. In the Kerala markets, the wholesale prices of coconuts, copra and coconut oil move in close sympathy with each other. Coconut oil being the end product, its price can be considered as the independant variable. The following mathematical relationship could be obtained for the wholesale prices of coconuts and copra, from the data for Calicut market (Table—2).

**Table 2. Average annual wholesale prices of Coconuts and coconut products at Calicut (1950 to 1979)**

| *Year* | *Coconuts* (*Rs.*/1000 *nuts*) | *Copra* (*Rs.*/*qntl.*) | *Coconut oil* (*Rs.*/*qntl.*) |
|---|---|---|---|
| 1950 | 179 | 152 | 229 |
| 1951 | 242 | 164 | 244 |
| 1952 | 133 | 110 | 164 |
| 1953 | 152 | 125 | 185 |
| 1954 | 144 | 118 | 175 |
| 1955 | 128 | 98 | 143 |
| 1956 | 128 | 95 | 148 |
| 1957 | 154 | 128 | 193 |
| 1958 | 190 | 150 | 230 |
| 1959 | 185 | 149 | 226 |
| 1960 | 205 | 158 | 240 |
| 1961 | 215 | 155 | 236 |
| 1962 | 247 | 177 | 264 |
| 1963 | 249 | 195 | 284 |
| 1964 | 242 | 183 | 277 |
| 1965 | 351 | 287 | 422 |
| 1966 | 366 | 285 | 456 |
| 1967 | 417 | 322 | 498 |
| 1968 | 411 | 315 | 497 |
| 1969 | 397 | 331 | 497 |
| 1970 | 543 | 456 | 702 |
| 1971 | 424 | 371 | 581 |
| 1972 | 374 | 335 | 521 |
| 1973 | 689 | 557 | 864 |
| 1974 | 923 | 730 | 1153 |
| 1975 | 708 | 527 | 846 |
| 1976 | 764 | 601 | 931 |
| 1977 | 921 | 694 | 1072 |
| 1978 | 982 | 793 | 1173 |
| 1979 | 947 | 769 | 1146 |

*Source*: "Report on the marketing of coconuts and coconut products in India" (1962) for the data upto 1960.

Bureau of Economics and Statistics, Trivandrum, for the data since 1960.

(i) Wholesale price of coconuts (with husk)
$y = 4.37 + 0.8138\ x\ (R^2 = 0.9937)$

(ii) Wholesale price of copra

$y = 2.04 + 0.6487\ x\ (R^2 = 0.9978)$, where x represents the wholesale price for coconut oil. From the above equations it can be seen that most of the variations in the prices of coconut and copra could be explained by the variations in the prices of coconut oil. Market for oil is also seen to be spatially well integrated. The close relationship in the prices of coconut oil at the different markets can be seen from Table 3, showing the coefficients of correlation between the prices at different pairs of markets.

**Table 3. Coefficients of correlation between the wholesale prices of coconut oil at important markets, during 1950 to 1976**

| | *Alleppey* | *Calicut* | *Bombay* |
|---|---|---|---|
| Cochin | 0.999978 | 0.999861 | 0.998778 |
| Alleppey | | 0.999827 | 0.998594 |
| Calicut | | | 0.998571 |

Source: Jacob Mathew (1978)

For analysing the price trends, the period 1950 to 1979 can be conveniently broken up into four sub periods (i) 1950 to 56, during which the prices of coconuts as well as the related products declined in a fairly continuous manner, (ii) 1956 to 1964 during which the prices generally increased with moderate fluctuations, (iii) 1964 to 1975 during which prices not only increased sharply but also tended to fluctuate very widely than in the preceeding period, and (iv) 1975 onwards during which the prices are increasing at a fairly continuous manner. Since the scope of the paper is limited to a study of intra-regional variations in Kerala State which came into existence only in 1956, the first period, viz. 1950–56 has not been considered for further analysis.

Bureau of Economics and Statistics, Trivandrum regularly collects data on wholesale prices of coconuts (with husk), copra and coconut oil from about 15–20 important marketing centres for these commodities, spread all over the State. District average figures are available from 1958 onwards for nine districts for coconuts (except for Ernakulam, Trichur and Cannanore districts for 1967 to 1969) and eight districts each for copra and coconut oil. Price data on copra and coconut oil are not reported from Trivandrum and Malappuram districts, while wholesale prices of coconuts are not available for Kottayam district. None of these data is available for Palghat district. Since Idukki and Wynad districts came into existence only recently, these have been excluded from this study. Whenever comparison betweern the prices of coconuts, copra and coconut oil was attempted, it was restricted to six common districts only, viz. Quilon and Alleppey in South Kerala, Ernakulam and Trichur in the Centre and Calicut and Cannanore in the north.

The inter-district coefficients of variation(%) for the wholesale prices of coconuts, copra and coconut oil are presented in table–4. The variation between districts for the wholesale prices of copra and coconut oil was more or less similar (less than 2%) and remained steady over the years. In the case of coconuts, even during the initial years, the CV was as high as 5% and during the 70s, it almost doubled. In other words, with increase in prices, the divergence between districts in the wholesale prices of coconuts also widened, where as in the case of copra and coconut oil, no such divergence was noticed.

In view of the importance of the crop to the state, it is worth examining how this divergence in coconut prices between districts has happened. In table 5, the mean wholesale prices of coconuts, copra and coconut oil obtained during three different periods, in the different districts have been given. During period 1(1959–64), the prices were generally increasing with moderate fluctuations, whereas in period 2(1970–75), the prices not only increased very sharply, but also tended to fluctuate violently. During period 3, the prices were again increasing at a fairly continuous manner.

### Table 4. Inter-district coefficients of variation (%) for the wholesale prices of cocounts (with husk), copra and coconut oil, during 1958 to 1979

| *Year* | *Coconut* | *Copra* | *Coconut oil* |
|---|---|---|---|
| 1958 | 3.32 | 1.80 | 2.20 |
| 1959 | 5.82 | 1.32 | 0.64 |
| 1960 | 6.60 | 2.01 | 1.02 |
| 1961 | 5.05 | 2.16 | 1.05 |
| 1962 | 1.79 | 2.51 | 1.41 |
| 1963 | 3.25 | 1.33 | 0.88 |
| 1964 | 3.43 | 0.87 | 1.47 |
| 1965 | 3.90 | 1.16 | 1.19 |
| 1966 | 5.63 | 1.90 | 1.34 |
| 1967 | .. | 1.29 | 1.09 |
| 1968 | .. | 1.45 | 1.10 |
| 1969 | .. | 1.02 | 0.91 |
| 1970 | 10.62 | 1.36 | 0.76 |
| 1971 | 10.57 | 1.81 | 1.76 |
| 1972 | 10.56 | 1.53 | 1.31 |
| 1973 | 10.27 | 1.68 | 0.24 |
| 1974 | 91.2 | 1.26 | 1.61 |
| 1975 | 7.46 | 1.18 | 1.78 |
| 1976 | 10.09 | 1.27 | 1.29 |
| 1977 | 8.54 | 3.24 | 1.22 |
| 1978 | 8.78 | 1.14 | 0.99 |
| 1979 | 10.15 | 1.14 | 1.05 |

**Table 5. Inter-district variations in the mean wholesale prices of coconuts (with husk), copra and coconut oil, and during different periods**

| *District* | *Mean wholesale price during* | | | *% increase over period* 1 | |
|---|---|---|---|---|---|
| | *Period* 1 (1959-64) | *Period* 2 (1970-75) | *Period* 3 (1976-79) | *Period* 2 | *Period* 3 |
| (i) *Coconuts* (*with husk*) (*Rs./*100 *nuts*) | | | | | |
| Trivandrum | 226.22 | 624.33 | 930.21 | 186.0 | 311.2 |
| Quilon | 236.38 | 670.72 | 1002.96 | 183.7 | 324.3 |
| Alleppey | 239.53 | 679.35 | 986.21 | 183.6 | 311.7 |
| Ernakulam | 245.38 | 728.06 | 1055.39 | 196.7 | 330.1 |
| Trichur | 241.07 | 758.29 | 1092.12 | 214.6 | 353.0 |
| Palghat | 214.83 | 613.65 | 928.26 | 185.6 | 332.1 |
| Calicut | 221.18 | 601.76 | 903.74 | 172.1 | 308.6 |
| Cannanore | 223.98 | 585.34 | 824.34 | 161.3 | 268.0 |
| Mean | 231.07 | 657.69 | 965.41 | 184.6 | 317.8 |
| (ii) *Copra* (*Rs./qntl.*) | | | | | |
| Quilon | 167.91 | 507.16 | 709.12 | 202.0 | 322.3 |
| Alleppey | 169.68 | 521.47 | 326.96 | 207.3 | 328.4 |
| Kottayam | 168.48 | 520.52 | 730.08 | 209.0 | 333.3 |
| Ernakulam | 163.04 | 502.99 | 711.37 | 208.5 | 336.3 |
| Trichur | 166.42 | 504.93 | 714.90 | 203.4 | 329.6 |
| Calicut | 167.66 | 506.84 | 727.77 | 202.3 | 334.1 |
| Cannanore | 162.69 | 500.39 | 710.56 | 207.6 | 336.8 |
| Mean | 166.55 | 509.19 | 718.68 | 205.7 | 331.5 |
| (iii) *Coconut Oil* (*Rs./qntl.*) | | | | | |
| Quilon | 249.18 | 762.02 | 1072.49 | 205.8 | 330.4 |
| Alleppey | 249.90 | 777.58 | 1097.39 | 211.2 | 339.1 |
| Kottaym | 249.77 | 777.60 | 1090.87 | 211.3 | 336.7 |
| Ernakulam | 248.92 | 780.63 | 1101.21 | 213.6 | 342.4 |
| Trichur | 249.75 | 777.27 | 1079.40 | 211.2 | 332.2 |
| Calicut | 253.51 | 780.73 | 1081.60 | 208.0 | 326.6 |
| Cannanore | 247.72 | 792.57 | 1094.10 | 219.9 | 341.7 |
| Mean | 249.82 | 778.34 | 1088.15 | 211.6 | 335.6 |

The wholesale price of coconuts varied between Rs. 215 in Malappuram district to Rs. 245 in Ernakulam district, during period 1, whereas during the subsequent period, the range was between Rs. 585 (for Cannanore district in North Kerala) and Rs. 758 (for Trichur district in Central Kerala). When the wholesale price in Cannanore district showed an increase of 161%, it rose by 215% in Trichur district. During period 3 also, the highest price of Rs. 1092 was reported from Trichur district and the lowest price of Rs. 824 from Cannanore district. Compared to period 1, the percentage increase during this period was to the extent of 353% in the case of Trichur district, where as it was only 268% in Cannanore district. Even now, the prices are increasing at a lesser rate in Cannanore district. Compared to period 2, the prices rose by 40% at Cannanore district during period 3, whereas in the other districts, it went up by 45 to 50%. During period 1, the prices at Trichur and Cannanore districts differed by only Rs. 17 per 1000 nuts. This rose to Rs. 173 during period 2 and to Rs. 268, in the recent years. In other words, during the latter two periods, the prices received at Trichur district was one-third higher than those received at Cannanore district. The maximum increase in price was noticed in Trichur district, followed by the adjoining district of Ernakulam, both in Central Kerala. The minimum increase took place in Cannanore district, followed by Calicut district, both of which are in North Kerala. In the southern districts of Trivandrum, Quilon and Alleppey, the prices increased at an intermediate level. In other words, the divergence between districts, during the 70s in the matter of wholesale prices of coconuts, has come about through relatively small increases in the northern districts, where the prices are usually lower and large increases in the central districts where the prices are usually higher.

The price reported for coconuts is for unhusked nuts. One probable reason for the comparatively higher price obtained for coconuts in central and south Kerala is due to the demand for coconut husk from the coir industry. Natural facilities exist in these areas for the retting of husk. It had been estimated (Anonymous 1962) that during the early 60s the husk from about 70% of the nuts produced in the state is consumed by the fibre industry. Judging from the present production levels of coir fibre, there is no reason to believe that this proportion has changed. Even then, the prices obtained in the southern districts are not as high as that in central Kerala, namely Ernakulam and Trichur districts. A survey report from the Directorate of Coconut Development (Anonymous, 1976) has shown that about 40% of the expeller units in the state are concentrated in the two districts of Ernakulam and Trichur (Table 6). It appears that it is the demand from the milling sector that has pushed up the price of cocnuts to the highest level, in this region. The annual production of milling copra in the state is estimated at nearly three lakh tons. Since two-thirds of the nuts produced in the state is converted to copra, the demand for copra from the oil mills appears to be the most important factor determining the fluctuations in coconut prices. Thus, Cannanore district suffers from lack of retting facilities and lack of demand from the oil mills.

**Table 6. Regional distribution of expeller units in Kerala**

| *District* | *Number of units* | *Number of expellers* | *Installed capacity (tonnes/day)* |
|---|---|---|---|
| Trivandrum | 4 | 4 | 14 |
| Quilon | 13 | 15 | 56 |
| Alleppey | 8 | 6 | 162 |
| Kottayam | 3 | 3 | 8 |
| Ernakulam | 10 | 21 | 174 |
| Trichur | 15 | 30 | 137 |
| Palghat | 2 | 2 | 30 |
| Malappuram | 7 | 12 | 68 |
| Calicut | 8 | 12 | 128 |
| Cannanore | 2 | 5 | 23 |
| Total | 72 | 120 | 800 |

*Source*: Coconut Bulletin, May 1976.

Availability of coconuts in the different regions (Table 1) is another reason for the differences in prices. In Cannanore district, where the per capita availability of nuts is the second highest, minimum prices are being received. Calicut district, where supply was in abundance, the prices were not lower than that at Cannanore. This may be because of the heavy demand from the up country buyers. However, since there is no restrictions on the inter-district movement of coconuts, the influence of total production as well as the per capita availability of nuts in each district on the prices appear to be minimum. Also, about 50% of the nuts produced is taken out from the state, in the form of copra and coconut oil. Hence, it may be the demand from the upcountry markets, rather than the internal supply that may be influencing the price movements.

In the case of copra and coconut oil, the differences in the wholesale prices between districts were only marginal at all the periods. Copra price ranged between Rs. 163 and Rs. 170, during period 1, compared to the variation between Rs. 248 and Rs. 254, in the case of coconut oil, for the same period. During Period 2, the copra price increased by 206% and coconut oil prices by 212%. The rate of increase was more or less uniform in all the districts. Similarly during Period 3 also, it increased at a more or less uniform rate of 332% (compared to period 1) for copra and 336% for coconut oil, in all the districts. Coconut oil being the end product, these marginal differences in the prices are not unexpected.

The implications of the low prices of coconuts obtained at Cannanore district is interesting to note. In an earlier study of the trends in the production and productivity of coconuts in the state as a whole and for some of the selected districts, the author (Jacob Mathew, 1979) had concluded that the declining trend in productivity (nuts/ha) was partly due to the reduction in the proportion of bearing palms in the population. Another reason for the negative rate of growth for productivity (Table 7) was the extension of coconut cultivation to marginal lands. Among the districts considered, the rate of decline was the highest in Cannanore district and the lowest in Trichur district. It now appears that the slower rate of increase in price trend of coconuts is one of the reasons for the faster rate of decrease in productivity observed at Cannanore.

**Table 7. Compound growth rates for productivity of coconuts (1957—58 to 1974—75)**

| | *Log* $y = a + bt$ | | *Growth* | |
|---|---|---|---|---|
| | *a* | *b* | *Rate* (%) | $R^2$ |
| India | 8.8127 | –0.0133(0.0011) | –1.317 | 0.9052 |
| Kerala | 8.8299 | –0.0167(0.0012) | –1.657 | 0.9215 |
| Trivandrum | 8.7871 | –0.0067(0£0017) | –0·673 | 0.4903 |
| Quilon | 8.8661 | –0.0189(0.0020) | –1·869 | 0.8533 |
| Alleppey | 8.8673 | –0.0086(0.0031) | –0·860 | 0.3196 |
| Trichur | 8.7806 | –0.0044(0.0013) | –0.439 | 0.4369 |
| Cannanore | 8.9034 | –0.0482(0.0052) | –4.710 | 0.8418 |

*Note:* Figures in parenthesis are standard errors of reg. coefts.

*Source:* Jacob Mathew(1978).

The above analysis of the inter-district variation in the prices of coconuts and coconut products points out the need for setting up of more coconut based industries in the northern districts, so that the producers may get a better price for their produce. This may also help to arrest the declining trend in productivity to a great extent.

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# MARKET PROSPECTS OF TECHNICALLY SPECIFIED NATURAL RUBBER IN BLOCK FORM

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## ABSTRACT

**The paper analyses in detail the market prospects of technically specified rubber in block form in the Indian polymer market, which is traditionally accustomed to conventional grades of ribbed smoked sheets and crepe. The advantages of block rubber over conventional grades are outlined in the first part. Besides, the existing production pattern of block rubber and the anticipated supply position in the coming decade are assessed. Against this background the demand potential of block rubber is evaluated in the second part. Gradewise demand potential is estimated and the various market segments to which block rubber could profitably penetrate are also identified. The competitiveness of block rubber vis-a-vis conventional grades is examined with particular reference to the price structure. After establishing the bright prospects of block rubber in the Indian Market, the problems being encountered to market this rubber are probed into the detail and a marketing strategy to ensure the successful marketing of this product is proposed.**

## INTRODUCTION

Block rubber, commonly termed as crumb rubber, is a modern marketable form of dry natural rubber (NR) which has to be graded and marketed according to the technical specifications of Indian Standards Institution. Block rubber can, therefore, replace conventional grades of dry natural rubber in all applications.

Block rubber is the product of relentless efforts made by the NR producing countries particularly Malaysia to present natural rubber in a comparable form with synthetic rubber. Malaysia has introduced technically specified natural rubber with the brand name Standard Malaysian Rubber (SMR) with a view to maintaining the intrinsically good and alround properties of natural rubber through processing and by presenting it in a more uniform form with technical specifications and in blocks of convenient size and packing so as to cater to the needs of the consumers. The initiative taken by

Malaysia in this regard was followed by other major NR producing countries. In a decade of existence, block rubber has won worldwide acceptance and recognition as seen from the consistent increase of its production in the major NR producing countries. About 58% of the total natural rubber produced in Indonesia is in the form of block rubber, while the corresponding percentage in Malaysia is around 35%.

### Block rubber in India

Block rubber production started in India in 1974–75. Now there are nine factories, of which four are situated in large estates, one in the co-operative sector, one is owned by the Rubber Board and the remaining three are in the private sector. The production during 1979–80 is estimated to be around 2000 tonnes.

This infant industry received a boost, with the implementation of the Kerala Agricultural Development Project financed by the International Development Association of the World Bank. This Project interalia includes a Rubber Processing Component which envisages the setting up of nine new 10 tonnes per day crumb rubber factories in a phased manner in the various rubber growing tracts of Kerala, and the expansion of the existing factory at Palai to 10 tonnes per day capacity. The Project, when completed in 1985 will contribute about 25000 tonnes of crumb rubber to the total polymer availability in the country. Besides there are also plans to set up new factories particularly in public sector plantations. It is provisionally estimated that block rubber production may be around 29300 tonnes in 1985, which will increase further to 45000 by 1990. The number of factories is also expected to increase to 17 in 1985 and further to 23 in 1990.

### Production of block rubber

Production of block rubber involves a series of unit operations such as precleaning, blending, final size reduction, drying and packing. The raw rubber in the form of latex and/or scrap is converted into crumbs after precleaning operations to remove foreign matter, washed, dried at a temperature not exceeding 110°C compacted into blocks of standard size and shape and wrapped in low density polythene film. Grading is done by taking sample from bales representing each lot and testing for dirt, ash, volatile matter, nitrogen content, initial plasticity and plasticity retention index. Block rubber is then packed in high density polythene bags marked with the grade and net weight. Each bag contains two blocks of 25 kg. each.

## Grades of block rubber

In India, block rubber is to be marketed adopting ISI specifications and therefore it is called Indian Standard Natural Rubber (ISNR). The grades of ISNR now marketed can be broadly classified into two, latex grades and scrap grades depending on the starting material used for production. ICNR 5 (Special), ISNR 5(L.C.) and ISNR 5 are latex grades while ISNR 10, 20 and 50 are scrap grades.

## Advantages of block rubber

Block rubber has certain distinct advantages over conventional grades such as ribbed smoked sheets and different forms of crepes, which are graded visually. The advantages are listed below:

1. Being available in five well defined grades, correct choice of the grades to suit the requirements of the consumers is easy.

2. Being processed in bulk quantities adopting latest technology, variation in technological properties within the same grade is minimum facilitating better raw material quality control and processing.

3. Being possible to assess the actual content of foreign and volatile matter, realistic assessment of the worth of the material is possible.

4. Being marketed in compact polythene wrapped bales, contamination of the rubber on storage, handling and transportation can be prevented.

## Lost benefits

It is well recognised that price is the most important factor influencing the selection of grades by the consumers. However, comparison based on market price alone will not be enough in selecting rubber grades. In fact, the overall cost of production and the quantity and quality of the saleable products are also important factors to be considered. Therefore, it is pertinent to consider the following benefits in cost and quality.

1. Block rubber can be efficiently handled at all stage of external and internal transportation in view of the optimum bale size and compact nature of bales. This will reduce handling and transportation cost.

2. Block rubber being in standard size and compact shape, can be conveniently stored one above the other and the floor area required will be much less compared to that for conventional grades. This will result in savings on storage cost.

3. Block rubber does not require removal of bale cover, precleaning, bale cutting and straining. Besides, being processed from crumbs, it requires comparatively less pre-mastication. It can be fed directly into the mill (depending upon its initial plasticity and mill size) or banbury. The extent of cost reduction in this respect can be quite significant in terms of labour, power and machinery output. Besides, the use of block rubber can minimise certain production problems, wastage and variability in product properties.

4. Raw material testing as well as in process testing can be minimised by using block rubber with guaranteed specifications. Factories where facilities are not available for quality control testing can, therfore, avail of this advantage.

5. Since dirt, volatile matter and ash content are controlled and regulated and there is no bale coating, consumers can obtain a more realistic pricing advantage in terms of the actual worth of the material.

### Analysis of demand

The demand prospects of block rubber in India depends on the future prospects of natural rubber in the country. The rubber manufacturing industry in the country is poised for rapid growth which would generate sufficient demand for natural rubber. The projected requirements of natural rubber in 1984–85 and 1989–90 are provisionally placed at 237,000 and 342,000 tonnes respectively.

Since 84% of the total polymer requirements of the country is proposed to be met by NR, the future prospects of natural rubber are certainly bright.

An analysis of the consumption pattern of rubber in the country will be useful in examining the demand prospects of block rubber. The product lines to which natural rubber is channelised now are shown below:

| | |
|---|---|
| Auto tyres and tubes | 50% |
| Cycle tyres and tubes | 12% |
| Camel back | 5% |
| Foot wears | 11% |
| Belts and hoses | 6% |
| Others | 16% |

Each product group may require more than one grade of natural rubber. Therefore, taking into account the requirements of each of the product groups and on the basis of the existing consumption pattern, the total demand for natural rubber is broken down into various market segments as shown below:

| | *Grade of Rubber* | *Market share* |
|---|---|---|
| 1. | ISNR 5 (Special), 5 light colour and 5 and its equivalent conventional grades. | 21% |
| 2. | ISNR 10 and its equivalent conventional grades. | 18% |
| 3. | ISNR 20 and its equivalent conventional grades. | 53% |
| 4. | ISNR 50 and its equivalent conventional grades. | 8% |

It may be noted in this context that the demand in each of the above segment will have to be met by conventional grades and its equivalent grade of block rubber. Among the various grades, ISNR 20 has the maximum demand potential. This is quite natural as this is the grade required for the manufacture of automobile tyres as well as cycle tyres. The automobile tyre industry has already recognised the advantages of block rubber as is evident from the fact that two tyre companies have already started using it on a regular basis. The other tyre companies are evaluating the suitability of block rubber to replace conventional grades and it can be reasonably expected that they will also change over to block rubber if supply is ensured. The technical collaborators of these companies are familiar with block rubber, particularly SMR and they would only welcome a transition. The cycle tyre industry is yet another potential field where block rubber could effectively penetrate.

The market share for latex crumb is 21%. ISNR 5 (Special) with minimum 80 PRI is the ideal grade for the manufacture of aero tyres. The demand prospects of this grade is rather limited. Coming to ISNR 5 with light colour, which can be effectively used to replace PLC and RMA IX in the production of pharmaceutical products, quality foot wear items and extruded products, the market share is again low. However, penetration of block rubber in this market segment is comparatively more easy considering the price advantage of this grade over the PLC grades. ISNR 5 could be used in all applications where RMA 1 is used at present. The manufacture of automobile tubes, cycle tubes, quality conveyor beltings etc. are areas where this grade could penetrate. ISNR 10 could be used in foot wear, hose etc. while ISNR 50 in the manufacture of handmade hoses, bushes, cheap foot wear items and such other products.

## Existing market for block rubber

At present the share of block rubber to total NR consumption in the country is only about 2.25%. About 60% of the block rubber is used in the tyre tube industry. However, block rubber forms only 3% of its total NR consumption. Similarly in the non-tyre sector the share of block rubber is only about 2%. It therefore becomes clear that block rubber has yet to penetrate into the various potential markets.

## Marketing problems

Block rubber being a new product in the Indian polymer market is not free from the initial problems which any new product experiences in the initial years of its life cycle. The producers have experienced difficulties in standardising the product and maintaining uniform physical properties. Similarly consumers have raised objections regarding the presence of dirt and other foreign matter beyond the permissible limits. These are problems of a transient nature often associated with the manufacture of a new product. The major block rubber producing countries have also experienced similar problems in the initial stages. Their experience show that these problems can be identified and resolved to the satisfaction of both the producers and consumers.

The manufacturers are keen to cut down cost of production without impairing the quality of finished products. They will change over to block rubber, only if they are convinced that this transition would result in a net advantage to them either in terms of cost or improvement in the quality of finished products. This brings out the importance of selling price, a factor which influences the buying habits of the consumers considerably. The price structure is reviewed and revised periodically on the basis of market survey and such other market information. The existing price structure may not be viewed in strict comparison with the price of equivalent conventional grades. Instead, the difference between these two prices may be weighed taking also into account the indirect benefits accruing to the manufacturer by using block rubber. If such an approach is followed the existing price structure will be certainly competitive and attractive.

Regular and uninterrupted supply is one of the main factors influencing demand. The supply position of block rubber has been quite irregular as a result many consumers were reluctant to replace conventional grades, as they cannot change their formulations every now and then. Past experience have shown that poor supply position has been the constraint in generating demand for block rubber. With the implementation of the KADP, the supply position will improve considerably.

By using block rubber, consumers can increase output, improve the quality of manufactured products, bring down cost of production and thereby realise better returns. The overall advantages accruing to the consumers vary depending on factors such as sophistication required for the products manufactured, the scale of operation in the factory, availability of cheap labour, and quality testing facilities, energy requirements and restraints and so on. The future of block rubber industry in India is full of exciting prospects. There is sufficient market potential and what is required is the proper exploitation of the existing potential.

# STRUCTURE OF RUBBER MARKET IN INDIA

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## ABSTRACT

**The paper gives a short review of rubber marketing in India. The various marketing agencies, their relative strength and functions are examined. The problems faced by estates and small holdings and possible solutions are discussed. The role of co-operatives and the Rubber Board is briefly reviewed. The distribution of rubber dealers and their strength are assessed. The paper also examines the rubber marketing in India, with the marketing situation in Malaysia, Thailand, Sri Lanka etc.**

## INTRODUCTION

The marketing of rubber in India was practically free before the conclusion of the International Rubber Regulation Agreement. The Agreement was brought into force to tide over the difficulties that befell on natural rubber plantation industry during the Great Depression in the thirties. India was a signatory to the Agreement along with the Federation of Malaya(Malaysia), the East Indies (Indonesia) etc. For enforcing the provisions of the Agreement, The Government of India enacted the Indian Rubber Control Act, 1934. The Indian Rubber Licensing Committee was constituted under the Act.

The Licensing Committee was mainly concerned with the restriction of export of rubber during the first eighty years of its inception. By 1942 the situation in India had changed completely and the internal demand for rubber was so much that the Government of India had to issue the Rubber Stocks (Control) Order to channelise rubber for war purposes. Under the Order, prices were statutorily fixed for the first time. The Government of Travancore, Cochin and Mysore also passed Rubber Control Orders to implement the regulations within their respective territories. In November 1942 the Government of India issued the "Indian Rubber Control and Production Order 1942" by which the Indian Rubber Production Board was constituted with a view to taking steps for increasing the production of rubber. After the war the Order ceased to operate. At the instance of the Government of India a conference of rubber growers was held in December 1945 and the conference recommended the setting up of a permanent organisation to develop the rubber plantation industry on scientific lines. The Rubber (Production and Marketing) Act 1947 was accordingly enacted to set up the Rubber Board.

### Provisions of the Rubber Act relating to marketing

According to Section 14 of the Rubber Act 1947, no person shall sell or otherwise dispose of, and no person shall buy or otherwise acquire rubber except under and in accordance with the terms of a general or special licence issued by the Rubber Board. Unlicensed dealing in rubber is a contravention of the Rubber Act and is punishable under Section 26 of the Act. The Act prohibits the possession of rubber other than by a licensed dealer, or processor, manufacturer or in a registered holding or estate. Therefore every person who wants to deal or acquire rubber has to obtain a licence from the Rubber Board.

### Marketing functions in rubber

The main functions involved in rubber marketing are assembling, processing, grading, packing, warehousing, insuring, transporting and financing.

*Assembling:* Assembling plays a very important part in the marketing of agricultural commodities which are generally produced in small quantities by a large number of growers in a widely scattered area. It is the putting together of goods for sale. In the case of rubber, assembling is carried out by small dealers spread mainly over the three South Indian States producing rubber.

*Processing:* Processing of rubber at the producers level may be in the form of smoked sheet or preserved latex or crepe or crumb rubber. Processing is also done at the crepe mills, crumb rubber factories and centrifuging plants.

*Grading:* Grading is the sorting of goods into lots which are alike in variety, size, and quality. The object of grading is to ensure uniformity and to bring about an understanding between the buyer and the seller as to the quality of the product. Usually a grade denotes uniformity of the specific product. There are 22 grades for sheet and crepe rubber. In addition, latex concentrates grouped into 3 types are also marketed in the country. Technically specified rubber (crumb) is marketed in five grades.

*Packing :* Proper packing ensures quality, external appearance and finish of the product. Rubber is usually packed as bare back (in rubber sheets) or in hessian. Polythene sheet has been introduced for packing technically specified rubber. Occasionally wooden cartons are used for packing pale latex crepe and sole crepe, while concentrated latex is filled in drums.

5. *Warehousing:* Many agricultural products are raised seasonally. But consumers require the products more or less evenly throughout the year. In such cases storage may become necessary to ensure regular supply. In the case of rubber there is a monthly fluctuation in production and this is represented in table 1. The table shows the average percentage share of production of rubber per month during the 10 year period ending 1978.

**Table 1. Percentage share of production of natural rubber per month in India**

| *Month* | | *Percentage* |
|---|---|---|
| January | .. | 10.68 |
| February | .. | 4.35 |
| March | .. | 6.76 |
| April | .. | 7.04 |
| May | .. | 7.91 |
| June | .. | 7.81 |
| July | .. | 6.60 |
| August | .. | 6.79 |
| September | .. | 8.72 |
| October | .. | 9.64 |
| November | .. | 11.11 |
| December | .. | 12.59 |
| Total | | 100.00 |

*Insuring*: Insurance is a commercialised form of covering risk. Marine and fire insurance are adopted in rubber business; marine insurance being used for coastal shipping of rubber.

*Transporting*: Rail, road and water are the means of transport used in rubber trade. Coastal shipping was an important form of transport a decade ago, but road transport now takes the lead. The result of the two studies conducted during 1967 and 1978 are presented in Tables 2 and 3.

**Table 2. Quantity of natural rubber transported from Kerala and Kanyakumari district of Tamil Nadu to other places**

| | *Mode of Transport* | | | |
|---|---|---|---|---|
| | *By ship* | *By rail* | *By road* | *Total quantity (in tonnes)* |
| **1967** | | | | |
| Quantity transported in (tonnes) | 34449 | 7089 | 17588 | 59126 |
| Percentage to the total | 58.3 | 12.0 | 29.7 | 100.00 |
| **1978** | | | | |
| Quantity transported (in tonnes) | 1403 | 26727 | 103555 | 131685 |
| Percentage to the total | 1.1 | 20.3 | 78.6 | 100.00 |

*Financing*: The financial institutions involved in trade in India are (a) Indigenous bankers known by different names in different parts, (b) Co-operative banks which advance money mainly to member cultivators and (c) Scheduled and non-scheduled joint stock banks. In rubber business all the above institutions are also involved.

Table 3. Total quantity of rubber transported from Kerala and Kanyakumari district of Tamil Nadu to other places in 1978 (Qty in tonnes)

| | *By road (in tonnes)* | *By sea (in tonnes)* | *By rail (in tonnes)* | *Total* |
|---|---|---|---|---|
| Estates | 19904(86.32%) | 950(4.12%) | 2204 ( 9.56%) | 23058(100.00%) |
| Dealers and processors | 26209(94.78%) | — | 1443 ( 5.22%) | 27652(100.00%) |
| Manufacturers | 57442(70.94%) | 453(0.56%) | 23080 (28.50%) | 80975(100.00%) |
| Total | 103555(78.64%) | 1403(1.06%) | 26727 (20.30%) | 131685(100.00%) |

**Table 4. Distribution of licensed rubber dealers in different states according to their purchase—(1978)**

| *State* | 10 *mt* *and below* | *Above* 10 *and upto and including* 25 *mt* | 25–50 | 50–100 | 100–250 | 250-500 | 500-1000 | *Above* 100 | *Total* |
|---|---|---|---|---|---|---|---|---|---|
| Kerala | 892 | 359 | 323 | 273 | 254 | 142 | 80 | 65 | 2388 (84.56%) |
| Delhi | 44 | 8 | 11 | 6 | 11 | 5 | 3 | – | 88 (3.12%) |
| West Bengal | 33 | 4 | 4 | 10 | 5 | 5 | – | 2 | 63 (2.23%) |
| Punjab | 22 | 2 | 4 | 2 | 6 | 4 | 2 | 1 | 43 (1.52%) |
| Haryana | 3 | – | – | 2 | 1 | 1 | – | – | 7 (0.25%) |
| Maharashtra | 30 | 3 | 5 | 1 | 3 | - | 1 | 3 | 46 (1.63%) |
| Tamil Nadu | 91 | 7 | 7 | 6 | 7 | 10 | 5 | 2 | 135 (4.78%) |
| Uttar Pradesh | 18 | 3 | 1 | 3 | 1 | 1 | – | 1 | 28 (0.99%) |
| Karnataka | 4 | 4 | – | 1 | – | 2 | 1 | – | 12 (0.42%) |
| Andhra Pradesh | – | – | – | 1 | – | – | – | – | 1 (0.04%) |
| Gujarat | 7 | – | 1 | – | – | – | – | – | 8 (0.28%) |
| Other states | 3 | 1 | 1 | – | – | – | – | – | 5 (0.18%) |
| TOTAL | 1147<br>(40.62%) | 391<br>(13.84%) | 357<br>(12.64%) | 305<br>(10.80%) | 288<br>(10.20%) | 170<br>(6.02%) | 92<br>(23.26%) | 74<br>(2.63%) | 2824<br>(100%) |

**Table 5. Distribution of licensed rubber dealers in Kerala according to their purchase—(1978)**

| *District* | 10 *mt and below* | *above* 10 *and upto and including in* 25 *mt* | 25–50 | 50–100 | 100–250 | 250–500 | 500–1000 | 1000 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Trivandrum | 64 | 14 | 9 | 11 | 14 | 6 | 3 | 3 | 106<br>(4.44%) |
| Quilon | 151 | 69 | 65 | 40 | 42 | 20 | 10 | 2 | 408<br>(17.09%) |
| Alleppey | 20 | 10 | 9 | 5 | 5 | 1 | — | — | 50<br>( 2.09%) |
| Kottayam | 327 | 142 | 129 | 134 | 125 | 70 | 32 | 41 | 1000<br>(41.88%) |
| Idikki | 68 | 34 | 25 | 18 | 13 | 11 | 4 | 6 | 179<br>( 7.49%) |
| Ernakulam | 96 | 30 | 31 | 34 | 22 | 16 | 13 | 7 | 249<br>(10.43%) |
| Trichur | 8 | 2 | 4 | 3 | 2 | 1 | 1 | 1 | 22<br>( 0.92%) |
| Palghat | 10 | 1 | 9 | 2 | 1 | 3 | 1 | — | 27<br>( 1.13%) |
| Malappuram | 30 | 5 | 4 | 4 | 4 | 4 | 1 | 3 | 55<br>( 2.30%) |
| Kozhikode | 62 | 22 | 18 | 6 | 12 | 5 | 1 | — | 126<br>( 5.28%) |
| Cannanore | 74 | 30 | 20 | 16 | 14 | 5 | 5 | 2 | 166<br>( 6.95%) |
| TOTAL | 892<br>(37.35%) | 359<br>(15.03%) | 323<br>(13.53%) | 273<br>11.43%) | 254<br>(10.64%) | 142<br>(5.95%) | 80<br>(3.35%) | 65<br>(2.72%) | 2388<br>(100%) |

### Marketing agencies

The agencies involved in marketing of rubber are country buyers, wholesalers, processors, commission agents, brokers, and auctioneers.

*Country buyers*: Country buyers undertake the initial work of assembling the produce from farms or country markets. In rubber they may be village shop-keepers, itinerant traders. agents of crepe mills, and agents of co-operative societies. It has been estimated that there were about 1500 such buyers for rubber in 1978. Most of them were purchasing 25 tonnes or less per annum. The licensed dealers classified according to the volume of their purchase are presented in Tables 4 and 5.

*Wholesalers*: They may be market intermediaries who sell goods to ultimate consumers. They generally undertake the transport, storage and preparation for consumption. The wholesalers are mainly located in Kottayam, Cochin and Calicut. There were around 200 such wholesalers in rubber in 1978. They were individually handling about 500 to 1000 tonnes of rubber during a year.

*Processors*:— In the case of rubber the smoke houses, estate factories, crepe mills, crumb rubber factories, latex concentrating factories etc. handle this function. There were 17 latex conncentrating factories, 8 crumb rubber factories and 119 crepe mills in India in 1978. Of these, 54 crepe mills were in and around Kottayam town. Most of the mills handled below 500 tonnes of rubber, with a few handling 1000 tonnes per annum. The details of processing units are shown in Table 6.

**Table 6. Number of rubber processing units in India in 1978**

| | *In Estate* | *outside Estate* | *Total* |
|---|---|---|---|
| Crepe mills | 21 | 98 | 119 |
| Crumb rubber factories | 4 | 4 | 8 |
| Concentrated latex factories | 11 | 6 | 17 |

*Commission Agents*: The commission agents specialise in buying and selling for absentee principals and take charge of goods on their behalf. The purchase is undertaken on the basis of an agreement entered into between the principal and the agent. There were 65 commission agents in rubber market in 1978, most of them in Cochin and Kottayam.

A study of the commission agents revealed that, the average annual purchase by an agent was around 1000 tonnes in 1978. The number of principals catered by an agent varied from 3 to 30. The majority of principals for whom they purchases were small manufacturers who had little knowledge about the market. The commission realised by the agent varied from principal to principal and the usual rate ranged between 1 to 2 percent. All other expenses incurred by the agent on grading, packing, forwarding, etc., were realised from the principal.

*Brokers*: They are potential buyers and sellers and they provide knowledge of suppliers' requirements and prices in various markets. The term 'broker' is best restricted to agents who do not own or physically handle goods. The actual transaction takes place between the original buyer and seller with the broker working as counseller and intermediary in return for a fee. The brokers in rubber operate mainly in Kottayam and in Cochin. There were 10 brokers in Kottayam and 5 in Cochin in 1978. Their fee was around Rs.5 per tonne. They do not have any licence nor do they make any physical purchase.

*Auctioneers*: An auctioneer also offers a specialised service in the negotiation of purchase and sale. The auctioneer brings buyers and sellers together at a particular time and place, negotiates sales, informs the bids and disposes of the produce offered. He may furnish a place for public dispaly and sale of the product and usually ensure prompt payment to the seller. Auctioning is popular in tea and a few auctioning firms are also handling rubber in Cochin.

## Distribution of rubber dealers

At the end of 1978 there were 2824 rubber dealers in India. Of these 85 percent of dealers were in Kerala. Within the State there was a concentration of dealers in Kottayam district (41.88%).

## Marketing of small holder's rubber

A Study (George Jacob, 1977) conducted in a village in Ernakulam district in 1977 had revealed that the marketing channels available to the small growers were licensed delears, co-operative societies and unlicensed dealers, and 94 percent of the rubber produced by small growers in the village was marketed through licensed dealers. The co-operative societies claimed 4 percent and the remaining, unlicensed dealers. Most of the local dealers combined rubber trade with other activities. The study found that 34 percent of growers had availed themselves of the advances from local dealers. Though no interest was charged on the advances, the dealers insisted on a regular supply of rubber. Rubber was not graded by growers before sale and the dealers purchased sheet rubber as 'lots' and the price received by small growers in the village was lower by Rs.5 to 15 per 100 kg of the Cochin market price for lot rubber. The local dealers made the deduction to cover the cost of packing, transporting, meeting establishment charges and profit.

The study confirmed the findings of similar studies conducted on the subject, that the majority of small growers did not know the correct methods of processing. Lack of facilities for proper collection, handling and coagulation was the common defect. Besides, insufficient drying, over smoking and use of insufficient or excess quantity of acid were also noticed.

## Marketing of estates' rubber

The estates presented a better picture in regard to marketing of rubber. A study covering 35 estates of Indian companies and 20 estates of non-Indian companies was conducted in 1974–75. It showed that all the 55 estates had sold rubber after proper grading and the majority of them sold rubber directly to manufacturers. The bulk of rubber was of superior quality viz. RMA IX and I, pale latex crepe and sole crepe, and concentrated latex. They realised the market price and in some cases a premium for their product. They had regluar customers also. The study also revealed that the non-Indian estates fared better than the Indian estates. The weighted average price realised by them was found to be 9 percent higher than that of Indian estates, over a five year period ending 1974–75. This is attributable to their better methods of production, processing and marketing. (Table 7).

Table 7. **Methods of sale of rubber (estates) 1974–75**

| *Sales* | *Indian Estates* | *Non-Indian Estates* | *Total* |
|---|---|---|---|
| To manufacturers | 13 | 15 | 28 |
| To dealers | 10 | — | 10 |
| To dealers and manufacturers | 12 | 5 | 17 |
| Total | 35 | 20 | 55 |

## Marketing margin

A study was carried out covering the purchase and sale of 10 big dealers in Kerala to find out the marketing margin obtained by the dealers. The study covered the period, July to December 1978. The 10 dealers purchased 5765 tonnes during the period. The study showed that although 90 percent of rubber was purchased as RMA 4 and 5 grades, the quantity sold as RMA 4 and 5 was 65 percent and the rest was in higher grades. This indicated that there was down grading at the time of purchase and upgrading at the time of sale. About 10 percent of sales during the period was RMA I, as against 3 percent of RMA I purchased. The gross margin obtained by sale of all grades was 6.5 percent over the weighted average purchase price.

## Co-operative marketing

At the end of 1978–79 there were 37 co-operative societies dealing in rubber in India. These societies handled about 7000 tonnes of rubber, which formed about 7 percent of the total production of small holdings in the country, during that year. The total members in the co-operative societies was around 60000 and they form about 42 percent of the total small rubber growers in the country. The co-operatives are the watch-dogs of small growers' interests and they have helped to narrow down the fluctuations in the rubber market.

## Marketing of rubber in other countries

A review of rubber marketing in Malaysia, Thailand and Sri Lanka, shows that licence has been introduced in all the three countries for rubber trade. In Malaysia the licences are issued by the State Governments and local authorities, while in Thailand they are granted by the officers of the Central Government and in Sri Lanka by the Rubber Controller. Special regulations exist in these countries for export trade of rubber. Malaysia and Thailand have set up rubber exchanges to overseas mainly the export transactions. In Malaysia and Thailand considerable portion of small growers' rubber is sold as unsmoked sheet. This practice is rare in Sri Lanka and practically nil in India. Unlike India, co-operative rubber marketing has not made any headway in these countries. However, Group Processing Centres have been organised in the three countries mostly under the encouragement of Government agencies. The Group Processing Centres have made considerable progress in Malaysia, compared to Thailand or Sri Lanka. The Centres provide common facilities to small growers for rolling and smoking of rubber. Both spot and forward transactions in rubber take place in these countries while spot sale is the practice in India.

By and large Indian small growers get a better deal compared to the small growers in the three countries. This is largely because Indian growers are mostly literates, with better awareness of scientific methods of processing and marketing and better facilities for communication and dissemination of market information. The existence of a net work of co-opertive societies has enhanced the bargaining strength of small growers. As a result the Indian small growers are getting a higher percentage of the F.O.B. price of rubber compared to their counterparts in other rubber growing countries.

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# PRICING EFFICIENCY OF INDIAN COFFEE MARKET

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## ABSTRACT

**The pricing efficiency of Indian coffee markets was interpreted in terms of spatial integration. The bivariate correlations of monthly prices among geographically separated markets at pool sale, wholesale and at retail levels used as indices of market integration showed a high degree of pricing efficiency. The relative efficiency is maximum at pool sale level because of better control by the Board. The efficiency was in the order of declining trend from wholesale to retail for want of adequate control of the Board. The location of distribution points and institutional constraint of differential sales tax were found to influence the movement of prices in unison. The markets located in Karnataka were more efficient than those within Tamil Nadu. Markets between different states were less integrated than those within the states. The analysis of three principal grades of coffee revealed that plantation-A, being relatively more in supply, was less efficient than arabica cherry-A and robusta cherry-A grades.**

## INTRODUCTION

In a competitive market structure, prices in a geographically separated markets are expected to move in unison in response to changing demand and supply. The accuracy and speed with which prices react and adjust to such stimuli can be taken as an indication of the degree of inter-relationship in the mechanism of price formation between various markets. The popular view in low income countries is that markets for agricultural commodities do not operate efficiently in price signalling. Efficient pricing of agricultural commodities plays a crucial role in fulfilling the objective of maximising the social welfare from both the producers

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and consumers point. The bivariate correlation coefficient (r) between prices at the same point of time in different markets is used to represent the degree of association among prices in various markets and is interpreted as an index of market integration. This is one of the methods of examining marketing efficiency in general and pricing efficiency in particular and has been attempted for the Indian coffee market.

The efficiency of food grain markets in India by examining the degree to which various village, primary, secondary and terminal markets are related to each other were studied with the help of intermarket correlations by Jasdanwala (1966), Cummings (1967), Lele (1971), George (1973) and Thakur (1974). Similar studies were attempted by Farruk (1972) with respect of rice marketing in East Pakistan and for apple marketing in India by Thakur (1973). In the context of coffee marketing, Haile Mariam (1973) analysed the efficiency of domestic and export coffee markets in Ethiopia using intermarket correlations within and between them.

## MATERIALS AND METHODS

The working of bivariate correlations among the markets are attempted at three levels of coffee marketing namely, pool sales auctions, wholesale and retail levels. At the retail level the analysis of raw and powder form of coffee are done separately. The monthly data on prices at various levels are obtained from the publications of the Board namely coffee statistics and Indian coffee. The analyses are carried out for three principal grades, plantation–A, Arabica cherry–AB and Robusta cherry-AB which account for about 53 percent of total coffee production. Linear interpolation of data is done whenever a value was missing at certain point of time due to want of sale. The price information for pool sales auctions and wholesales are available on 50 kg basis. The prices of raw and powder coffee are reported either in one or half kilogram basis which are converted to 50 kg basis so as to have uniformity in the analysis.

The inter market correlations for the monthly pool sales auction prices between Bangalore, Coimbatore and Vijayawada centres is for the period January 1970 to June 1979. This is due to the fact that auctions were centralised at Bangalore for some time prior to 1970. The monthly data for the period January 1967 through June 1978 are considered for analysis in case of retail prices of raw and powder coffee at important consuming centres. The retail prices of arabica cherry are not available for many centres during certain years and hence are excluded from the analysis. The period covered with respect of wholesale prices are from January 1964 through March 1976. The important consuming centres included in this study are Mysore, Bangalore, Mangalore, Bellary and Chikmagalur in Karnataka; Palaimcottah, Virudhunagar, Madras, Coimbatore, Salem, Kumbakonam, Trichy, Madurai in Tamil Nadu, Kottayam and Kozhikode in Kerala; Vijayawada and Guntur in Andhra Pradesh. The number of centres included varied at different levels and also between grades.

The bivariate correlation coefficient (r) of prices at two points $X_1$ and $X_2$ over a period of time is given by

$$rX_1 X_2 = \sum_{i=1}^{r} \frac{(X_{1i} - \bar{x}_1)\,(X_{2i} - \bar{x}_2)}{\sum_{i=1}^{n} (X_{1i} - \bar{x}_1)^2\,(X_{2i} - x_2)^2}$$

where i = 1......n is the number of monthly prices

$$\bar{x}_1 = \sum_{i=1}^{n} X_{1i}/n \text{ and } \bar{x}_2 = \sum_{i=1}^{n} X_{2i}/n$$

From this the correlation matrices of prices are obtained and discussed below.

## RESULTS AND DISCUSSION

The correlation matrices for the monthly average prices secured at the pool sales auctions for three principal grades of coffee are presented in table 1. It is evident from the table that all the correlations are highly significant and are over 0.90. In case of plantation–A. and Robusta cherry–AB grades, they are over 0.95, there by supporting the hypothesis of spatial integration in the auction markets of coffee.

**Table 1. Correlation matrices of pool sales auction prices of coffee.**

| *Auction Centres* | *Grades of Coffee* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | *Plantation A* | | | *Arabica Cherry AB* | | | *Robusta Cherry AB* | | |
| | *Bangalore* | *Coimbatore* | *Vijayawada* | *Bangalore* | *Coimbatore* | *Vijayawada* | *Bangalore* | *Coimbatore* | *Vijayawada* |
| Bangalore | 1.0000 | 0.9823 | 0.9680 | 1.0000 | 0.9522 | 0.9060 | 1.0000 | 0.9714 | 0.9654 |
| Coimbatore | | 1.0000 | 0.9675 | | 1.0000 | 0.9369 | | 1.0000 | 0.9690 |
| Vijayawada | | | 1.0000 | | | 1.0000 | | | 1.0000 |

In the pool sales auctions, wholesalers and/or retailers mostly located in South India bid for lots. The price correlation matrices of wholesale prices for plantation-A (Table 2), Arabica cherry-AB (Table 3) and Robusta Cherry–AB (Table 4) grades among the important centres reveal a very high correlation (70.95%) in 80 percent of the cases. These correlations for arabica and robusta cherry–AB *grades in all but one case was more than* 0.90. For *plantation–A, a superior grade this percentage was slightly less* (84.17%) and may be attributed to the fact that it is the principal grade of coffee accounting for about 24 percent of total coffee production. So it is relatively more in supply than other grades leading to less competition.

The percentage of very high correlations are higher in case of Karnataka when compared to Tamilnadu. The auctioning of coffee in pool sales are based on the demand and accordingly the board controls the releases in each state. The existence of sales tax (more than 6 percent) at the point of entry forbids a trader to purchase coffee stored in other states since he has to pay a double tax. This institutional constraint on the movement of coffee amongthe consuming centres limits the movement of coffee between states. This, in turn, could lead to less harmonious movement of wholesale prices in all the centres located in different states than we expect of coffee prices in centres located next to each other of the distributional points. Despite the physical and institutional constraints to free flow of coffee from a marketing centre located in one state to another centre located in other state, the price correlations in most of the cases (90 percent) are above 0.90. In this context, Haile-Mariam's (1973) interpretation of the bivariate correlations of wholesale coffee markets in Ethiopia with institutional constraints is noteworthy. Mariam pertinently puts a question "How do we account for the positive correlations of prices in all the marketing centres?" It is answered by a counter question—"Is it necessary to have a physical flow of coffee among all markets to maintain positive price correlations?" Thus the high price correlations of wholesale coffee markets located within and between different states in India also can be argued. But the fact that institutional hindrances reduces the degree of competetiveness cannot be ignored.

**Table 3.** Correlation matrix of wholesale prices of arabica cherry–AB grade of coffee at important consuming centres in India.

| *Centres* | *Mysore* | *Bangalore* | *Bellary* | *Mangalore* | *Chik-magalur* | *Palaim Cottah* | *Virudhu-nagar* |
|---|---|---|---|---|---|---|---|
| Mysore | 1.0000 | 0.9929 | 0.9779 | 0.9398 | 0.9935 | 0.9648 | 0.9680 |
| Bangalore | | 1.0000 | 0.9787 | 0.9398 | 0.9935 | 0.9656 | 0.9673 |
| Bellary | | | 1.0000 | 0.9323 | 0.9789 | 0.9593 | 0.9578 |
| Mangalore | | | | 1.0000 | 0.9376 | 0.9186 | 0.9184 |
| Chikmagalur | | | | | 1.0000 | 0.9610 | 0.9681 |
| Palaim Cottah | | | | | | 1.0000 | 0.9705 |
| Virudhunagar | | | | | | | 1.0000 |

Table 2. Correlation matrix of wholesale prices of plantation–A grade of coffee at important consuming centres in India

| *Centre* | *Mysore* | *Banga-lore* | *Manga-lore* | *Bellary* | *Chika-magalur* | *Madras* | *Coimba-tore* | *Salem* | *Palaim cottah* | *Kumba-konam* | *Trichy* | *Madurai* | *Virudhu-nagar* | *Kozhi-kode* | *Kotta-yam* | *Vijaya-wada* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mysore | 1.0000 | 0.9867 | 0.9815 | 0.9793 | 0.9859 | 0.9668 | 0.9799 | 0.9772 | 0.9780 | 0.9614 | 0.9729 | 0.9118 | 0.9736 | 0.8523 | 0.9503 | 0.9767 |
| Bangalore | | 1.0000 | 0.9899 | 0.9854 | 0.9930 | 0.9725 | 0.9840 | 0.9847 | 0.9824 | 0.9630 | 0.9764 | 0.9849 | 0.9780 | 0.8736 | 0.9534 | 0.9792 |
| Mangalore | | | 1.0000 | 0.9834 | 0.9890 | 0.9737 | 0.9821 | 0.9824 | 0.9830 | 0.9650 | 0.9755 | 0.9856 | 0.9765 | 0.8975 | 0.9628 | 0.9777 |
| Bellary | | | | 1.0000 | 0.9889 | 0.9733 | 0.9830 | 0.9824 | 0.9838 | 0.9700 | 0.9730 | 0.9860 | 0.9752 | 0.8662 | 0.9557 | 0.9805 |
| Chikamagalur | | | | | 1.0000 | 0.9770 | 0.9902 | 0.9877 | 0.9869 | 0.9879 | 0.9800 | 0.9910 | 0.9821 | 0.9871 | 0.9562 | 0.9835 |
| Madras | | | | | | 1.0000 | 0.9813 | 0.9813 | 0.9860 | 0.9738 | 0.9771 | 0.9808 | 0.9732 | 0.8805 | 0.9491 | 0.9756 |
| Coimbatore | | | | | | | 1.0000 | 0.9924 | 0.9908 | 0.9728 | 0.9863 | 0.9939 | 0.9834 | 0.8825 | 0.9595 | 0.9834 |
| Salem | | | | | | | | 1.0000 | 0.9920 | 0.9750 | 0.9845 | 0.9937 | 0.9864 | 0.8756 | 0.9642 | 0.9811 |
| Palaimcottah | | | | | | | | | 1.0000 | 0.9796 | 0.9828 | 0.9920 | 0.9838 | 0.8795 | 0.9645 | 0.9809 |
| Kumbakonam | | | | | | | | | | 1.0000 | 0.9684 | 0.9722 | 0.9647 | 0.8536 | 0.9506 | 0.9652 |
| Trichy | | | | | | | | | | | 1.0000 | 0.9846 | 0.9763 | 0.8742 | 0.9511 | 0.9732 |
| Madurai | | | | | | | | | | | | 1.0000 | 0.9864 | 0.8785 | 0.9612 | 0.9832 |
| Virudhunagar | | | | | | | | | | | | | 1.0000 | 0.8717 | 0.9521 | 0.9754 |
| Kozhikode | | | | | | | | | | | | | | 1.0000 | 0.8781 | 0.8735 |
| Kottayam | | | | | | | | | | | | | | | 1.0000 | 0.9603 |
| Vijayawada | | | | | | | | | | | | | | | | 1.0000 |

## Table 4. Correlation matrix of wholesale prices of robusta cherry—AB grade of coffee at important consuming centres in India

| *Centres* | *Mysore* | *Bangalore* | *Mangalore* | *Bellary* | *Chikamagalur* | *Madras* | *Coimbatore* | *Salem* | *Palaimcottah* | *Kumbakonam* | *Trichy* | *Madurai* | *Virudhunagar* | *Kozhikode* | *Kottayam* | *Vijayawada* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mysore | 1.0000 | 0.9797 | 0.9766 | 0.9721 | 0.9793 | 0.9022 | 0.9755 | 0.9717 | 0.9663 | 0.9443 | 0.9604 | 0.9706 | 0.9542 | 0.9651 | 0.9666 | 0.9635 |
| Bangalore | | 1.0000 | 0.9928 | 0.9888 | 0.9896 | 0.9186 | 0.9802 | 0.9892 | 0.9799 | 0.9560 | 0.9862 | 0.9886 | 0.9701 | 0.9651 | 0.9829 | 0.9762 |
| Mangalore | | | 1.0000 | 0.9867 | 0.9927 | 0.9191 | 0.9769 | 0.9898 | 0.9811 | 0.9540 | 0.9851 | 0.9891 | 0.9698 | 0.9884 | 0.9866 | 0.9781 |
| Bellary | | | | 1.0000 | 0.9835 | 0.9062 | 0.9790 | 0.9871 | 0.9787 | 0.9580 | 0.9796 | 0.9883 | 0.9716 | 0.9576 | 0.9815 | 0.9785 |
| Chikamagalur | | | | | 1.0000 | 0.9185 | 0.9780 | 0.9882 | 0.9757 | 0.9529 | 0.9784 | 0.9854 | 0.9651 | 0.9717 | 0.9829 | 0.9808 |
| Madras | | | | | | 1.0000 | 0.9140 | 0.9217 | 0.9182 | 0.9069 | 0.9161 | 0.9193 | 0.9067 | 0.9118 | 0.9268 | 0.8813 |
| Coimbatore | | | | | | | 1.0000 | 0.9844 | 0.9684 | 0.9524 | 0.9730 | 0.9842 | 0.9617 | 0.9551 | 0.9720 | 0.9758 |
| Salem | | | | | | | | 1.0000 | 0.9837 | 0.9591 | 0.9864 | 0.9959 | 0.9787 | 0.9633 | 0.9865 | 0.9814 |
| Palaimcottah | | | | | | | | | 1.0000 | 0.9635 | 0.9781 | 0.9861 | 0.9907 | 0.9637 | 0.9777 | 0.9671 |
| Kumbakonam | | | | | | | | | | 1.0000 | 0.9449 | 0.9668 | 0.9604 | 0.9455 | 0.9540 | 0.9402 |
| Trichy | | | | | | | | | | | 1.0000 | 0.9865 | 0.9705 | 0.9546 | 0.9777 | 0.9743 |
| Madurai | | | | | | | | | | | | 1.0000 | 0.9815 | 0.9612 | 0.9846 | 0.9784 |
| Virudhunagar | | | | | | | | | | | | | 1.0000 | 0.9465 | 0.9671 | 0.9571 |
| Kozhikode | | | | | | | | | | | | | | 1.0000 | 0.9659 | 0.9565 |
| Kottayam | | | | | | | | | | | | | | | 1.0000 | 0.9712 |
| Vijayawada | | | | | | | | | | | | | | | | 1.0000 |

## Table 5. Correlation matrix of retail prices of raw plantation—A coffee at important consuming centres in India

| *Centres* | *Mysore* | *Bangalore* | *Chikamagalur* | *Madras* | *Coimbatore* | *Salem* | *Palaim cottah* | *Kumbakonam* | *Trichy* | *Madurai* | *Kozhikode* | *Kottayam* | *Vijayawada* | *Guntur* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mysore | 1.0000 | 0.9827 | 0.9577 | 0.9794 | 0.9663 | 0.8196 | 0.9496 | 0.9561 | 0.9421 | 0.9419 | 0.8884 | 0.9669 | 0.9623 | 0.9273 |
| Bangalore | | 1.0000 | 0.9608 | 0.9767 | 0.9693 | 0.8371 | 0.9478 | 0.9677 | 0.9432 | 0.9450 | 0.8667 | 0.9652 | 0.9583 | 0.9229 |
| Chikamagalur | | | 1.0000 | 0.9701 | 0.9736 | 0.8199 | 0.9347 | 0.9402 | 0.9485 | 0.9324 | 0.9062 | 0.9523 | 0.9489 | 0.8976 |
| Madras | | | | 1.0000 | 0.9789 | 0.8294 | 0.9435 | 0.9605 | 0.9529 | 0.9439 | 0.9207 | 0.9621 | 0.9712 | 0.9306 |
| Coimbatore | | | | | 1.0000 | 0.8333 | 0.9231 | 0.9444 | 0.9576 | 0.9249 | 0.9206 | 0.9713 | 0.9574 | 0.9139 |
| Salem | | | | | | 1.0000 | 0.8164 | 0.8218 | 0.7659 | 0.8075 | 0.7467 | 0.8420 | 0.8159 | 0.7970 |
| Palaimcottah | | | | | | | 1.0000 | 0.9593 | 0.8838 | 0.9623 | 0.8235 | 0.9321 | 0.9158 | 0.8640 |
| Kumbakonam | | | | | | | | 1.0000 | 0.9249 | 0.9672 | 0.8834 | 0.9564 | 0.9402 | 0.9302 |
| Trichy | | | | | | | | | 1.0000 | 0.9028 | 0.9467 | 0.9331 | 0.9454 | 0.8924 |
| Madurai | | | | | | | | | | 1.0000 | 0.8421 | 0.9428 | 0.8182 | 0.8892 |
| Kozhikode | | | | | | | | | | | 1.0000 | 0.9158 | 0.9113 | 0.8932 |
| Kottayam | | | | | | | | | | | | 1.0000 | 0.9538 | 0.9251 |
| Vijayawada | | | | | | | | | | | | | 1.0000 | 0.9212 |
| Guntur | | | | | | | | | | | | | | 1.0000 |

### Table 7. Correlation matrix of retail prices of powder plantation coffee at important consuming centres in India

| *Centres* | *Mysore* | *Bangalore* | *Mangalore* | *Bellary* | *Madras* | *Coimbatore* | *Salem* | *Palaimcottah* | *Kumbakonam* | *Trichy* | *Madurai* | *Virudhunagar* | *Kozhikode* | *Kottayam* | *Vijayawada* | *Guntur* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mysore | 1.0000 | 0.9595 | 0.9473 | 0.8728 | 0.9189 | 0.9331 | 0.9288 | 0.9225 | 0.8952 | 0.8870 | 0.8201 | 0.9238 | 0.8663 | 0.9348 | 0.9413 | 0.8827 |
| Bangalore | | 1.0000 | 0.9749 | 0.9321 | 0.9606 | 0.9684 | 0.9566 | 0.9442 | 0.9174 | 0.9126 | 0.8592 | 0.9684 | 0.8898 | 0.9569 | 0.9527 | 0.9111 |
| Mangalore | | | 1.0000 | 0.9413 | 0.9635 | 0.9794 | 0.9821 | 0.9419 | 0.9109 | 0.9214 | 0.8514 | 0.9758 | 0.8995 | 0.9536 | 0.9538 | 0.8953 |
| Bellary | | | | 1.0000 | 0.9194 | 0.9216 | 0.9073 | 0.9327 | 0.8765 | 0.9045 | 0.7882 | 0.9188 | 0.7956 | 0.8986 | 0.8734 | 0.8736 |
| Madras | | | | | 1.0000 | 0.9855 | 0.9656 | 0.8768 | 0.8743 | 0.9048 | 0.9143 | 0.9625 | 0.9021 | 0.9394 | 0.9471 | 0.8771 |
| Coimbatore | | | | | | 1.0000 | 0.9825 | 0.9116 | 0.8949 | 0.9093 | 0.9005 | 0.9784 | 0.9278 | 0.9628 | 0.9637 | 0.9014 |
| Salem | | | | | | | 1.0000 | 0.9047 | 0.9004 | 0.8963 | 0.8720 | 0.9673 | 0.9342 | 0.9661 | 0.9699 | 0.9108 |
| Palaimcottah | | | | | | | | 1.0000 | 0.9361 | 0.9317 | 0.7437 | 0.9368 | 0.7787 | 0.9062 | 0.8974 | 0.8404 |
| Kumbakonam | | | | | | | | | 1.0000 | 0.9090 | 0.7663 | 0.9250 | 0.7891 | 0.8980 | 0.9161 | 0.8556 |
| Trichy | | | | | | | | | | 1.0000 | 0.8043 | 0.9337 | 0.7890 | 0.9035 | 0.8943 | 0.8515 |
| Madurai | | | | | | | | | | | 1.0000 | 0.8594 | 0.8654 | 0.8469 | 0.8781 | 0.8188 |
| Virudhunagar | | | | | | | | | | | | 1.0000 | 0.8938 | 0.9471 | 0.9587 | 0.8808 |
| Kozhikode | | | | | | | | | | | | | 1.0000 | 0.9315 | 0.9112 | 0.8958 |
| Kottayam | | | | | | | | | | | | | | 1.0000 | 0.9525 | 0.9281 |
| Vijayawada | | | | | | | | | | | | | | | 1.0000 | 0.9082 |
| Guntur | | | | | | | | | | | | | | | | 1.0000 |

**Table 8. Correlation matrix of retail prices of powder robusta cherry coffee at important consuming centres in India**

| *Centres* | *Bangalore* | *Mysore* | *Madras* | *Coimbatore* | *Salem* | *Palaim cottah* | *Kumba-konam* | *Trichy* | *Madurai* | *Virudhu-nagar* | *Kozhi-kode* | *Kottayam* | *Vijaya-wada* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bangalore | 1.0000 | 0.9324 | 0.9259 | 0.9099 | 0.9250 | 0.9205 | 0.9398 | 0.9120 | 0.8428 | 0.9403 | 0.8978 | 0.9231 | 0.9425 |
| Mysore | | 1.0000 | 0.8500 | 0.8345 | 0.8428 | 0.8520 | 0.8534 | 0.8113 | 0.7184 | 0.8682 | 0.8281 | 0.8546 | 0.9492 |
| Madras | | | 1.0000 | 0.9827 | 0.9827 | 0.9554 | 0.9682 | 0.9740 | 0.9323 | 0.9585 | 0.9612 | 0.9855 | 0.9062 |
| Coimbatore | | | | 1.0000 | 0.9872 | 0.9529 | 0.9644 | 0.9716 | 0.9492 | 0.9629 | 0.9678 | 0.9805 | 0.8935 |
| Salem | | | | | 1.0000 | 0.9579 | 0.9725 | 0.9852 | 0.9445 | 0.9640 | 0.9631 | 0.9783 | 0.9006 |
| Palaim cottah | | | | | | 1.0000 | 0.9755 | 0.9508 | 0.8810 | 0.9713 | 0.8936 | 0.9631 | 0.8880 |
| Kumbakonam | | | | | | | 1.0000 | 0.9648 | 0.9056 | 0.9775 | 0.9309 | 0.9547 | 0.9004 |
| Trichy | | | | | | | | 1.0000 | 0.9495 | 0.9578 | 0.9545 | 0.9667 | 0.87[illegible] |
| Madurai | | | | | | | | | 1.0000 | 0.9182 | 0.9413 | 0.9322 | 0.79[illegible] |
| Virudhunagar | | | | | | | | | | 1.0000 | 0.9303 | 0.9490 | 0.902[illegible] |
| Kozhikode | | | | | | | | | | | 1.0000 | 0.9679 | [illegible] |
| Kottayam | | | | | | | | | | | | 1.0000 | [illegible]166 |
| Vijayawada | | | | | | | | | | | | | [illegible] |

The whole sale markets located at or near the distributional points had higher bivariate correlations than that of the farther markets both in Karnataka and Tamilnadu. For example, Bellary centre exhibited certain low correlations (specially for arabica cherry–AB) with other centres in Karnataka. Similarly, Madras Kumbakonam and Trichy exhibited low correlations with other centres in Tamil Nadu. This low spatial integration is mainly due to variations in transportation and incidental charges.

The percentage of very high correlations are higher in Karnataka when compared to that of Tamil Nadu, indicating that the markets in Karnataka are more competetive. This may be attributed to the speculative activity of traders in Tamil Nadu (Chengappa 1980).

At the retail level, coffee is either obtained by direct participation in the pool sales auctions by the retailers and/or through the wholesalers. In addition, allotments are directly made from the Board. These are sold either in raw or powder form in small quantities to consumers. The price correlation matrices for raw (Table 5 and 6) and powder coffee (Table 7 and 8) reveal that in 78 and 66 percent of cases the correlations are over 0.90. There are 6 percent of correlations below 0.80, which were totally absent in case of wholesale prices. The lowest value of 0.72 is observed between Mysore and Madurai centres in case of robusta cherry powder. The presence of correlations as high as 0.980 observed in 88 cases with respect of wholesale prices are totally absent for coffee sold in powder form and noticed only in one case in raw form. Thus, it is clear that the retail prices are less spatially integrated than the wholesale prices. This kind of observation is consistent with the study by Farruk (1972) with respect to rice marketing in East Pakistan. He found high correlations among the distribution markets which were relatively lower than those between intermediate and primary markets. As in the case of wholesale prices the percentage of higher correlations were relatively more for centres in Karnataka and so also for Plantation–A grade of coffee.

**Table 6. Correlation matrix of retail prices of raw robusta cherry –AB grade of important consuming centres in India**

| *Centres* | *Bangalore* | *Madras* | *Palaim Cottah* | *Kumbakonam* | *Trichy* | *Madurai* | *Kozhikode* | *Kottayam* |
|---|---|---|---|---|---|---|---|---|
| Bangalore | 1.0000 | 0.9580 | 0.9345 | 0.9428 | 0.9684 | 0.9125 | 0.9564 | 0.9707 |
| Madras | | 1.0000 | 0.9459 | 0.9465 | 0.9718 | 0.9328 | 0.9459 | 0.9707 |
| Palaim Cottah | | | 1.0000 | 0.9658 | 0.9306 | 0.9690 | 0.8847 | 0.8458 |
| Kumbakonam | | | | 1.0000 | 0.9627 | 0.9515 | 0.9242 | 0.9477 |
| Trichy | | | | | 1.0000 | 0.9235 | 0.9713 | 0.9672 |
| Madurai | | | | | | 1.0000 | 0.8856 | 0.9419 |
| Kozhikode | | | | | | | 1.0000 | 0.9574 |
| Kottayam | | | | | | | | 1.0000 |

It is evident that the pricing efficiency was highest at pool sales followed by wholesale and retail levels. At retail level also, prices of raw form was more integrrated than the powder form. This could be attributed to the degree of Control Board exercises at various levels. At pool sales the auctions are conducted by the Board implying full control. At other levels the traders are free to sell at a price based on market demand and supply although indirect check by way of other methods of releases and making it obligatory for the traders to maintain details of sales and stocks exist. Moreover the number of traders are too large too keep constant check, especially at retail levels.

In the aggregate, all the markets show significantly high correlation among their prices at various levels. This kind of very high spatial integration of food grain market was observed by Lele (1971). She observed that the rice markets in west Bengal were more efficient with all intermarket correlations above 0.95 and in some cases as high as 0.99. On the other hand, the low correlations observed in Tamil Nadu were attributed to aggregation of a number of varieties unlike the same veriety considered in West Bengal.

In conclusion, the observance of 81 percent of correlations over 0.90 at various levels considered grade wise shows a very high degree of spatial integration of coffee markets in India despite various physical and institutional constraints within which the coffee marketing system operates. From this study, certain important variations with respect to individual market levels and grades are interesting and noteworthy.

(a) Pricing efficiency of spatially separated coffee markets at retail levels were less than those at the wholesale level.

(b) Pricing efficiency at retail level also varied with the markets more integrated for raw coffee compared to powder form.

(c) Spatial integration of markets between the states of Karnataka and Tamilnadu were relativley lower than within and are attributed to the location of distribution points and institutional constraints of sales tax.

(d) The markets with in Tamilnadu were less integrated than in Karnataka which is attributed to the speculative activities of the traders.

(e) Price-correlations between markets were generally low for plantation–A grade, attributed to its relative availability.

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# ECONOMIC EVALUATION OF THREE MAJOR PLANTATION CROPS NAMELY CASHEW, RUBBER AND COCONUT IN KERALA

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## ABSTRACT

**This paper attempts to evaluate the economic efficiency of three major plantation crops viz. coconut, cashew and rubber, extensively cultivated in Kerala. Economic efficiency is expressed in terms of net returns per hectare of crop activity. The determinants of net income viz., yield and input-output prices are analysed in detail, also the growth potentials such as expansion of area, increase in yield etc. which influence aggregate income and employment are also being investigated.**

**The data used have been obtained mainly from a recent study undertaken in connection with a Ph. D. thesis, timely reporting survey and crop cutting experiments conducted by the Bureau of Economics and Statistics, evaluation studies undertaken by the State Planning Board and secondary data from other sources. Benefit-cost ratio, net present value and internal rate of return are used for measuring relative efficiency.**

**The results reveal that discounted net returns from cashew are higher than that of rubber and coconut, quality of land, location, environments and management factors remaining equal, the NPV being Rs. 10,537, Rs. 6,854 and Rs. 4,758 respectively. But the preferential treatment given to rubber and coconut because of various economic and noneconomic reasons have made them more acceptable. Consequently there have been an indiscriminate expansion of area under these crops which have even extended to the marginal and submarginal lands thereby depressing their yields. Since cashew has a comparative advantage in the marginal land over the other crops, a rational allocation should take this also into consideration. With a steep rise in product price since 1966-67 cashew cultivation has turned out to be very profitable with an NPV of Rs.5,316 even on submarginal lands. It is estimated that 39 percent of the cashew area in the state belongs to the lowest category. Yet the availability of 1.2 lakh hectares of cultivable waste land in the state, mostly in the laterite regions, would facilitate a doubling of the cashew area (1.2-2.4 lakh hectares) over the next 10 year period, if adequate investment is made with the necessary extension support.**

**The analysis helps to understand the economic basis of the allocation of land and to facilitate an optimum crop mix at the farm level.**

**At the state level the question becomes one of the cropping patterns to be encouraged through appropriate public policies.**

**But maximisation of net income is not the sole determinant of cropping pattern. Farmers' consumption needs, resource availability, accessibility to factor and product markets, attitude towards risk and uncertainty, availability of family labour, readiness to deviate from the existing cropping pattern etc. are also other factors to be considered.**

## INTRODUCTION

One of the special features of Kerala agriculture is the predominance of perennial crops. About 60 perecent of the net sown area of the state is occupied by tree crops—mainly chashew, rubber and coconut. Kerala is the largest producer of these crops in India. Because of the undulating topography (terrain) of the State, growing of tree crops is particulary suited for alleviating the enormous damage inflicted by floods, soil erosion and silting. It also helps to generate larger income as compared to seasonal crops and even out the demand for labour throughout the year. However, an important production problem facing the economy of Kerala is the rational allocation of land among different crops. This is so because the same unit of land could be used for growing a number of crops. For an individual farmer maximisation of returns from a unit of land involves a decision regarding optimum crop combination based on costs and returns from each component crop.

An attempt is made in this paper to evaluate the economic efficiency of cashew as compared to competing crops such as rubber and coconut, economic efficiency is expressed in terms of net returns per hectare of crop activity. More specifically the paper seeks (1) to estimate the relative costs and returns from these, crops and (2) to examine the reasons for the tardy growth in the production of cashew.

The data relating to costs and returns have been obtained mainly from a research study undertaken by the author. The returns have been worked out on the basis of average prices prevailing over the past five years. Other sources of data are timely reporting survey and crop cutting experiments conducted by the

Bureau of Economics and Statistics and evaluation studies undertaken by the State Planning Board.

## MATERIALS AND METHODS

The tool employed for this exercise is cost-benefit analysis. The first step in the process is identification of the costs and benefits. Cost does not include land and management as they are common to all the alternative crops under study. Similarly benefits do not include the indirect and intangibles which are difficult to assess. Further, cost-benefit analysis poses many technical problems in the case of perennial crops. Unlike in the case of seasonal and annual crops the accounting period of perennials generally extends over a number of years. The analysis should cover two phases, namely investment phase and operation and maintenance phase. The investment is spread over many years, so too the flow of returns. If 'J' years is the economic life of a perennial and 'a' is the gestation period, the duration of the flow of returns is reduced to 'J–a' years. Again for the returns to get stabilised a few more years (say b) will be required, the structure of costs and returns being different for each period. Statbilised returns would be available only for [ J–(a+b) ] years. Although the economic life of a perennial crop project may extend over 50 years, the analysis is generally limited for a period of 25 years since the net present value becomes very insignificant after that stage. Because of the varying time periods involved, cost and benefits have been discounted inorder to work out benefit-cost ratio, net present value and internal rate of return. To explain further benefit-cost ratio is the ratio of the present worth of gross benefits to the present worth of gross costs. For a project to become acceptable, the absolute value of the benefit-cost ratio must be greater than one. The second measure-net present value (NPV) of a project–is the present value of the net cash flow stream. If $M_1$, $M_2$,...... $M_n$ = the margin between revenue and cost in years 1 to n, the present worth of the total net margin is

$$\frac{M_1}{(1+r)} + \frac{M_2}{(1+r)^2} + \dots\dots\dots + \frac{M_{n-1}}{(1+r)^{n-1}} + \frac{M_n}{(1+r)^n} = V$$

where V is the net present value, n is the life span of the investment in years and r is the discount rate. In the determination of B—C ratio and NPV, crucial factor is interest or discount rate. It is taken as 11 percent—the interest rate charged on long term loans by the Land Mortgage Bank. The third measure namely internal rate of return (IRR) is the discount rate which just makes the net present worth of the cash flow equal to zero. It represents the average earning power of the money used in the project over the project life. When projects of heterogenous character are evaluated, NPV is considered as the best measure of profitability.

## RESULTS AND DISCUSSION

Results of a field study conducted in Vembayam village in Trivandrum district in 1975 and subsequent revision of data regarding costs and prices are presented below. With the discount rate of 11 percent, the benefit-cost ratio (B) is found to be above unity NPV positive and IRR greater than the discount rate for all the three crops. Therefore investment in these crops can be considered to be economically justified. Further it is seen that the economic efficiency of cashew is higher than that of rubber and coconut, the quality of land, location, environments and management factors remaining equal.

**Discounted measures of economic efficiency**

| *Crop* | *Benefit Cost Ratio* | *Net present value (NPV)* | *Internal rate of return (IRR)* |
|---|---|---|---|
| | (*B*) | (*Rs.*) | (*Percent*) |
| Cashew | 5.3 | 10537 | 30 |
| Rubber | 1.6 | 6854 | 16 |
| Coconut | 2.0 | 4758 | 17 |

But inspite of the marked gains from cashew crop activity, absolute increase in cashew area during the reference period has been much lower than the other two as seen from table 1. This is because of the preferential treatment given to rubber and coconut in all development programmes, reluctance of the farmers to adapt cashew as a component crop in mixed and intercropping systems of cultivation in the garden lands and other reasons which are discussed below. However there was an indiscriminate expansion of area under rubber and coconut leading to an extension of their cultivation to marginal and submarginal lands since the supply of fertile lands is limited. This phenomenon had a depressing effect on their yields too. At the same time cashew has a comparative advantage on the marginal land over other crops. While rubber and coconut yield poorly in laterite soil with a hard pan, cashewnut does fairly well under such conditions. It can penetrate through the laterite rock especially through the broken crevices and can tolerate the severe drought of the summer months. This peculiar feature has led to the allocation of only poor lands to cashew during the last two decades thereby depressing the yield considerably.

Further analysis of the tardy progress in the development of cashew reveals that in any crop activity maximisation of income is not the sole concern of the decision making farmer: minimisation of risk is also given due consideration. In this aspect rubber is in a favourable position than others. Risks are of three types viz. technical, biological and commercial. The first one is relatively low for all these crops because of the favourable agro-climatic environment prevailing in the State. A steady increase in the yield rate of rubber from 219 kg. to 673 kg. per hectare indicates the technological gains of that crop. Eventhough biological risk is not a serious problem for cashew and rubber, the very high incidence of root wilt and leaf disease for coconut palms in the 5 districts of Kerala viz. Quilon, Alleppty, Kottayam, Idukki and Ernakulam has brought down considerably the yield rate and total production of coconuts. But commercial risk is more with cashew mainly because of the vagaries of demand in foreign markets and its use as a consumption goods only. Although the price of cashew increased by about 800 percent during the 22 year period under study its yearly variability is comparatively higher with a coefficient of variation of 80 percent against 36 and 57 percent respectively for rubber and coconut.

Table 1. Area, production, yield and farm price of selected crops

| *Year* | *Area* (*in '0000 hec*). | *Production* (*in '000 tonnes* | *Yield* (*Kg./hec*) | *Farm price* (*Rs./Qtl.*) |
|---|---|---|---|---|
| | | CASHEW | | |
| 1957–58 | 44 | 69.1 | 1569 | 46 |
| 1978-99 | 134+(205) | 89.8(+30) | 662(—58) | 406(+783) |
| | | RUBBER | | |
| 1957–58 | 99.9 | 21.8 | 219 | 323 |
| 1978–79 | 215.5(+116) | 144.9(+565) | 673(+207) | 861(+167) |
| | | COCONUT | | |
| 1957–58 | 463.3 | 3199(m.nuts) | 6832(nuts) | 178/1000 |
| 1978–79 | 678.7(+47) | 3075 ,, (—4) | 4531 ,, (—34) | 1022 ,, (+474) |

Figures given in brackets are the change in percentage of the terminal year to the base year.

Table 2. **Cashew : benefit-cost ratio, net present value and internal rate of return**

| *Year* | *Cash flow* | *Discount Factor at 11%* | *Present worth at 11%* | *Discount Factor at 30%* | *Present worth at 30%* |
|---|---|---|---|---|---|
| 1 | – 839 | .9009 | – 756 | .7692 | – 645 |
| 2 | – 452 | .8116 | – 367 | .5917 | – 267 |
| 3 | – 590 | .7312 | – 431 | .4552 | – 269 |
| 4 | – 590 | .6587 | – 389 | .3501 | – 207 |
| 5 | – 590 | .5935 | – 350 | .2693 | – 159 |
| 6 | – 302 | .5346 | – 161 | .2072 | – 62 |
| 7 | + 579 | .4817 | — 79 | .1594 | + 92 |
| 8 | +1658 | .4339 | — 719 | .1226 | + 203 |
| 9 | +2837 | .3910 | —1109 | .0943 | — 268 |
| 10 to 25 | +3773 | 2.8847 | —10884 | .3096 | —1168 |

— 2454 + 12991
= + 10537

— 1609 + 1731
= + 122

IRR — 30%
NPV — 10537

$$\text{B–C ratio} \quad — \quad \frac{12991}{2454} = 5.3 : 1$$

**Table 3. Rubber: benefit-cost ratio, net present value and internal rate of teturn**

| *Year* | *Cash flow* | *Discount factor at 11%* | *Present worth at 11 %* | *Discount factor at 16%* | *Present worth at 16%* |
|---|---|---|---|---|---|
| 1 | – 4236 | .9009 | – 3816 | .8621 | – 3652 |
| 2 | – 1866 | .8118 | – 1514 | .7432 | – 1387 |
| 3 | – 2127 | .7312 | – 1555 | .6407 | – 1363 |
| 4 | – 1998 | .6587 | – 1316 | .5523 | – 1103 |
| 5 | – 1788 | .5935 | – 1061 | .4761 | – 851 |
| 6 | – 1662 | .5346 | – 889 | .4104 | – 682 |
| 7 | – 1662 | –4817 | – 801 | .3538 | – 588 |
| 8 to 25 | + 4800 | 3.7095 | +17806 | 2.0585 | +9881 |

$$-10952 + 17806 = +6854$$

$$-9626 + 9881 = -255$$

IRR — 16%

NPV — 6854

$$\text{B–C ratio} - \frac{17806}{10952} = 1.63 : 1$$

## Table 4. Coconut: benefit-cost ratio, net present value and internal rate of return

| *Year* | *Cash flow* | *Discount factor at 11%* | *Present worth at 11%* | *Discount factor at 17%* | *Present worth at 17%* |
|---|---|---|---|---|---|
| 1 | – 1905 | .9009 | – 1716 | .8547 | – 1628 |
| 2 | – 630 | .8116 | – 511 | .7305 | – 460 |
| 3 | – 650 | .7312 | – 745 | .6244 | – 406 |
| 4 | – 660 | .6587 | – 435 | .5337 | – 352 |
| 5 | – 660 | .5935 | – 392 | .4561 | – 301 |
| 6 | – 660 | .5346 | – 353 | .3898 | – 257 |
| 7 | – 660 | .4817 | – 318 | .3332 | – 220 |
| 8 | – 660 | .4339 | – 286 | .2848 | – 188 |
| 9 | – 848 | .3910 | – 332 | .2434 | – 206 |
| 10 | + 165 | .3522 | + 58 | .2080 | + 34 |
| 11 | + 797 | .3173 | + 253 | .1778 | + 142 |
| 12 | + 1685 | .2858 | + 482 | .1520 | + 256 |
| 13 | + 2573 | .2575 | + 663 | .1299 | + 334 |
| 14 | + 3461 | .2320 | + 803 | .1110 | + 384 |
| 15 to 25 | + 5082 | 1.4398 | + 7317 | .5369 | + 2769 |

— 4818 + 9576 = + 4758 — 4018 + 3879 = —139

IRR — 17%

NPV — 4758

$$\text{B–C ratio} \;—\; \frac{9576}{4818} = 2{:}1$$

Further, apart from the decline in yield, its variability in cashew is found to be very high being 25 percent as compared to 12 percent for rubber and 21 percent for coconut. This is mainly because of the poor management; very little attention is paid for proper manuring, weeding, plant protection and harvesting which are most crucial in stabilising the yield.

Cashew is a more profitable crop on marginal and submarginal lands and has high development potential. But there are several constraints for the expansion of area under cashew. For instance, substitution of existing perennial crops with more remunerative perennials is not feasible because of various economic and non-economic reasons. About the possibility of extension of cashew to new areas it is estimated that there are 1.5lakh hectares of land available for cultivation in the State. Of this, 1.2 lakh hectares are cultivable waste mostly in the laterite regions and which cannot be profitably utilised for other crops and 0.3 hectares of other fallow. If the first category of land could be brought under cashew cultivation with adequate investment and extension support the present cashew area could be doubled. This in turn would generate an annual income of Rs.35 crores and employment for 26000 persons. However, the study has revealed that increase in the production of cashew is possible only if measures are taken to stabilise the prices and to minimise the yield variability through better management practices.

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# TECHNOLOGY—QUALITY IMPROVEMENTS

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10 papers were scheduled to be presented in this session. Of this, the paper dealing with causes of deterioration in coconut leaf thatch was not presented; but in its place, another paper on general aspects on tea processing was accommodated. This raised the total number of papers presented on tea processing to four. One paper each was presented on coffee, coconut, cashew and ginger. There were two papers on cocoa been processing.

An improvement over split-CTC processing for tea was described which inparts richer colour and better appearance to black tea in addition to the improvement of colour of infused leaf and liquor characteristics which are achieved byconventional split-CTC processing. Another paper discussed the effect of addition of RC dust on the formation of colouring constituents in black tea. It was shown that RC dust addition results in increased formation of theaflavins in clonal black tea which in turn improves the appearance of tea. Chemical alterations brought about by UV irradiation which is used to check microbial contamination during CTC processing was the subject matter of yet another paper. It was reported that apart from bringing down the microbial count, UV irradiation significantly increases theaflavin content of tea and reduces the optimum fermentation time by 5-10 minutes. Investigations were called for to ascertain whether any other concomitant chemical changes take place alongwith increased formation of theaflavins on exposure of tea leaves to UV during CTC-processing. The possibility of liberation of ozone by action of UV on miosture was suggested and it was felt that ozone so liberated might be responsible for the bleaching action observed on tea leaves. A doubt was also expressed whether UV irradiation would affect essential oil level in the leaves.

Post-fermentation soaking of parchment coffee in water and in 1% sodium metabisulphite solution was reported to improve the raw appearance of poor quality beans like S.795. However, the latter treatment adversely affected liquour characteristics. Kent coffee, a better quality coffee than S.795, did not register any further improvement by this treatment. The question of why only poor quality coffee improves by the treatment was discussed at length and the consensus emerged was that good quality beans may offer no scope for further improvement in appearance via polyphenol oxidase because the polyphenols in such beans are already in the reduced state. This point, however, needs verification. The chemical changes brought about by post-fermentation soaking of coffee beans in water and in sodium metabisulphite would offer another interesting area of study. A suggestion was made that other strong reducing agents like hydrogen peroxide may also be tried in place of sodium metabisulphite for post-fermentation treatment.

In one of the papers on cocoa processing, it was pointed out that the high acidity of Indian cocoa beans is not an inherent characteristic, but is induced due to faulty curing. Based on experimental data the authors recommended timely harvest, frequent turning of beans and increased aeration during fermentation and slow initial drying as preventive measures. Another paper was presented on the effect of various parameters like season of curing; aeration, insulation and turning of beans during fermentation; method of storage of dried beans etc., on the end quality of cured cocoa beans. During discussion, it was pointed out that sugar content of the pulp and the local microbes involved may be contributing to high acidity and so, analysis of these factors is very much nescessary. The need for priority studies on underlying causes for high acidity of Indian cocoa beans and on devising ways and means to overcome this problem was stressed, in view of the acute marketing problems faced by our farmers on this account. Another suggested field of study demanding immediate attention is on effective methods to cut short the too long curing period without sacrificing quality of end product. To achieve this objective, possibility of direct addition of mircobes responsible for fermentation or addition of end products of microbial action such as acetic acid and lactic acid was discussed.

Roasting coconut gratings at 160°C for 10 min. prior to extraction of oil was shown to enhance the mutty flavour of coconut oil and prolong its shelf-life. Isolation of chemical entities imparting the roasted nutty flavour to coconut oil was suggested. Stress was also laid on the need to assert whether toxic substances like carcinogenic aldehydes are produced during the roasting treatment. Dr. Rege, however, expressed the opinion that such carcinogenic substances are more likely to be produced, when polyunsaturated oils are heated and a highly saturated oil like coconut oil may not be that suseptible.

The characteristics of CNSL obtained by a second extraction, by expeller method, of already oil bath processed shells were described. The shell liquid so obtained, however, does not satisfy ISI specifications. Heating the product followed by centrifuging was reported to bring about a certain degree of improvement.

On spices, a method to extract oleoresin from fresh ginger which was said to retain the fresh flavour of green ginger was described.

# PROCESSING CONDITIONS AND IMPROVEMENTS

### A. G. MATHEW

(*Chairman*)

The session on Processing conditions and Impro vements, as held in the forenoon 11th December (Chairman: A. G. athew; Rapporteur: Bangali Baboo). Nine papers were presented; the following recommendations were made.

Large scale trials may be conducted on the extraction and purification of caffeine from tea waste and its economics worked out. (Action: UPASI, Tea Research Institute, RRL Trivandrum)

Suitability of cellulose film and metallized polyster film as tea chest liners may be assesed under different conditions of tea storage in the country. (Action: UPASI, Tea Research Institute)

An economically viable industrial process for vacuum heating of coconut oil in order to prolong its shelf-life may be developed. (Action: RRL, Trivandrum.)

A small drier for drying nutmeg and mace retaining its natural colour and quality be developed. (Action: RRL, Trivandrum and CPCRI)

Copper sulphate treatment of arecanut leaf sheath prior to hot pressing may be taken up in order to avoid fungus attack on arecanut leaf sheath boards under humid conditions. Production cost of arecanut leaf sheath boards may be worked out and use of latex based adhesives tried in making the boards.

Weather data at various places in coconut growing areas may be evaluated for drying and storage of copra. Based on the evaluation the growers may be advised about the care they should take during different periods of the year for storage and proper drying of copra. (Action : CPCRI, Agricultural Universities.)

# PROCESS DEVELOPMENT

N. M. NAYAR
*(Chairman)*

In this session nine papers were presented by the respective authors. Of these, four papers were on tea, two on arecanut and one each on rubber, cardamom and cocoa. These papers were open for discussion and the details given hereunder:

In the paper on thermal processing of tea, a comparison was made of the processing operations involved in making black tea by the conventional method and by the technique developed by Russian workers. The chemical quality parameters of black teas were evaluated and compared with the control samples and factory-made samples. However, it was pointed out that organoleptic evaluation of black tea should have been undertaken to find out the consumer acceptability.

A study on the mechanical properties of arecanut leaf sheath have shown the possibility of utilizing the same in making various noval articles and packaging materials. It was stated that 'fire proof' packaging materials could be made out of arecanut leaf sheath plyboards. The paper received much notice and appreciation in view of the potential uses of the product.

Artificial drying of cardamom using a forced hot air circulated drier was reported to give satisfactory results and improve the green colour of dried cardamom. Flushing of hot humid air during drying and combined with other operating factors, a drier capable of drying 120 kg was field-tested.

A paper on drying of rubber described various drying equipements used in processing different forms of rubber, fuels used and the factors affecting the efficiency of drying. Experience on the indigenously developed electrically heated crumb rubber drier developed by the Rubber Board was brought out. It was stated that further studies on the utilization of renewable energy sources for drying rubber would be taken up.

A description of a bench scale laboratory model of a small scale cocoa drier, working with ordinary electric bulbs and its performance for drying 4 kg of cocoa in less than 24hr was presented in the next paper. During the discussions that followed, it was suggested that the use of infra-red lamps for the purpose of efficient drying could be tried.

Two papers on mechanization of certain cultural operations in tea, namely, a liquid fertilizer applicator developed indigenously and a motorised pruning aids, were then presented opening up new vistas in tea cultivation.

In a paper on manually operated arecanut husker the author showed that the new machine would cost about Rs.1000/- and it could be operated by an unskilled labour. Its capacity is about 5 kg husked nuts/hr. The machine does not have any delicate parts which would require frequent service excepting occasional changing of wheels on prolonged usage of the machine.

In the last paper, the authors presented the details of a carbonated bottled tea beverage. Various suggestions were offered by the scientists present during the symposium to increase the consumer acceptability of the tea beverage. The levels of additives in the beverage to conform to the Indian Standards were greatly emphasized.

Concluding, the Chairman commented that the session could have been more appropriately called as Product Development. He thanked the authors for presenting the paper generally within the perscribed time and the delegates for the very useful comments and questions put to the authors since they helped to bring out more useful information.

# MARKETING AND DEVELOPMENT

S. S. MEENAKSHI SUNDARAM
(*Chairman*)

Seven papers were presented in this session. There were two papers each, relating to rubber and spices crops, viz. pepper and ginger, and one each relating to coconut, cashew and coffee.

The paper on cashew dealt with the development programmes in the VIth plan period. The plan proposals are drawn up with the objective of increasing the production of raw nuts from the present level of 1.8 lakh tons to three lakh tons, by the end of the plan period, in order to maintain the present level of exports and to meet the internal requirements. More area will be brought under cashew in the eastern coast. Some delegates felt that the incentives offered under the scheme are not satisfactory.

The papers on pepper and ginger dealt with the supply, demand and price aspects of these crops. In the case of black pepper, in recent years, India has yielded its virtual monopoly position to Malaysia, Indonesia and Brazil in matters of both production and exports. This is the result of the high price of the Indian pepper, which in turn is associated with the low productivity of the crop. The author has stressed the need for appropriate institutional measures to avoid distress sale of the produce by the growers and to concentrate more on the export of white pepper. In the case of ginger, during the last decade, the prices have been fluctuating violently. It was suggested that efforts must continue to reduce the uncertainties of both the prices and production of ginger.

The increasing disparities noticed in the wholesale prices of coconuts between the central and northern districts of Kerala were highlighted in one of the papers. This study pointed out the need for having an organised marketing system for coconuts in the northern districts and setting up of more coconut based industries in these areas so that producers may get a better price for their produce.

The two papers on rubber dealt with the marketing of rubber in India and the market prospects for technically specified natural rubber. The first paper outlined the role of co-operatives and Rubber Board in solving the problems faced by the estates and small holdings. The second paper discussed the advantages of technically specified natural rubber compared to the conventional grades. The author was optimistic about the prospects of block rubber in the Indian Market.

Pricing efficiency of Indian Coffee Markets was interpreted in terms of spatial integration, in one of the papers. Pricing efficiency was found to be maximum at pool sale level, because of better control by the Coffee Board. The markets located in Karnataka were more efficient than those within Tamilnadu and markets between different states were less integrated than those within the states.

In this concluding remarks, the chairman stressed the need to ensure quality and minimum cost of production, as survival depends on this.

# PLANTATION PRODUCTS : TRENDS IN TECHNOLOGICAL RESEARCH

D. V. REGE
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India has given the world in the past many things to make the human life more happy, more contented; more meaningful from mathematics, philosophy, literature, fine arts, medicine, to culinary art. In many of these areas the country has now climbed down to the receiving end. However, one type of item this country has continued to give the world since ancient times and the flow of which has continually been on the increase is the spices. New items of plantation products have been added to these traditional ones a few centuries ago—tea and coffee—and this list has of late been expanding with the inclusionof many essential oil bearing seeds and herbs, cashew nuts and walnut. Our cocoa plantation have picked up so well that I won't be surprised if this becomes an exportable item within a few years. Pioneering efforts have been made in the past by individual planatation owners and companies which have now been organized on a more scientific basis by the research organizations CPCRI, UPASI, Tocklai Experimental Station, Coffee Research Institute and others. The work has been predominantly agronomical and has, no doubt, solved many problems of selection of cultivars, of their cultivation, plant protection, farm management and related areas which have helped in increasing yield and improving the crops.

In the case of tea and coffee the plantations over the years developed their own post harvest technology, processing and grading procedures, packaging and shipping practices. During the past few decades the Tocklai Experimental Station and the UPASI Research Institute as well as the manufacturers of machinery have strived to put in technological innovations including development of a continuous process for black tea manufacture. With the advent of the CFTRI, active attention has been paid to some of the chemical and technological problems of tea, coffee and spices. Indeed, great strides have been made in developing processes for the production of oleoresins, processed spice varieties, instant coffee and tea.

And yet I must say that such an important group of crops with the production of the order of Rs.1000/– crores and an export potential of Rs. 500/– crores has not been receiving as much attention as it deserves. Competition for our export products in the international market is building up fast and there is no absolute certainty that we will be able to maintain our export earnings on this scale indefinitely. Such an unhappy situation is entirely due to the lack of a rational and coordinated policy of research and development. There is an urgency that steps are taken to provide for balanced agricultural scientific, technological, engineering and managerial inputs to streamline and upgrade existing process. know-how and develop modern technologies geared to future needs. It is my purpose to outline here the chemical and technological research areas that need attention.

## Technological parameters for cultivar selection

At the outset I must venture to point out a lacuna in the selection of cultivars of the crop plants. It is apparent that this is primarily done on the basis of agronomic grounds of yield. The quality parameters of the finished products are hardly taken into consideration.

Genetic approaches—including hybridization, polyploidy, mutations—to development of new varieties which have to be evolved for increasing yield and improving quality will have to keep the organoleptic and technological quality parameters into consideration. The parameters—phenotypic markers—for each crop will have to be clearly characterized. Predominance of particular aroma notes, taste characteristics, colour, in sensory terminology along with the chemical characteristics responsible for these, soluble and insoluble or fibrous contents, total volatile constituents, amenability to processing with respect to colour, flavour and texture changes—several such quality aspects will have to be identified and included in such studies.

It is our rich legacy that this country abounds in a vast genetic potential with respect to the spice plants. It was a pleasant surprise for me to see some 150 varieties of pepper in the collection made with such strenuous efforts by the CPCRI scientists at Vittal. Although extensive investigations are needed for it, such studies will have to be undertaken expeditiously before we lose such valuable germ plasm of several spice crops by the unavoidable deforestation proceeding at such rapid pace. The recent conference 'Global 2000' has forecast that half a million species will be extint by the year 2000. Some 15 to 30 percent of plants and animals are expected to vanish from this planet. Collaborative efforts are called for to screen these strains for various agronomic as well as technological quality parameters. The quality needs are also undergoing changes as emphasis switches from raw spices to essential oils and oleoresins, from spice as a whole to separately to taste and colouring matter. Perhaps the different wild strains may prove more valuable from one or other of these quality parameters than the cultivated crops.

A new technique that has emerged recently and has now been successfully adapted in the country is that of plant tissue culture. The technique has a vast potential for propagating plants with the choicest quality characters, healthy—free from infections—at faster growth rates. This technique has an immense potential and may revolutionise the cultivation procedures.

## Technological research

Work on improving post-harvest technology for reducing losses, on the production of ground spices, oleoresins, essential oils, on packaging and waste utilization has been going on in some centres and this, no doubt, needs intensification. However, on the technological front we shall have to strive hard to catch up with the advanced nations. The trend in technology is towards development of convenience products. This is an age of instant beverages, micro-encapsulated spices and flavorants. We are yet to solve the problem of instantizing tea with acceptable aroma and body. Success in these is bound to open up new avenues for its application in other instant beverages—both alcoholic and non-alcoholic.

New approaches are needed for upgrading inferior grades of plantation products. Analytical characterization of the defects in inferior grade products like tea and attempts to remedy these by suitable modifications in the processing details have to be systematically carried out. Measures such as the use of superior aroma from good coffee for flavoring by coating inferior grades have been patented for coffee powders and instant coffee preparations. Can such measures be tried for tea ? Is it possible to fortify with missing precursors or enzymes before processing ? Use of external enzyme in fermentations of tea, coffee and cocoa or mechanical depulping of coffee and cocoa, followed by controlled treatment with heat and chemicals for curing the beans—several such approaches need to be tried.

New techniques are emerging for extraction of active principles. Extraction with liquid CO2 and nitrogen under pressure is one with great promise for extraction of oleoresins, caffeine etc. Several new approaches are being tried for concentration such as freeze concentration, membrane processes such as dialysis against macromolecular compounds by reverse osmosis. Concentration of aroma may be tried by steam stripping, high resolution distillation or gas chromatographic separation procedures. Techniques such as continuous fluidized bed drying, infrared and micro-wave ovens for drying and roasting operations may also be tried.

## Basic studies

An area that has been largely neglected is the understanding of the basic phenomena both underlying the biogenesis of taste and flavour principles in spices and the physico-chemical changes during processing operations that are responsible for the formation of quality parameters of tea, coffee and cocoa beverages.

In this age of genetic and enzyme engineering an understanding of the biogenetic pathway of spice constituents will go a long way in making it possible to control the sensory characteristics of the spices and spice products. Although this is a strenuous work, not immediately likely to pay dividends, and will need the application of biochemical and molecular biological techniques, it will no doubt, prove to be a worth-while investment in the long run. It may be necessary to enlist the cooperation of Universities in such basic work.

The ultimate sensory characteristics for which tea, coffee and cocoa are valued and on the basis of which a product is graded and rated are determined, apart from the botanical variety, environment, soil, season, cultivation and such other agro-horticultural conditions, by the post-harvest technological operations. A systematic study correlating the processing and the quality parameters has to be carried out for understanding the exact role of each operation, what physico-chemical changes take place during each operation and how these can be controlled. Flavour generation during drying, roasting as in coffee and cocoa and effects of additives need to be studied. Such a study can ultimately lead to finding ways to utilize naturally inferior raw material into improved products by suitable adjustment of the processing technology.

It is necessary to study indigenous methods of curing such as of turmeric. Surveys are necessary of microbiology of spices such as capsicum, and cardamom and develop methods for prevention of these contaminations.

**Innovative applications**

In order to maintain and even increase the volume of export and utilization locally we have to systematically try to open up new avenues for application of various plantation products. New soft drinks, alcoholic beverages, liquors, cheese-based or other bread spreads, pastes to go with meat-fish-poultry-preparations flavourings for milk-beverages, yoghurt, ice-creams, for fermented pickles, fruit and vegetable ketchups and sauces, baked goods such as bread, biscuits, cookies, deep fat fried chips, wafers and snacks, in the modern extrusion puffed and popped cereal-legume crispies and what not. New appetising drinks, carminatives, flavoured tea varieties, iced teas etc. can be developed.

**Chemo-Botanical Surveys**

Food technologists in the western countries have been on the look out for new plant materials for developing food products of varied characteristics in appearance, colour, texture and flavour. This country has unlimited resources—still untapped—of potential additives. The story of guar gum is a recent one how new and important applications have been found to a well-known common seed. Dhaincha (Sesbania) seeds are on the anvil, of late. With the safety of synthetic chemicals being suspect a new gold rush has started. We have to cash in and for this extensive surveys and intensive work is needed on priority. What I want to advocate are extensive chemo-botanical surveys for starches, gums, mucilages, pectic substances, pigments, flavorants, sweetners, acidulants, bitter principles, new bases for soft drinks. In fact along with this quest we shall have to look for insect control agents, medicinally active agents also. This should be taken up as a movement involving the school science teachers, college science students, Universities and the national laboratories. The RRL, Jammu, has recently found a substitute for clove oil from a plant called Vana-tulsi (Clocium). The plant has been cultivated with increased yield of the oil and eugenol content of 70 percent.

### Health aspects

In spite of the fact that spices have been consumed by man from time immemorial and tea and coffee for centuries a murmer about their possible ill effects is heard occasionally. In these days of applying the Ames' test and dominant lethal test or chromosome aberration test in tissue cultures several common food constituents are being branded for mutagenicity and carcinogenicity. Spices causing, gastro-intestinal tract irritations, tea and coffee with their high level of caffeine and tannin causing gastro-intestinal disturbances, nervous disorders or coffee and areca nut acting as potential co-carcinogen–such reports do appear occasionally.

On the other hand, as mentioned earlier, reports attributing beneficial effects of spices and beverages have often appeared. It is high time our scientists thoroughly thrash out this problem by systematically surveying the pharmaco-dynamic effects of these on the metabolic systems. A few compounds like saffrole and myristicine occurring in nutmeg, for example, have been found to be toxic. In such cases their toxicity will have to be characterized and tolerance limits established.

Several of the spices and tea in particular are rich sources of polyphenolic compounds that are highly reactive and possess strong reducing properties. They can act as free radical scavengers. Some of these have been reported to possess vitamin P activity although this activity is as yet not clearly understood. The several Ayurvedic preparations claimed to have remarkable rejuvenating or vital effects are also known to be rich in such compounds. It is high time that the metabolic effects of these are given a renewed attention using modern biochemical pharmacologic techniques.

Another field of investigation that suggests itself is the possible role that spices play in the biogenetic mechanisms of skin pigments. It is well-known that psoralen derivatives are now used in darkening the skin, in treatment of psoriasis, leucoderma, vitiligo and such cases of depigmentation or in lotions to accelerate tanning. Many of the spice commodities are rich in psoralens which have the property to photosensitize. I feel this property on the psoralen bearing plant products duly deserves active attention.

**A word of caution**

I wish finally to bring to the attention of scientists, technologists, manufacturers and traders of plantation products a few pertinent points on the future of these products.

There has been an awakening amongst the consumers of the western countries and amongst the health authorities about the importance of the nutritive constituents of foods. Foods which do not supply more than 5 percent of the daily needs of nutrients are categorised as 'junk foods'. Spices and beverages like tea and coffee cannot by any stretch of imagination be claimed to be carriers of nutrients. Even though food acceptability is going to depend largely on the judicious blends in food products of spices, condiments and flavouring agents, with the deficiency of food value in these along with the possible scare of harmful reactions it is risky always to take for granted that these will continue to enjoy the place of pride they hold currently.

The field of flavour and perfume technology has of late made astounding progress with application of modern analytical instrumentation and creative chemistry. The flavour technologists have shown a remarkable ability to simulate precise flavour notes with the help of synthetic chemicals with or without natural isolates. Artificial flavours simulating processed meats, cheese, nuts and what not are already known. The time may not be too distant for the production of successful formulations simulating the taste and aroma characteristics of spices and other natural flavorants as has already been achieved in the case of several perfumes.

We shall have to be prepared for such eventualities. A great upsurge of planned and coordinated activity is necessary for this in which the various specialized research institutes and Universities must play a concerted role. It is imperative that a proper share of the value of the plantation products produced annually should be invested in these efforts.