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Development of a Process for Coconut Cream on Commercial Scale

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A demonstration plant for production of coconut cream, envisaging utilisation of coconut residue and shell, has been developed to process 1000 nuts per 8 h. Its operation and machinery are described. The canned coconut cream is superior in terms of quality parameters of comparable products marketed abroad.

Keywords : Demonstration plant, Coconut cream, Pasteurization, Milk extraction, Heat penetration, Product composition.

With a total production of 9200 million nuts during 1989-90, India is the third largest producer of coconut in the world (George et al. 1991). Coconut culture and processing play a dominant role in the agricultural economy of the Southern States. More than 50% of the nuts are consumed as raw in the household sector and some in the form of ready - to-eat sweet meats using sugar or jaggery (Satyanarayana Rao et al. 1990 a,b). Newer products such as processed coconut milk, coconut water and many other food products including infant foods have been developed and marketed abroad (Timmins and Kramer 1977; Lupke 1979; Husin and Hassan 1978; Goncalves and Teixeira Neto 1982; Hagenmaier 1977; Prasanna et al. 1969). However, no serious R & D efforts are made in India and, therefore, coconut economy depends mainly on a single commercial product, i. e. coconut oil. Processed coconut cream is one of the products that has good market potential. An improved process for shelf stable coconut cream has been developed and a demonstration plant was established at Kochi. This paper relates to the details of the equipments, optimised unit operations etc., of the demonstration plant of a capacity to process 1000 coconuts/8 h.

Materials and Methods

Well ripened fresh nuts, husked and aged for a week, were split manually. Specially made scooping knives were employed for manual deshelling. The kernel was washed with water containing 100 ppm H_2O_2 in S.S. tank of 500 l capacity. For blanching, these were immersed in hot water at 80°C for 10 min in a S.S. tank of 500 l capacity, fitted with open steam coils for steam sparging to heat water to boiling temperature. Prior to milk extraction, the wet kernel was subjected to size reduction using hammer mill (Batliboi Engineers, Bangalore). The optimum particle size obtained by using 6 mm sieve in a hammer mill was arrived at, as a result of laboratory, and pilot plant trials. It has a throughput of 500 kg kernel/h and was provided with a chamber to collect wet gratings.

The wet grating was fed into a S.S. screw press specially designed and fabricated for maximum milk extraction on commercial scale, based on the data with respect to size of the gratings, performance of other extraction equipments, pressure, and other physical requirements. It has a progressively tapering worm screw, housed in a perforated cage, lined with 2 mm S.S. sieve. The drive consisted of 7.5 HP motor and a reduction gear. The compression ratio was 12 and the back pressure was adjusted by controlling the exit slit. The milk is expelled through the perforation on the cage and collected in the reception chamber at the bottom. The residue from the screw press was mixed with hot water for the final milk extraction, using a hand driven geared residue mixer. It is a S.S. vessel of 300 l capacity, provided with baffles and scraper. The cycle of extraction optimised here, was first two passes without water and the third with water equal to half the weight of the residue. Under these conditions, about 70% of the soluble solids of the coconut gratings can be extracted.

Filtration : The milk obtained was filtered using a vibratory sieve (J. T. Jagtiani, Bombay). The sieve (60 mesh, 24" dia) is subjected to gyratory motion by an electric motor of 2 HP.

Additive mixing : Additives which consisted of Tween-80, casein, guar gum, CMC sodium salt of high viscosity and sugar were dispersed in hot water in a 100 l capacity steam jacketted S.S. kettle, the pooled milk was added, heated to 80°C

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and emulsified in a portable industrial mixer (Remi Engineering, Bangalore). The cream was pasteurized, using a plate heat exchanger system, specially designed for the pasteurization of coconut cream (92°C for 20 min). This system has a plate and frame heat exchanger made of S.S. holding tank of 200 l and hot water tank. The cream is charged into the holding tank, and circulated through the product channel of the heat exchanger and hot water at 95°C is circulated through the heating medium channel with the aid of 2 HP pumps. The cream was hot-filled in plain tin cans using a volumetric filling machine (J. T. Jagtiani, Bombay). The cans with loosely placed lids were passed through a continuous exhaust box (Gardner's Corp., New Delhi). The exhausted cans were sealed using a standard industrial sealer of the capacity 300-400 cans/h. A rotary retort (Fabricated by Plants (India) Ltd., Cochin - as per our design) consisting of a horizontal cylindrical vessel with rotating inner drum and a stationary outer shell was used for can retorting. The inner drum is provided with 660 slots to hold the standard 301 x 204 size cans. The central shaft to the inner drum is connected to a geared motor to rotate at 1 rpm. Steam is passed into the retort to maintain a pressure of 15-30 psi. While the inner drum is in rotation, holding the cream filled cans, a continuous mixing of the cream is achieved, facilitating faster heat penetration, and uniform heating. The rotary retort was designed, and fabricated specially for coconut cream sterilization.

Residue drying : The residue was dried to a moisture content of 3% by using a through flow electrical dryer (Premier Engineering Co., Cochin). Fifty kg of the residue could be dried in 1 h. A boiler (Laxmi Boilers, Bombay), with an evaporation capacity of 300 kg/h and fuelled by coconut shell supplemented with firewood, was used. Total connected load for the plant is 65 KW, while the estimated water requirement for 8 h shift is about 10,000 l. The demonstration plant has a total area of 2,500 sq. ft., divided into boiler house, work area and processing area. It processes 1000 coconuts in 8-10 h to yield about 250 kg coconut cream, and 50 kg coconut powder.

Analytical methods : Microbiological analysis of samples was carried out as per standard procedure (Ranganna 1986). Total solids, fat, protein, sugars, minerals and gums were estimated as per BIS (1961) methods.

Results and Discussion

Yield of kernel : About 50 trials (200-400 coconut batch size) were conducted. Normally, the weights of coconuts of the commercial varieties in India, range from 400-600 g with a mean value of 500 g. The average yields recorded were 50 kg fresh meat, 20 kg water and 30 kg shell from 100 kg dehusked coconut, consistently with narrow limits of variation. The overall average ±SD value for dehusked coconut, shell, water and kernel for the selected trials (6 trials comprising 1890 nuts) were 173 ± 20, 52 ± 6.2, 35 ± 4.2 and 87 ± 9.6, respectively. The average weight (800 g) reported for major coconut growing countries like Philippines, Indonesia and Sri Lanka is much higher than that of Indian varieties, probably due to varietal variations (Woodroof 1979).

Milk extraction : The sequential operations for the coconut cream process is presented in the flow chart (Fig. 1). Attempts to mechanise breaking and deshelling did not yield desirable results. The process of removal of brown testa (called paring) is a labour intensive operation, which also reduces the weight of the kernel by 10-15% (Child 1974). Earlier processes for coconut cream include paring as an important step to obtain white milk (Woodroof 1979). The colour of the milk was not affected with or without paring (Arumughan et al. 1984). Therefore, the step of paring has been avoided to not only save labour but also increase the milk yield. The washing of kernel in water with 100 ppm H_2O_2, followed by blanching for 10 min at 80°C, was intended to reduce the initial load of microflora. The blanching step is reported to reduce enzymes like lipases (Krishnamurthy and Chandrasekhara 1979) that may cause undesirable flavour. Size reduction of the kernel into small particles is an essential step for subsequent milk extraction.

Stabilization of emulsion : Extensive studies incorporating permitted emulsifiers and stabilizers, followed by emulsification, were conducted to arrive at optimum levels (Arumughan et al. 1987). The pH of the additive mixture which consisted of Tween-80, casein, guar gum, CMC and sugar was adjusted for complete dissolution of various ingredients and then only this was added to the pooled milk prior to emulsification.

Preservation : A pre-heat treatment using plate heat exchanger for 20 min at 92°C was found to reduce the population of spoilage organisms to a

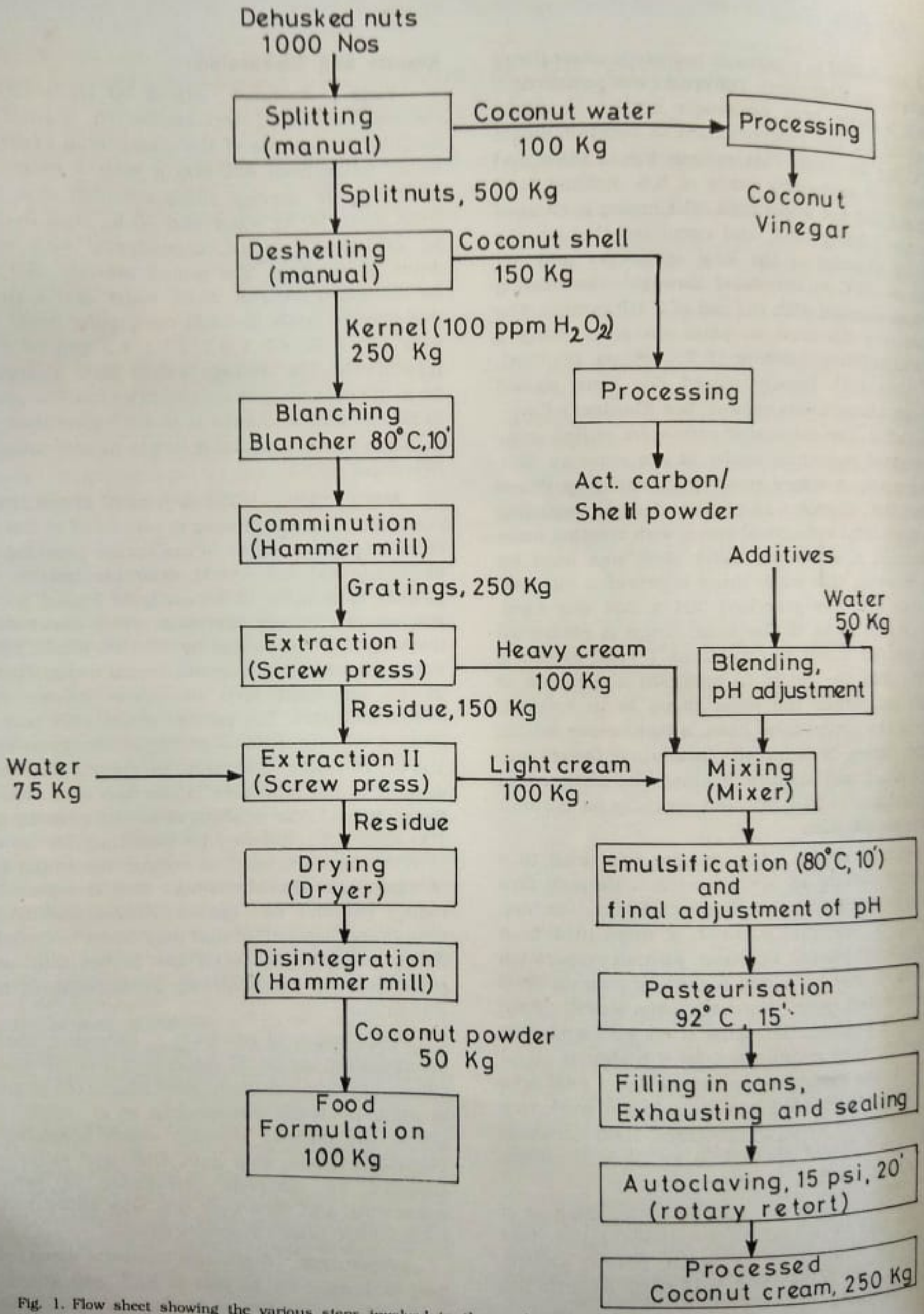

Fig. 1. Flow sheet showing the various steps involved in the production of processed coconut cream.

TABLE 1. MICROBIOLOGICAL ANALYSIS OF SAMPLES DURING VARIOUS STAGES OF PROCESSING*

Sample collected	Total count/ml
Coconut-kernel wash water	$10^4 - 10^5$
Water after blanching	$10^3 - 10^4$
Crushed gratings	10^4
Milk extract (First)	$10^4 - 10^5$
Additives	0 - 10
Milk + additives	10^5
Milk after stirrring and homogenization	$10^6 - 10^8$
During pasteurization	$10^3 - 10^5$
Pasteurized sample in bottle (which showed spoilage in 7-10 days) collected on the day of preparation	10^3

* *Bacillus* were present in all the samples. *Micrococcus* and *Proteus* were encountered in coconut-kernel wash water (before and after blanching) and crushed gratings, respectively.

great extent (Table 1). As pasteurization alone was found to be inadequate, the coconut cream was subjected to further treatments such as exhausting and retorting. Based on heat penetration studies, a time-temperature profile of 35 min at 15 psi was arrived at for sterilization in a stationary retort. Though this heat treatment was found to give a sterile product, the product quality suffered from browning, curdling and off-flavour. Coconut proteins have been shown to be highly sensitive to temperature (Samson 1971) and pH (Balachandran and Arumughan 1992). Exposure to high temperature for long time resulted in denaturation and precipitation of proteins. The process of denaturation was accelerated in the acidic and basic regions. In the process for coconut cream, these problems have been overcome by the incorporation of additives and adoption of rotary retort. While the additives minimized the impact of heat treatment, mixing of the cream during sterilization facilitated faster and uniform heat penetration, and reduction in the time of heat treatment. Under these conditions, sterilization at 15 psi for 20 min was found to give a product free from curdling and browning. The effectiveness of sterilization was further confirmed by microbiological analysis for mesophilic aerobes, mesophilic spore formers, *Bacillus stearothermophillus*, total anaerobes and presumptive coliforms. These organisms were found to be absent in the product.

The available reports for the coconut cream process from the Philippines (Timmins and Kramer 1977), Malaysia and Thailand (Hagenmaier 1977) involved severe heat treatment to impart product sterility. For example, the Philippine process has adopted autoclaving of the cans for 45-70 min. In the case of Malaysian and Thailand processes, the milk is subjected to heat treatment in open steam kettles at 80°C for 4 h, followed by addition of sodium metabisulphite before packing. These resulted in the browning, curdling and phase separation of the product. The analytical data of coconut cream processed at RRL(T) and two commercial brands from Malaysia and Singapore are presented in Table 2. The process reported here has overcome these quality defects by adopting suitable additives coupled with sterilization conditions, as already described. Further, this process also avoided preservative, which usually imparted undesirable flavour and taste.

TABLE 2. ANALYTICAL DATA OF COCONUT CREAM PROCESSED AT RRL (T) AND OF TWO COMMERCIAL BRANDS FROM MALAYSIA AND SINGAPORE*

	RRL (T)	From Malaysia 155 g	From Singapore 170 g
Colour	White	Dirty white	Dirty white
Texture	Smooth	Curdled	Curdled
Flavour	Coconut like	Slight burnt flavour	Synthetic coconut flavour
Appearance	Homogeneous	Two phases	Two phases
Consistency	Creamy	Watery	Watery
Total solids %	37	21.2	15.6
Solids non-fat, % (SNF)	12	7.2	4.1
Fat, %	25	14.0	11.0
Protein, %	4.5	0.3	0.5
Sugars, %	5.5	2.9	2.0
Minerals, %	1.8	0.7	0.6
Added gums, %	0.4	2.5	1.5

* Procured from the Middle East

Composition and material balance : The composition of the canned coconut cream and coconut powder by this process and the material balance data are shown in Table 3 and Fig.1. The coconut powder was converted into ready-to-use food formulations such as curry or *chutney* powder with acceptable quality attributes. This further

TABLE 3. COMPOSITION OF THE COCONUT CREAM, COCONUT RESIDUE AFTER MILK EXTRACTION AND DESICCATED COCONUT

	Coconut cream (wt %)	Residue (wt %)
Moisture	65.0	3.0
Fat	23.0	45.0
Protein	4.5	8.0
Sugars	5.5	9.0
Fibre	-	15.0
Minerals	1.0	1.5

adds to the economic viability of this process. The coconut water is yet another byproduct that can be converted into coconut vinegar, thereby adding value to a waste product. Further formulation of the coconut powder could give 100 kg ready-to-use chutney or curry powder. The shell (150 kg) is used as a boiler fuel at present. However, it can be profitably used for making shell powder or activated carbon.

The demonstration plant was established at a cost of Rs. 25 lakhs, and the canned product was test marketed at metropolitan and other cities. The feedback obtained from this programme suggested that the product was acceptable in all household dietaries and catering establishments, where coconut is used.

Technology transfer for commercialisation : The process has been transferred for commercial production to a private company. The proposed commercial plant will have a capacity to process 10,000 fresh coconuts per day, which would yield 2500 kg coconut cream and 500 kg dry coconut powder. Economic viability for the commercial plant has also been worked out for the detailed project report. The total cost of this project is Rs. 150 lakhs of which Rs. 90 lakhs account for capital cost. The project breaks even at 40% capacity with a pay back period of 4 years for the term loan. The commercial plant is proposed to be located in Trichur district of Kerala State.

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References

Arumughan C, Balachandran C, Jayalekshmy A, Satyawathi, Thomas PP (1987) Technology of coconut cream - How important is it in India's economy. Ind Coconut J 18:3-11

Arumughan C, Balachandran C, Sreedhara N, Gopalakrishnan N, Narayanan CS (1984) Convenience food based on coconut - RRL experience. Ind Coconut J 15:1-6

Balachandran C, Arumughan C (1992) Solubility and electrophoretic characteristics of proteins in different regions of coconut endosperm. J Food Sci Technol 29:91-96

BIS (1961) Methods of Test for Dairy Industry IS : 1479, 1961- Part II. Chemical Analysis of Milk. Bureau of Indian Standards, New Delhi

Child R (1974) Coconut, 2nd ed. Longman Group Ltd., London

George MV, Vijayakumar K, Jacob Mathew (1991) Trend, production and productivity of coconut in India. Ind Coconut J 22:45-49

Goncalves JR, Teixeira Neto RO (1982) Industrial aspects of preservation of coconut milk. Boletin do Instituto de Technologia de Alimentos 19:359-368

Hagenmaier R (1977) Coconut Aqueous Processing. University of San Carlos Press, Cebu City, The Philippines

Husin A, Hassan HM (1978) Processing of coconut milk (Santan) I. Processing of Santan into coconut butter. Malaysian Agric J 51:299-304

Krishnamurthy MN, Chandrasekhara N (1979) Distribution of lipase in different parts of coconut. J Food Sci Technol 16:74-75

Lupke J (1979) Gekremte kokosnuss. Gordian 79:86-89

Prasanna HA, Rama Rao G, Desai BLM, Chandrasekhara MR, Use of spray dried infant food based on coconut in the treatment of protein malnutrition (Kwashiorkor). J Food Sci Technol 6:187-188

Ranganna S (1986) Manual of Analysis of Fruit and Vegetable Products, 2nd ed. Tata McGraw Hill, Bombay.

Samson AS (1971) Heat treatment of coconut meats and coconut meal. J Sci Fd Agric 22:312-318

Satyanarayana Rao TS, Kaverappa NM, Hema Prakash Reddy T, Jayaraman KS (1990a) Development of ready-to-eat traditional Indian sweet dishes based on jaggery and coconut. J Food Sci Technol 27:355-358

Satyanarayana Rao TS, Kaverappa NM, Jayaraman KS (1990b) Development of shelf stable ready-to-eat Indian sweet meats based on sugar and coconut. J Food Sci Technol 27:359-361

Timmins WH, Kramer EC (1977) The canning of coconut cream. Phil J Coconut Studies 2:15-25

Woodroof JG (1979) Coconuts: Production, Processing. AVI Publishing Co. Inc, Westport, Conn

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