

MODELLING OF COCONUT PROCESSING COMPLEX THROUGH INTEGRATED SYSTEM

S. J. D. Bosco and C. V. Sairam

Central Plantation Crops Research Institute, Kasaragod – 671 124

ABSTRACT

Though India is one among the largest producers of coconut in the world, its relative share in the international trade arena is non-significant as compared to other major coconut producing countries such as the Philippines and Indonesia. Lack of organized marketing having vertical integration with the agro-processing is the prime reason for the same. Technologies are available for individual processing for the production of edible oil, DC powder, vinegar, coconut chips, shell powder, industrial oil and cakes. However due to their small scale operation the economies of scale and their relative profitability is low as compared to those, which could be achieved through scientific integration. This paper proposed different models of integrating them and tested the economic worthiness of this process. The results indicated that scientific integration of different coconut based processed products would be economically viable as compared to their individual production. Establishment of these units in those areas with less labour cost proves to be more beneficial. Since integration of various agro processing units of coconut involves heavy investment, entrepreneurs who are willing to invest in few of these low or high intensive models, needs to undertake an assessment of the demand and supply pattern of in puts and possible domestic and international demand.

INTRODUCTION

Coconut is the major small holder's plantation crop grown in the humid tropics and tropical regions of India. India is one among the largest producers of coconut in the world with an annual production of 12535.9 million nuts from an area of 17.54 lakh hectares. The average productivity of 7145 nuts/ha is the highest in the World. The southern states of India viz., Kerala, Tamil Nadu, Karnataka and Andhra Pradesh account for more than 90 percent of the country's area and production. Out of the total production, it is estimated that 55 – 60 per cent is consumed as raw nuts, 11 per cent as tender coconut and the balance is converted into copra mainly for oil extraction. Low productivity due to predominance of small and marginal holdings, lesser-marketed surplus through unorganized marketing systems, lesser value addition and byproduct utilization are the major challenges faced by the Indian coconut industry. Under the present global scenario, value addition through product diversification and byproduct utilization are the major themes identified in the X plan for sustained development of coconut industry in India.

Major by-products in coconut processing industry are coconut water coconut shell and husk. Coconut water contains about 2-3% sugars and 0.5% minerals. After fermentation the water can be profitably utilized for coco vinegar with the

pleasing aroma of coconut and therefore it can be sold as premium quality as compared to synthetic vinegar now available in the market. Shell is yet another valuable by-product which can be converted to value added product like shell charcoal, shell powder, etc. Coconut husk is another valuable by-product of coconut industry which can be used for the fibre extraction and compost production. At present these by-products are processed further in separate industry or thrown as waste. Commercial viability of coconut processing can be further enhanced through the integrated processing of coconut and its by-products.

MATERIALS AND METHODS

This paper depicts the technical feasibility and economical viability of the developed models by aggregating several coconut based products. Adoption of these models on industrial basis would pave way for higher returns. Depending on the initial success, export oriented coconut processing complexes can be created, thereby ensuring better price stability in coconut farming. All the successfully running coconut industries were taken as the component of the modeling. In addition to the above, the new viable technology 'coconut chips' was also included as one of the component. Flow diagram of product in the model coconut processing complex is given in Fig. 1. Cost of dehusked coconut is taken for this study as these

component industries are having usual practice of purchasing the dehusked coconut through middle person. For the fibre extraction unit, cost of husk has been included. If the coconut is purchased as such and brought to the complex, then the additional benefit of about 10 - 15 paise per nut may be obtained. Initial investment is calculated for the individual unit and the same has been taken for the processing complex. There will be about 15 - 20 percent reduction in the total investment for the processing complex which will be obtained by having common facilities for the storage room for raw and final product, generator, water supply, cost of land and building, hot air producing system, etc. Cost of maintenance and depreciation cost for the machinery are assumed as 10 per cent of the cost of the machinery for each item. Cost of electricity is taken as Rs. 4/- which will be obtained from the generator. Subsidies given by the various development agencies are not considered for the calculation of the initial investment. Estimated investment and return of each component of the model processing complex is given in Table 1. Estimated investment and return of the different models of coconut processing complex is given in Table 2. Processing capacity of each model complex is assumed as 25000 nuts per day. In all the models, there is no production during first year.

To assess the economic viability of coconut based agro-processing complex, Investment

analysis was performed based on compounding and discounting method (Gittinger 1981, Sairam *et al.*, 2000). The investment parameters viz., Benefit-Cost Ratio (BCR), Pay Back Period (PBP), Net Present Worth (NPW) and the Internal Rate of Return (IRR) were estimated considering the life span of the investment as 20 years and using 15 percent as interest rate, which is the opportunity cost for long-term investment.

RESULT AND DISCUSSION

A detailed account of the technologies of the component industry of the proposed model are as follows.

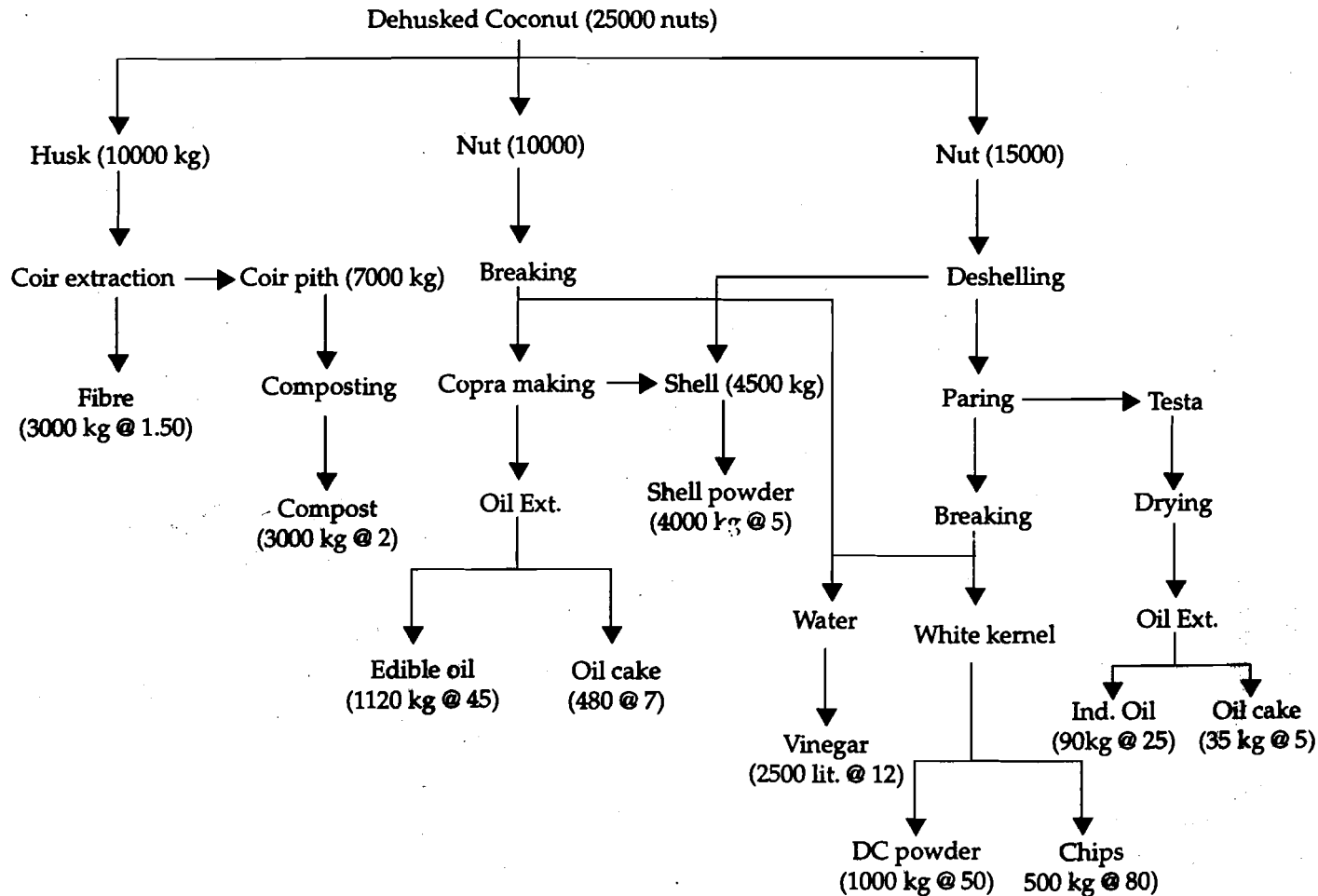
Coconut oil

It is the one of the traditional coconut products produced in India. Copra drying and oil extraction are the major unit operations in the production of coconut oil. Fresh coconut kernel contains 50-55 per cent moisture content, which is to be brought down to 5-6 per cent by drying. The methods generally used for drying of copra are sun drying, smoke drying or kiln drying and drying by mechanical dryers. The quality of milling copra determines the quality of oil and the residual coconut oil cake. Higher capacity mechanical dryers of 5000 - 20000 coconut per batch copra dryers are available. For extracting the oil from the copra, a double crushing unit gives

Table 1. Estimated investment and return of the each component of the processing complex

Final product	Quantity	Cost/ unit	Return (Rs)	Electricity required (KW)	Labour required	Initial investment (Rs. in lakh)
Edible oil	1120 kg	45	47040	80	13	7.00
DC powder	1000 kg	60	60000	70	50	42.00
Chips	500 kg	80	40000	50	35	16.00
Vinegar	2500 lit.	12	52500	-	2	14.00
Shell powder	4000 kg	5	20000	50	3	11.00
Fibre	3000 kg	1.50	4500	150	10	29.00
Compost	3000 kg	3	6000	-	2	2.00
Ind. Oil	90 kg	25	2250	-	-	-
Oil cake	480 kg	7	3360	-	-	-
Oil cake from testa	35 kg	5	175	-	-	-
Other				25	5	
Total			235825	425	120	121.00

Fig. 1. Flow diagram of product in the model coconut processing complex



better extraction, hence, series of expellers are preferred for large scale industries. The clean copra is passed to disintegrator, where it is converted into a coarse meal. The meal is heated in the cooker by steam up to 88°C. Then it is fed continuously to the expeller from which the oil and the cake are forced in different streams. The oil cake is used as cattle feed either directly as such or after removing the oil by the solvent extraction method.

Desiccated coconut

It is also one of the traditional coconut product produced in India. It is the white kernel of the coconut, comminuted and desiccated to a moisture content of less than 3 percent. This is a very important commercial product having demand all over the world in the confectionery and other food industries, as an ingredient in the fillings of chocolate, bakery products and candies. The major unit operation in desiccated coconut industry are seasoning, shelling, peeling of testa, washing, and disintegration of the white kernel and then drying. Other than the unit operations like disintegration of the white kernel and drying, all unit operations are normally done manually. Continuous type fluidized bed dryer of higher capacity are also available for the large scale industries.

Coconut chips

Coconut chips is a new kernel based product. It is a dehydrated coconut slice of intermediate moisture content. Intermediate moisture coconut kernel is the mature coconut kernel after removing the moisture content of the kernel partially by osmotic dehydration by using osmotic mediums like sugar syrup, salt brine, etc. (Bosco *et al.*, 2002). Important steps involved in the production of the coconut chips are dehusking, removal of shell, removal of testa, slicing of kernel, blanching of slices, osmotic dehydration of slices, drying of osmotically dehydrated slices in hot air dryer and then packaging in aluminium foil. Cane sugar or table salt of commercial grade is used. The time of osmotic dehydration will be one hour. For the large scale industry, agitation of the syrup during osmotic dehydration is required. The time of osmotic dehydration will be 40 minutes only. The drying time in hot air dryer is about three hours. The conversion ratio from fresh kernel

weight to coconut chips is about 50 per cent. The coconut chips is crispy in nature and ready-to-eat form. No frying is required before the consumption. It is having its own good coconut flavour as no oil is used for frying. It can be used as snacks. After rehydration of the chips, it can also be used as fresh kernel. Rehydration of the chips is done by immersing the coconut chips in hot water. The rehydration character of the chips is better than that of the desiccated coconut powder.

Coconut vinegar

Coconut water can be converted into vinegar by using vinegar generators. The vinegar generator assembly comprises a feed vat, an acetifier and a receiving vat for collection of vinegar. The matured coconut water consisting of about 3 per cent sugar content is concentrated to 10 per cent level by fortifying with sugar. The fortified coconut water is then fermented by inoculating the solution with yeast, *Sacharomyces cerevisiae*. After alcoholic fermentation for about 4 to 5 days, the clear liquid is siphoned off and inoculated with mother vinegar containing acetobacter bacteria. The alcoholic ferment obtained is then fed into a vinegar generator where the feed is uniformly sprayed over the surface of the porous packing medium (corn cobs). Here the alcoholic ferment is oxidized to acetic acid. The product is run out from the packing medium by gravity flow into the receiving vat from where it is recycled into the vinegar generator and the process of acidification is repeated until strength of 4 per cent is attained. This acetified vinegar is then aged before bottling. Vinegar has extensive use as a preservative in the pickle industry and flavouring agent in food processing sector. Traditionally synthetic vinegar is produced and marketed. Natural vinegar enjoys export market in place of such synthetic vinegar. Coconut vinegar enjoys a wide market segment as a preservative in pickling industry and as a flavoring agent for food stuffs.

Nata-de-coco

Nata-de-coco is formed by the action of a microorganism *Acetobacter xylinum* in a culture medium of coconut water. The culture solution is prepared by mixing coconut water with sugar and acetic acid at a stipulated proportion, which is

Modelling of coconut processing complex

inoculated with *Acetobacter xylinum* through a culture liquid. It is filled in glass jars covered with thin cloth and kept for 2-3 weeks without any disturbance. During this period a white or cream colored jelly like substance forms and floats on the top of the culture medium. It is harvested, cut into pieces and washed in pure water to remove all acid. It is then immersed in flavoured sugar syrup for 12 hours and packed in glass bottles. The product can be used as a dessert and as an ingredient in ice cream and fruit cocktails.

Fibre extraction from husk

Coir industry is one of the oldest industries in India. The husk usually forms 35 to 45 per cent of the weight of the whole nut when ripe. About 30 per cent of the husk is fiber and 70 per cent is coir dust. At present only 35 per cent of the total husk available is utilised by the industry while there is scope for utilising at least 50 per cent of the husk produced in the country. There are two distinct varieties of coir namely white fibre and brown fibre. The white fibre is extracted from retted coconut husk. Kerala produces mostly white fibre, which is used for making traditional coir products like mats, mattings, rugs and carpets. Brown fibre is extracted from unretted husk. It is mainly used for the manufacture of curled coir. Curled coir is used in the rubberised coir mattresses, sofa cushion, bolsters, pillows, carpet underlay etc. The non-retting process involves direct decortication or mechanical extraction. Fibre from the non-retted husk or partially retted husk or fresh green husk is extracted by mechanical means. The yield from retted husks is more than that from unretted husks.

Composting of coir pith

Composting of coir pith has the advantages of detoxifying phenolic compounds, which are deleterious to microbial growth, reducing the bulk of the material and converting plant nutrients to a form more readily available to plants. Basidiomycetous fungus, *Pleurotus sajor caju* can be used to convert the pith into compost, which is capable of detoxifying phenolics and producing bio-polymerizing enzymes. After 30 days of decomposition, coir pith turns into a black mass of compost with reduced lignin, cellulose, and organic carbon and C:N ratio. The volume of the material is also reduced by 50 per cent.

Coconut Shell charcoal

The most important produce derived from shell is charcoal. The yield of shell charcoal is about 30 per cent of the weight of the shells used. Several methods are in vogue for the production of charcoal. Carbonisation of the shell for charcoal is usually done in trenches. The trench may need a lining of masonry so that the shells are clean and are not mixed with earth or sand. Carbonisation will be completed after three days.

Shell flour

It is prepared by grinding clean coconut shells to a fine powder. The shells are first precrushed in a beater type disintegrator into, 5 cm pieces, which are then conveyed to the first hammer mill. Suction in the conveying system draws the particles of flour into a cyclone, where they are separated into coarse and fine particles. Ultrafine particles are drawn away and collected separately. From the cyclone the coarser particles pass to the second hammer mill, and the ground products are subjected to the same air separation as the particles from the first grinding. The fine particles from the cyclone are fed onto a vibrator sieving unit and graded into the required mesh size. It is used mainly as filler, replacing wood flour either partially or wholly in the manufacture of phenolic moulding powders by the thermoplastics sector. The inclusion of shell flour results in an improvement in the surface finish of the mouldings, and because of its higher resinous content and lower absorption properties, it can be used in higher concentrations than wood flour. Shell flour has a variety of other uses. It is used as a filler in phenolic glues for plywood and laminated sheets manufacture, filler for mosquito incense coils, filler in specialised surface finishes, resin castings, etc. As a mild abrasive it is used as a soft blast to clean piston engines. It has been incorporated into hand cleaners and used as a diluent for potent insecticides.

Economic analysis

Coconut based agro processing complex is a suggested long term investment with an initial expenditure of 121 lakhs for setting up processing units (including land and buildings) integrating copra, coconut oil, fibre, compost, shell powder, vinegar, desiccated powder and coconut chips for

processing 25,000 nut per day (Table 1 & 2). Based on the initial availability of the capital few or more components of these products can be integrated. Maximum investment (34.71%) is required for DC units and the minimum (1.65%) for compost unit. A total labour of 36,000 mandays is required. The average power requirement is 12750 units. The realized gross returns of various integrated coconut processing models over edible oil industry alone varies from 19.05% in case of DC powder to 98.4% in case of model VI. Though the present BCR of certain highly intensive models are lower as compared to low intensive models, in the long run, subject to technology development and price trends, it is better to integrate more number of

possible components. Such an integrated approach ensures better price stability for coconut and its products and stabilizes the gross farm income for coconut farmers. This would lead to better rate of adoption of technologies by the coconut farmers in different parts of the country and the overall productivity of coconut industry would improve.

Investment analysis for integrated coconut processing models was performed and the results are given in Table 3. The investment parameters were highly positive and increased with the degree of integrations. Combination of edible oil, DC Powder, Chips, Vinegar, Shell Powder, Industrial Oil and Oil Cakes proved to be economically viable

Table 2. Estimated investment and return of the different models of Coconut processing complex

Model No.	Component of the model	Initial Investment (Rs. in lakh)	Man power requirement	Electricity (KW)	Cost of coconut & other items (Rs. in lakh)	Returns/day (Rs. in lakh)	Percentage increase of returns over edible oil
I	Edible oil + DC powder + Chips + Vinegar + Shell powder + Oil extraction from testa + Fibre + Compost	121	120	425	1.065	2.36	87.3
II	Edible oil + DC powder + Chips + Vinegar + Shell powder + Oil extraction from testa	90	108	275	1.04	2.03	61.1
III	DC powder + Chips + Vinegar + Shell powder + Oil extraction from testa	120	150	255	1.08	2.20	74.6
IV	Edible oil + Vinegar + Shell powder	36	40	250	1.00	1.45	15.08
V	DC powder + Vinegar + Shell powder + Oil extraction from testa	130	130	225	1.00	2.00	58.73
VI	Chips + Vinegar + Shell powder + Oil extraction from testa	105	180	300	1.20	2.50	98.41
VII	DC powder + Chips	95	145	205	1.08	1.70	34.92
	Edible oil	18	35	200	1.00	1.26	
	DC powder	105	125	175	1.00	1.50	19.05
	Chips	80	175	250	1.20	2.00	58.73

and their economic worthiness was higher than the conventional edible oil production or DC powder manufacturing. It could be inferred from the table that investment in coconut based agro-processing is economically viable and the realized BCR ranged from 1.63 (Chips + Vinegar + Shell Powder+ Industrial Oil + Oil Cake from Testa) as compared to 1.18 in the case of edible oil alone. It could be observed from the table that though the BCR between the edible oil and DC is not significantly different, the additional NPW of 94.82 lakhs confirms the economic worthiness of investment in DC as compared to edible oil. Moreover DC has a steady domestic demand and price as compared to fluctuating coconut oil prices.

It could be observed from the Table 3 that if the labour cost in the operating area was less

(@ Rs.50/manday), the relative profitability in all the combinations of coconut based processing industries considerably increased. This suggests to formulate appropriate coconut based agro-processing complexes in those areas with less labour cost and consistent supply of labour for running the processing units.

The Internal Rate of Return (IRR) was highly positive for all the agro-processing models which indicate that subject to the availability of infrastructure and other major inputs, it is economically worth to start these industries by availing institutional credit.

The estimates of economic worthiness are made based on the domestic market conditions and prices. However those who are willing to start

Table 3. Investment analysis of coconut based agro-processing models

Model No.	Component of the model	If labour cost is Rs. 125/manday				If labour cost is Rs. 50/manday			
		BCR	NPW	IRR	PBP	BCR	NPW	IRR	PBP
I	Edible oil + DC powder + Chips + Vinegar + Shell powder + Oil extraction from testa + Fibre + Compost	1.56	1440.07	166	01	1.67	1609.08	186	01
II	Edible oil + DC powder + Chips + Vinegar + Shell powder + Oil extraction from testa	1.61	1446.35	224	01	1.70	1573.10	244	01
III	DC powder + Chips + Vinegar + Shell powder + Oil extraction from testa	1.57	1504.86	175	01	1.71	1716.11	200	01
IV	Edible oil + Vinegar + Shell powder	1.32	658.79	255	01	1.36	715.12	277	01
V	DC powder + Vinegar + Shell powder + Oil extraction from testa	1.54	1317.47	142	01	1.67	1500.56	161	01
VI	Chips + Vinegar + Shell powder + Oil extraction from testa	1.63	1812.33	241	01	1.79	2065.74	274	01
VII	DC powder + Chips	1.25	636.49	94	01	1.36	840.71	124	01
	Edible oil	1.18	359.28	278	01	1.21	408.57	316	01
	DC powder	1.19	454.10	64	02	1.28	622.89	83	02
	Chips	1.33	937.61	164	01	1.43	1194.07	206	01

these units on a larger scale need to understand the basics of international demand for diversified coconut products and the expected quality parameters at the international level.

CONCLUSION

Perennial crops like coconut requiring heavy financial investment in the gestation period and with multiplicity of vegetative and reproductive phases face major challenges in the domestic and international trade sector. Though India is one among the largest producers of coconut in the world, its relative share in the international trade arena is non-significant as compared to other major coconut producing countries such as the Philippines and Indonesia. Lack of organized marketing having vertical integration with the agro-processing is the prime reason for the same. In addition, the end produce of coconut palm and its derived products like copra and coconut oil faces high degree of fluctuating price trends leading to severe economic loss to the coconut farming community. To overcome these problems, value addition through product diversification and byproduct utilization is the major solution suggested by the researchers and developmental personnel.

Technologies are available for individual processing for the production of edible oil, DC powder, vinegar, coconut chips, shell powder, industrial oil and cakes. However due to their small scale operation the economies of scale and their relative profitability is low as compared to those, which could be achieved through scientific integration. This paper proposes different models of integrating them and tested the economic worthiness of this process. The results indicated that scientific integration of different coconut based processed products would be economically viable

as compared to their individual production. The existing individual units of coconut based agro processing, say edible oil and DC units, may be integrated with the by-products, say shell and water, utilising units on a smaller scale to realize better net returns. In these units, involvement of family labour would considerably reduce the cost of production of diversified coconut products and increases the overall benefit cost ratio of the industry. Establishment of these units in those areas with less labour cost proves to be more beneficial. Appropriate developmental schemes may be formulated and effectively implemented in these aspects for achieving better price stability for coconut and its products in the domestic markets. Since integration of various agro processing units of coconut involves heavy investment, entrepreneurs who are willing to invest in few of these low or high intensive models, need to undertake an assessment of the demand and supply pattern of inputs and possible domestic and international demand.

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