Virgin Coconut Oil process and economics

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Coconut is the most important versatile crop, which provides all required amenities for human life. Nearly one third of the world's population depends on coconut for food and economic needs. Widely acclaimed as *Kalpavriksha* or Tree of Heaven, coconut provides food security and livelihood opportunities to 10 million people in India through cultivation, processing, marketing and trade related activities and thus it exerts profound influence in rural economy. Coconut processing sector in India is largely confined to copra production, oil extraction, desiccated coconut and manufacture of coir & its products. One third of the annual production is used by processing industry for coconut oil production, while rest is processed into desiccated coconut and other products. Even though India is the third largest coconut growing country in the world, its contribution to the processing, value addition and export market is significantly less as compared to other coconut cultivating countries. The problems of fluctuation in the prices of coconut and its products due to local as well as international competition, acute shortage of skilled manpower necessitated the need for development of broad based entrepreneurship driven processing technologies for the sustainable growth of coconut based industries. Central Plantation Crops Research Institute (CPCRI), a constituent of Indian Council of Agricultural Research (ICAR) has contributed immensely in the area of research and developmental activities for plantation crops such as coconut, arecanut and cocoa. The institute has come out with successful post harvest technologies for value addition of coconut for small and medium scale farmers and entrepreneurs. One such technology is Virgin Coconut Oil (VCO) production, for which CPCRI has standardized the process and machineries for the production of VCO by hot and fermentation process. CPCRI has transferred VCO production technology to many entrepreneurs at the nominal technology transfer fee of Rs. 25,000.

VCO is the purest form of coconut oil, water white in colour; contains natural Vitamin E and very low free fatty acid content. It is called "virgin" because the oil obtained is pure, raw and pristine and it maintains the natural aroma and nutrients of coconut. VCO is one of the most valuable processed products of coconut. The fast developing and high value niche market for virgin coconut oil offers a good prospect for the improvement of the income of coconut farmers. It is obtained from the fresh and mature kernel of coconut by mechanical or natural means with or without the application of heat which does not lead to alteration of the oil and its properties. VCO is suitable for human consumption in its natural state immediately after extraction and filtration. VCO greatly differs from the traditionally produced coconut oil from copra in terms of quality attributes. RBD (refined, bleached and deodorized) coconut oil does not contain natural Vitamin E since this is degraded when the oil is subjected to high temperature and various chemical processes.

VCO is unique among all the vegetable oils because of its high lauric acid content. The lauric acid present in VCO is converted to monolaurin which provides disease fighting ability to body and keeps infants away from getting viral or bacterial or protozoal infections. Since mother's milk also contains monolaurin, VCO can be considered as equivalent to mother's milk. VCO can also be used as (a) hair and skin conditioner, (b) oil base for various skin and hair care products, (c) carrier oil for aroma therapy & massage and (d) nutraceutical and functional food.

There are several methods of VCO production *viz.*, Hot-processing, Natural fermentation, Extraction from Dried Gratings (EDG) and Centrifugation. The choice of the method to be adopted depends to a great extent on the scale of operation, the degree of mechanization, the amount of investment available and the market demand.

Health Benefits of VCO

VCO has many advantages, which include the health benefits from the retained vitamins and antioxidants, the antimicrobial and antiviral activity from the lauric acid components and its easy digestibility due to the presence of medium chain fatty acids (MCFA). VCO and coconut oil have been traditionally used to enhance the beauty and the growth of our tresses, refine and moisturizes our skin in addition to being used as an "ethnomedicine" for minor illnesses such as diarrhea and skin inflammations. Studies proved that the topical application of VCO increased the wound healing rate of rat skin. Lauric acid, a medium chain fatty acid component in VCO showed potential use in anti-obesity treatment as it increases energy expenditure, gets directly absorbed and burnt as energy in the liver, resulting in early satiety and thus leading to weight loss.

PROCESS TECHNOLOGY FOR VCO

CPCRI has developed a processing technologies for production of VCO by hot and fermentation method. In hot process, coconut milk is cooked in specially designed cooker whereas in fermentation process, coconut milk is allowed to ferment in a specially designed fermentation tank for specified period to get VCO. The process protocol is described below.

Fully matured 11-12 months old coconut is selected for

VCO production. The husk is removed from coconut by using manual or mechanical dehusker. The shell is removed by using chisel type tool or shell removing machine. Testa, brown outer layer of coconut kernel is removed by using a manual peeler or coconut testa remover. Testa removed coconut is washed in clean water and cut into 3-4 pieces followed by blanching in 50°C hot water for 5 minutes to arrest enzyme activity. Blanched coconut pieces are pulverised using pulverizer. The pulverized coconut is fed to either manual or mechanical milk extractor to produce coconut milk. Second and third milk extraction is also carried out by mixing warm water (250 ml/kg of residue) to the residue of the first and second milk extractions, respectively. Third milk extraction is recommended for fermentation method and it will not be economical for hot processing method. First, second and third milk extracts are mixed together vigorously for few minutes.

In fermentation process, the extracted milk is allowed to stand for 20-24 hours in a food grade plastic or stainless steel container with a conical bottom with outlet tap and a sight glass to see the different layers as the oil separates during fermentation. Under favourable conditions of 35-40°C temperature and 75% relative humidity, fermentation process results in fine quality VCO yield which is about 16-18% of the coconut kernel weight. To fasten the fermentation process, skim milk at the rate of 30 mL per litre of coconut milk is added to the mixture before the start of fermentation process. If proper operating conditions and sanitary precautions are strictly followed, four distinct layers can be seen in the fermentation container after allowing it to settle for 16 hours. The bottom layer is made up of gummy sediment. The next layer is watery, and contains fermented skim milk that is no longer fit for human consumption. The next layer is the separated oil for recovery as VCO. The top layer has floating fermented curd. The fermented curd also contains a considerable amount of trapped oil. By carefully removing the distinct layers, the oil can be separated. After VCO separation, the fermented curd is heated at 90°C to recover the residual oil which can be used for making skin care products and soap.

In hot process, the extracted coconut milk is allowed to stand for maximum 3 hours under refrigerated condition in order to separate coconut cream from coconut skim milk. Coconut cream is separated and placed in a double walled boiler known as VCO cooker developed at CPCRI to coagulate the protein and release the oil. After slow heating for about 2 to 2.5 hours, coconut cream will begin to coagulate and separate out the pure oil. In the first hour of heating, temperature can be allowed to reach 120°C. Thereafter, the temperature is brought down to 90°C for the protein to coagulate and temperature is reduced to 60°C when the oil starts to separate. The heating source may be LPG, biogas or steam or agricultural waste. The VCO is separated from the protein rich residue (kalkam) by straining the mixture through a muslin cloth or stainless steel mesh. Kalkam is pressed in hydraulic press to yield more oil. The remaining kalkam can also be further slow heated to recover more oil. However, this type of oil, is yellow in colour and is suitable for skin care or massage products. The oil recovery from hot process is about 20-22% of fresh weight of the coconut kernel.

The oil is filtered through sterilized cotton wool, filter paper or filter cloth and dried in a double walled boiler at 50°C for 15 minutes or until the turbid oil becomes crystal clear. VCO can be stored in stainless steel containers and poly-lined drums. However, for long-term storage, the recommended packaging material for VCO is glass containers and should be kept away from light. PET bottles can be used for day-to-day use. The packaging material should be free from moisture before filling the oil in it.

Important steps involved in the production of virgin coconut oil are given in process flow chart.

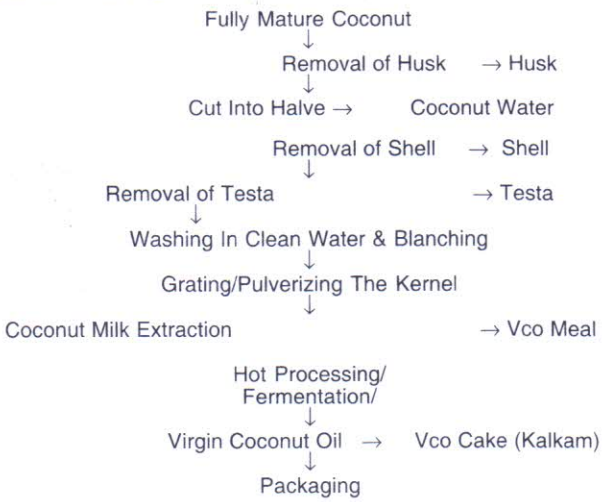

Fig. 1 : *Process flow chart for the production of virgin coconut oil*

The protocol and machineries required for the production of VCO is given in the Figure 2.

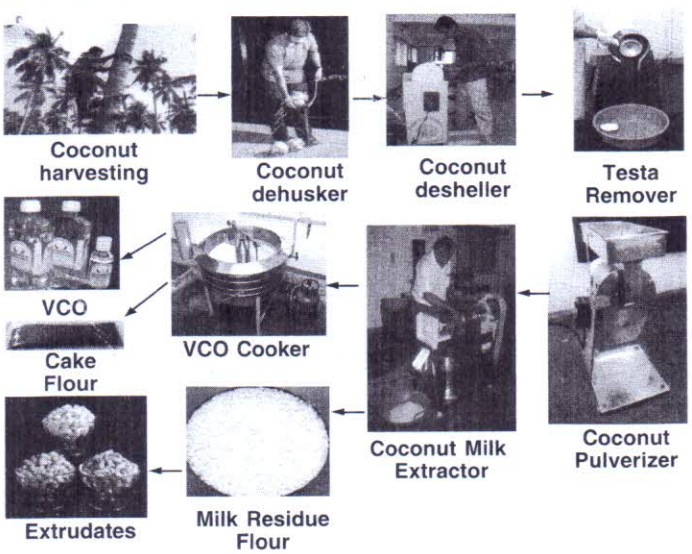

Fig. 2 : *Process protocol developed for production of VCO*

Utilization of By-Products

VCO meal (milk residue flour) and *Kalkam* (VCO cake flour) are the by-products of VCO process. The residue represents approximately 25-50% of the weight of freshly grated kernel on wet basis, depending on the coconut milk extraction process used. The VCO meal usually retains about 35-40% of the original oil content of the fresh coconut kernel and is very rich in dietary fibre (about 32%). *Kalkam* also contains protein, fat, and dietary fibre. VCO meal and *kalkam* can be utilized in various formulations that are listed below:

1. It can be used for preparing fortified atta. Addition of VCO meal will increase the dietary fibre, protein and fat in the atta which are essential for good nutrition.
2. They can be used for making many value added products namely VCO meal/*kalkam* based *laddu*, biscuits, extrudates, *halwa*, porridge etc. When using VCO meal and *kalkam* for biscuits by partially substituting wheat flour, the cost is reduced and the nutritional value of the product is enhanced in terms of dietary fibre and protein.
3. The VCO meal can also be used as high quality animal feed ingredient.

The quality characteristics of VCO prepared by CPCRI developed hot and fermentation processes are compared with that of commercial coconut oil in the following Table 1.

TABLE 1: ***Comparative Quality Characteristics of VCO by hot and fermentation processes with commercial coconut oil and APCC* standard for VCO***

Chemical Parameters	Hot Process VCO	Fermented VCO	Commercial Coconut Oil	APCC* Standard
Tocophero (µg/g)	15-20	20-30	2-6	- I
Polyphenols (µg/g)	500-700	350-500	150-250	-
Antioxidant activity (%)	80-90	65-75	35-45	-
Monoglycerides (%)	1.5-2.0	2.0-3.0	0.5-1.5	-
Phytosterol (µg/g)	2.5-3.0	2-2.5	0.5-1.0	-
Color (Lovibond)	0.1R+ 0.5Y	0.1R+ 0.1Y	0.1R+ 0.5Y	Water clean
Refractive Index at 40°C	1.4480-1.4490	1.4480-1.4490	1.4480-1.4490	1.4480-1.4492
Saponification value	250-260	250-260	250-260	250-260
Iodine value	7-8.6	7.5-8.4	7.4-8.1	4.1-11.00
Specific gravity at 30°C	0.915-0.920	0.915-0.920	0.915-0.920	0.915-0.920
Moisture (%)	0.09-0.1	0.08-0.1	0.08-0.1	0.1-0.5

**APCC – Asia Pacific Coconut Community, Jakarta, Indonesia*

Economic Analysis of VCO Process

The economic analysis comprised of estimation of fixed cost, variable cost, production cost, profitability projection and break even period for processing of 500 coconuts per day for a period of 300 days in a year (Table 2). The fixed cost includes manpower, interest on capital loan and working capital, depreciation on machinery and building, administrative, insurance and sales promotion expenses. The variable cost includes working capital, expenses on electricity, water and other utilities. The expenditure on raw material and packaging material is taken into account under working capital. During hot process VCO production from 150000 nuts/year, 60000 kg husk, 20000 kg shell, 15000 litres water, 7500 kg VCO, 7500 kg milk residue flour, 1500 kg VCO cake flour and 1000 kg testa are obtained. In the case of fermentation process, 60000 kg husk, 20000 kg shell, 15000 litres water, 6750 kg VCO, 7500 kg milk residue flour, and 1000 kg testa are obtained. The additional benefit of selling these co-products is not accounted in this analysis. The Virgin Coconut Oil processing unit shall be located in the vicinity of the coconut growing area to ensure the continuous supply of raw material "coconut". Approximately 2000 square feet land which includes 1000 square feet building area is required. The cost of machineries and equipments for hot and fermentation process is estimated at Rs.13 lakhs and Rs. 11 lakhs, respectively. One supervisor and three skilled labours are required for operation and maintenance of VCO unit. Using the above assumptions, the total fixed cost is estimated at Rs.15.75 lakhs for fermentation process and Rs.15.12 lakhs for hot process VCO. The total variable cost is estimated at Rs. 32 lakhs. The unit cost of production is estimated at Rs. 635/l and Rs.698/l for hot and fermentation process respectively.

TABLE 2 : ***Economic analysis for processing 500 coconuts/day for 300 days in a year to produce VCO by hot and fermentation processes***

Particulars	Hot Process	Fermentation Process
Land and building cost (Rs)	1500000	1500000
Machinery and equipment cost (Rs)	1300000	1100000
Miscellaneous assets (Rs)	300000	300000
Capital investment (Rs)	3100000	2900000
Raw material cost (Rs)	3000000	3000000
Cost of packaging material & miscellaneous items (Rs)	100000	100000
Working Capital (Rs)	3100000	3100000
Other miscellaneous cost (Rs)	100000	100000
Total variable cost (Rs)	3200000	3200000
Depreciation cost on machinery @ 10 % (Rs)	130000	110000
Depreciation cost on building @ 5% (Rs)	50000	50000
Interest on capital investment @ 12.5 % (Rs)	387500	362500
Interest on working capital @ 11% (Rs)	341000	341000
Repair and maintenance of machinery @ 5% (Rs)	65000	55000
Manpower expenditure (Rs)	450000	450000
Administrative overheads expenditure (Rs)	60000	60000
Insurance (Rs)	24000	24000
Sales promotion and advertisement expenditure (Rs)	60000	60000
Total fixed cost (Rs)	1567500	1512500
Total cost of production (Rs)	4767500	4712500
Total annual production (kg)	7500	6750
Unit cost of production (Rs/kg)	635.67	698.15
Total selling cost @ 800/kg (Rs)	6000000	5400000
Profit (Rs)	1232500	687500
Net profit percentage	20.54	12.73
Breakeven point (kg)	4200	4640
Breakeven period (days)	168	206

The above table clearly indicates that by processing 1,50,000 nuts/year, entrepreneur can produce 7500 litres and 6750 litres VCO by hot and fermentation processes respectively. By selling VCO at the rate of Rs 800/kg, entrepreneur can get a net profit (per year) of Rs. 12,32,500 and 6,87,500 for Hot and fermentation process VCO, respectively. Additionally by selling the co-products like coconut husk, shell, testa, water, milk residue, VCO cake, entrepreneur can earn more income. It is concluded that after producing 4200 kg of hot process and 4640 kg of fermentation process virgin coconut oil, no profit no loss point will occur after 168 and 206 days of functioning of the unit respectively. Thus, VCO based venture can contribute modest increase in the income and livelihood of the entrepreneur.