SMALL SCALE PROCESSING OF COPRA AND COCONUT OIL IN SRI LANKA

By

A. Tillekeratne*

Summary

The average annual yield of coconut in Sri Lanka is about 2.5 billion nuts and a quantity of about 1.5 billion nuts or 60% out of this, is used as fresh coconuts for domestic culinary purposes, while the balance 1 billion nuts is available for industrial processing. Most of the surplus of 1 billion nuts come from small scale farms, as small lots or parcels. The largest single use of this surplus supply of nuts is in small scale manufacture of copra, which in turn is processed into coconut oil - the most widely used domestic cooking fat in Sri Lanka and for which there is a ready market throughout the country.

A large number of small scale enterprises, located in the principal growing areas, are engaged in the processing of copra and coconut oil, catering mainly to the domestic market. These small-scale processing operations offer great logistical and comparative advantages, in that small quantities of surplus coconuts available within a particular growing area are processed into copra and oil within the same area and the coconut oil (as well as the residual copra meal) is distributed mostly amongst consumers in that area; regular operation of these small scale processing units enable coconut farmers within the area to obtain a reasonable farm gate price for their produce; they provide regular employment to people in the area.

The cost of production of copra and coconut oil in these small scale processing units is much lower than in large scale operations. The viability of the small scale copra and oil processing units is therefore of vital importance to the coconut industry, as, a whole.

The technologies used in small scale manufacture of copra and coconut oil are simple and are of low cost - factors which contribute to the proliferation of small scale processing units. However, in order to maintain a high level of processing efficiency and quality of product - moot factors in maintaining the viability of small-scale processing units - the technologies must be correctly applied and the process operations should be carried out properly. Guidelines laid down for the process operation, if followed properly, would result in high process efficiency and quality of products.

1. Introduction

Sri Lanka has a total acreage of approximately 1 million under coconut cultivation. The main coconut growing areas are concentrated in the wet and intermediate wet zones of the Island; encompassing the key agricultural districts of Kurunegala, Puttalam, Kegalle, Gampaha, Colombo and Kalutara.

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* Director, Processing Development, Coconut Development Authority, Colombo 5, Sri Lanka.

Coconut farms are largely under private ownership. While 99% of the farms are in small allotments of less than 8 hectares, over 85% of them are even less than 2 hectares in extent. These small allotments are owned mostly by low-income families, who depend on this crop to supplement their family income.

The total annual yield of coconut in an average year is about 2.5 billion nuts. Most of this crop comes from small. farms, in small lots or parcels.

The biggest single use of coconuts in Sri Lanka is in domestic culinary preparation, where milk extracted from the fresh coconut kernel is used as a cooking medium, in the preparation of the main meals. Thus, out of the total annual yield, a quantity of about 1.5 billion nuts or 60% is used for household consumption.

The next most important use of coconut is in the manufacture of copra and coconut oil, the latter being the principal vegetable oil available both for domestic cooking as well as for industrial purposes such as in the manufacture of soaps, shampoos, detergents and also in the manufacture of margarine.

The annual requirement of coconut oil for edible as well as industrial purposes is about 60,000 metric tons and a steady demand exists throughout the year for this commodity, in the local market.

A large number of enterprises scattered throughout the principal growing areas are engaged in the manufacture of copra and coconut oil, to supply mainly the local requirements.

2. Prevalence of small scale processing of copra and coconut oil

As in the case of most other coconut products, the copra processing and oil milling sectors comprise a substantial "informal" sector, as well as an organized "formal" sector.

The "informal" sector is made up of a large number of very small scale units, operating at domestic scales of capacity and production. Typically, the very small scale copra units are geared to process a few hundred coconuts at a time. They depend mainly on the surplus coconuts collected from home gardens and from very small holdings, e.g., of less than 0.5 hectares. Coconut oil mills in the "informal" sector, typically, have one or two "baby expellers" capable of producing upto about 750 kilograms of oil per day.

The "formal" sector engaged in copra processing and oil milling is dominated by small scale enterprises. These are typically family-owned and managed, with capacities to manufacture from about a metric ton to about 4 metric tons of copra or coconut oil per day, i.e., to process about 5,000 - 20,000 coconuts per day. Their raw material requirements are generally obtained from small scale farms, of generally upto about 4 hectares in extent within the area.

These "small scale" units generally employ between 10 - 50 persons, comprising both skilled and semiskilled village labour.

The process technology used in these "small scale" operations is simple and involves:

(i) a high content of labour and

(ii) almost totally locally manufactured machinery, equipment and material.

The scale of operation of these units fits ideally Into the rural economy in terms of:

(i) utilisation of surplus raw material available within the area for processing into products (copra, coconut oil and poonac) which are in turn supplied to meet the requirements of the area,

(ii) ensuring satisfactory farm-gate prices to the small-scale coconut farmers in the area, and

(iii) employment of village labour.

Over 1000 small scale copra processing units and 75 small scale oil mills operate within the main growing areas with a total of 300,000 hectares under coconut. A large proportion of the population within these areas is engaged in collection, transport and delivery of coconuts and copra to these small scale units as well as in selling and distributing their products. The "small scale" processing units are thus the nuclei of economic activity of the coconut industry in the major growing areas.

3. Principles of Scientific Copra. Making and Oil Extraction

3.1 Manufacture of Copra

The fresh coconut kernel is a high oil bearing material which also contains a high percentage of water. Thus, the kernel of mature, seasoned coconuts (once they are split open), contain about 43.3% water and 42.0% oil. This high content of water renders the exposed wet kernel susceptible to rapid decomposition and also complicates any attempt to mechanically extract the oil from the kernel. Manufacture of copra as an intermediary product in oil extraction serves a dual purpose; it stabilises the coconut kernel against microbiological attack and spoilage by reducing its moisture content to below 6.0%, so that it could be stored for a period ranging from a few to several weeks; it renders the process of oil extraction easier. The essential principle involved in copra manufacture is the reduction in moisture content of the kernel from 43.3% to below 6.0% as quickly as possible after splitting open the coconuts, but in such a manner, as to retain the composition, quality and quantity of the oil. Copra curing is, therefore, essentially a controlled process.

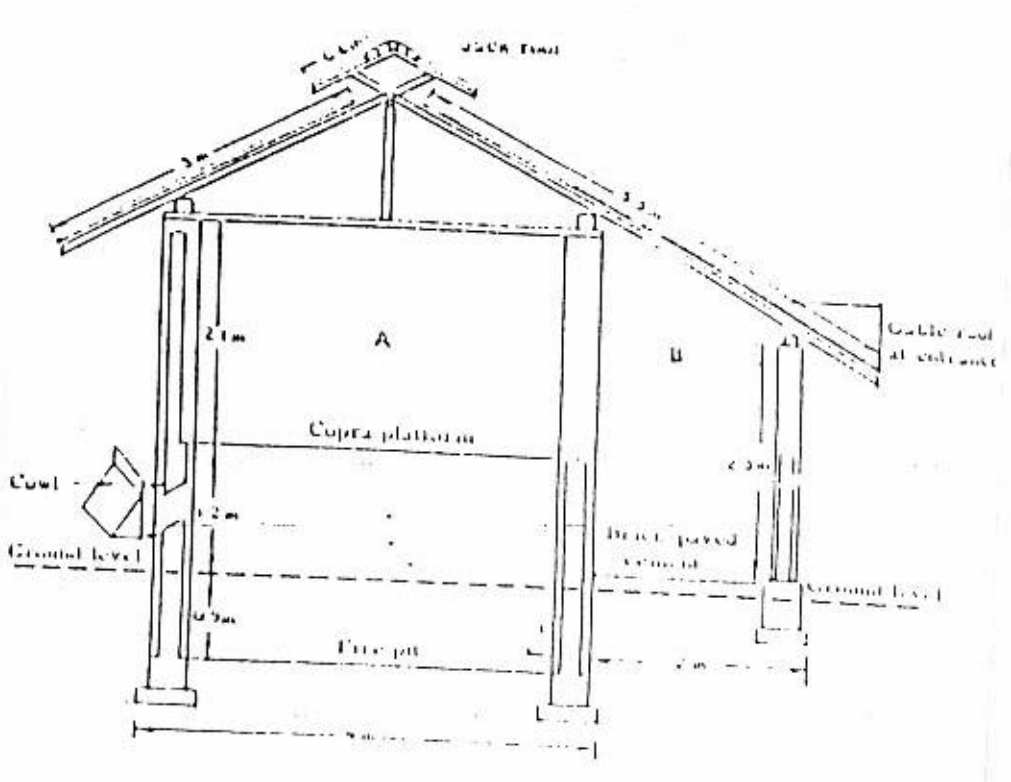
Literature abounds regarding the principles of copra drying. Grimwood (1975), in particular, gives a comprehensive account of the various techniques utilized in copra drying and their underlying principles.

The traditional method of copra drying in Sri Lanka is a multi-stage process, and comprises: (a) an initial stage of sun-drying where the halves of the split nuts are arranged on a barbeque and exposed to the sun for a period of 8 - 10 hours, followed by (b) a series of hot air curings, with intermittent cooling, in an open kiln. During each hot air curing, a draught of hot air is made to flow through the bed of kernels laid on a wooden platform, housed in a simple well ventilated building structure.

A diagrammatic sketch of a standard Sri Lanka copra kiln with a capacity to cure 2500 coconuts per day is given in Figure 1 below (Grimwood, 1975). The kiln consists essentially of a fire pit about 0.9 meters below ground level; a drying grill or platform of wooden rafters 1.2

meters above ground level; a corrugated iron roof provided with a ventilation gap at the top; and a covered working verandah. Well dried coconut shell is used as fuel in the fire pit.

Fig. I - Diagrammatic Sketch of a standard Sri Lanka Copra Kiln.



The initial sun-air drying stage achieves a loss of surface moisture from the exposed surface of the kernel from 43.3% to 37.8%. During the ensuing hot air curings (with intermittent cooling), a moisture gradient is established within the kernel, where moisture gradually migrates from deeper layers to the surface, resulting in a process of uniform dehydration of the kernel (usually from 37.8% to the desired 5.4%). The moisture changes occurring in the coconut kernel during the above process of dehydration are as follows (Nathanael, 1966):

Stage	% Moisture, in Kernel
On Splitting	43.3
After Sun Drying	37.8
After lst hot-air curing	24.8
After 2nd hot-air curing	16.4
After 3rd hot-air curing	10.0
After 4th hot-air curing	08.0
After 5th hot-air curing	07.4

After 6th hot-air curing	06.5
After 7th hot-air curing	06.0
After 8th hot-air curing	05.4

Thus, upto 8 successive hot-air curings are necessary to produce copra with a moisture content desirably less than 6.0%.

3.2 Extraction of Oil

Coconut oil is contained in innumerable minute cells within the dehydrated coconut kernel or copra. The walls of these oil-bearing cells must be softened and ruptured before processing, if a good yield of oil is to be obtained.

Copra is therefore subjected to pre-treatment in preparation for oil extraction. Pre-treatment consists of :

(i) disintegration into small pieces of about 0.4 cm to 0.8 cm, and

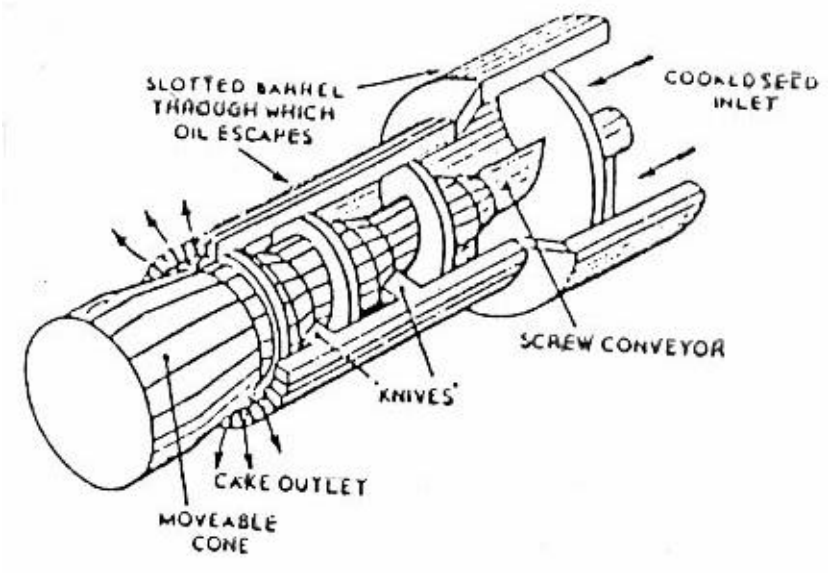
(ii) exposure, of the cut meat to dry heat or to steam.

Extraction of oil from pre-treated copra is carried out using "expellers". An expeller consists essentially of a screw worm shaft rotating inside a cylindrical barrel made up of a large number of small steel liner bars. When pre-treated material is fed into an expeller, the rotating screw worm forces the material through the cylindrical barrel, whose outlet is restricted by an adjustable cone. The design of the screw is such that the material is subjected to increasing pressure as it travels along the barrel, by a steady reduction in the annular space. The oil which is expelled. is drained away through a series of small spacings between liner bars forming the barrel, while the cake is discharged through the narrow circular gap at the end of the barrel.

A diagrammatic cross section of an expeller is shown in Figure 2 below (BOCM, 1965)

Expellers are generally of two types viz: "low pressure" and "high pressure" expellers. Low pressure expellers are normally used to reduce the oil content of initially oil rich material such as copra, as a preliminary to high-pressure expelling, which extracts most of the oil remaining in the material, leaving behind only a very low percentage in the meal. (usually less than 10.0%)

Figure 2. Expeller (diagrammatic)



4. Outline of the Manufacturing Processes

4.1 Copra Processing

Early on the day of commencement, the coconuts are split into two and the cups are laid carefully on the barbeque, facing upwards, for a day's sun-drying. In the late afternoon, the cups are collected and put on the platform of the kiln, to form a bed of not more than 12 inches depth.

Dry coconut shells are arranged in the fire pit, in parallel double rows, each shell being fitted into the cavity of the next. At the commencement of each stage of the curing process, the rows of coconut shells are fired to produce a heat source. The working programme for the multi-stage curing process is as follows (Coconut Research Institute, 1968)

Day l:

Early morning	Split the nuts
7.00 a.m. - 4.30 p.m.	sun-drying
5.00 p.m. - 10.30 p.m.	1st firing, with 02 double rows ot shells; allow to Cool

Day 2:

2.00 a.m.- 7.00 a.m.	2nd firing, with 1 double row of shells
4.00 p.m.	Turn the copra.
5.00 p.m. -10.00 p.m.	3rd firing, with 1 double row of shells.

10.00 p.m.	Allow to cool.
Day 3:	
2.00 a.m. - 7.00 a.m.	4th firing, with 1 double row of shells
4.00 p.m.	Remove shells.
5.00 p.m. - 10.00 p.m.	5th firing, with 1 double row of shells.
10.00 p.m.	Allow to cool.
Day 4:	
2.00 a.m. - 7.00 a.m.	6th firing, with l double row of shells.
4.00 p.m.	Turn the copra
5.00 p.m. - 10.00 p.m.	7th firing, with 1 double row of shells.
10.00 p.m.	Allow to cool.
Day 5:	
2.00 a.m. - 7.00 a.m.	8th firing, with a short double row
5.00 p.m.	Remove the copra while returning any under-dried cups to the kiln for further drying.

4.2 Oil Processing

The raw material (copra) is first thoroughly cleaned of all foreign matter, by passing it through mechanical vibratory screens. It is then fed into a disintegrator for size reduction into small pieces ranging from about 0.4 cm to 0.8 cm. The cut material is then fed into a hot air dryer or a steam cooker, where the material is heated or "cooked" at temperatures ranging from about 750C to 1000C for a period of 20 - 40 minutes.

Heating or cooking serves basically three purposes:

(i) It raises the temperature of the material and increases the volatility of the contained oil rendering its extraction process easier;

(ii) It makes the material less abrasive and thereby reduces wear in the expeller; and

(iii) It regulates the moisture content of the raw material.

The heated or cooked material is then fed into the expeller at specified feed rates.

Oil is extracted inside the expeller and emerges from it, heated and containing fine particles of raw material. These fine particles or "foots" are removed from the oil in two stages. First, the oil is allowed to settle in ground level tanks, where the fines separate out and settle at

the bottom of the tanks and are removed periodically. In the second stage, the oil is pumped through an oil filter, to remove remaining fines and impurities.

Filtered oil is then pumped into storage tanks. The residual meal emerging from the expeller is broken up by passing through the disintegrator and is fed into a 2nd expeller (high - pressure) for further extraction of the residual oil in the meal.

The average rates of extraction efficiency (expressed as percentage of residual oil in poonac) achieved by oil mills using only single pressing and those using double pressing in Sri Lanka, as compiled by the Coconut Development Authority over two successive years, are given below (Coconut Development Authority, 1982).

Processing Method	% Residual Oil in Poonac	
	Year 1	Year 2
Single Press	12.3	12.7
Double Press	10.75	10.6

5. Quality of the Product

5.1 Copra

A batch of copra manufactured according to the process operation described in section 4.1 above, could comprise a range of qualities, depending on the actual conditions of operation of the process, the quality of initial raw material used etc, and can then be sorted into the following grades :

1. Milling Superior (MS) - Grades 1 to 3
2. Milling Ordinary (MO) - Grades 1 to 3

The characteristics specified for "Milling Superior" grade copra are provided below (Sri Lanka Standard 612, 1983)

Characteristics		M.S Grade 1	M.S Grade 2	M.S Grade 3
(i)	Moisture percent by mass maximum.	6.0	6.0	6.0
(ii)	Oil content (moisture free basis), percent by mass minimum.	68.0	68.0	68.0
(iii)	Free fatty acid (as lauric acid) of extracted oil, percent by mass, maximum	0.8	0.8	0.8
(iv)	Impurities, percent, by mass maximum	0.5	1.0	1.0

(v)	Broken cups or chips percent by number, maximum	10	15	15
(vi)	Mouldy cups, percent by number, maximum	10	15	20
(vii)	Lovibond colour expressed as Y + 5 R, maximum	4	4	4

Milling Ordinary (MO) grades of copra have higher values for above characteristics, e.g., moisture percent (by mass), maximum is 10 for all grades of Milling Ordinary, while the maximum percent by count of mouldy cups is 20 for grade 1, 50 for grade 2 and 80 for grade 3.

The composition of a batch of copra processed under average conditions in Sri Lanka could be reasonably expected to be as follows:

MS grade 1	40%
MS grade 2	30%
MS grade 3	20%
MO grade 1	10%

5.2 Coconut Oil:

With the use of good quality copra and correct processing procedures, the quality of coconut oil obtained by the mechanical extraction process described in Section 4.2, generally conforms to the following specifications for white coconut oil (Sri Lanka Standard 32, 1978).

Characteristic

G)	Colour in a 1" cell on the Lovibond colour scale, expressed as Y + 5R	less than 4
(ii)	Specific gravity at 30^0C	0.915to 0.920
(iii)	Refractive index at 40^0C	1.4480 to 1.4492
(iv)	Total. of moisture, volatile matter and insoluble impurities percent by weight max	0.40
(v)	Free Fatty Acids, calculated as Lauric Acids, percent by weight, max.	1.0
(vi)	Iodine Value	7.5 - 9.5
(vii)	Saponification value	225 min.
(viii)	Unsaponifiable matter	0.8

percent by weight, max.

(ix) Mineral acidity Nil.

6. Guidelines on Good Practices to be Followed. in Small Scale Processing of Copra and in Oil Miffing

In order to maintain certain levels of processing efficiency and quality of products, in both copra processing and oil milling, it is necessary that certain guidelines and good practices are followed as a matter of routine. Some of the guidelines, which are of particular relevance in small scale manufacture, are provided below :

6.1 Copra (Coconut Research Institute, 1970)

6.1.1. Raw Material

Mature, seasoned and undamaged coconuts should be used; under-ripe nuts yield a thin, rubbery product while over-ripe nuts give thin, broken, discoloured pieces.

6.1.2. Sun Drying

Coconuts should be split in the morning of the first day of curing, the cups should be rinsed of any adhering sap and should be spread evenly on a hard, clean surface. It should be protected from rain and also from crows and other birds. Retention of any sap or moisture on the surface at this stage results is a gummy slime in the product. Precautions should be taken to avoid adulteration with sand and other extraneous matter.

6.1.3 Kiln Drying

Semi-dried half-coconuts should be spread evenly and at stipulated depths of layers on the kiln. The material should be allowed to cool adequately between successive firings. The material should be turned over at the end of each firing, to ensure uniform drying as possible. There should be no undue delays between successive firings. Such delays result in moisture condensation and slime formation. The use of unclean, wet shells as fuel in the fire pits result in a smoky product and hence should be avoided. The arrangement of shells in the fire pit, for each firing, should be done according to specifications. Over-firing leads to 1. case-hardening", irregular drying, superficial scorching and discoloration. The stipulated number of firings should be applied in order to obtain copra with less than 6% moisture.

6.2 Oil Milling (Coconut Development Authority, 1989)

6.2.1 Raw Material

Copra purchased for oil milling should be of sound quality viz:

(i) Properly dried; ideally with moisture content below 6.0%;

(ii) Free of mould and fungus; and

(iii) Completely free of foreign matter such as sand, shell pieces, pebbles, stones and other abrasive material which are likely to cause damage to sensitive parts of machinery, particularly the expellers.

6.2.2 Storage of Raw Material

(i) Copra should be stored in well constructed store room, with proper ventilation and lighting, hard surfaced floor and a leak-proof roof, so as to prevent any exposure of the dry raw material to the elements. The store room should. be kept clean and dry and should. be maintained. free of insects, rodents and other pests.

(ii) Consignments of copra accepted. into the store should be stored in such a manner so as to ensure that the consignment accepted earliest is processed. first (first-in, first-out sequence).

(iii) Copra cups or pieces showing signs of mould growth or deterioration should be quickly sorted out and separated from the rest of the stored material and should be sent for oil extraction as quickly as possible.

6.2.3. Pre-treatment of Raw material prior to oil extraction

(i) Copra should be cleaned of sand, dirt etc. by passing through a suitable wire mesh screen system.

(ii) Clean, dry copra should be cut to small pieces of stipulated. size range and pre-heated or steam-cooked using stipulated temperatures and retention time, so as to meet the specifications and operating conditions laid down for the expellers, used in the production line.

(iii) In non-mechanised process lines, where the material is not carried in conveyers and hence becomes exposed during various pre-treatment stages, e.g., after disintegration, after drying etc., care should be taken to prevent contamination of material with extraneous matter, particularly sand and soil. This could be ensured. by storing the intermediate material either in metal bins or in protected storage areas. If material is stored temporarily on the floor, such areas should be enclosed by a short apron or wall and separated from the rest of the working area.

(iv) Pre-treated copra (disintegrated, dried or steam-cooked) should not be left to accumulate for long periods as it is unstable and is prone to deterioration.

6.2.4. Oil Extraction

(i) Pre-treated copra should be fed into the expeller under stipulated conditions of temperature and feed rate, so as to maintain optimum load conditions in the expeller.

(ii) Copra is a high oil bearing material (over 65% by weight) and hence should be double pressed in order to obtain maximum oil yield. A suitable 2nd press capacity, matching the capacity of the first press expellers, should therefore be used in the production line. Where several. Expellers are installed in a production line, a sufficient number should be set apart and used for second pressing, rather than deploying all of them for a single

press operation only (to process a higher volume of copra with high residual oil in poonac).

(iii) In non-mechanised process lines, care should be taken to prevent adulteration of the first pressed meal with extraneous matter particularly sand and soil, by storing it in bins or in a protected area.

(iv) First pressed meal should not be kept stored for long and should. be further processed (sent for 2nd pressing) on the same day.

(v) Oil from the first pressing is generally lighter in colour than oil from the 2nd pressing. Hence, particularly in instances of exacting quality requirements, oil from the first pressing and the second pressing should be collected and stored separately.

(vi) If inferior quality copra is used for oil extraction

(a) the oil extracted from such copra should be collected and stored separately; and

(b) the process machinery, filtration, flow-line and storage systems should be suitably cleaned, before using the processing facility, again for manufacture of good quality oil.

(vii) The extraction efficiency of an expeller diminishes with wear and tear on the worm-shaft assembly, which is caused mainly by:

(a) abrasive action of the raw material and

(b) abrasive action of foreign matter.

While factor (a) above is unavoidable, (b) above results from careless handling of raw material leading to contamination of copra and intermediate products with sand, soil and other foreign matter referred to at section 6.2.1 above.

Extreme care should therefor be taken at all times to ensure that copra is not subject to such contamination either during storage or at any of the pre-treatment stages.

(viii) When the performance and extraction efficiency of an expeller falls by 20% of its rated norms, as indicated by its through-put and residual oil content in the poonac, it should be dismantled. The worm assembly and the liner bars should be closely examined and the worn-out/damaged worms and distance pieces should be replaced or refilled and ground to original specifications and worn-out liner bars should be replaced.

6.2.5 Filtration:

(i) Oil extracted from the expeller contains solid particles. Oil when left in contact with such solid particles for long periods is prone to deterioration and hence, it should be sent through the filtration system without undue delay.

(ii) Oil filters should be examined and cleaned regularly to ensure proper functioning and damaged filter cloth should be replaced.

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APPENDIX I

Export Revenues Earned from Major Coconut Products
(Rupees '000)

Year	Kernel Products	Fibre Yarn	Fibre finished products	Shell Products	Other by Products	Total
1985	2,432,540	443,780	117,8462	34,509	26,470	3,255,145
1986	1,816,640	565,490	159,6902	63,390	33,610	2,838,820
1987	1,566,840	531,910	242,5503	47,070	52,810	2,741,180
1988	986,670	503,530	262,9104	04,370	23,590	2,181,070
1989	2,070,650	785,671	328,0606	43,146	68,480	3,896,047

Source: Coconut Development Authority, Sri Lanka.