Technological Capability of Palm Oil Mills under the Contract-Growers Scheme in India

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ABSTRACT

India has been importing edible oil to augment the local production due to the increasing demand for vegetable oil. Palm oil production was seen as a viable alternative to boost the local production (and hence reduce importation) due to the oil palm's less water requirement, low maintenance and longevity. Some palm oil mills have been established in association with plantations under the contract-growers scheme backed by an Oil Palm Act. This study assesses the performance of these mills under this programme in terms of technology acquisition, production efficiency and product quality. It was observed that most of the technologies adopted were locally sourced and the maintenance of the technologies are handled locally. Technologies imported are also locally maintained. The extraction efficiencies of the mills are very high. The quality of palm oil produced meets the recommend standard. However there is the need to plan the processing operations to prevent nut-cracking in mills. Adequate plan should be put in place for the use of the nuts as well as waste products.
Key words: Palm oil, India-Oil Palm Act, extraction efficiency, oil quality

1. INTRODUCTION

Processing of oil palm fruit into palm oil yields a lot of by-products including palm kernel oil, palm kernel cake and empty palm fruit bunches which have numerous domestic and industrial applications. Palm oil, the principal product of the crop has a great number of uses. About 80 per cent of production is destined for human consumption with the remaining going to animal feed and to various industries.

Palm oil serves as the main cooking oil in most of the countries where it is produced. In common with all fats, palm oil is a good source of energy, provides carotenoids (pro-Vitamin A), and tocopherol or Vitamin E (Babatunde, 1987). Palm oil is utilized as margarine, as a base vegetable fat, as an industrial frying oil and several special purpose fats (Tropical Agriculturalist, 1998). Tropical Agriculturalist (1998) also reported that the derivatives of palm oil are used world wide for a wide range of purposes. These include the manufacture of ice cream and confectioneries, soaps, detergents, inks, epoxy resins and animal feeds.

World production of palm oil has shown astonishing growth having risen tenfold since 1948. The commodity is now the World's second most important vegetable oil after soyabean oil (Tropical Agriculturalist, 1998). The reason for the change in the total World's production of palm oil is due to the fact that oil palm has the highest oil yield per unit area. This is about 5-10 times greater than that of other oilseeds. Tropical Agriculturalist (1998) reported further that the key to this growth is found in the Asia where output is more than 80 % of the World's total with Malaysia and Indonesia leading production in that order. Other countries including Nigeria (the former World- leading producer) are still struggling to be on the export list (MPOB, 2002).

India has been reported to have the largest cultivated area under oil seeds in the World but the irony is that the domestic production is not adequate to meet the minimal edible oil requirements of the population (Arumughan *et al.*, 2000). The factors responsible for this are low productivity (owing to the land conditions - the land used being marginal lands under rainfed situations) and the growing population. The demand for edible oil has been growing at an average rate of 5.0 % against the average growth rate of 2.0 % for oil seeds per annum during the last two decades (Chadha and Rethinam, 1991). There has also been perceptible upward trend in the per capital consumption of edible oil among the Indian population. The current per capital edible oil consumption is about 7 kg per annum. This is among the lowest in the World as against 35.0 to 40.0 kg per head per year in the Western countries. It is also far below the daily allowance of 20 kg/head/year recommended by the Indian Council of Medical Research (ICMR) equivalent to 15-20% of the dietary calories. Majority of the Indian population suffers from calorie deficiency. Owing to the high cost of edible oil, its consumption is excluded from the daily menu of the economically weaker section of the population.

It has been reported (Arumughan *et al*., 2000; Arumughan and Sundareson, 1992) that oil seeds production in India is highly susceptible to the vagaries of nature particularly the monsoon. The shifting pattern of rainfall which is beyond the control of farmers affects the production and productivity of oil crops drastically. Average low productivity of oil seeds in India could be attributed primarily to the dependency on the monsoon.

Shortage of edible oils assumed a crisis proportion of perennial nature during the 1980s and this prompted government agencies to evolve long term and short term mechanisms to step up production and productivity of oil seeds in the country. Part of the efforts was the launching of The Technology Mission on Oil Seeds by the Ministry of Agriculture of the Government of India in 1986 to address the problem (Rethinam, 1992). The major objective of the mission was to increase production through the supply of farm inputs and provision of better infrastructural facilities like irrigation as short time measures of which the workability depends on other factors. The introduction of high potential crops has been considered as viable option to the conventional ones as a long-term measure to satisfy the increasing demand for edible oils. It is in this context that oil palm assumes significance.

Oil palm is a high potential perennial oil crop that suits the humid tropical climate of Southern India. Furthermore, unlike annual crops, perennial crops like oil palm are fairly stable with respect to their annual oil yield. However to realise the full potential of oil yields, oil palm requires around 2000 mm rainfall well distributed over the year as in Malaysia. No region in India gets a well distributed rainfall, and therefore, the oil palm cultivation will have to be supported with surface irrigation. Interestingly, the estimated daily water requirement is about 140 litres per palm or about 2100 litres for the production of 1 kg palm oil as against 9600, 2500 and 3300 litres for groundnut, soybean, mustard and safflower respectively. Bearing in mind that the annuals have to be recultivated every year, may be observed that oil palm is more efficient as compared to other conventional annuals in India (Arumughan *et al.*, 2000; Arumughan and Sundareson, 1992) .

The agricultural situation of India is in contrast with those in the major oil palm growing countries like Malaysia and Indonesia where large scale cultivation by the professionally managed companies have undertaken both development and processing of oil palm as an integrated project because of the unique process requirements for oil palm fruits. In India, the land tenure system is such that the farmers have access to small fragmented lands and as a result large scale plantation is difficult to obtain. To ensure large processing of oil palm fruit the cultivation of oil palm in India will have to be arranged in a way similar to cultivation of sugarcane as practiced in the country. Basic features of oil palm development in India, therefore, were that a large number of farmers depend on a central processing facility.

The Government of India through the Technology Mission, provides subsidy on planting materials and cultivation to the extent of. 12 500 INR /ha out of the total cost of. 38 000 INR /ha during the first 4 years of plantation development. A net return of. 41 000 INR /ha is considered quite attractive to encourage oil palm development. The crop is not fastidious and is comparatively free from diseases. The fact that the cultivation is less labour intensive coupled with lower maintenance cost serves as an incentive.(Arumughan *et al.* ,2000)

The Indian Council of Agricultural Research through its breeding and agronomy programmes on oil palm has identified about 5 700 000 hectares of land suitable for oil palm cultivation in India (Arumughan *et al.*, 2000; Rethinam, 1992). In order to bring this hectarage of land under oil palm cultivation thousands of small scale farmers were encouraged with financial support and extension services. This warrants a careful planned linkage between the farmers and palm oil mills to integrate production and processing of palm fruits. While integrating the production and processing, a specified area was earmarked for the processing plant for assured supply of raw materials meaning, a captive plantation for a captive processing unit. This further call for appropriate level of process technology optimised to cater for the need of the specified area balancing the spread of the plantation, transport and infrastructural facilities. It becomes necessary since oil palm fruits are highly perishable requiring processing within 24 hours after harvest. Development of oil palm processing facilities therefore needs special attention considering the socio-economic and agricultural situations of India and constraints associated with them.

The India oil Palm Act was enacted to facilitate the production of high quality palm oil in large quantity. Under the Act, farmers produce oil palm fruit and supply the privately owned mill located at strategic positions. A substantial hectarage of land is now full cultivation of oil palm and intercropped with crops such as banana and cocoa in some cases. Farmers in different states of India are now in full business of the cultivation of oil palm under the contract-growers scheme and linked with different mills. Collection centres are located at strategic points for easy collection of harvested fruits and subsequent haulage to the mill. The Act stipulate that no body is allowed to establish palm oil mill apart from those recognised by the Government. This implies that farmers can not process their oil palm fruit themselves but are compelled to feed the mills. Therefore the usual traditional and intermediate small scales are discouraged. This is however in contrast with what operates in some other developing countries e.g Nigeria, where majority of processors are farmers who cultivate the oil palm themselves and thus there are many small scale processors (Taiwo *et al*., 2000) . These levels of scale have been found to be characterized with low oil yield and poor palm oil quality (Owolarafe *et al.*, 2002; Owolarafe *et al.* , 2006).

Irrespective of the type of processing plant, processing of palm fruit to obtain palm oil involves five basic operations, which include fruit loosening, fruit sterilization, digestion, oil extraction and oil clarification (Babatunde et al, 1988; Owolarafe et al, 2002) . The mode of carrying out these operations however differs from one plant to another. Additional operations carried out include drying and storage of oil, fibre-nut separation, as well as channeling of the waste to appropriate places or spots in large scale plant. The large scale plant is capital intensive and the technical know-how is very high. Both these conditions are beyond the reach of the small scale processors. Typical palm oil mill in India is such that the mill operates on small scale with modern machines for each processing operation. This study assesses the technological capability of the Indian mills in the use of modern palm oil technologies whilst preserving the small scale features.

2. METHODOLOGY FOR ASSESSMENT

Five model palm oil mills were visited in Tamil Nadu and Adhra Padesh states of India. Information relating to the progress of the mills in terms of production efficiency and quality of products was gathered using well structured questionnaires, observation on sites and analysis of oil, sludge and fibre samples collected from the site. The first part of the questionnaire inquires about the background of the mill in terms of age, ownership, scale of operation, structure, number of personnel and land acquisition. The second part requested the type of equipment, capacity and source. The third part is about the maintenance schedule and cost. Information about abandonment of machine is sought in the fourth part while the fifth part concerns education and training of operators. The sixth part has to do with the processing operation in terms of plantation-mill distance, fruit harvesting and haulage, schedule of processing and mill extraction efficiency. The seventh part inquires about the oil quality and losses while the eighth and ninth parts deals with product marketing and waste disposal respectively.

The quality parameters considered for palm oil include free fatty acids, moisture content, iodine value, peroxide value, carotene content and saponification value. Oil losses assessed include steriliser loss, digester loss and clarifier loss. The quality parameters and oil losses were determined by laboratory experiment following standard procedure (AOAC, 1994) where possible. Data were extracted from the records of the mill where available.

3. RESULTS AND DISCUSSION

3.1 Background Information and Organisation Structure

All the mills are privately owned, except one, which is public and serves as a model for the private mills. The mills are small scale having capacity ranging from 5 t/h to about 10 t/h .The mills acquire the land for establishment by purchase. The structure used by the mills is permanent. The average number of personnel in the mills is about 25. Figure 1 shows a typical organogram of each mill. Apart from the personnel handling the processing operations in the mill, each of the mills has additional personnel who are charged with the responsibilities of overseeing the farmers' plantations, haulage of palm fruits, and monitoring of the activities of the mills' nursery sites. Thus there are extension workers who provide the technical expertise to farmers on the establishment and maintenance of plantations as well as harvesting of palm fruits. Fresh fruit bunches' collection centers are located at strategic places. Weigh bridges are also erected at collection centers farther away from the mill in some cases. There are personnel who handle the collection and weighing of fresh fruit bunches (FFB) from the farmers and subsequent haulage of same to the mill. The mills also have officers in charge of recording farmers claim on sales of FFB. Each district has a set of the above mentioned officers, the number of which depends on the size of the district and the number of plantations in the district. This organization structure is to ensure the smooth management of plantations and the mills.

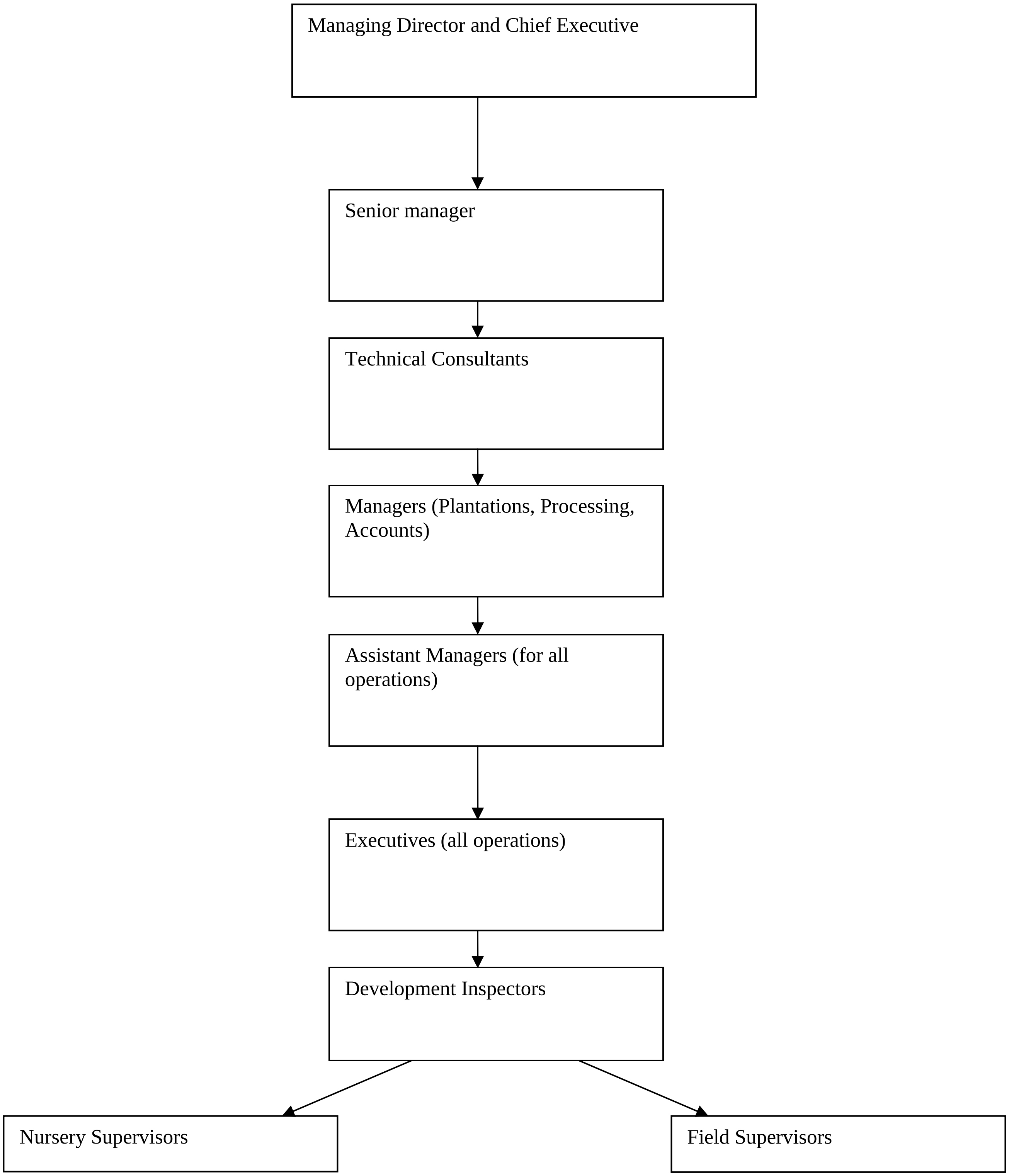

Fig. 1: Typical organogram for Indian mill

Two of the mills were established in the last five years, two within the last 10 years and the fifth one was established more than 10 years ago (13 years). Thus the mills are in a position to be assessed for their performance.

3.2 Processing Machines, Available Processing Technologies, and Sources

Tables 1(A-K) show the machines available in each of the mill, the purchase sources of the machines as well as their spares. Figure 2 shows a typical flow process adopted in each of the mills. The flow process is similar to that adopted in the large scale mill but scaled down to meet the current small scale of operation while all the necessary features are preserved. Most of the machines and their spares were sourced locally. However one mill imported most its machines while two other mills imported one or two items but the spares of the machines are obtained locally. This is an indication of the potential for sustainability in terms of equipment procurement and replacement. The degree of importation is high in digester, press and centrifuge especially for those with higher capacity. The implication of this is that a critical look has to be taken into the local fabrication of these machines not only at small scale machines but even at higher capacity with the aim of necessarily importing them.

Table1. Types of processing machines, capacity and sources

A. Steriliser

Mill	Type	Age (yrs)	Capacity (FFB t /h)	Source	Source of Spare parts
A	Horizontal	1-5	2.6-5.0	Local	Local
B	Horizontal	>10	1-2.5	Local	Local
C	Horizontal	6-10	>10	Imported	Local
D	Vertical	1-5	1-2.5	Local	Local
E	Horizontal	6-10	2.6-5.0	Parts imported and Assembled locally	Local

B. Stripper

Mill	Type	Age (yrs)	Capacity (FFB t /h)	Source	Source of Spare parts
A	Horizontal	1-5	2.6-5.0	Local	Local
B	Horizontal	>10	1-2.5.0	Local	Local
C	Horizontal	6-10	>10	Imported	Local
D	Horizontal	1-5	2.6-5	Local	Local
E	Horizontal	6-10	>10	Local	Local

C. Digester

Mill	Type	Age (yrs)	Capacity (FFB t /h)	Source	Source of Spare parts
A	Vertical	1-5	2.6-5.0	Local	Local
B	Vertical	>10	1-2.5	Local	Local
C	Vertical	6-10	>10	Imported	Local
D	Vertical	1-5	2.6-5.0	Local	Imported and Local
E	Vertical	6-10	7.6-10	Imported	Local

D. Press

Mill	Type	Age (yrs)	Capacity (FFB t /h)	Source	Source of Spare parts
A	Twin-screw Horizontal	1-5	2.6-5.0	Local	Local
B	Twin-screw	>10	2.6-5.0	Local	Local
C	Twin-screw	6-10	>10	Imported	Local
D	Twin-screw	1-5	2.6-5	Local	Local
E	Twin-screw	6-10	7.6-10	Imported	Local

E. Centrifuge

Mill	Age	Capacity (FFB t /h)	Source	Source of Spare parts
A	1-5	2.6-5.0	Local	Local
B	7-10	1-2.5	Local	Local
C	6-10	>10	Imported	Local
D	1-5	2.6-5.0	Local	Imported
E	6-10	7.6-10	Imported	Local

F. Clarifier

Mill	Type	Age	Capacity (FFB t /h)	Source	Source of Spare parts
A	Cylindrical with cone	1-5	2.6-5.0	Local	Local
B	Cylindrical with cone	>10	2.6- 5.0	Local	Local
C	Cylindrical with cone	6-10	>10	Imported	Local
D	Cylindrical with cone	1-5	>10	Local	Local
E	Cylindrical with cone	6-10	5.1-7.5	Imported	Local

G. Crude palm oil tank

Mill	Type	Age	Capacity (FFB t /h)	Source
A	Cylindrical	1-5	2.6-5.0	Local
B	Cylindrical	>10	1-2.5	Local
C	Cylindrical	6-10	>10	Imported
D	Cylindrical	1-5	2.6-5.0	Local
E	Cylindrical	6-10	7.6-10	Local

H. Decanter

Mill	Age	Capacity (FFB t /h)	Source	Source of Spare parts
A	1-5	2.6 – 5.0	Local	Local
B	>10	2.6 –5.0	Local	Local
C	6-10	>10	Imported	Imported
D	NA	-	-	-
E	NA	-	-	-

I. Vaccum Drier

Mill	Type	Age	Capacity (FFB t /h)	Source	Source of Spare parts
A	Cylindrical	1-5	2.6 –5.0	Local	Local
B	Cylindrical	>10	2.6 – 5.0	Local	Local
C	Cylindrical	6-10	10	Imported	Imported
D	Cylindrical	1-5	2.6-5	Local	Local
E	Cylindrical	6-10	1-2.5	Local	Local

J. Nut fibre Separator

Mill	Type	Age	Capacity (FFB t /h)	Source	Source of Spare parts
A	Paddle +air cyclone	1-5	2.6-5.0	Local	Local
B	Paddle +air cyclone	>10	1.5	Local	Local
C	Paddle + air	6-10	>10	Imported	Local

	cyclone				
D	Paddle + air cyclone	1-5	2.5-5	Local	Local
E	Paddle + air cyclone	6-10	2.5-5.0	Local	Local

K. Boiler

Mill	Type	Age	Capacity (tonne of steam/h)	Source
A	agro-based fired and firetube	1-5	3	Local
B	agro-based fired and firetube	>10	4	Local
C	agro-based fired and firetube	6-10	4	Imported
D	agro-based fired and firetube	1-5	3	Local
E	agro-based fired and firetube	6-10	3	Local

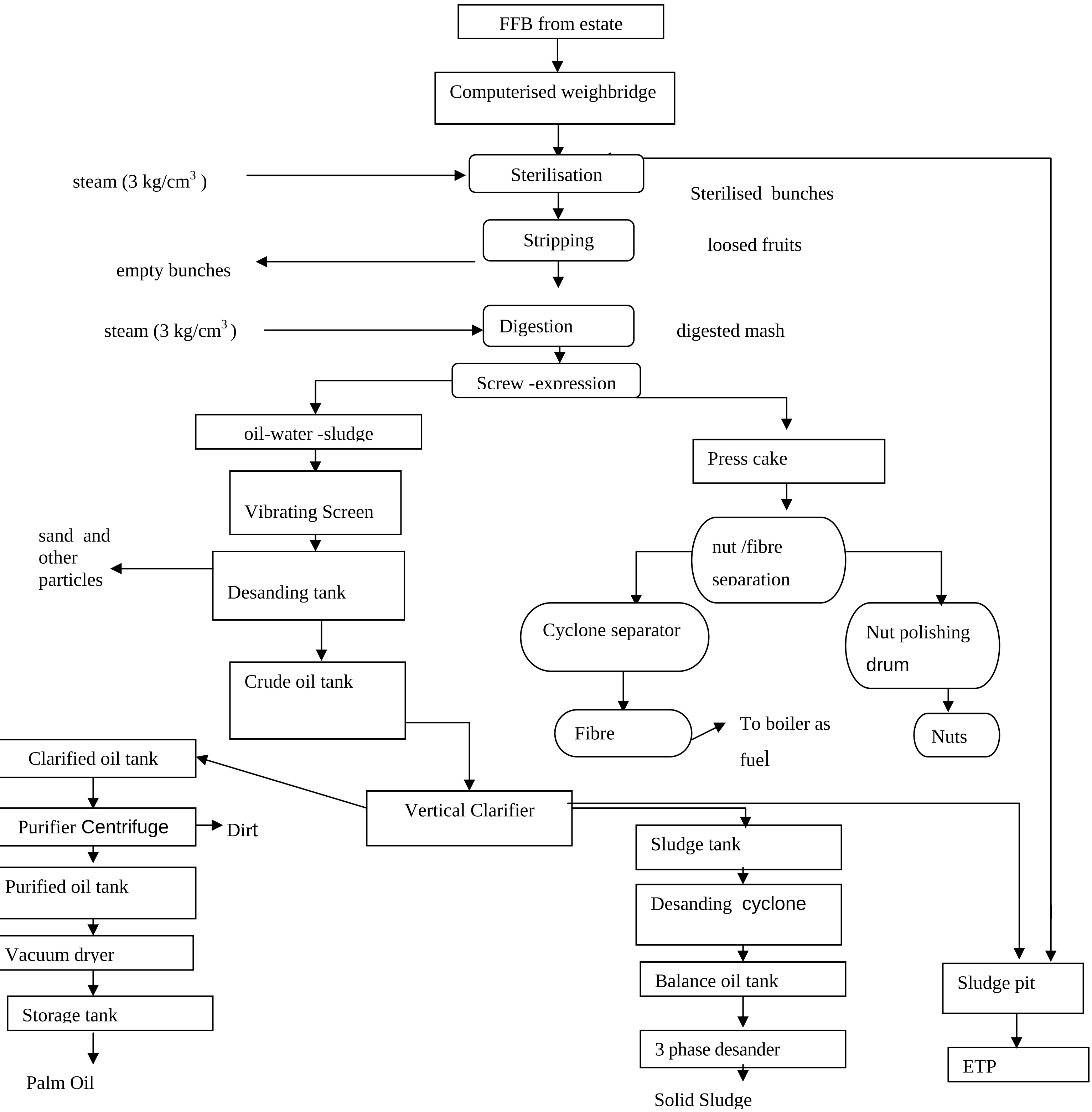

Fig. 2 : Flow chart of model palm fruit processing mills

The mills have the processing machines in appropriate capacity in conformity with the scale of operations. However two mills have some machines in excess capacity above the overall throughput of the mill. This is to provide for future expansion. All the mills have the same types of machines though in different capacities except for the case of the steriliser where a mill (mill D) has vertical steriliser as against the horizontal type found in the other four mills. Although this mill takes the advantage by gravity discharge of the sterilised palm fruit into the slat conveyor system, there is the problem of non-uniform sterilisation of the fruits, which results in some fruits being overcooked.

3.3 Maintenance of Equipment

Tables 2 (A- F) show the information on maintenance of the equipment in the mills. In nearly all the mills, maintenance of the machine is mostly done locally. There is however traces of expatriate services in the maintenance of digester, press and centrifuge. This is an indication that the more complex the machine, the higher the chance of needing expatriate services. The interval of maintenance of the machines differs from one mill to the other. Three of the mills (mills C, D and E) do maintain their machines weekly while mill B performs maintenance fortnightly. Mill A maintains its own machines annually. Annual maintenance is not advisable as this may have effect on the life span of the machines and operational performance.

A. Steriliser Maintenance

Mill	Interval of maintenance	Source of maintenance	Ease of maintenance	Cost of Maintenance (INR ‘000)
A	Bimonthly	Local	Easy	<1
B	Annually	Local	Easy	1-5
C	Weekly	Local	Easy	<1
D	Weekly	Expatriate	Easy	<1
E	Weekly	Local	Easy	>10

B. Stripper maintenance

Mill	Interval of maintenance	Source of maintenance	Ease of maintenance	Cost of Maintenance (INR ‘000)
A	Bimonthly	Local	Easy	<1
B	Annually	Local	Easy	1-5
C	Weekly	Local	Easy	<1
D	Weekly	Local	Easy	<1
E	Weekly	Local	Easy	>10

C. Digester

Mill	Interval of maintenance	Source of maintenance	Ease of maintenance	Cost of Maintenance (INR ‘000)
A	Fortnightly	Local	Easy	<1
B	Annually	Local	Not Easy	1-5
C	Weekly	Expatriate and Local	Easy	<1
D	Weekly	Expatriate and Local	Easy	<1
E	Weekly	Local	Easy	>10

D. Press

Mill	Interval of maintenance	Source of maintenance	Ease of maintenance	Cost of Maintenance (INR ‘000)
A	Fortnightly	Local	Easy	<1
B	Normally	Expatriate and local	Not Easy	1-5
C	Weekly	Local	Easy	<1
D	Weekly	Expatriate	Easy	6-10
E	Weekly	Local	Easy	>>100

E. Centrifuge

Mill	Interval of maintenance	Source of maintenance	Ease of maintenance	Cost of Maintenance (INR ‘000)
A	Bimonthly	Expatriate local	Easy	<1
B	Normally	Local	Easy	>10
C	Weekly	Local	Easy	1-5
D	Weekly	Expatriate local	Easy	1-5
E	Weekly	Expatriate local	Not Easy	>50

F. Clarifier

Mill	Interval of maintenance	Source of maintenance	Ease of maintenance	Cost of Maintenance (INR ‘000)
A	Bimonthly	Local	Easy	<1
B	Normally	Local	Easy	6-10
C	Weekly	Local	Easy	<1
D	Weekly	Local	Easy	<1
E	Weekly	Local	Easy	>10

Depending on the complexity of the machines, the cost of maintenance ranges from 1000 to 100 000 INR. As expected, digester, press and centrifuge cost more in maintenance. The source of maintenance also depends on the source of the machines. Two mills that have high incidence of importation (in machines acquisition), employ expatriate hands in maintenance and this increase the cost of maintenance and the overall production cost. For example mill E spends more than 100000 INR and. 50 000 INR on maintenance of the press and centrifuge respectively.

3.4 Abandon of Machines

Tables 3 and 4 below show the machines abandoned by mills B and E respectively. The machines were mostly abandoned due to obsolescence and upgrading of the mills. Upgrading mills implies increase in mill capacity and as s result it was impossible to use the small machines for the operations. The mills affected plan to dispose the machines to other mills operating at the capacities of the machines to be disposed.

Table 3. Machines abandoned by Mill B

Item Abandoned	Age (yrs)	Reason for abandon
Sterilizer	10	Obsolescence
Stripper	10	Obsolescence
Digester	10	Obsolescence
Centrifuge	10	Upgrading of mill capacity

Table 4. Machines abandoned by Mill E

Item Abandoned	Age	Reason for abandon
Sterilizer	5	Upgrading of mill capacity
Stripper	5	Upgrading of mill capacity
Digester	5	Upgrading of mill capacity
Centrifuge	6-10	Obsolescence
Hoist crane	5	Upgrading of mill capacity

3.5 Education and Training of Operators

The operators of all the machines in each of the mills have post secondary education. Most of them attended technical schools where they acquired the knowledge of handling the equipment. In addition the operators were given formal training in the mills. This makes it easy to handle the machines.

3.6 Harvesting and haulage of fruits

All the mills depend on contract farmers for supply of fresh fruit bunches (FFB). Each of the mills has more than 100 plantations in its domain. The average size of each plantation is in the range of 1-5 ha while the average distance of the mill from the plantations is in the range of 30-60 km. The farmers harvest the FFBs and transport them to a collection centre, where the FFBs are hauled to the factory by the officers of the mill. The transportation cost is shared by both the mill and the farmer. In cases where the farmers transport the FFBs to the factory, the farmers are reimbursed in the range of 50-75 INR/ ton of FFBs.

The FFBs collected are transported to the mill within 24 hrs of harvesting. This implies that it takes a maximum of 24 hrs for the FFBs harvested to be processed. The fact that labour for haulage and handling the fruit is readily available makes it possible to achieve this. Price for FFB varies from one location to the other. In Tamil Nadu state the price of FFBs is 2500 INR per ton, while in Andhra Padesh it is 3800 INR.

3.7. Mills Extraction Efficiencies

The extraction efficiencies of the mills were obtained by analyzing the samples or obtained from the quality control data of the mill. The extraction efficiency of mill is measured by taking into consideration maximum extractable oil, and the actual yield. The extraction efficiency is based on the residual oil in the fibre. The efficiencies of the mills are between 81- 90 %. However there are losses at other stages after extraction from press. The main oil quality parameters and losses at different stages are also shown in Tables 5 and 6. The oil losses need to be addressed. In terms of oil quality, only two mills have records for five out of the seven oil quality parameters considered. Two mills have for only three while the fifth has for only two.

Table 5. Oil Quality

Mill	FFA(%)	MC (%)	IM (%)	PV (mequivalent of oxygen/ 1000g of oil)	Ca (ppm)	IV (grams of iodine/ 100 g of oil)	S.V Mg of potassium hydroxide/ 1 g of oil
A	2.5-3.5	0.05	N.R	7.04	500.9	51.3	
B	<5	0.25	N.R	N.R	N.R	N.R	N.R
C	2-2.5	0.11-0.15	N.R	6.30	N.R	50-51	196-199
D	<3	0.25	0.7	N.R	N.R	N.R	N.R
E	<2.95	0.10	0.01	N.R	N.R	N.R	N.R
*Recom m-ended Standard	1.0 -5.0	<0.1		< 2.61	500 -700	45- 56	195 - 205

FFA- Free Fatty Acid
MC – Moisture content
IM- Impurity
Ca- Caretenoid
S.V- Saponification Value
PV- Peroxide Value
IV – Iodine Value
N.R – No Record

* Source : Hartley (1988); UNIDO (1974); and Swern (1945)

Table 6. Oil Losses*

Mill	Steriliser %	Stripper %	Digester%	Clarifier%
A	0.08	<1	N.R	2.22
B	<1	<1	<1	<0.5
C	0.20-0.25	0.35-0.40	0.45-0.5	0.35-0.4
D	2.0	0.5	0.6	2
E	7.5	4.6	5.0	10.0

* losses are calculated as percentage of FFB processed

3.8 Mill Products, Quality Control and Disposal

The product of prime importance to all the mills is palm oil. Palm nuts are not given enough attention. Though some quantity of the nuts is sold, more than 60% of the nuts are wasted (Owolarafe, 2005). The result of the nut sample analysis indicates that there is a high percentage of breakage and this leads to fast deterioration of the nuts. The percentage of breakage ranges from 18 to 40% which is considered to be too high for screw press. Nut breakage in press is expected to be less than 10% (Hartley, 1988). The nut breakage could be traced to high pressure being used in the press. The operators couldn't quantify the pressure used for the expression process. This may also be due to over sterilization of fruits. In some mills fruits are sterilised for more than one hour and some left overnight. Recommended sterilisation period for fruit with pressurized steam (about 2.5 – 3 bar) is about 45 minutes (Tropical Agriculturalist, 1998). Processing operations have been found to affect the properties of oil palm fruit. Owolarafe et al (2006) observed that increase in sterilisation time from 30 minutes to 90 minutes (in unpressurised steriliser reduces the fracture resistance of the fruit. The operators need to be trained on optimum processing operations that will preserve the quality of the products particularly the nut. The nut breakage analysis also shows that small size nuts constitute the major quantity of the nuts indicating that tenera fruits dominate the fruits being processed. Mill C has a device for grading the nuts into different sizes and that is why no characterization into sizes was done for the nuts from the mill

Mill A does not have a laboratory but has special arrangement with an external standard laboratory where the samples are analyzed. Mill C however has a standard laboratory while Mills B, D, and E do not have a standard laboratory and this limit them to the number of quality parameters that they could analyze. However the values of the quality parameters for the oil are within the recommended standard. Emphasis is on the quality of palm oil for it to be acceptable at the World market. The importance of the quality parameter has been stressed (Weiss, 1983; Babatunde *et al*., 1988). High free fatty acid (FFA) is associated with the degradation by hydrolysis which results in high refining loss. High FFA implies high cost of refining. The peroxide value is a measure of the development of rancidity while iodine value is a measure of unsaturation of fatty acids and of esters. The higher the iodine value the higher the rate of absorption of oxygen from air at ordinary temperature . The saponification value suggests the possible use of the oil in soap industry. Carotenoid is an important in bleaching of the oil. Large concentration of carotenoids impairs bleachability and may also lead to rancidity. Nearly all the mills have records for oil losses. The losses were however observed to be high for mill E.

The palm oil produced is sold mainly to the industries. Very few local consumers buy the palm oil probably because the people preferred processed palm oil. The mills get orders from customers and meet the orders.

3.9 Waste Disposal and Uses

The major wastes include empty fruit bunches, fibre and effluent (sludge). The fibre is used for firing the boiler while there is yet to be appropriate use of the empty fruit bunches (EFB). Some quantity of EFB is used for mulching in the plantations. A considerable quantity of the EFB is wasted due to lack of appropriate plan for its utilisation. The mills sell effluent from the sludge to fish farmer but the quantity produced is more than the demand for the sludge. The mill should take advantage of research output from National Research Centre for Oil Palm of India (NCROP). The centre has developed techniques of processing EFB to useful products such as mattress, particle board etc as in Malaysia (NCROP, 2005)

4. CONCLUSION

An assessment of five model palm oil mills India carried out in this study reveals that all the mills operate on small scale (leaving room for expansion) with technologies used sourced locally. The maintenance of the technologies is also done locally. The palm oil produced from the mills is of high quality. However, less attention is given to palm nuts as a good byproduct that can attract additional income. The breakage percentage is very high and this predisposes the nuts to spoilage. The processing operations need to be adjusted to minimize nut breakage and appropriate plan for its utilization should be put in place. Also, alternative uses for wastes such as empty fruit bunches and sludge should be devised to meet the current production volume in order to prevent environmental pollution. In general, developing countries (e.g Nigeria, Ivory Coast, Ghana etc) engaging in palm oil production should borrow a leaf from India by adopting this type of palm fruit production and processing system in order to take advantage of their potentials.

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