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Palm Kernel Oil Extraction - The Malaysian Experience

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ABSTRACT

In direct screw pressing, kernels must undergo seed preparation steps of size reduction, flaking and steam conditioning prior to mechanical extraction. Mechanical wear and tear, maintenance expenses and electricity are the major costs.

The direct solvent extraction process is used in larger plants. Production cost depends mainly on solvent loss and energy used in solvent recovery and pelletizing. However, oil recovery is more complete than in screw pressing.

A third processing method uses pre-pressing followed by solvent extraction.

The choice of process or machinery depends on capital investment, production cost, oil recovery and its value. Whether the higher investment and production cost incurred in solvent extraction is offset by the higher oil extraction rate needs to be determined.

Strict quality control right from fruit processing to kernel extraction is necessary to ensure production of good quality oil and by-products. Malaysian palm kernel oil has proven to be of consistent quality, with narrow ranges in chemical characteristics. The palm kernel cake and pellets are important ingredients for animal feed.

INTRODUCTION

Palm kernels are important by-products from oil palm mills. They constitute about 45-48% (by weight) of the palm nut of the oil palm *Elaeis guineensis*. On a wet basis, the kernels contain about 47-50% by weight of oil whose properties and characteristics are quite different from palm oil, but rather resemble coconut oil. A typical composition of Malaysian clean kernels is shown in Table I.

The production of palm kernel has increased steadily over the years, as shown in Table II. The trend was most significant in 1982, when production reached a high of 910,000 tons, an increase of more than 50% over 1981. This remarkable achievement was attributed generally to the introduction of the pollinating weevils *Elaeidobius kamerunicus* in late 1981 (1), which has changed the fruit bunch composition of the oil palm resulting in an increase in the kernel to bunch (K/B) ratio (2).

TABLE I

Typical Composition of Malaysian Palm Kernels (% by Weight)

Oil content	49.0
Protein (N × 6.25)	8.3
Crude fiber	8.1
Moisture content	6.5
Ash	2.0
Carbohydrate	26.1
	100.0

TABLE II

Production of Palm Kernels in Malaysia

Year	Tonnage ('000 metric tons)
1977	334.8
1978	367.5
1979	475.0
1980	557.1
1981	589.0
1982	910.0
1983	834.6

The local kernel crushing industry started on a small scale in the sixties; most of the kernels then were exported to Europe. Rapid expansion took place in the seventies, and today in Malaysia there are more than 100 mills varying in capacity from 30 tons/day to 500 tons/day. It has been estimated that about $90 million has been invested in this industry which provides direct and indirect employment to about 19,000 people. Today all the kernels produced are processed locally into palm kernel oil and palm kernel cakes/pellets, making Malaysia the world's leading producer and exporter of these two commodities (Table III).

Extraction Processes

In the earlier days all the factories used mechanical extraction for kernel oil recovery. However, with the installation of bigger plants many have gone into solvent extraction. At present three types of extraction processes are being used in Malaysia:

—Mechanical extraction using high pressure screw pressing.

—Direct solvent extraction.

—Prepressing followed by solvent extraction.

TABLE III

Production and Exports of Palm Kernel Oil and Palm Kernel Cakes/Pellets in Malaysia ('000 Metric Tons)

	Palm kernel oil		Palm kernel cakes/pellets	
	Produced	Exported	Produced	Exported
1977	142.5	105.0	177.3	160.8
1978	142.3	129.5	175.7	102.8
1979	195.6	198.5	244.8	221.2
1980	222.3	214.9	278.6	255.9
1981	243.4	242.2	339.1	266.3
1982	335.6	333.4	444.2	387.5
1983	360.1	361.9	477.1	454.4

MECHANICAL EXTRACTIONS

Mechanical extraction processes are suitable for both small and large capacity operations. The three basic steps in these processes are (a) kernel pretreatment, (b) screw-pressing and (c) oil clarification.

Kernel Pretreatment

Proper kernel pretreatment is necessary for efficient oil extraction from the kernels. The feed kernels must first be cleaned of foreign materials which cause both damage to the screw presses, thus increasing maintenance costs and down time, and contamination of products. Magnetic separators commonly are installed for removal of metal debris, while vibrating screens are used for sieving out sand, stones or other undesirable materials.

The kernels are then broken into small fragments by a swinging hammer grinder, breaker rolls or a combination of both. This process increases the surface area of the kernels, thus facilitating flaking. The kernel fragments subsequently are subjected to flaking in a roller mill. A large roller mill can consist of up to 5 rollers mounted vertically above one another, each revolving at 200-300 rpm. The thickness of kernel flakes is progressively reduced as it travels from the top roller to the bottom. This progressive rolling initiates rupturing of cell-walls. The flakes that leave the bottom nip are about 0.25 to 0.4 mm thick.

The kernel flakes are then conveyed to a stack cooker for steam conditioning. The purpose of steam conditioning is:

- To adjust the moisture content of the meal to an optimum level.
- To rupture cell-walls (initiated by rolling).
- To reduce viscosity of oil.
- To coagulate the protein in the meal which will facilitate the separation of oil from protein materials.

The meal flows from the top compartment down to the fifth compartment in series, and in each stage it is agitated by a mechanical stirrer sweeping close to the floor. The cookers are heated by steam trays, and live steam may be injected into each compartment when necessary. The important variables are temperature, retention time and moisture content. In palm kernel, the meals normally are cooked to a moisture content of 3% at 104-110 C.

Screw-Pressing

The properly cooked meal is then fed to the screw-press, which consists of an interrupted helical thread (worm)which revolves within a stationary perforated cylinder called the cage or barrel.

The meal is forced through the barrel by the action of the revolving worms. The volume axially displaced by the worm diminishes from the feeding end to the discharge end, thus compressing the meal as it passes through the barrel. The expelled oil drains through the perforation of the lining bars of the barrel, while the de-oiled cake is discharged through an annular orifice. In order to prevent extreme temperatures which could damage the oil and cake quality, the worm-shaft is always cooled with circulating water while the barrel is cooled externally by recycling some cooled oil.

Oil Clarification

The expelled oil invariably contains a certain quantity of fines and foots which need to be removed. The oil from the presses is drained to a reservoir. It is then either pumped to a decanter or revolving coarse screen for removing a larger part of the solid impurities. The oil is then pumped to a filter press for removal of the remaining solids and fines in order to produce a clear oil prior to storage.

The cakes discharged from the presses are conveyed for bagging or bulk storage.

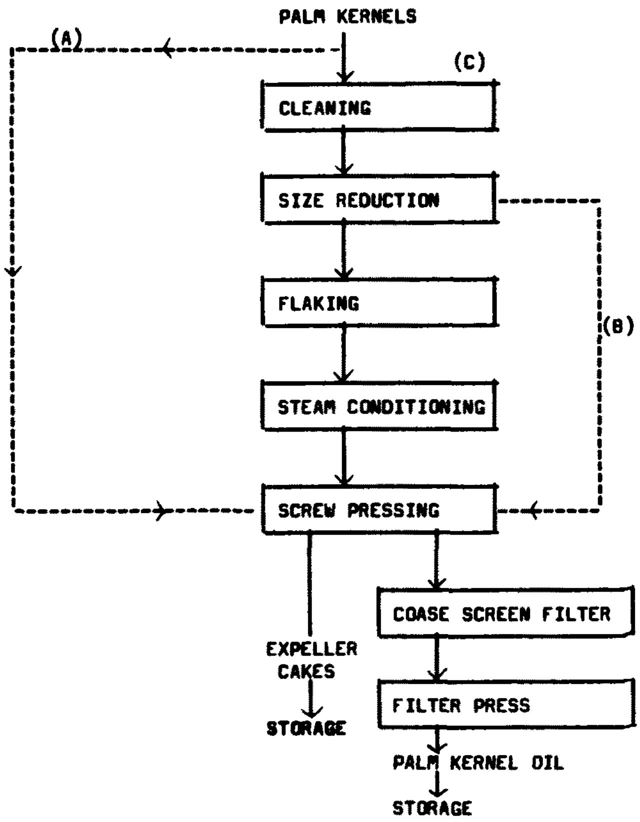

FIG. 1. Mechanical extraction of palm kernel oil. Line (A) is for direct screw pressing without kernel pretreatment; line (B) for partial kernel pretreatment followed by screw pressing, and line (C) for complete pretreatment followed by screw pressing.

As can be seen from Figure 1, not all crushers used the same procedure for mechanical extraction of kernel oil. There are three variations, direct screw-pressing, partial pretreatment and complete pretreatment.

Direct Screw-Pressing

Some mills crush the kernels directly in the presses without any pretreatment. Double pressing usually is required to ensure efficient oil extraction. The screw-presses used normally are less than 10 MT per unit per day.

Partial Pretreatment

The kernels are first broken down to smaller fragments by grinding prior to screw-pressing. In some cases, cooking is also done. The cookers and presses are imported mainly from China and Taiwan.

Complete Pretreatment

The full pretreatment processes described earlier are done prior to screw-pressing. These usually are adopted by plants with larger capacities (200-500 tons per day) and equipment usually is imported from Europe.

SOLVENT EXTRACTION

Solvent extraction processes can be divided into three main unit operations, kernel pretreatment, oil extraction and solvent recovery from the oil and meal. A simplified flow chart of the process is given in Figure 2.

Kernel Pretreatment

Kernel pretreatment in solvent extraction plants is very

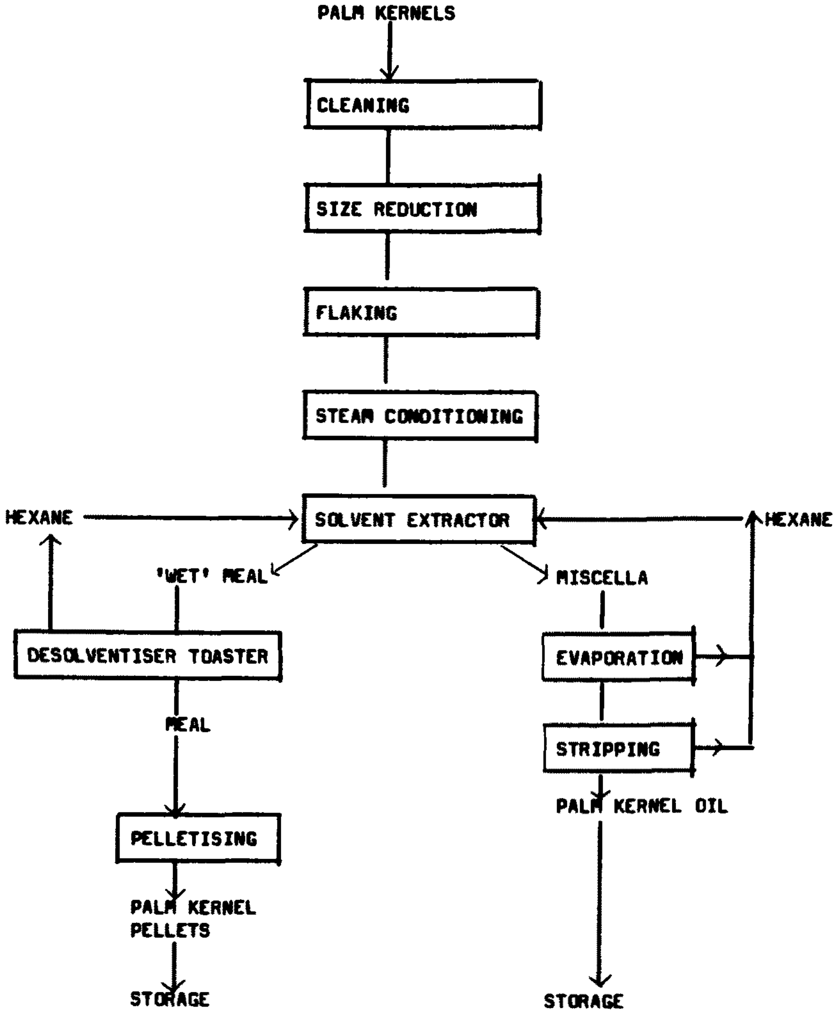

FIG. 2. Solvent extraction of palm kernel oil.

similar to that discussed earlier for mechanical extraction, but generally the cooking step is omitted.

Oil Extraction

Solvent extraction of oil can be effected either by percolation or immersion processes, though percolation seems to be preferred in Malaysia. In percolation, hexane or dilute miscella is pumped over and percolates through a moving bed of kernel flakes. The enriched miscella then leaves the bed through a perforated screen. Both the chain and bucket system and the perforated belt type currently are being used in this country.

In the immersion process, the kernel flakes travel in elevators countercurrent to the fresh hexane in a vertical extractor. This technique is used in combination with percolation.

Solvent Recovery from Meal

The de-oiled flakes discharged from the extractor are conveyed into a desolventizer-toaster which is heated by live steam and steam-trays for efficient solvent removal. The meal is agitated mechanically in this vessel. The meal discharged from the desolventizer-toaster is then sent to the pelletizing plant for pelletizing.

Solvent Recovery from Miscella

Solvent recovery is effected by a 2-stage process of evaporation and stripping under vacuum and elevated temperature. The condensed hexane is channelled back to the storage tank for recycling to the extractor.

TABLE IV

Cost Comparison of a 200 TPD Full Pressing and Solvent Extraction Plant

	Full pressing	Solvent extraction
Estimated price	MR 4.7 million	MR 4.4 million
Power consumption	113 kwh/ton	46 kwh/ton
Steam consumption	192 kg/ton	470 kg/ton
Hexane consumption	NIL	10.5 l/ton

PRE-PRESSING FOLLOWED BY SOLVENT EXTRACTION

This is a combination of mechanical extraction and solvent extraction and also is currently being practiced in Malaysia. In this process the pretreated kernel flakes are first pre-pressed, leaving about 15 to 20% oil in the pre-expelled cake. The cake subsequently is solvent-extracted to remove the remaining oil.

COMPARISON OF DIRECT EXPELLING, DIRECT SOLVENT EXTRACTION AND PRE-EXPELLING/SOLVENT EXTRACTION

Different opinions have been expressed regarding the most

TABLE V

Comparison of Production Utility Requirements (per ton of kernel input)

	Mechanical extraction	Solvent extraction	Pre-pressing solvent extraction
Utility			
Electricity, kwhr	60-110	80-100	80-100
Hexane, lit.	nil	10-20	10-15
Steam (fuel) lit.	0-9	25-35	20-25
Water, lit.	0-140	400-600	400-600
Repair and maintenance, MR	$5-10	$4-8	$5-10
Products			
Palm kernel oil, %	40-43	44.5-46.5	44.5-46.5
Expeller cake/pellets, %	55-51	53.5-51.5	53.5-51.5
Losses, %	4-6	0-3	0-3

economical palm oil extraction method. Some feel that direct solvent extraction is suitable for oilseed containing less than 20% oil, while pre-press followed by solvent extraction is used for high oil content (exceeding 20%) seeds (3). However, an investor has to consider various factors such as capital investment cost, intended capacity, expected cost of production and flexibility before making a decision on the type of processing route or plant type he intends to install. Table IV gives a comparison of the estimated cost of a 200 ton/day full pressing and solvent extraction plant.

Table V shows some comparative data on the utility requirements and extraction efficiency of the 3 processing methods. One can notice that cost of production will be higher in the case of solvent processed because of (a) higher electricity due to pelletizing; (b) additional cost of hexane loss, and (c) larger volume of steam needed for solvent recovery system.

However, the higher cost in the solvent extraction often is offset by the higher percentage of oil recovery and lower operation losses, as indicated in Table V. The relative prices of the kernels, oils and the cakes/pellets and also the operating efficiency of a plant often are instrumental in contributing to the profitability of the operation.

QUALITY AND CHARACTERISTICS OF RAW MATERIALS AND FINISHED PRODUCTS

Raw Materials

The primary aim of the processes is to maximize oil recovery from the kernels. As the qualities of the final products are dictated primarily by the qualities of the raw material, the kernel processor usually is very concerned about the nature and quality of the kernels he receives from the suppliers. Parameters analyzed invariably are dirt and shell content, moisture, oil content and FFA of the extracted oil. Some go further into checking for moldiness, whole nut, broken kernels and color of kernels. All these parameters can affect the yield and quality of the products in one way or another, and these are well documented in various publications (4,5).

At the moment, almost all kernel transactions are based on the standard Malayan Edible Oil Manufacturers' Association/Malaysian Oil Palm Growers' Council (MEOMA/MOPGC) contract which specifies the limits on the various quality parameters (Table VI). In these contracts only dirt and shell content, moisture content and FFA are specified. In general the kernel processors do not have much problem with "oil content" and "FFA" except for some slight deviation in FFA during peak crop seasons. Most kernel crushers are very disturbed by incidences of high dirt and shell, as this will give rise to various processing and quality problems such as higher wear and tear due to the hard abrasive shells, lower oil yield, and poorer quality cakes/pellets.

TABLE VI

MOPGC/MEOMA Palm Kernel Specifications Against Actual Received

	MOPGC/MEOMA	Actual received[a] Average	Range
Oil content	–	48.6	46.4-50.8
Moisture content, %	7% max, 10% rejectable	6.5	5.9- 8.5
FFA (as lauric), %	5% max	3.5	1.05-8.23
Dirt and shell, %	6% max, 10% rejectable	6.4	3.3-11.4

[a]According to our own laboratory data.

TABLE VII

Some Chemical and Physical Characteristics of Malaysian Palm Kernel Oil

Tests	Range	Mean
Iodine value	16.2 - 19.2	17.8
Saponification value	243 - 349	245
Unsaponifiable matter	0.1 - 0.8	0.3
Fatty acid composition %		
C6	0.1 - 0.5	0.3
C8	3.4 - 5.9	4.4
C10	3.3 - 4.4	3.7
C12	46.3 - 51.1	48.3
C14	14.3 - 16.8	15.6
C16	6.5 - 8.9	7.8
C18	1.6 - 2.6	2.0
C18:1	13.2 - 16.4	15.1
C18:2	2.2 - 3.4	2.7
Others	Trace - 0.9	0.2
Refractive index (40C)	1.4500 - 1.4518	1.450
Slip melting point	25.9 - 28.0	27.3
Carotene content, ppm	4.3 - 11.8	7.6
Solid fat content (by NMR)		
5 C	68.0 - 76.8	72.8
10 C	61.6 - 71.2	67.6
15 C	50.5 - 60.0	55.7
20 C	34.2 - 45.5	40.1
25 C	10.2 - 21.5	17.1
30 C	NIL	–

Data in Table VI also give the annual average of the various parameters of the palm kernels we received in 1983. On the average, the quality of the kernels has been satisfactory, except that the dirt and shell content is above the contractual requirement of 6% max. The Palm Oil Research Institute of Malaysia (PORIM) recently has expressed con-

TABLE VIII

Typical Composition of Malaysian Palm Kernel Cakes and Pellets

	Cakes	Pellets
Oil content, %	7.9	1.5
Protein, %	14.8	15.0
Profat, %	22.7	16.5
Moisture content, %	6.4	12.0
Crude fiber, %	16.7	17.0
Carbohydrate	50.3	50.9
Ash	3.9	3.6

cern over this high dirt and shell content (6). The kernel processors generally feel there is ample room for improvement, especially in the dirt and shell content, the desirable maximum limit for which should be 5%.

Palm Kernel Oil

Most of the palm kernel oil produced is exported as crude oil. However, there is a gradual increase in the export of refined, bleached and deodorized (RBD) palm kernel oil. The quality of Malaysian palm kernel oil exported has been excellent. FFA's were generally low, ranging from 2.36-3.60%; iodine value from 17.6-18.2, and moisture and impurities content were consistently below 0.5%.

Palm kernel oil and palm oil differ greatly in their characteristics and properties even though they are derived from the same plant. The kernel oil is similar to coconut oil in that it is light in color, sharp melting and high in lauric and myristic acids. It also is relatively low in unsaturation, thus has excellent stability against oxidative randicity. PORIM has conducted a survey on the characteristics of Malaysian palm kernel oil; its results are given in Table VII.

PORIM's data showed that the characteristics and composition of Malaysian kernel oil are very consistent and generally, a narrow range of values is observed for most characteristics. The observed range of iodine value of 16.2-19.2 is in fact much narrower compared to that accepted by CODEX which stipulates a range of 13-24 (7). Traces of carotenes were found present in the kernel oil and 4 ppm is inherent in the oil (8).

Palm Kernel Cakes/Pellets

Kernel cakes and pellets are important byproducts of the kernel oil extraction processes. Because of low cost and availability, they have been used almost exclusively in animal feed formulation (9). The minimum profat (protein and fat combined) requirements for cakes and pellets are 22% and 16%, respectively. The composition of the Malaysian palm kernel cakes and pellets is given in Table VIII. The two differ mainly in oil and moisture content; otherwise they are quite similar. PORIM currently is conducting an extensive survey on the characteristics of locally produced cakes and pellets; the results, when released, will provide more comprehensive data about these Malaysian products.

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