Palm Oil and Palm Kernels

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ABSTRACT

Events leading up to the introduction of the pollinating weevil (*Elaeidobius kamerunicus*) into Malaysian plantations are described, and the effect of this on the industry is discussed. The main benefits so far are increased kernels and savings in estate pollination costs. It is as yet too early to assess other benefits. The changes in bunch composition have given rise to some processing problems, i.e., sterilization and nut processing, which are currently being corrected.

There have been no major changes in processing procedures, but process developments, such as the use of decanters, computerization, steam utilization and quality improvements, are being made. A review of effluent treatment from palm oil mills shows that most mills conform to government standards using mostly biological digestion processes and land application. Research and development projects are discussed. These include tissue culture and utilization of byproducts.

INTRODUCTION

The first commercial plantings of the oil palm (*Elaeis guineensis*) in Malaysia were undertaken in 1917. However, planted area remained small until 1965 when there was a dramatic increase due to large-scale plantings by the private sector and by statutory bodies such as the Federal Land Development Authority (FELDA). Since then there has been a continuous increase in the number of hectares under oil palm, and by 1983 1.2 million hectares had been so planted.

In terms of the production of palm oil, 101,600 tons were produced in 1960. This had increased to 3.02 million tons by 1983.

The major growers of oil palm in Malaysia are members of the Malaysian Oil Palm Growers Council (MOPGC). This body was established in 1978 from a merger between the former Oil Palm Growers Council (OPGC) and the Malaysian Palm Oil Producers Association (MPOPA). The MOPGC represents the owners of some 862,000 hectares of oil palm in Malaysia.

The MOPGC has two main technical committees: the Agricultural Research Committee (ARC) which looks into agricultural matters, and the Technical Research Committee (TRC) which deals with technical matters concerning the extraction process and related subjects. This paper will deal with technical matters covered by the TRC over the past few years. It is, however, difficult to draw a distinct line between agricultural and technical matters, and therefore some agricultural topics are also covered briefly.

A previous paper (1) covers the various processes in palm oil production, as well as development up to 1976. A schematic diagram of the production process is reproduced from that paper in Figure 1. Raw material input to the extraction process is fruit bunches (FFB) harvested in the plantations, and from this the main products, crude palm oil (CPO) and palm kernels, are extracted.

RAW MATERIAL (FFB): THE EFFECT OF POLLINATING WEEVIL

Without doubt the major recent development within the

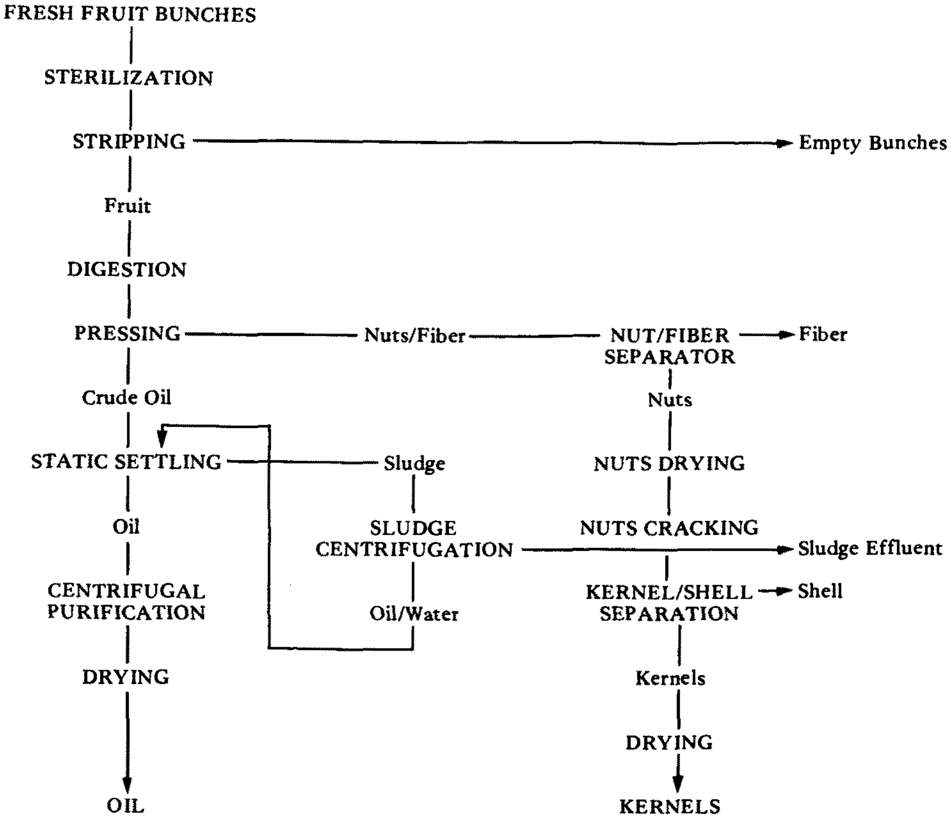

FIG. 1. Flow diagram of the extraction process of Malaysian palm oil (1).

Malaysian palm oil industry has been the introduction into plantations of the pollinating weevil (*Elaeidobius kamerunicus*). It was long thought that the oil palm was pollinated mostly by wind. The received textbook on the crop, for example (2) states that "the oil palm is almost exclusively wind pollinated." Observations on the degree of pollination of FFB in Africa, Malaysia and in particular, East Malaysia, prompted a group of people in Unilever Ltd. to doubt this hypothesis, and they therefore commissioned the Commonwealth Institute of Biological Control to study the possibility that the oil palm might be insect pollinated. An entomologist, Dr. R.A. Syed, was appointed to carry out the study.

As a result of this work, it soon became clear that the oil palm is, in fact, insect pollinated, and that the very poor fruit set in some growing regions (e.g., East Malaysia) was due to the absence of appropriate insect pollinators. Furthermore, the insect pollinator in West Malaysia was discovered to be a species of thrips, which did not seem to be as efficient as those in Cameroun in Africa. Thus began a search for the most promising insect to translocate from Africa to Malaysia. This was found to be a small weevil (*Elaeidobius kamerunicus*), and after an exhaustive study to eliminate possible counterindications had been carried out, a program to import the weevil into Malaysia was undertaken in conjunction with the Malaysian Agricultural Department.

The weevil, which reproduced rapidly from the original importation, was introduced on a massive scale into plantations within the country in 1981, and is currently thriving in its new situation. Literature provides a fuller coverage of this development (3-6). Now, some two and a half years later, it is possible to make an initial, tentative assessment of the effect of the weevil on the oil palm industry.

Without question FFB currently being produced in Malaysia is much more efficiently pollinated than previously. However, the extent of the improvement varies considerably, probably due to the efficiency of pollination prior to the introduction of the weevil. This in turn depends on the age of the palms and also the particular environment in which they grow. Many papers deal with this subject (7), and it is difficult to select data from these to illustrate a typical change due to weevils. However, the important point is that trends are similar although the amount of change varies. With this note, Table I shows the changes recorded on one estate in West Malaysia.

The most important differences due to weevils are:

- Bunch size and weight have increased.
- The quantity of fruit per bunch has increased, but individual fruit weight is smaller. The net overall result is an increase in the weight percent fruit to FFB.
- Despite the decrease in individual fruit weight, individual kernel weight is only slightly reduced, as a result of which weight percent kernel to FFB is very significantly increased.
- Weight percent mesocarp to fruit is reduced, but this has not caused a significant reduction in percent oil to FFB. Indeed, data from some fields show that the weight percent oil to FFB has increased in cases where, prior to the introduction of weevils, weight percent fruit to FFB was very low (e.g., in young

In general then, FFB are now being produced which are much more tightly packed with fruit. These contain more kernels and, in some cases, more oil per unit weight of FFB.

To what extent these changes will influence profitability in the oil palm industry remains to be seen. This will depend on changes in agricultural practices, eventual yield levels of FFB, oil and kernel content of FFB, changes in efficiency of processing, and changes in quality of products. Each of these factors is considered briefly below.

Changes in Agricultural Practices Due to Weevils

The most obvious change is that the practice of artificial pollination has ceased entirely. This practice was widely used in palms of up to 10 years old at a cost of about M$120/per hectare. There has therefore been an immediate, large cost saving for the industry.

Other changes might be expected to occur in harvesting and transport as fewer, heavier bunches are available for harvest. This means that cutting and collection time will decrease, but the saving in time because of this is offset by an increased walking distance between bunches. Whether or not an overall gain or loss in harvester productivity will result is not yet clear.

TABLE I

Bunch Composition Before and After Weevils[a]

Parameters		April to June 1981 Mean (Before)	January to June 1982 (After)		
			Mean	% Change	Unpaired 't' test
1.	B. Wt. (kg)	23.8	27.2	(+14)	2.92*
2.	F S	52.4	69.1	(+32)	5.03**
3.	F/B %	59.5	63.0	(+ 6)	3.85**
4.	M/F %	75.9	71.4	(− 6)	3.01*
5.	O/B %	21.4	21.0	(− 2)	0.47 n.s.
6.	K/F %	9.2	11.0	(+20)	2.88*
7.	S/F %	10.8	11.2	(+ 4)	1.03 n.s.
8.	K/B %	5.5	7.1	(+29)	3.00*
9.	M/B %	45.2	44.9	(− 1)	0.15 n.s.
10.	Fruit Wt. (g/fruit)	10.6	8.0	(−25)	4.64**
11.	Kernel Wt. (g/fruit)	0.98	0.88	(−10)	2.11 n.s.
12.	Shell Wt. (g/fruit)	1.14	0.90	(−21)	4.75**
13.	Mesocarp Wt. (g/fruit)	8.05	5.71	(−29)	4.75**
14.	Total Oil (kg)	5.1	5.7	(+12)	
15.	O/M	47.7	46.4	(− 3)	2.41*
16.	No. of samples	240	360		296*

[a] Data taken from Pamol Estate Kluang, Johore.
FS = Fruit set
F = Fruit
B = Bunch (FFB)
M = Wet mesocarp
O = Oil
K = Kernel
S = Shell

Another point is that because of the extra fruit per bunch, ripeness standards, which are based on detached fruit, will need to be reinvestigated.

Changes in FFB Yield

The effect of the weevil on the yield of FFB cannot yet be specified with any certainty; at least five to seven years will be needed to resolve that question. Estimates vary, but most agriculturalists appear to think that yield will remain unchanged except in those areas which were very badly pollinated before.

Changes in Oil and Kernel to Fruit Bunch Ratios

As shown in Table I, kernel:bunch ratio has substantially increased and oil:bunch ratio is about the same. As a consequence of this the weevil will give more kernels per hectare and the same oil per hectare if FFB yields remain constant. However, in those areas which were poorly pollinated before, increases in both oil and kernels per hectare should occur.

Changes in the Efficiency of Product Recovery

The immediate impact of the different bunch composition in processing mills was severe, particularly as the change corresponded initially with a high level of FFB. The first stage of the extraction process is sterilization of bunches, one of the chief objectives of which is to loosen fruit from the bunchstalk. The heavier, more densely packed bunches resulting from weevil pollination are very difficult to penetrate with steam, so that a more efficient use of steam is now required than previously. In some instances installation of extra sterilization capacity was necessary to overcome this problem.

The second area where processing difficulties were experienced was in the kernel extraction plant. Essentially kernel processing capacity, which was designed for 4.5% kernels to FFB, suddenly had to cope with 6.0% kernel to FFB. The building of extra capacity had to be undertaken. By now most processing mills have adapted themselves to the changes brought about by weevils. Although a few problems still remain, processing efficiencies are back to those attained in preweevil days.

Changes in Product Quality

Oil quality is not directly affected by weevils, but if harvesting criteria remain similar, then weevil FFB appear to give lower free fatty acids (9).

Kernel moisture was high in the period immediately after the introduction of weevils, due to the strain on drying capacity with a higher kernel:FFB ratio. This has now been generally brought under control by the installation of extra capacity and a more efficient use of available heat.

While it is still early to assess the overall effect of the weevil on the industry, the immediate benefits have been a reduction in cost and the production of more kernels. It is very possible that even more significant gains will be forthcoming.

PROCESSING TECHNIQUES

The conventional extraction process for CPO and palm kernels proceeds as follows (see Figure 1). FFB is first sterilized using steam at 3 kg/cm^2 for about 75 min. This process loosens fruit from the bunch and destroys the lipase which produces FFB in palm oil. The sterilized FFB is then threshed in a rotary drum stripper constructed of longitudinal channel bars which allow fruit to fall through upon detachment from the bunch. The empty bunch is retained within the drum and passes out from the end. The separated sterilized fruit are then converted to a homogeneous oily mash by a mechanical stirring process known as digestion. The digested mash is pressed using screw presses.

The liquor from the press (which contains oil, water and fruit solids) is clarified in a continuous static settling tank. The palm oil layer from this process is continuously decanted and passed through a centrifugal purifier and then a vacuum drier to remove solids and moisture, respectively. It is then pumped into storage tanks to await shipment. The underflow from the continuous settling tank is centrifuged to concentrate the oil which is then recycled into the continuous settling tank. The remaining watery liquor is taken off to the effluent treatment plant.

The deoiled fiber/nut mixture after pressing, passes to an air separation system. The fiber after separation is used as a fuel for the process. The nuts are dried in silo driers and then cracked using centrifugal crackers. Kernels are separated from shell using air and water separator systems. Kernels are finally dried in silo driers and bagged to await transport from the mill. The shells are also used to fuel mill boilers along with pressed fiber.

This process has remained fundamentally unchanged for many years. However, there have been significant advances in some parts of the process and some of the most important of these are discussed below.

There has been a general move within the industry to make more efficient use of steam in palm oil mills. This was given additional impetus by changes in bunch composition due to weevil pollination. Increased efficiency is accomplished by automating the flow of steam from boilers, which in palm oil mills are fired by process waste products. This ensures that maximum available steam is used for power generation and for sterilization, thus increasing process efficiency.

There is a slow but noticeable trend toward the utilization of decanter centrifuges in palm oil mills. These were first tried to help solve effluent treatment problems, but there are potential benefits quite apart from this.

Decanters can be used in several different ways in palm oil mills. A typical layout is shown in Figure 2. Among the advantages claimed for the process are:

- A saving in oil loss compared to the conventional process,
- A valuable byproduct, decanter solid cake, which has potential use as a fertilizer or animal food, and
- A saving in water usage.

It is not clear whether this type of equipment will find common use in the oil palm extraction process, but there are already quite a number in use as production machines.

There is a slow trend toward the use of computers in palm oil extraction mills. Computers have potential application for weighbridge transactions, stores and maintenance systems, process control systems, etc. Undoubtedly they will continue to be used more extensively in the future, and this should result in better management information systems, which will allow better processing efficiency and improved quality of products.

Quality of products is always a priority of MOPGC members, and there have been significant improvements made over the past years. Among these measures are:

- Use of magnetic traps to remove iron from palm oil (11),
- Use of more sophisticated harvesting/transport systems to prevent formation of FFA,
- Total elimination of copper or copper-based alloys from those parts of the mill in contact with CPO, and

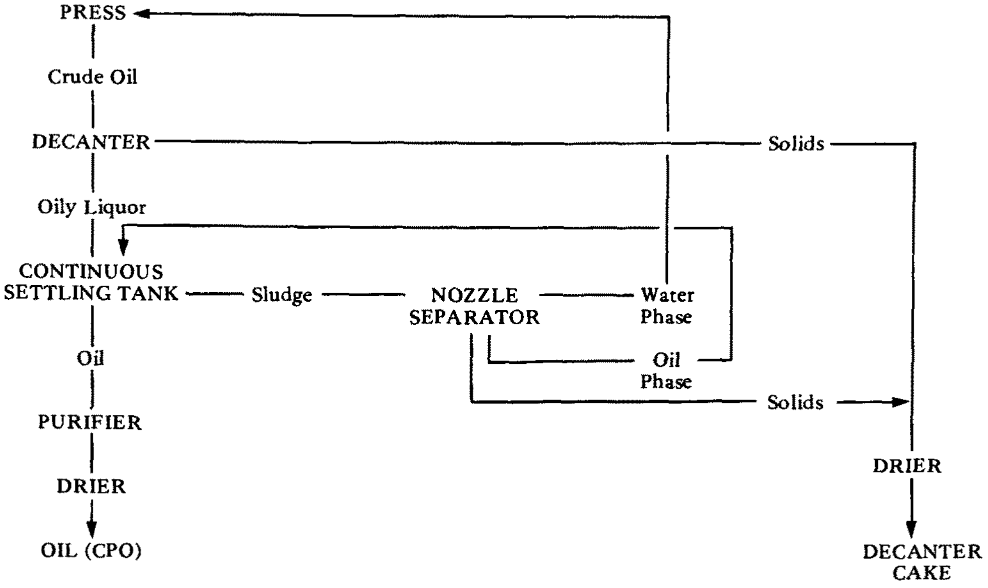

FIG. 2. Schematic diagram of decanter/drier system (10).

- Use of stainless steel, as well as other corrosion and erosion resistant metals, to prevent iron contamination of CPO.

EFFLUENT TREATMENT

The government of Malaysia enacted the Environmental Quality Act in 1974 and prescribed crude palm oil regulations in 1977. The Clean Air Act was enacted in 1978.

The industry has made tremendous strides towards the treatment of liquid effluents since 1977, and it has been estimated that a total expenditure of some $110 million has been committed to this end. A variety of processes are now available for the treatment of liquid wastes. The most common are:

- Anaerobic digestion followed by application of the nutrient rich liquor to palm-growing land,
- Anaerobic followed by aerobic digestion so that the effluent is suitable for recycling into water courses, and
- The decanter process, which aims for a zero liquid effluent.

Ma et al. (12) provided a general review of effluent treatment schemes.

The MOPGC is currently working with the Department of Environment towards solving the air pollution problem due to boiler and empty bunch incinerator operation. An interesting potential benefit of the anaerobic digestion process for effluent is the production of biogas which can be used as fuel to produce additional electrical power (13).

RESEARCH AND DEVELOPMENT

The palm-producing industry supports a considerable research effort both by government institutions (e.g., Palm Oil Research Institute of Malaysia) and by private companies. Among the more significant areas engaging research attention at this time are:

- The development of tissue culture to produce clonal palms is currently receiving considerable attention, and it seems likely that this technique, which produces better forecasts of oil yields, will become commercially viable in the next few years (14,15). The possibility of exploiting beneficial secondary characteristics (e.g., low palm height to facilitate harvesting and higher unsaturation in the palm oil) is much more likely than before. In this latter connection the use of *Elaeis guineensis/Elaeis oleifera* hybrids is of interest (16).
- Research is under way on the mechanization of harvesting to increase harvester productivity and improve palm oil quality.
- Research continues on improved processing methods from the point of view of increased efficiency, improved quality and lower costs. In this area the use of the decanter is being extensively studied as is the use of automation in palm oil mills. This will allow better control of unit process within palm oil mills.
- Research on beneficial uses of mill byproducts, i.e., empty bunches, fiber, shells and effluents is receiving increased attention. Further work on potential uses of biogas from digestion of effluents continues.

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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 X 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