ABSTRACT

Palm oil is obtained from the fruit flesh of Elaeis guineensis. Whole bunches of ripe fruit are harvested and brought to the oil mill. Processing involves sterilization, mechanical removal of fruit from the bunch, and mechanical breakdown of the fruit structure followed by expression of the oil in a screw press. Oil mixed with water and fruit debris is purified in settling tanks and centrifuges, dried and stored. Empty bunches are incinerated, while fiber and shell are used to fire the mill boilers. The liquid effluents are mixed and usually treated by anaerobic/aerobic fermentation until fit for discharge. Various treatment systems are described. Quality control in the oil mill concentrates on (a) minimizing deterioration of the oil by hydrolysis and by oxidation, and (b) optimizing oil yield by frequent measurements of oil losses.

There are today 168 oil mills, processing nearly 3 million tons of oil in Malaysia. The production of palm oil is divided into 2 main stages: (a) harvesting of fruit and transport to oil mill; and (b) production of crude palm oil and palm kernels in the oil mill.

Harvesting of Fruit

The oil palm produces bunches of ripe fruit throughout the year, although there are peak and trough periods. Each bunch weighing 10-20 kg contains more than 1,500 fruits, and they do not all ripen together. However, most of the oil is synthesized in the last two weeks, and a correct judgment of ripeness is essential to ensure good yield. Overripeness leads to biodeterioration and poor quality—oil and lower mill efficiency. Optimum ripeness is judged according to the proportion of loose fruit—at about 10%. The palm frond beneath the bunch is cut off, then the bunch itself is cut. With young palms an axe is used. With the older, taller palms, a sharp hooked knife on a bamboo pole is required. The bunches and loose fruit are picked up manually and loaded into transport.

The commonest form of transport is by lorry. However, on the older estates in flat coastal areas, rails have been laid. This enables loading to be done into metal cages suitable for the first mill process. There is considerable reduction in handling and bruising of fruit with this method.

Oil Mill Process

A flow sheet for the mill process is given in Figure 1.

Loading sterilizer cages. Lorries are driven up a ramp and the fruit tipped into a chute. Rail cages are loaded beneath the chute, 2½ tons in each, and pushed into horizontal cylindrical pressure vessels.

Sterilizing. The fresh fruit bunches (FFB) are cooked at 40 lb/sq. in. pressure. It is necessary to expel all the air from the sterilizer vessels and this is usually done by bringing up to pressure, and releasing pressure twice. On the third occasion, pressure is maintained for 20-30 min. Pressure is released rapidly, resulting in a beneficial drying effect on the fruit. Automatic systems for controlling sterilizer cycle are available. A typical cycle is illustrated in Figure 2 (1).

The objectives of sterilization are: inactivation of enzymes, loosening of fruit on the bunch, softening of fruit, conditioning of nuts, and coagulation of proteins. The total time of the process is 80-90 min, including loading and unloading.

Bunch stripping. After removal from the sterilizer, the cages are hoisted in turn and emptied into the feed hopper of the bunch stripper. This consists of a horizontal rotating drum in which each bunch is lifted and dropped several times to shake out the fruit.

Digester and press. The loose fruit is elevated to a vertical cylindrical vessel, steam-jacketed and fitted with beater arms. The vessel is kept filled. The action of the arms breaks up the fruit, especially the oil-containing cells. The temperature is kept at 90-95 C. The digester is linked by means of a screw feed conveyor to a continuous single- or double-screw press. The back-pressure within the press is adjusted by means of a cone to obtain maximum oil expulsion with minimal breakage of nuts. The press squeezes out liquid consisting of 53% oil, 7% finely divided solids and 40% aqueous phase and a press cake containing fruit fiber and nuts.

Vibrating screen. The mixed liquid phase flows through a 20 and a 40 mesh vibrating screen to a settling tank where it may be diluted with hot water. Fiber, shell and some solids removed by the screen are recycled to the digester.
Oil clarification and purification. During a 2-hr residence period in the settling tank, a fairly clean oil and a sludge layer separate. Dirt and moisture are removed from the oil layer in a hermetically sealed purifying centrifuge and the oil is dried in a vacuum drier operating at ca. 50 mm pressure to 0.10-0.15% moisture before storage. The sludge layer may be passed through a small desanding cyclone before going to a sludge centrifuge. The recovered oil from this stage is returned to the settling tank and the remaining sludge to the waste treatment system.

Recovery of palm kernels. A large part of the space in an oil mill is taken up by the kernel processing, because large air separation and drying systems are used.

Depericarper. The cake from the screw press passes down a conveyer, specially designed to break up the cake and to dry it somewhat. In other designs, the mixture is first treated in a horizontal drum before pneumatic separation. The broken-up cake, nuts and fiber are fed into a moving air column which blows most of the fiber away. The nuts drop into a polishing drum, which frees the rest of the fibers, so that they can also be removed in air stream.

Nut cracking. Before the nuts are cracked, they are stored in a silo, where their moisture content is reduced, typically from 16% to ca. 11%, by a stream of heated air. Alternatively, drying may be done by heating in an autoclave and rapidly releasing the pressure.

The nuts are cracked in a centrifugal nut cracker, mostly of the self-grading type. The nuts drop onto a rotor and are hurled outwards against a cracking ring where they break on impact. It is at this point that correct conditioning of the nuts is important. It ensures that the shell is brittle enough to crack, and that the kernel has dried enough to detach from the shell.

The mixture of kernels and shell fragments is separated first in a pneumatic column and then in a hydrocyclone. Finally, the kernels are dried in a silo with hot air to below 8% moisture, and bagged for despatch.

Palm kernels are processed into oil and meal in conventional pressing and solvent extraction processes usually sited in separate factories.

The capacity of most oil mills ranges from 20 to 80 tons/hr. Sizes of equipment are appropriately related to the expected proportions of the various product and byproduct streams. At the time of writing, a series of operational problems have arisen resulting from the introduction and proliferation during 1981 of the weevil Elaedobus kamerunicus. The purpose of this introduction from West Africa was to improve fertilization of the flowering bunch, and avoid the cost of manual pollination which is sometimes required.

As a result, there has been an increase in fruitlets per bunch, an increase in bunch weight and a higher proportion of kernels. A higher yield of oil is obtained, but the following consequences are being experienced:

- Bunch ripeness is less uniform because there are more fruits on the inside of the bunch and the correct ripeness for harvesting is more difficult to determine.
- Sterilization is more difficult, so that the sterilizer treatment has had to be increased (see Fig. 2).
- In consequence, the steam supply is less adequate.
- More fruits remain in the empty bunches so that they have to be recycled.
- The higher proportion of kernels to mesocarp makes press operation more difficult.
- The equipment for processing kernels is insufficient.

In due course, the necessary engineering adjustments will be made. The practical effect, in terms of yield can be seen from Table I. There is a higher oil yield and a much higher proportion of kernels.

Treatment of Oil Mill Wastes

One hundred tons of fresh fruit bunches produce 20-24 tons of palm oil and about 3.6 tons of palm kernels. The remaining material emerges at various stages of the oil mill process as byproduct giving rise to problems of disposal. The solid wastes in various forms have been successfully used in animal feeds as the recommendations (2) in Table II show. They are based on considerations of chemical composition and digestibility in feeding trials. These uses have not yet been applied beyond the experimental stage.

Empty Fruit Bunch

The most usual practice is to burn the bunches in an incin-