Continuous Processing of Palm Fruit

BERNARD DE RAMECOURT, Vice-Chairman, Société des Plantations et Huileries de Côte d'Ivoire, Abidjan, Ivory Coast

ABSTRACT

In the last few years we have seen a remarkable breakthrough of palm oil products into the oilseed world. The old extraction techniques, often inherited from artisan methods, have been modernized to give birth to a veritable "palm oilworks" industry. Present equipment and methods permit obtaining, under optimum yield conditions, high quality products responding well to the requirements of the manufacturers of oil and vegetable fat products.

INTRODUCTION

Products of the palm tree, palm oil, and palmkernels, today represent 6% of total world fat production. In the judgment of experts, world trade in palm oil will reach 2.3 million metric tons in 1980, or some 20% of world trade in food oils. The important place which the palm tree has taken in the oilseed world is surely explained by its exceptional production capacity (more than 6 tons of palm oil per hectare under the best conditions) and thus a low cost. This is also explained by the fact that the oil finds many food and industrial uses.

This breakthrough would not have been possible, however, if modern manufacturing methods had not permitted putting on the market semifinished products of good and constant quality responding to the requirements of manufacturers of oil and vegetable fats.

Only 10 years ago, an important part of production came from semiindustrial works and even from artisan installations producing, at the rate of 20 days' work per ton of clusters, at extremely low yields, an oil which was often high in free fatty acids (FFA) and loaded with impurities.

Production today represents less than a half day's work per ton of cluster, allowing one to obtain, with yields of $>20\%$, an oil in which the FFA is down to ca. 2% and impurities are present in no more than "traces."

This processing does not require complex techniques but, as we shall see, a number of important successive operations.

It is necessary in a short time to separate the fruits from the stem. If we observe the cross section of palm fruit, we see that the palm oil is contained in the exterior pulp (the mesocarp) whereas the palmkernel, which contains 50% oil, can only be freed after the very hard shell which surrounds it has been broken.

Therefore, we have to recover the oil and the kernels destined for the users with a minimum of impurities and acidity and also with a minimum of waste. At the same time, we must convert into energy the combustible byproducts which are the fibers and the shells.

RECEPTION OF THE CLUSTERS

The average acidity of the oil in the fruits at the moment of cutting is normally $< 1\%$. This acidity rises very rapidly after cutting, especially in the injured exterior fruits which will particularly undergo enzymatic hydrolysis. This increase in acidity will be stopped only by sterilization. The quality of the palm oil is therefore conditioned in large part by the maturity of the clusters and by the speed with which they will be processed after cutting.

On arrival from the plantation, the clusters are weighed, then unloaded in a holding area. A receiving hopper is often used which receives the clusters from transport vehicles in order to fill up perforated iron carts reserved for sterilization. One original method consists of directly transporting the crop in these carts, which avoids double handling and new injuries to the fruit.

The clusters are harvested on the trees all year round but in the peak month harvesting can reach in certain cases 15% of the annual production.

The factory therefore anticipates this maximum flow. The collection of clusters obviously has to be sufficient to supply the plant during the night hours if the abundance of the harvest justifies 24 hr processing.

OIL EXTRACTION

The first operation consists of cooking the clusters for 60-90 min in steam sterilizers under 3 kg of pressure (140 C). As indicated, this sterilization stops the development of acidity. It also allows separation of the fruits from the stem. The pressure variations inside the sterilizers further allow the palmkernels to come out of the nut shell more easily.

The sterilizers are most often the horizontal type. These are strong iron cylinders supplied with a rapid-closing door. The carts containing 1.5-2.5 tons of clusters are brought in on tip-trucks mounted on rails. Steam is let in at one or several points at the top of the apparatus, the rise in pressure being affected only when all the air contained in the apparatus has been purged.

Sterilizer capacity can vary from 6 to 20 tons of clusters per hour according to the size of the factory. Two or three sterilizers ensure continuous feed for the extractors.

After cooking, the loaded carts or hampers are taken by a monorail hoist and emptied into a hopper feeding the picker. This apparatus is a cylindrical cage with bars, turning 20 revolutions per minute. The clusters are brought in at one end, and the rotation of the cage with repeated tumbling knocks the fruits off the stem. The fruits then fall through the bars, and the stalks are ejected at the other end. They can be burned or scattered in the plantations, thus giving back the potash which they contain.

Poor harvesting will cause important loss of fruits, which will be ejected along with the stems. Good plant performance depends on the maturity of the clusters and also on correct cooking and uniform processing.

Coming out of the picker, the palm fruits fall into a conveyor, are taken by elevator, and pass on to a vibrating strainer equipped with a washing ramp using boiling water. They will thus be rid of the coarsest impurities. Then they fall into the mixers, vertical cylindrical vats with a central shaft with several pairs of horizontal arms. For 20 min they continuously undergo a vigorous mashing, at the end of which the pulp of the fruit begins to detach itself from the nut. At the same time, the oil-bearing cells break into pieces, freeing the oil that they contain. To attain good mixing, it is important that the apparatus always be full. At 3 kg of steam pressure, the temperature will stay at ca. 90-95 C.

The base of the mixers opens onto a water channel which feeds the presses. These are the essential parts of the extractor system. Their hourly capacity often determines the capacity of the factory in terms of tons of clusters per hour, and the rate of oil extraction from the clusters depends on their good operation. Their function is to press dry the fibrous and oily mixture coming out of the mixer, at the same time reducing as much as possible the loss in oil from the fibers, without breaking the nuts which contain the palmkernels which would then be lost.

Several methods have been used: washing in hot water, centrifugal separation, and, more recently, hydraulic presses in which the material is dried under the action of a piston working in a perforated cage. The percentage of broken nuts is very low with this last system; however, the losses in oil are relatively high (running to 9-11% on dried fiber basis). This apparatus works discontinuously with a low unit capacity which requires the use of "batteries" of several presses.

Today the continuous press, expeller type, is in general use. With this system, the material coming out of the mixer is forced along continuously by one or more screws across a perforated cage. Exit from the cage is provided by an adjustable cone which limits the ejection of the oil cakes while creating a pressure which frees the raw juices through the cage perforations. Presses of this type have capacities varying from 6 to 15 tons of clusters per hour; the losses in oil on dried fibers remain < 6%.

Equipment most used today includes the Colin type press (the oldest), in which one feed screw and one pressure screw turn on the same axis in opposite directions; the De Wecker press, with two screws operating in a parallel direction; the Stork press, which has two screws in a series; and the latest, the M50 conceived by Speichim, a monoscrew which allows very regular drying, therefore limiting broken nuts and requiring a smaller consumption of energy. The simple screw simplifies maintenance and facilitates taking apart. The raw juices from the presses contain 35% palm oil and a mixture of water and deposits formed from sand and vegetable residue. The oil cakes coming out of the press contain the dehydrated fibers of fruits from which the palm nuts, still whole, are recovered.

CLARIFICATION OF RAW JUICES

The old methods used static decantation—the raw oil being put into a tank at the bottom of which were left the residues and the water while the decanted oil was collected from the surface. This not very speedy system necessitated cumbersome equipment promoting an increase in oil acidity and causing important losses in the residues. Centrifugal separation is now in general use. The manufacturers (Westfalia and De Laval) have made separators designed especially for the treatment of palm oils.

The raw oils coming from the presses are first strained to remove most of the impurities which will be returned to the mixer. To improve the separation, the juices are then reheated in a preparation tank at a temperature as close as possible to 100 C, then strained again to avoid plugging the separator.

The straining circuit is also equipped with a sand cyclone which frees the juices from the high density solid foreign matter they may still contain. The straining is effected in closed circuit with residues returned to the preparation tank. A pump placed next to the strainer feeds the centrifugal separators. The "water" from the separators again passes an exterior florentine oil-water separator, which constitutes a security device allowing the recovery of oil in case of a mistake or faulty operation.

The purified oil can be reclarified in a second centrifuge serving as a finisher, but one also obtains good results with a decantation vat. The bottom layer in the vat is periodically recycled in operation; the surface oil is dehydrated under a vacuum to eliminate the remaining moisture.

The finished dry oil is pumped into holding tanks; its good preservation will be assured if it corresponds to the norms which can be obtained with the method we have just described, i.e., free fatty acids < 2%, moisture < 0.1%, and impurities practically nonexistent.

PALM NUT

The oil cakes coming out of the press consist of a mixture of fibers and nuts. They are transported in a steam jacketed screw conveyor to break up the cakes.

The action of the paddles which are on the screw shaft crumbles the mass and separates the nuts from the fibers, which will dry by the heat in the conveyor jacket. At the end of the breaker screw is the de-fibering apparatus, consisting of a vertical column on the inside of which circulates a current of air created by a powerful fan. The lightest dried fibers are sucked in and transported by pipe into the boiler feed tanks. The heaviest nuts fall and will eventually pass into a polisher before being stored in silos.

We have seen that one of the effects of sterilization was to loosen the palmkernels from inside the nuts. If this operation has been badly managed (bad cleansing of the sterilizer causing air pockets, for example), numerous kernels will adhere to the nuts and break during crushing. They will then be lost.

The nuts remain in the silos for ca. 10 hr to dry further in the warm air. Then they are sent by conveyor to the crusher. This apparatus is composed of a rotor turning at great speed which continuously projects the nuts onto the stationary metallic wall of the stator; the shock breaks the shell, which frees the kernel.

According to the age of the palm trees and the varieties planted, the size of the nuts can be very different. It is often best to use a sorter that sends small nuts and large nuts to two different crushers turning at different speeds. Under the action of a dust remover, the crushed mixture is freed of the small debris that has been sucked in and sent on to the boilers. The kernels and the large shells can then be separated.

For a long time, salt or mud baths have been used for this separation. The density of the bath allows the kernels to rise to the surface while the heaviest shells are eliminated at the bottom of the vat. Now an installation of hydrocyclones is used. The crushed mixture falls continuously into a vat full of water. It is taken by a pump which swirls it into a conical cyclone where the separation is effected—the lightest pure kernels come out while a mixture made up of shells and some nuts returns for further processing.

A second pump then repeats the operation on a second hydrocyclone, the setting allowing extraction of the shells; meanwhile, the other portion still containing some kernels and some shells returns to the first vat to be recycled.

Management of the hydrocyclone station is delicate and requires frequent adjusting of cones and return tanks. It is necessary to find the proper balance between the tolerance of impurities allowed by kernel purchase contracts and the losses in the shells.

The shells coming out of the hydrocyclones pass into a sorter, which recovers the unbroken nuts and sends them back to the crusher. A third pump again sends them to a vibrating, draining strainer. Then from there they fall into the boilers' feed screw. They constitute an excellent fuel (ca. 4,000 calories/kg).

The kernels are strained on a vibrating strainer and then sent to a dryer for some 10 hr. The dryer contains a predrying zone made up of warming plates and two drying zones in which the warm air circulates from radiators regulated by thermostats. Upon coming out, they contain 6-7% moisture and a little more than 50% palmkernel oil. This oil will be extracted in oil plants, producing a by-product oil cake used in numerous livestock feeds.

Current commercial specifications for palmkernels are minimum 49% oil in seeds, maximum 4.75% FFA as lauric acid, and maximum 2.75% impurities.

HEAT AND POWER

In order not to deviate from our subject, we shall only touch on the question of waste utilization. Remember that the factory produces its own energy from the excellent fuels which are the waste fruit fibers and the nut shells.

The production of steam from the boilers feeds a steam turbine that turns an alternator which supplies the current for the electric motors. The exhaust steam from the turbine is used for sterilization and for the factory's various reheating and drying units.

For a plant processing 20 tons of clusters per hour, the needs are on the order of 500 kg of steam and 20/22 KVA per ton of clusters.

This energy is very cheap, but its use implies the factory's proper operation since interruption will very quickly be reflected in a fuel deficiency and pressure variations to the cookers which will have repercussions on the entire manufacturing process.

We have discussed only the principal techniques used for the manufacture of palm oil in a modern plant. Of course, this technique remains perfectible and improves every day, gaining from advances in the industry at all levels.