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Oil Palm Bunch Processing and Oil Extraction Process

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Summary

Post-harvest processing of oil involves many tasks such as bunch handling, crude palm oil extraction, and conversion of by-products into commercial forms. However, extraction of crude palm oil is the primary task. A sequence of processing steps designed to extract a high yield of palm oil with acceptable quality for the international edible oil trade from a harvested oil palm bunch. The oil-milling process involves the reception of fresh fruit bunches from the plantations, sterilizing and threshing of the bunches to free the palm fruit, mashing the fruit, and pressing out the crude palm oil. The crude oil is further treated to purify and dry it for storage and export. The sterilization step plays a key role in extracting maximum oil yield and high-quality oil. So, knowledge on the steps involved in oil palm processing is much needed in maximizing oil yield, maintaining oil quality, and converting by-products into commercial forms.

Introduction

Oil palm is the highest oil-yielding perennial crop, outperforming other vegetable oil crops. In India, so far, an area of 3.69 lakh ha has been covered under oil palm cultivation with fruiting area of 1.89 lakh ha, and palm oil production during 2020-21 is recorded as 0.29 million tonnes. The main harvest from the oil palm consists of fresh fruit bunches (FFB) from which are obtained a wide variety of products, the chief of which is crude palm oil (CPO) extracted from the mesocarp or flesh of the fruit and palm kernel oil (PKO) extracted from the palm kernel or seed within the fruit. After the harvesting process, FFB is collected and transported to the palm oil milling factories to be processed into crude palm oil. The milling process begins with receiving and weighing operation, followed by sterilization and stripping, which are required to soften the FFB for the sterilization process. Next, the sterilized FFB will be stripped, resulting in a huge quantity of empty fruit bunch (EFB). Detachment of palm fruits from bunches is not possible without sterilization. Heat treatment destroys oil-splitting enzymes and arrests hydrolysis and autoxidation. For large-scale installations, where bunches are cooked whole, the wet heat weakens the fruit stem and makes it easy to remove the fruit from bunches on shaking or tumbling in the threshing machine. The process is followed by digestion and pressing to attain crude palm

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oil for further clarification and purification, and finally storage. The sterilization step plays a key role in processing of oil palm bunches. Proper sterilization of fresh fruit bunches can increase the oil extraction rate and processing of oil palm bunches make simple. So, knowledge on the steps involved in oil palm processing is much needed in maximizing oil yield, maintaining oil quality, and converting by-products into commercial forms.

Post-Harvest Processing of Oil Palm

The processing of oil palm involves the following steps; reception of fresh fruit bunches from the plantations, sterilizing and threshing of bunches to free the palm fruit, mashing the fruit, and pressing out the crude palm oil. The crude oil is further treated to purify and dry for storage and export.

Bunch reception

Fresh fruit arrives from the field as bunches or loose fruit. The fresh fruit is normally emptied into wooden boxes suitable for weighing on a scale so that quantities of fruit arriving at the processing site may be checked. Large installations use weighbridges to weigh materials in trucks. The quality standard achieved is initially dependent on the quality of bunches arriving at the mill. The mill cannot improve upon this quality but can prevent or minimize further deterioration. The field factors that affect the composition and final quality of palm oil are genetics, age of the tree, agronomic, environment, harvesting technique, handling, and transport. Many of these factors are beyond the control of a small-scale processor. Perhaps some control may be exercised over harvesting techniques as well as post-harvest transport and handling.

Sterilization of bunches

Sterilization means the use of high-temperature wet-heat treatment of loose fruit. Cooking normally uses hot water; sterilization uses pressurized steam. The cooking action serves several purposes.

- Heat treatment destroys oil-splitting enzymes and arrests hydrolysis and autoxidation.
- For large-scale installations, where bunches are cooked whole, the wet heat weakens the fruit stem and makes it easy to remove the fruit from bunches on shaking or tumbling in the threshing machine.
- Heat helps to solidify proteins in which the oil-bearing cells are microscopically dispersed. The protein solidification (coagulation) allows the oil-bearing cells to come together and flow more easily on application of pressure.
- Fruit cooking weakens the pulp structure, softening it and making it easier to detach the fibrous material and its contents during the digestion process. The high heat is enough to

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partially disrupt the oil-containing cells in the mesocarp and permits oil to be released more readily.

- The moisture introduced by the steam acts chemically to break down gums and resins. The gums and resins cause the oil to foam during frying. Some of the gums and resins are soluble in water. Others can be made soluble in water when broken down by wet steam (hydrolysis) so that they can be removed during oil clarification. Starches present in the fruit are hydrolyzed and removed in this way.
- When high-pressure steam is used for sterilization, the heat causes the moisture in the nuts to expand. When the pressure is reduced the contraction of the nut leads to the detachment of the kernel from the shell wall, thus loosening the kernels within their shells. The detachment of the kernel from the shell wall greatly facilitates later nut-cracking operations. From the foregoing, it is obvious that sterilization (cooking) is one of the most important operations in oil processing, ensuring the success of several other phases.
- However, during sterilization it is important to ensure evacuation of air from the sterilizer. Air not only acts as a barrier to heat transfer, but oil oxidation increases considerably at high temperatures; hence oxidation risks are high during sterilization. Over-sterilization can also lead to poor bleach ability of the resultant oil. Sterilization is also the chief factor responsible for the discoloration of palm kernels, leading to poor bleach ability of the extracted oil and reduction of the protein value of the press cake.

Threshing of fruits

The fresh fruit bunch consists of fruit embedded in spikelets growing on a main stem. Manual threshing is achieved by cutting the fruit-laden spikelets from the bunch stem with an axe or machete and then separating the fruit from the spikelets by hand. Children and the elderly in the village earn income as casual labourers performing this activity at the factory site. In a mechanized system, a rotating drum or fixed drum equipped with rotary beater bars detaches the fruit from the bunch, leaving the spikelets on the stem. Most small-scale processors cannot generate steam for sterilization. Therefore, the threshed fruits are cooked in water. Whole bunches which include spikelets absorb a lot of water in the cooking process. High-pressure steam is more effective in heating bunches without losing much water. Therefore, most small-scale operations thresh bunches before the fruits are cooked, while high-pressure sterilization systems thresh bunches after heating to loosen the fruits. Small-scale operators use the waste of bunch (empty bunches) as cooking fuel. In larger mills, the waste of bunch is incinerated and the ash, a rich source of potassium, is returned to the plantation as fertilizer.

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Digestion of fruits

Digestion is the process of releasing the palm oil in the fruit through the rupture or breaking down of the oil-bearing cells. The digester commonly used consists of a steam-heated cylindrical vessel fitted with a central rotating shaft carrying several beater (stirring) arms. Through the action of the rotating beater arms the fruit is pounded. Pounding, or digesting the fruit at high temperature, helps to reduce the viscosity of the oil, destroys the fruits' outer covering (exocarp), and completes the disruption of the oil cells already begun in the sterilization phase. Unfortunately, for reasons related to cost and maintenance, most small-scale digesters do not have heat insulation and steam injections that help to maintain their contents at elevated temperatures during this operation. Contamination from iron is greatest during digestion when the highest rate of metal wear is encountered in the milling process. Iron contamination increases the risk of oil oxidation and the onset of oil rancidity.

Pulp pressing/Extracting palm oil

There are two distinct methods of extracting oil from the digested material. One system uses mechanical presses and is called the 'dry' method. The other called the 'wet' method uses hot water to leach out the oil. In the 'dry' method the objective of the extraction stage is to squeeze the oil out of a mixture of oil, moisture, fibre and nuts by applying mechanical pressure on the digested mash. There are a large number of different types of presses but the principle of operation is similar for each. The presses may be designed for batch (small amounts of material operated upon for some time) or continuous operations.

Batch process

In batch operations, material is placed in a heavy metal 'cage' and a metal plunger is used to press the material. The main differences in batch press designs are as follows: a) the method used to move the plunger and apply the pressure; b) the amount of pressure in the press; and c) the size of the cage. The plunger can be moved manually or by a motor. The motorized method is faster but more expensive. Different designs use either a screw thread (spindle press) or a hydraulic system (hydraulic press) to move the plunger. Higher pressures may be attained using the hydraulic system but care should be taken to ensure that poisonous hydraulic fluid does not contact the oil or raw material. Hydraulic fluid can absorb moisture from the air and lose its effectiveness and the plungers wear out and need frequent replacement. Spindle press screw threads are made from hard steel and held by softer steel nuts so that the nuts wear out faster than the screw. These are easier and cheaper to replace than the screw. The size of the cage varies from 5 kg to 30 kg with an average size of 15 kg. The pressure should be increased gradually to

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allow time for the oil to escape. If the depth of material is too great, oil will be trapped in the centre. To prevent this, heavy plates' can be inserted into the raw material. The production rate of batch presses depends on the size of the cage and the time needed to fill, press and empty each batch. Hydraulic presses are faster than spindle screw types and powered presses are faster than manual types. Some types of manual press require considerable effort to operate and do not alleviate drudgery.

Continuous process

The early centrifuges and hydraulic presses have now given way to specially designed screw presses similar to those used for other oilseeds. These consist of a cylindrical perforated cage through which runs a closely fitting screw. Digested fruit is continuously conveyed through the cage towards an outlet restricted by a cone, which creates the pressure to expel the oil through the cage perforations (drilled holes). Oil-bearing cells that are not ruptured in the digester will remain unopened if a hydraulic or centrifugal extraction system is employed. Screw presses, due to the turbulence and kneading action exerted on the fruit mass in the press cage, can effectively break open the unopened oil cells and release more oil. These presses act as an additional digester and are efficient in oil extraction. Moderate metal wear occurs during the pressing operation, creating a source of iron contamination. The rate of wear depends on the type of press, method of pressing, nut-to-fibre ratio, etc. High pressing pressures are reported to have an adverse effect on the bleach ability and oxidative conservation of the extracted oil.

Clarification and drying of oil

The main point of clarification is to separate the oil from its entrained impurities. The fluid coming out of the press is a mixture of palm oil, water, cell debris, fibrous material and non-oily solids. Because of the non-oily solids, the mixture is very thick (viscous). Hot water is therefore added to the press output mixture to thin it. The dilution (addition of water) provides a barrier causing the heavy solids to fall to the bottom of the container while the lighter oil droplets flow through the watery mixture to the top when heat is applied to break the emulsion (oil suspended in water with the aid of gums and resins). Water is added in a ratio of 3:1. The diluted mixture is passed through a screen to remove coarse fibre. The screened mixture is boiled from one or two hours and then allowed to settle by gravity in the large tank so that the palm oil, being lighter than water, will separate and rise to the top. The clear oil is decanted into a reception tank. This clarified oil still contains traces of water and dirt. To prevent increasing FFA through autocatalytic hydrolysis of the oil, the moisture content of the oil must be reduced to 0.15 to 0.25 percent. Re-heating the decanted oil in a cooking pot and carefully skimming off the dried oil from any engrained dirt removes any residual moisture. Continuous clarifiers consist of three

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compartments to treat the crude mixture, dry decanted oil and hold finished oil in an outer shell as a heat exchanger. The wastewater from the clarifier is drained off into nearby sludge pits dug for the purpose. No further treatment of the sludge is undertaken in small mills. The accumulated sludge is often collected in buckets and used to kill weeds in the processing area.

Oil storage

In large-scale mills, the purified and dried oil is transferred to a tank for storage before dispatch from the mill. Since the rate of oxidation of the oil increases with the temperature of storage the oil is normally maintained around 50°C, using hot water or low-pressure steam-heating coils, to prevent solidification and fractionation. Iron contamination from the storage tank may occur if the tank is not lined with a suitable protective coating. Small-scale mills simply pack the dried oil in used petroleum oil drums or plastic drums and store the drums at ambient temperature.

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