Abstract: A method for extracting crude palm oil from fresh fruit bunches based on removing a portion of the moisture in press liquor (51) by evaporation (54) followed by oil clarification (56) using a system that is capable of achieving the oil/sludge separation without water addition to reduce the effluent from the palm oil extraction process.
METHOD FOR EXTRACTING CRUDE PALM OIL

FIELD OF INVENTION

The present invention relates to a method for extracting crude palm oil from oil palm fresh fruit bunches and more particularly to a crude palm oil extraction method for reducing the amount of effluent discharged compared to the prior art methods.

BACKGROUND OF THE INVENTION

The conventional palm oil milling process is shown in Figure 1. Fresh fruit bunches (FFB) 1 are cooked during sterilization 2 using steam at a pressure of 3 bar in horizontal autoclaves of cylindrical shape for about 60 to 90 minutes. The sterilized fruit bunches 3 are then stripped 4 to separate the sterilized fruits from the empty fruit bunches. The sterilized fruits 5 are then reheated and agitated in steam-heated vessels known as digesters 6 to loosen the mesocarp from the nuts in preparation for pressing 7. The screw press expels a liquor of oil, water and finely divided solids, and a press cake of fibre and nuts.

The oil in the press liquor has to be separated from the water and solids and this takes place during clarification. In the conventional clarification process, the primary separation is achieved in settling tanks using gravity. For optimum separation, it is first necessary to dilute the press liquor 8 with hot water 21 to reduce its viscosity. The diluted press liquor is then screened 9 to remove the coarse fibrous solids 20 that are subsequently returned to the digesters 6. The screened and diluted press liquor 10 is then heated and pumped into the clarification tank 11 where it separates into two phases, i.e. oil 12 and sludge 16.

The separation is carried out using either horizontal or vertical continuous clarifiers. The horizontal clarifier is a long rectangular tank partitioned into three or more compartments along its length. A retention time of about two hours is normally used. The cylindrical vertical clarifier is preferred in most modern palm oil mills. Dimensions of this tank have been
significantly increased to allow a sludge retention time of about four to five hours, and stirrers with shear plates have also been fitted to improve the oil/sludge separation efficiency.

The oil layer 12 in the clarification tank is skimmed off and passed to centrifugal purifier 13 which reduces the dirt content to 0.01 percent or less. The centrifuged oil is then dried in vacuum drier 14 to give a product of crude palm oil 15 with a moisture content of approximately 0.1 percent.

Sludge 16 from the clarification tank has approximately 4 to 10 percent oil, the bulk of which can be recovered using centrifugal separator 18 after desander 17 leaving substantially de-oiled sludge 19. The oil recovered by the sludge centrifuge i.e. the centrifugal separator 18 contains some water and dirt and is therefore returned to the clarification tank 11 for further treatment. Two types of sludge centrifuge are currently used. The first is the stacked disk centrifuge. This centrifuge can handle a much larger capacity and its operation is quite easily automated. The second centrifuge uses a star-shaped rotating bowl. In spite of its smaller capacity, this centrifuge is still popular because of its lower capital and maintenance costs.

The conventional milling process generates about 0.6 tons of palm oil mill effluent (POME) for every ton of FFB processed. In 2005, Malaysia produced about 42 million tons of POME from about 400 palm oil mills. The biological oxygen demand (BOD) of the POME discharged from all palm oil mills in Malaysia had a population equivalent of about 62 million people (i.e., approximately 2.5 times the population of Malaysia). It is widely acknowledged that a more effective method of treating the POME than the widely used anaerobic/aerobic ponding system is needed. Silting of ponds due to the high concentration of suspended solids reduces their effectiveness and leads to higher operating cost. POME treatment under anaerobic conditions also leads to the emission of methane (i.e., a greenhouse gas that has a global warming effect that is 21 times more potent than carbon dioxide).

One solution to the problem is to modify processes in the mill to achieve significant reduction in the amount of POME, making it viable to treat the POME using approaches that were previously considered to be not technically and/or economically viable.
Attempts have been made to reduce the amount of water added to the press liquor to achieve efficient oil clarification. The use of membrane filter presses and peeler centrifuges to separate out the bulk of the suspended solids to enhance oil clarification without the addition of water has been suggested. The use of peeler centrifuges leads to higher oil loss, while membrane filter presses have been found to be not suitable due to fouling by gummy substances present in the crude palm oil.

The use of decanting centrifuges in palm oil mills has aroused considerable interest since the 1970s, both for separating the suspended solids from crude palm oil in a fairly dry state thereby reducing the biological oxygen demand (BOD) of the liquid effluent, as well as for clarifying the oil. A decanter consists of a cylindrical-conical shaped bowl equipped with a screw conveyor rotating at a speed slightly different from that of the bowl. The cylindrical section of the bowl is used for clarification of liquids or separation of two immiscible liquid phases, while the conical section is suitable for drying of the separated solids. The feed slurry enters the machine through a feed pipe into a feed zone in the centre of the conveyor. After acceleration, centrifugal force causes feed material to pass through a series of feed ports to the bowl where it forms an annular layer. Within this layer, the solid particles of greater specific gravity than the liquid are sedimented under the high centrifugal force. Continued admission of slurry to the bowl allows the clarified liquid to build up and to overflow over adjustable weirs at the cylindrical end of the bowl. Action of the screw conveyor, which rotates in the same direction as the bowl but at a slightly slower speed, conveys the sedimented solids in the opposite direction out of the liquid layer (i.e., drying zone or beach) and through discharge ports at the conical end of the bowl.

Various clarification plant configurations incorporating two-phase and three-phase decanters have been tried. A three-phase decanter allows two immiscible liquid phases with different densities to be separated and discharged from the cylindrical end of the bowl, while the sedimented solids are discharged from the conical end.

Two-phase decanters have primarily been used in palm oil mills for separating out the suspended solids, which may subsequently be dried using a rotary drier. It is claimed that up to 70 percent of the suspended solids and 20 percent of the dissolved solids can be separated by the decanter. Installing them prior to oil clarification leads to reduction in the amount of water
needed to facilitate oil clarification. Nevertheless, they are normally used for treating the underflow from the clarification tank since this leads to lower oil loss in the cake. No significant reduction in the amount of POME is achievable in the latter case, since water is still needed to facilitate oil settling in the clarification tank.

5 The use of a three-phase decanter makes possible oil clarification and separation of the suspended solids concurrently. If press liquor is used as the feed to a three-phase decanter, it is possible to replace both the clarification tank and sludge centrifuge. This not only reduces the amount of water needed to facilitate oil clarification significantly, but also greatly simplifies the clarification process. Nevertheless, the oil loss was observed to be higher than with the conventional process. Nowadays, three-phase decanters are normally used in large capacity mills, with or without sludge separators, for treating the underflow from the clarification tank. As in the case of two-phase decanters, no significant reduction in the amount of POME is achievable since primary oil/sludge separation using clarification tanks is still needed.

The use of a special two-phase decanter that makes possible oil/sludge separation using a zero-dilution clarification process has recently been suggested. Unlike other two-phase decanters that focus on separating out the suspended solids, this decanter's main function is to achieve efficient oil/sludge separation. The decanter does not have the drying zone found in a typical decanter. The amount of POME can be reduced to about 0.4 tons per ton of FFB processed in a mill using the new clarification process.

The use of an evaporator system has also been suggested for removing moisture from POME. The use of an evaporator to treat POME suffers from a number of significant disadvantages. The high moisture content and large quantity of raw POME means that the load on the evaporator system will be high. Nevertheless, concentration beyond 20 to 30 percent solids is not possible because the product becomes highly viscous. The use of a decanter to minimize the suspended solids concentration before evaporation and a drier to increase the solids concentration beyond 20 to 30 percent after evaporation adds to the cost. The need to burn empty fruit bunches to meet the very high energy demands of the evaporator and drier systems also add to the overall cost.
In consideration of the large quantity of POME discharged from the conventional milling process, and the failure of existing effluent treatment methods to address this problem, there is an urgent need in the art for a means to significantly reduce the amount of POME discharged from a palm oil mill.

SUMMARY OF THE INVENTION

It is an objective of the present invention to provide a simple and cost-effective method for extracting crude palm oil from fresh fruit bunches that significantly reduces the amount of effluent discharged from palm oil mills, making it viable to treat the POME using zero-discharge approaches that were previously considered to be not technically and/or economically viable. For example, the POME from mills using the new extraction process can possibly be dried or co-composted with empty fruit bunches. Hence, palm oil mills will be made more environmentally-friendly.

It is a further objective of the present invention to provide a method for the extraction of crude palm oil that can be more easily automated than the prior art methods, thereby facilitating monitoring and control from a control room.

It is a further objective of the present invention to provide a method for the extraction of crude palm oil that requires significantly less processing time than the conventional clarification method. The shorter processing time will lead to improvements in oil quality.

The above objectives are achieved in the present invention by providing a method for extracting crude palm oil from the press liquor obtained from FFB that comprises the steps of firstly removing the coarse fibrous solids and sand in the said press liquor to form a clean press liquor, secondly reducing the moisture content of the clean press liquor to form a concentrated liquor, and thirdly clarifying the concentrated liquor into a sludge phase and an oil phase for further processing to obtain crude palm oil. The feature that characterizes the novelty of the invention is the second step, where the moisture content of the clean press liquor is reduced using an evaporator prior to clarification in the third step.
The concentrated liquor from the evaporator is clarified using a clarification system that is capable of achieving the separation of oil from sludge without water addition and without significantly increasing the oil loss from the clarification process compared to the prior art methods. Naturally, a plurality of evaporators or any other suitable moisture-extracting system that is capable of reducing the moisture content of the liquor expelled by screw presses may be used in step two of this invention.

According to the present invention, the method thereof may be adapted for FFB that may be sterilized using either the conventional batch sterilization process or the patented continuous sterilization process (Malaysian Patent Number MY-121530-A) or any other suitable sterilization process. The amount of effluent produced by the continuous sterilization process is significantly less than the batch sterilization process. Much of the effluent from a conventional mill is due to heating up of the sterilizer vessels and cages during the start-up of each batch sterilization cycle. The continuous sterilization process is not subjected to the heating-cooling cycle typical of the batch sterilization process, and is therefore preferred for significantly reducing the quantity of effluent discharged.

According to the present invention, at least one multiple-effect evaporator system is used to remove moisture from the press liquor prior to oil clarification. The presence of a significant quantity of oil in the press liquor makes possible the use of a multiple-effect evaporator system to remove moisture using a fraction of the energy required by a drier system to remove an equal amount of moisture from POME, especially if heated air is used to supply the energy for drying.

The significant energy savings can be explained by using the following example. If we consider the heat balance of a single-effect evaporator, we find that the heat content (enthalpy) of the evaporated vapour is approximately equal to the heat input on the heating side. About 1 kg/hr of vapour will be produced by 1 kg/hr of live steam, as the specific evaporation heat values on the heating and product sides are about the same. If the vapour produced is used as heating steam in a second effect, the energy consumption of the overall system is reduced by 50 percent. This principle can be continued over further effects to save even more energy. The theoretical steam consumption of a triple-effect evaporator system is therefore one-third
of the steam consumption of a single-effect evaporator system for an equivalent evaporation load.

Evaporation of moisture from the press liquor according to the present invention provides a number of advantages compared to evaporation of moisture from POME as proposed in a prior art method. The presence of approximately 50 percent oil in the feed to the evaporator ensures that the evaporated liquor does not become viscous. Fouling of evaporator tubes will be significantly less, even if a large percentage of the moisture in the feed is removed. Also, the quantity of moisture to be removed from the undiluted press liquor is significantly less than the quantity of moisture to be removed from raw POME in a conventional mill. The overall energy demand of the new oil extraction process can probably be met using just fibre and shell as the energy sources, making it unnecessary to burn the empty fruit bunches.

Removing moisture from the press liquor may also help to minimize the formation of the third layer that inhibits oil/sludge separation during the oil clarification process.

According to the present invention, the separation of oil from sludge is achieved using a clarification system that can process the viscous liquor after evaporation without water addition. Many factors affect the efficiency of the oil/sludge separation, including the moisture content of the feed. A distinction should be made between free and bound moisture. The removal of a significant quantity of moisture will result in the remaining moisture being mostly bound to the sludge solids.

The bulk of the oil can be separated quite easily using a settling tank or a decanter. The decanter may be a two-phase decanter or a three-phase decanter. A decanter makes possible the use of very high g-force to achieve the separation of oil from sludge. If a significant amount of the moisture in the feed to the decanter still exists as free moisture, a decanter with no drying zone can be used, similar in design to that used in a prior art method, for facilitating the oil/sludge separation without water addition using just one processing step.

If the sludge phase from the oil/sludge separation step has a low oil content, it is discharged directly as effluent, otherwise it undergoes further treatment using an oil recovery system.
step before it is discharged. To minimize the quantity of effluent, this separation is also achieved without water addition. The actual method used will depend on the moisture content of the sludge.

Mechanical separation using a two-phase decanter, a three-phase decanter, a rotary press or a membrane filter press is possible if the moisture content is low. The nozzle-based sludge centrifuge used in the conventional clarification process should be avoided due to the much higher viscosity of the sludge. A screw press can be used if the sludge can first be mixed with fibre from the kernel extraction process. The oil recovered by this oil recovery step will most likely be contaminated with water and solids, and is therefore recycled back to the oil/sludge separation step for further processing.

According to the present invention, the oil in the sludge from either the oil/sludge separation step or the oil recovery step can be recovered by drying the sludge to a low enough moisture content to facilitate using a solvent extraction process. To justify investing in the setting up of a solvent extraction plant, it may be necessary to consider recovering the sludge oil from a number of crude palm oil factories using a single solvent extraction plant.

According to the present invention, a portion of the oil phase from the oil/sludge separation step may be recycled back to the evaporator system to increase the oil content of the feed to minimize fouling of the evaporator tubes.

By combining the continuous sterilization, evaporation and zero-dilution clarification processes, it will be possible to achieve more than 50 percent reduction in the quantity of POME.

**BRIEF DESCRIPTION OF THE DRAWINGS**

Figure 1 illustrates schematically the conventional crude palm oil extraction process using oil palm fresh fruit bunches as the feed.
Figure 2 illustrates one embodiment of the present invention using undiluted press liquor as the feed.

Figure 3 illustrates another embodiment of the present invention that facilitates the recovery of the residual oil in the sludge by solvent extraction.

Figure 4 illustrates the integration of the first embodiment of the present invention with the batch sterilization process.

Figure 5 illustrates the integration of the first embodiment of the present invention with the continuous sterilization process.

In describing the preferred embodiments of the invention, which is illustrated in the drawings, specific terminology will be resorted to for the sake of clarity. However, it is not intended that the invention be limited to the specific terms so selected and it is to be understood that each specific term includes all technical equivalents which operate in a similar manner to accomplish a similar purpose.

DESCRIPTION OF PREFERRED EMBODIMENTS

The liquor 51 expelled from screw presses is first fed to screening means 52 as illustrated in Figure 2 to remove the coarse fibrous solids 52a that are subsequently recycled. The screened liquor is heated to approximately 95°C and fed to desanding means 53, such as a cyclone desanding system, for sand (53a) removal before it enters evaporation means 54 as clean press liquor (53b).

Evaporation means 54 is used to reduce the moisture content of the liquor expelled by the screw presses. A multiple-effect falling film evaporator is preferably used as this evaporator has high heat transfer coefficients and can operate at small driving forces, and is less susceptible to scaling. It also permits very short product contact times, typically just a few seconds per pass. A multiple-effect forced circulation evaporator may also be used for this purpose.
The liquor 55 from evaporation means 54 is stored in a holding tank, which also serves as the feed tank for oil/sludge separation means 56. The contents of this tank are agitated to keep the product homogenous. This is achieved by an agitator or by direct steam injection. It is essential that the product fed to oil/sludge separation means 56 has a temperature of approximately 95° C.

The liquor 55 from evaporation means 54 is clarified using a zero-dilution clarification process. The bulk of the oil can be separated without water addition using oil/sludge separation means 56. This separation can be achieved by gravity using a settling tank or by centrifugal force using either a two-phase or a three-phase decanter. If the moisture content of the feed is high, much of the recoverable oil can be separated using a two-phase decanter with no drying zone, similar in design to that used in a prior art method, and no further treatment of sludge phase 61 to recover oil will be required.

If sludge phase 61 from oil/sludge separation means 56 contains oil that is recoverable, it is further treated using oil recovery means 62 before it is discharged as effluent. This oil recovery is also achieved without water addition using a two-phase decanter, a three-phase decanter, a rotary press, a membrane filter press or other equipment that can be used to achieve a similar objective. A screw press may be used if sludge phase 61 can first be mixed with fibre from the kernel extraction process.

The oil 63 recovered by oil recovery means 62 will most likely be contaminated with water and solids, and is therefore recycled back to oil/sludge separation means 56 for further processing.

In another preferred embodiment of the present invention, as illustrated in Figure 3, the sludge phase 61 or 64 respectively from either the oil/sludge separation means 56 or the oil recovery means 62 may be dried using drying means 65 as shown in Figure 3 to a moisture content of less than 15 percent and the oil in dried sludge 66 extracted by solvent extraction means 67 to produce dried and de-oiled sludge 68.

The oil phase 57 from oil/sludge separation means 56 is discharged into a holding tank and is further processed using purification means 58 to remove traces of dirt in the oil to form
a purified oil phase (58a) that is subsequently dried using drying means 59 to obtain crude palm oil (60).

Figure 4 illustrates how the present invention can be integrated with the rest of the milling process in a conventional palm oil mill, where sterilization is carried out using the batch sterilization process. The FFB 30 are cooked during the sterilization process 31 using steam at a pressure of 3 bar in horizontal autoclaves of cylindrical shape for about 60 to 90 minutes. To raise the temperature of bunches quickly to a sufficiently high temperature, it is necessary to remove the air in the sterilizer. This is partially achieved by steam sweeping at the start of the sterilization cycle. Removal of air from spaces within the bunch is, however, dependent on diffusion and must be assisted by intermediate blow-offs (i.e. multiple pressure peaks). A large amount of condensate is formed (i.e., approximately 20 percent of the FFB processed) and must be removed from sterilization process 31 if it is not to interfere with the heat transfer during sterilization. All or a portion of this condensate may be mixed with feed 51 to screening means 52.

The sterilized fruit bunches 32 are sent to stripper 33. The objective of stripping is to separate the sterilized fruits from the empty fruit bunches. The sterilized fruits 34 from stripper 33 are reheated to loosen the mesocarp from the nuts in preparation for pressing. This is carried out in the steam-heated digesters 35. Digesters commonly used are vertical cylindrical vessels with rotating shafts to which are attached stirring arms. These arms agitate the fruits, loosening the mesocarp from the nuts and, at the same time, breaking open as many of the oil cells as possible. The temperature of the digested fruit must be close to 100°C, which can be achieved by fitting the digester with a steam jacket or using live steam injection or a combination of both.

The screw press 36 consists essentially of a perforated cage in which runs either one or two screws. Cones restrict the discharge from the cage, and it is this restriction that creates pressure in the cage and thus controls the amount of de-oiling of the digested fruit mesh. The screw press 36 expels liquor 51 consisting of oil, water and finely divided solids, and a press cake of fibre and nuts.
The press liquor 51 is subjected to further processing using the present invention as described earlier. The amount of POME is reduced to less than 0.4 tonnes per tonne of FFB processed by combining the batch sterilization process with the new oil extraction process.

Figure 5 illustrates how the present invention can be integrated with the patented continuous sterilization process. In this process, the closed-knit arrangement of the spikelets in FFB 40 is first disrupted using double-roll crusher 41. The crushed bunches 42 are heated using live steam at low pressure during sterilization process 43 to facilitate continuous processing. Although the sterilization process 43 is carried out using steam at low or atmospheric pressure, the process significantly improves the strippability of bunches compared to the batch sterilization process.

The amount of condensate discharged by the continuous sterilization process 43 is significantly lower than the batch sterilization process. This is because the continuous sterilization process is not subjected to the heating-cooling cycle typical of the batch sterilization process. Also, the bulk of the sterilizer condensate is trapped and discharged with bunches from the continuous sterilizer and is eventually discharged from the mill with the sludge from the clarification process.

The extent of cooking achieved by the continuous sterilization process 43 is insufficient to optimize the oil and kernel extraction by the rest of the milling process. The fruits from the continuous sterilization process 43 are therefore further heated after stripping 45 using post-heating process 47.

Digestion 49 is carried out using either the conventional vertical digester described above or a new horizontal digester. The fruits are heated and agitated during digestion to loosen the mesocarp from the nuts and to break open the oil cells to facilitate oil recovery during pressing. The main advantage of using the horizontal digester is a slightly lower oil loss in the press cake due to improved drainage from the digester.

The press liquor 51 is subjected to further processing using the present invention as described earlier. The amount of POME discharged from the palm oil milling process can be
reduced to less than 0.3 tons per ton of FFB processed in a mill using the continuous sterilization and the new crude oil extraction processes.

The embodiments of the invention described herein are only meant to facilitate understanding of the invention and should not be construed as limiting the invention to those embodiments only. Those skilled in the art will appreciate that the embodiments of the invention described herein are susceptible to variations and modifications other than those specifically described. It is to be understood that the invention includes all such variations and modifications which fall within the scope of the inventive concept thereof.
1. A method for extracting crude palm oil from press liquor obtained from oil palm fresh fruit bunches that reduces the amount of effluent discharged and comprising the steps of:

5 (a) removing the coarse fibrous solids (52) and sand (53) in said press liquor (51) to form a clean press liquor (53b);

(b) reducing the moisture content of said clean press liquor (53b) to form a concentrated liquor (55); and

(c) separating (56) the oil from sludge in said concentrated liquor (55) into a sludge phase (61) and an oil phase (57) for further processing to obtain crude palm oil (60).

2. A method according to Claim 1, wherein the moisture content of said clean press liquor (53b) is reduced by at least one evaporation means (54).

3. A method according to Claim 2, wherein the said at least one evaporation means (54) is a multiple-effect falling film evaporator.

4. A method according to Claim 2, wherein the said at least one evaporation means (54) is a multiple-effect forced circulation evaporator.

5. A method according to any one of the preceding Claims, wherein said coarse fibrous solids in said press liquor (51) are removed by screening (52) before desanding (53).

6. A method according to Claim 5, wherein said press liquor (51) is heated to approximately 95°C before desanding (53).
7. A method according to any one of the preceding Claims, wherein the removed coarse fibrous solids (52a) are recycled.

8. A method according to any one of the preceding Claims, wherein the sand (53a) is removed using a cyclone desanding system.

9. A method according to any one of the preceding Claims, wherein oil/sludge separation (56) is effected without water addition.

10. A method according to Claim 9, wherein the means for effecting said oil/sludge separation (56) is a decanter.

11. A method according to Claim 10, wherein said decanter is a two-phase decanter.

12. A method according to Claim 10, wherein said decanter is a three-phase decanter.

13. A method according to Claim 9, wherein the means for effecting said oil/sludge separation (56) is a settling tank.

14. A method according to any one of Claims 9 to 13, wherein the oil content of said sludge phase (61) from said oil/sludge separation (56) is reduced to a level sufficiently low to permit discharge of said sludge phase as effluent without further treatment to recover residual oil therein.

15. A method according to any one of Claims 9 to 13, further comprising the steps of:

   (a) drying said sludge phase (61) from said oil/sludge separation (56) to produce a dried sludge; and

   (b) extracting the residual oil in said dried sludge using a solvent.
16. A method according to any one of Claims 9 to 13, wherein said sludge phase (61) from said oil/sludge separation (56) is further treated using oil recovery means (62) to recover residual oil in said sludge phase without water addition.

17. A method according to Claim 16, wherein said oil recovery means (62) is a decanter.

18. A method according to Claim 17, wherein said decanter is a two-phase decanter.

19. A method according to Claim 17, wherein said decanter is a three-phase decanter.

20. A method according to Claim 16, wherein said oil recovery means (62) is a membrane filter press.

21. A method according to Claim 16, wherein said oil recovery means (62) is a rotary press.

22. A method according to any one of Claims 16 to 21, further comprising the steps of:

   (a) adding fibre from the kernel extraction process to the sludge phase (61); and

   (b) recovering said residual oil in said fibre-enriched sludge phase using a screw press as said oil recovery means (62).

23. A method according to any one of Claims 16 to 22, wherein the oil recovered by said oil recovery means (62) is recycled back (63) to said oil/sludge separation means (56).

24. A method according to any one of the preceding Claims, wherein a portion of said oil phase (57) is recycled back to increase the oil content of the feed to said evaporation means (54).
25. A method according to any one of the preceding Claims, further comprising the steps of:

(a) processing said oil phase (57) using purification means (58) to remove traces of dirt in the oil; and

(b) drying the purified oil phase (58a) using drying means (59).

26. A method according to any one of the preceding claims, further comprising the steps of:

(a) drying (65) said sludge phase (64) from said oil recovery means (62) to produce a dried sludge (66); and

(b) extracting the residual oil (67) in said dried sludge (66) using a solvent.

27. A method according to any one of the preceding Claims, wherein the said method is adapted for a milling process using the batch sterilization technique.

28. A method according to any one of Claims 1 to 26, wherein the said method is adapted for a milling process using a continuous sterilization technique.
Figure 1
(Prior Art)
Figure 2
Figure 3
fresh fruit bunches

condensate

batch sterilization

empty fruit bunches

striping

fibrous solids

digestion

press cake (to kernel plant)

pressing

screening

sand

desanding

water

evaporation

oil + sludge

studge phase

oil/sludge separation

oil phase

dirt

purification

drying

sludge

crude palm oil

Figure 4