Wastie & D.A. Earp, Kuala Lumpur, Incorporated Society of Planters, 1973.
8. Southworth, A., Field Factors Affecting Quality, The Planter, pp. 440-451, 1979.
9. Wood, B.J., et al. A Preliminary Report on a Long-Term Study of the Effect of Oil Palm Harvesting, Strategy on Product Recovery, Including a Comparison Before and After Weevil Pollination, Symposium on Impact of the Pollinating Weevil on the Malaysian Oil Palm Industry, Kuala Lumpur, 1984.
10. Clegg, A.J., An Analysis of Damage Incurred by Oil Palm Bunches During Handling and Transport, in Advances in Oil Palm Cultivation, edited by R.L. Wastie & D.A. Earp, Kuala Lumpur, Incorporated Society of Planters, 1972.
11. Bek-Nielsen, B., Factors Responsible for the Development of Peroxides During Production and Handling of Palm Oil, ISP Conference on Quality & Marketing of Oil Palm Products, 1969.
12. Jacobsberg, B., Quality of Palm Oil, PORIM Occasional Paper No. 10, Palm Oil Research Institute of Malaysia, 1983.
13. Bek-Nielsen, B., Palm Oil and Kernel Extraction Plants in Relation to Quality, ISP Conference on Quality & Marketing of Oil Palm Products, 1969.
14. Chan, K.S., IKM Conference on Chemical Research, Kuala Lumpur, 1979.
15. Chong, C.L., and Ab. Gapor Mohd Top, Effects of Moisture and Trace Metals on Oil Quality, PORIM Workshop on Quality in the Palm Oil Industry, Kuala Lumpur, 1983.
16. Mongana Report, Research on Production and Storage of Palm Oil, Congo Palm, 1952-1955.
17. Bek-Nielsen, B., Quality Aspects of Oil Palm Kernel Production, ISP Conference on the Quality and Marketing of Oil Palm Products, 1969.
18. Lim, K.H., D.A.M. Whiting, & C.S. Chia, Magnetic Traps for Removal of Iron in Crude Palm Oil from an Estate Factory, International Conference on Palm Oil Product Technology in the Eighties, Kuala Lumpur, 1981.
19. Juran, J.M., Quality Control Handbook, 3d edition, New York, McGraw-Hill.

Treatment of Empty Fruit Bunches for Recovery of Residual Oil and Additional Steam Production

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ABSTRACT

The fiber and shells in fresh fruit bunches (FFB) are important as fuel in a standard palm oil milling process, with the empty bunches being incinerated or mulched for fertilizer application to oil palms. However, dewatering the empty bunches in an additional pressing station can substantially enhance the available energy. Recovery of residual oil which results from the pressing of the empty bunches is an attractive economic proposition in itself, especially with the change in the composition of the fresh fruit bunches as a result of the introduction of the weevil. The resultant fibrous material serves as valuable fuel for steam generation which can be profitably used for further downstream processing, especially where a refinery is located near a palm oil mill.

INTRODUCTION

Production of energy from waste material is more than adequate for efficient operation of a standard palm oil mill. However, the pressing of empty bunches makes more fuel available for the production of steam for activities further downstream, such as kernel oil extraction, palm oil refining and possibly cocoa drying.

The value of the empty oil palm bunch has so far been neglected due to the following reasons:

- The assumed low level of residual oil,
- The high water content of about 65% (low fuel value), and
- The difficulty in handling due to its bulky and fibrous nature.

The initial aim was to dewater the empty bunches to render them suitable for boiler fuel.

The pressing operation soon revealed that the average residual oil content in the empty bunch was higher than the anticipated 0.5% to empty bunch, and that the oil was easily recovered from the press liquid, drastically changing the economic aspect of the pressing operation.

At Jendarata, where the oil mill and the refinery are situated side by side, steam is supplied from the oil mill to the refinery, hence the requirement for all additional energy. The system under review has been developed over the past two years at the Jendarata palm oil mill and has been in operation on a continuous basis over the past 8 months, processing all empty bunches from the mill.

THE PROCESS

The empty bunches are removed from the conveyor normally transporting the bunches to the incinerator and are dropped through a chute provided with large circular saw blades mounted on a common shaft. The bunches are split longitudinally and are then passed onto large single worm screwpresses for dewatering and removal of residual oil (Fig. 1).

Manual transfer of bunches to the station is essential to ensure that only well-sterilized and stripped bunches are transferred, while the understerilized and partly stripped bunches (which might overload the press) are left on the conveyor and transferred to cages for resterilization. Further splitting of the hard bunches sent for recycling is quite easily arranged by the installation of a circular saw splitting mechanism into the chute leading to the sterilizer cage. The pressed empty bunches approximate palm press fiber in fuel value, and are passed on to the boiler platform to be burned in conventional boilers for additional steam generation.

The calorific values of palm wastes are 3460 cal/g of empty bunch (dry), 4420 cal/g of mesocarp (dry), and 4848 cal/g of shell.

Oil recovery

The average oil recovery from empty bunches is recorded over a period of 6 months at a minimum of 1.5%. At the ratio of 23% empty bunch to FFB this is equivalent to 0.35% oil to FFB.

The press liquid

The press liquid is passed through the conventional system of thermal heating and centrifugal separation of oil from the liquid. The separation process is efficient because almost all of the oil present in the press liquid is free oil.

DESCRIPTION OF MACHINERY

Bunch Splitting

The empty bunches are split by circular saw blades mounted on a common shaft and placed in the feed chute of the screw press.

The Screw Press

The sliced empty bunches are fed into a single worm screw press (Fig. 2). The screw is specially developed for the purpose with a tapering cone for gradual compression over the full length of the press cage.

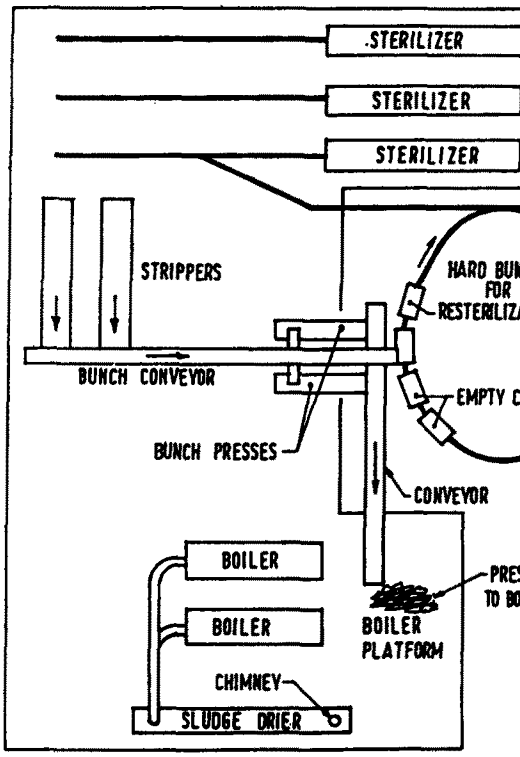

FIG. 1. Dewatering of empty bunches.

There is no pressure cone at the press discharge. Experience has shown that hard facing of the screw is essential. The press cage is of stainless steel. Live steam is injected into the low-pressure end of the press cage for increased lubrication and higher pressing efficiency. The capacity of the press is 5 tons empty bunches per hour.

Steam Boilers

The dewatered and split empty bunches burn particularly well in boilers with a stepgrate furnace, but the bunch waste is also successfully burned in high-rated flat grate furnaces provided overfeeding is avoided.

OIL MILL ENERGY SOURCES

The standard palm oil mill processing the Tenera variety of fruit will have large volumes of waste material available for production of steam and electricity. After oil extraction, waste material consists of about 23% empty bunches containing about 65% water, 11% fiber containing 40% water and 7% shells containing 10% water.

For several reasons, the empty bunches have not been used as fuel, i.e., their high water content renders them unsuitable as boiler fuel, and the energy from burning the available shell and fiber is sufficient for normal operation of the mill.

The fiber and shell from 1 ton Tenera FFB provides a potential heat supply of:

110 kg of fiber at 4420 x 0.6 cal/gm	291,720 kcal
70 kg of shell at 4848 x 0.9 cal/gm	305,424 kcal
Total:	597,150 kcal

At a boiler efficiency of 60% the useful heat of fiber and shells will produce:

$$\frac{597{,}150 \times 0.60}{620} = 578 \text{ kg steam/ton FFB}$$

In the event the empty fruit bunches are dewatered and burned, the additional steam per ton FFB will be:

230 kg empty bunch at 65% moisture dewatered to 161 kg at 45% moisture.

NHV of the dewatered empty bunch would be 3460 x 5.5 = 1903 kcal, hence:

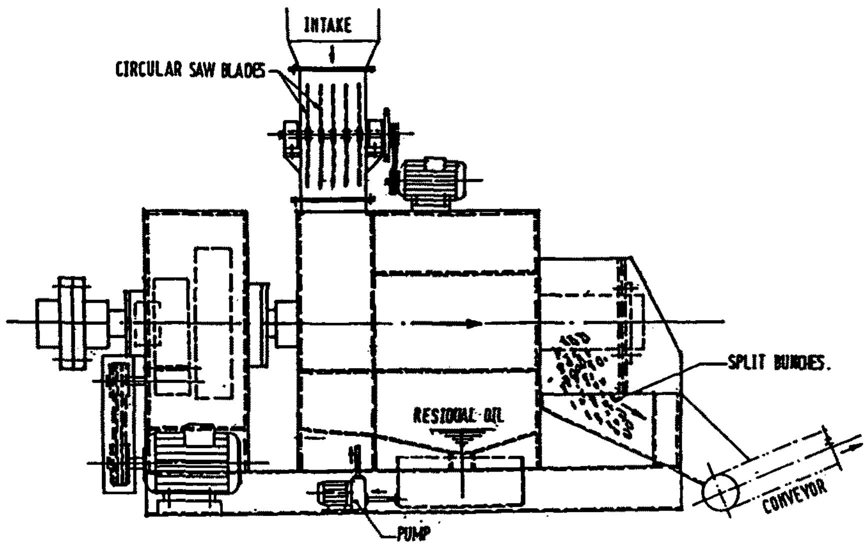

FIG. 2. Single worm screw press for empty bunches.

161 kg empty bunch @ 1903 cal/gm 306,383 kcal

At a boiler efficiency of 60% the useful heat of empty dewatered bunches from 1 ton FFB will be:

$$\frac{306{,}383 \text{ kcal} \times 60\%}{620} = 296.5 \text{ kg steam/ton FFB}$$

An increase in available steam of 51% occurs (Fig. 3).

ECONOMIC CONSIDERATIONS

Additional Steam Production

Although most mills will have a surplus steam-generating capacity of 15-20% from burning all shells and fiber depending on the size of the mill and type of the equipment installed, only steam production from burning of the dewatered empty bunches is considered in the following calculations.

At present all palm oil refineries are heated by heavy fuel oil at an average cost in fuel of $36/ton steam produced. Based on this figure the fuel value of the empty bunches from one ton FFB will be:

296.5 kg steam @ $36/ton = $ 10.67

In an oil mill processing 100,000 tons FFB/year the potential revenue would come to:

100,000 x 10.67 $1,067,000/year

Recovery of Residual Oil

Investment cost: 2 single screw presses with bunch splitter inclusive of installation etc. = $ 300,000

Operational Cost: Throughput 100,000 ton/FFB year @ 23% bunch to fruit is 23,000 tons bunch/year.

Cost of maintenance at $3/ton empty bunch	=	$ 69,000
Cost of labor at $3/ton empty bunch	=	$ 69,000
Total operational cost	=	$138,000

Revenue:

Throughput 100,000 tons FFB/year
Oil to FFB 0.35%
Oil Value $1,000 tons
Oil produced @ 0.35% = 350 tons
Income from sale of oil = 350 x 1,000
= $350,000

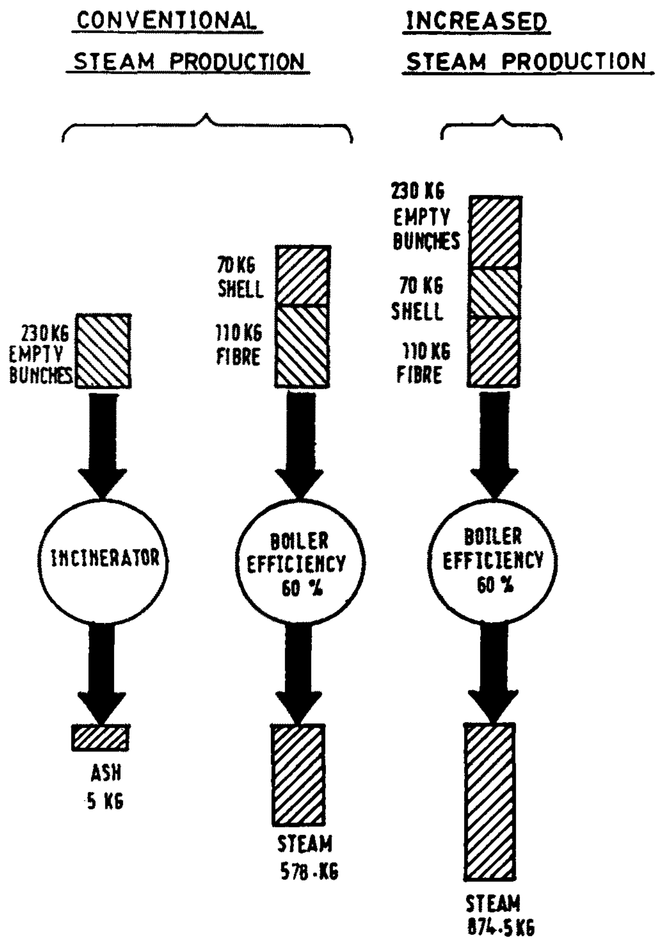

FIG. 3. Palm waste from 1 ton fresh fruit bunches.

Return on investment:

Income from sale of oil	-	$350,000
Less: Cost of operation	-	$138,000
Depreciation (300,000 @ 10%)	-	$ 30,000
Return on investment	=	$182,000

ACKNOWLEDGMENT

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Session III Discussion

The following questions, answers and comments were presented during the informal discussion held at the conclusion of the day's plenary talks.

Q: Is technology available for continuous sterilization of FFB?

Southworth: The objective of sterilization is to sterilize bunches so as to give complete stripping of fruit from bunch with minimum oil loss on stalk and at lowest cut. Continuous sterilization is likely to be as cheap as conventional batch process. It therefore must be advantageous in terms of efficiency of stripping of bunches or in terms of oil loss. I imagine that engineering technology is available but so far as I know no one is currently either using or working on such a system.

Q: It was said that the hexane usage is 10.5 liter/ton (or about 1.05% weight). Is this figure specifically for palm kernel? Is it a figure on direct solvent extraction or prepressing before solvent extraction? How is the figure for other material, e.g. soybean? Do you have any data?

Tang: The figure of about 1.5 liters/ton for palm kernel is based on our own experience and discussion with other processors. The figure is quite similar for both of the processes. No, sorry.

Comment, Neoh Soon Bin: It is about 2 liters/ton for soybean. The latest plants offered by manufacturers have guaranteed solvent loss figure of 4 kg/ton.

Q: What is the best condition to pre-press palm kernel with respect to temperature, moisture content and press-pressure?

Tang: Cooking temperature around 104 C-110 C, moisture 3%-5%, press-pressure depends on the design of the screw press. However, conditions also depend on the quality of the kernel and need to be changed when necessary.

Q: Palm kernel meal normal composition have been commonly centered in the following parameters: protein, fat moisture, shell dirts (ash and silica), fiber and starch. It has been known, however, by observation, that the total composition of the above parameters by percentage does not add up to the numerical value of 100% upon analysis. Could you elaborate if there are any additional parameters or an explanation for the above phenomenon? Also, there have been ongoing attempts by the trade to verify authenticity in palm kernel meal; what would you recommend, if any, as reliable criteria other than the normally subjective microscopic admixture verification?

Tang: In normal circumstances, carbohydrate is usually not analyzed by itself. It is obtained by subtracting from 100% the total content of other parameters such as protein, fat, moisture, fiber and ash. I have no comment regarding the possible presence of other constituents. Palm kernel cake/pellet has a characteristic range of protein content of about 14%-16%. Any large variation from this probably could be indicative of contamination or adulteration. Perhaps a detailed analysis of the amino acid composition may be used as an indication of authenticity of the meal.

Q: Are there noticeable traces of aflatoxin content of the cake or even palm oil produced by any of the processes mentioned? If there is any, what are the recommended measures to minimize or even prevent its occurrence?

Tang: No. There has been no complaint of aflatoxin traces in Malaysian palm kernel oil, cakes or pellets. This can be attributed to the high standard of quality control and storage management practiced in this country. The main precaution required is to control the moisture content of the cakes and pellets.

Q: It is observed that FFA of resulting palm oil products ranges from 3% to 4%, which is high relative to the coconut industry standard. Is this an indication of non-profitable operation of palm oil extraction with respect to (a) raw material preparation cost and (b) no incentives in producing low FFA products?

Tang: FFA of the extracted oil is affected by the time lapse between harvesting and processing, the degree of ripeness, and the handling of bunches prior to processing. By carefully controlling the degree of ripeness of the bunches in harvesting and by ensuring minimum handling and early processing of the bunches, low FFA oils, e.g. SPB or SQ oils, can be produced. A price premium is of course expected for such premium oils.

Q: With all the recent research and development and the use of improved methods of harvesting and extraction, it is puzzling to note that SIRIM is proposing a FFA content of 5% max for the draft standard for crude PKO oil. We feel this figure is rather high. Even your figures for FFA from export from Butterworth/Port Kelang are much lower than the proposed figure of 5% max. What is your view on this and what do you feel would be a more realistic figure?

Tang: Results given in the slides are based on shipped quality. Allowance must be made for inevitable increase during voyage and transshipment. The SIRIM standard was adopted many years ago and I understand that it currently is under review. PORIM has started another national survey on the quality and characteristics of palm kernels and its products. When this is completed, more representative and up-to-date data will be available for formulating a revised standard.

Comment, Lim Kang Hoe: After the introduction of the weevil, kernel extraction rates increased. The existing process causes more broken kernels and this results in higher FFA.

Q: In your solvent extraction process for PKO, what specification do you impose on hexane level in the crude PKO? How do you monitor the hexane level in these oils derived from solvent extraction?

Tang: Normally, solvent residue is not measured as a routine. Flash point is checked instead, and this should be above 150 C. At this flash point, hexane residue is about 800-1000 ppm. The most accurate method is by gas chromatography. However, it is much more convenient to check the flash point. A calibration graph is prepared by measuring the flash point of palm kernel oils containing known amounts of added hexane. From the measured flash point, one can then estimate the residual hexane content in the oil.

Q: What is the residence time in the extractor and do you have any problems with fires that prevent percolation and drainage?

Tang: The pre-expelled cake should not be subjected to too high a pressure (compression) or temperature so as not to burn the cake. If this happens, chances are the hexane will not percolate through the bed of meal. The pre-expelled cake which has not been subjected to high compression and temperature is still "fluffy" and this helps in the percolation.

Q: Can the speaker give us some names and addresses of activated carbon (from coconut shell) process suppliers?

Augustine: Pacific Activated Carbon, BO. Garcia, Tagaloan, Misamis Oriental, Philippines, or Room 402 Cattleya Condominium, 235 Salcedo St. Legaspi Village, Makati, Metro Manila, Philippines; Davao Central Chemical, Bunawan, Davao City, Philippines; Philippine Japan Active Carbon, Nalagamot, Panacan, Davao City, Philippines; and Cenapro Chemical Corp., Jagobiao, Mandaue City, Cebu, Philippines.

Q: In the production of activated carbon from coconut shell, how much activated carbon can be produced from one ton of coconut shell?

Augustine: 3,597 MT coconut shell = 1 MT charcoal = 0.25 MT activated carbon.

Q: Would you kindly describe the dewatering process of empty bunches with respect to expeller design, applied pressure, power requirement, and final moisture content of the dry bunches?

Krishnan: The design is much like a single screw press. A pressure of 2,000-3,000 psi is applied. The final moisture is 45-47%.

Q: The dewatered empty bunches are more corrosive due to their high potash content. Do you foresee any problem?

Krishnan: No corrosion is detected after more than two years. The flue gas is above dew point, thus there will be no condensation and no corrosion.

Q: It is quite interesting to note that higher boiler efficiency as well as operation profitability can be achieved using fiber and shells in FFB as fuel in a boiler for steam generation. This question is

therefore directed to the availability of these fuel materials to generate steam based on a daily raw materials plant requirement. Due to its lower caloric value compared to fuel oil and coconut water (husk, shell and charcoal) is its capability to generate daily plant steam requirement still doubted?

Krishnan: As has been pointed out, with the burning of the empty bunch, about 51% more energy is obtained. One ton empty bunch can generate 1.8 tons steam.

Q: Is the quality of the oil recovered from the empty bunches the same as that from mesocarp?

Krishnan: Yes.

Q: Is the new press that was developed by your company available to the general public?

Krishnan: It will become available to the public at a later date, depending on the board of United Plantation Bhd.

Q: Could you please let us know the quality and stability of your residual oil from squeezed empty bunches in terms of FFA, PV and iron determination, etc.? What is the percentage of oil extracted from the empty bunches?

Krishnan: Provided they are processed on the same day, the FFA level is 3%, PV less than 1.5 (meq/l), P 20-25 ppm, and 3-4 ppm of iron. The empty bunch oil depends on the conditions that are also good for palm oil, like good harvesting, rapid transport, etc. In terms of empty bunches, the oil extraction is from 1.5-1.87%. In terms of FFB extraction, it is about 0.35%.

Q: To which country/countries are the activated carbons exported?

Augustine: Exports are mainly to Japan and also to the U.S. and Europe, particularly France.

Q: Is there any preservative added to coconut drinks?

Augustine: Yes, sodium benzoate.

Q: You mentioned 214 palm oil mills in Malaysia. How many of them can meet the present effluent regulations?

Ma: The actual number of mills which can meet the D.O.E. standards is not available, but there have been no complaints by the public.

Q: How is the inspection usually carried out?

Ma: It is monitoring rather than inspection. The D.O.E. monitors the performance of the system. Millers have to send in a quarterly report on their systems. The D.O.E. assesses the performance, and if there are any suspicious cases or complaints, the D.O.E. officer will visit the mill concerned and collect the discharge samples for analysis by the Chemistry Department. In case of disputes, PORIM will act as the reference laboratory.

Q: Biogas collection was expected to be economically profitable. Do you have some figures on the financial result during the last two years? How many mills are presently adopting the biogas collection?

Ma: First, there are a number of papers by Sime Darby. Second, there are four mills which recover the biogas.

Q: Is water recycling being used so as to reduce the overall waste water rate?

Ma: Yes, some mills use the treated effluent as the process water. The water from the decanter also is recycled.

Q: Have there been studies on the use of polymer flocculants for sewage water treatment in place of the decanter; what are the results, if any?

Ma: A lot of studies have been carried out, but so far, the results are not promising.

Q: To improve the quality of CPO do you think a premium scheme is necessary and would be an incentive? If so, what form should it be?

Teoh: There are at present premium oils already available on the market for those who are willing to pay for them, e.g. SPB or SQ oils.

(Various comments were given on this topic, and the general view is that a premium price is required for a premium product and as long as palm oil is traded as a general commodity, it is difficult to command premiums.)

Q: Is it economical to recover the oils from condensates, sludges, etc.? If so, what use can these oils be put to?

Teoh: The oil from the sterilizer condensate and sludge is generally recovered in pits and sold as sludge oil for non-edible uses, e.g. soaps and candles.

Q: Somewhere in June/July 1983, after the post-weevil effect was felt, there seemed to be a drop in the oil in kernels. It went down to as low as 42-43% (wet and dirty basis). Is there any explanation for the above phenomena?

Teoh: The observed phenomena could be due to over-drying of palm kernels during this low crop season and/or it also could be due to seasonal variation.

Comment, Chong Chew Let: The water level in the CPO of 0.15% to 0.25% is optional for maximizing the oxidative and hydrolytic stability of the oil upon a reasonable length of storage time by minimizing PV and FFA. In minimizing PV, it will perhaps have an indirect effect on refining later on.

Q: Is the residual oil recovered from the empty bunches mixed with the normal crude palm oil? Has the extra boiler ash generated caused any increased problem regarding disposal of the extra ash?

Krishnan: First, the residual oil is separately clarified, purified and its quality tested; it is then mixed. Second, there are no increased problems that we know of. Since the boilers will now be run 24 hours/day, the total ash will definitely be more.

Q: It has been claimed that oil reclaimed from empty fruit bunches is 1.5%. Would you please supply the following information? Oil content in shredded FFB before processing and oil to N.O.S.; oil content in shredded FFB after processing, and oil to N.O.S.

Krishnan: The oil content in terms of shredded FFB before processing is 3.0 to 3.5%; after processing, 1.8 to 2%. We have no data on the other questions.

Q: How much of the oil is actually surface oil from the empty bunches and oil from the undetached fruits?

Krishnan: Hard bunches are not sent in. If stripping is good we still get 0.35% oil to FFB. Attached fruitlets could possibly contribute to 0.5% while empty bunches contribute 2.6%.

Q: How does the oil loss in the sterilizer condensate compare to oil in empty bunches?

Krishnan: Higher pressure has little effect on oil loss. There is little relationship in oil loss between the empty bunches and condensate. Much depends on the ripeness or amount of loose fruits. Oil oozed out during stripping will be picked by the bunches.

Comment, Lim Kang Hoe: It has been found that in triple peak sterilization there is lower oil loss in the empty bunches.

Q: The oil content in press fiber is higher than that in empty bunches. Are shredding and pressing of empty bunches actually done for fuel supply rather than for oil recovery?

Krishnan: Yes, the primary aim is for better steam generation rather than oil recovery.