Quality Control in Fruit Processing

TEOH GUAN ENG, and **MUK MUN TAT,** Felda Mills Corporation, Socfin Co. Bhd.

ABSTRACT

The attainment of high-quality palm products at minimum cost demands that more emphasis be placed on the production side, i.e., the effort must be concentrated at the field and mill level. All field and mill personnel must be involved in quality control and must be responsible for the quality requirements.

A long-range effort at developing employee responsibility and job enlargement is required. For this to have a real chance of success, the following should be present:

- *Top management's commitment:* The estate manager and the mill manager are the key to assuming responsibility for quality. Estate and mill managers must be openly and actively committed to improving quality.
- *Quality policy:* Estate and mill managers must decide what level of quality they can deliver to the marketplace, as well as how they expect to accomplish their goals.
- *Quality responsibility:* Estate and mill organizations should be structured to utilize quality improvement efforts through quality control circles (QCC).
- *Quality supervision:* Field supervisors, mill foreman and mill supervisors should be trained in human relations and quality control methods.
- *Quality consultation:* Quality control department should be well run to assist field and mill personnel in establishing good quality practices and procedures.
- *Quality training:* QCC should be provided with in-house training on basic statistical tools and cause/effect diagrams.
- *Quality incentives:* Compensation of workers and QCC should be linked to reduction of product losses, reduced downtime, etc.
- *Quality recognition:* Public recognition should be provided for groups and individuals responsible for quality improvements and suggestions.
- *Quality feedback:* A well-organized system should exist to disseminate information and improve quality improvement. Continuous informal and formal interaction should occur between design and mill personnel, thereby stimulating quality improvement in the milling stage.

The activities needed to achieve high-quality palm products are scattered among many persons in many specialized departments. Some of these are in-house, while others may be a part of vendor companies, subsidiaries, etc.

INTRODUCTION

In the processing of oil palm fruit bunches (FFB) it is essential:

- To minimize the deterioration in quality of palm oil and palm kernel during their passage through the mill,
- To maintain product losses at the lowest possible level, and
- To maintain production cost at the lowest possible level.

In spite of all precautions, however, some palm oil and palm kernel inevitably escape extraction, and find their way into the solid and liquid wastes. In addition, palm oil and palm kernel do undergo some changes during their passage through the mill. The extent to which the quality of palm oil and palm kernel changes and the magnitude of such losses during the milling process depend on how much control is exercised by the mill management.

Apart from economic influences and product losses, the ability of a mill to secure income is influenced by the quality of the products produced by the mill. Good-quality products will result in better prices or greater share of the market and lower production costs as a result of less rework and reruns. On the other hand, off-quality products result in lower prices or a lesser share of the market and higher production costs as a result of more rework and reruns.

Quality control can be expected to go most of the way in minimizing product losses and in controlling product quality because the objectives of having quality control in a palm oil mill are:

- To increase productivity by getting the job done correctly the first time, and so ensuring production,
- To reduce the cost of production by: reducing product losses and associated stock problems, and reducing the amount of rework and the number of reruns,
- To achieve a factory reputation for quality by delivering product quality controlled within limits acceptable to the customer, and
- To satisfy the customer.

This paper reviews the current quality-control systems generally being practised in the palm oil mills and the developments in quality-control practices in Malaysian palm oil mills.

STATE OF THE ART

In most palm oil mills in Malaysia, quality objectives are generally achieved through a systematic approach (see Fig.

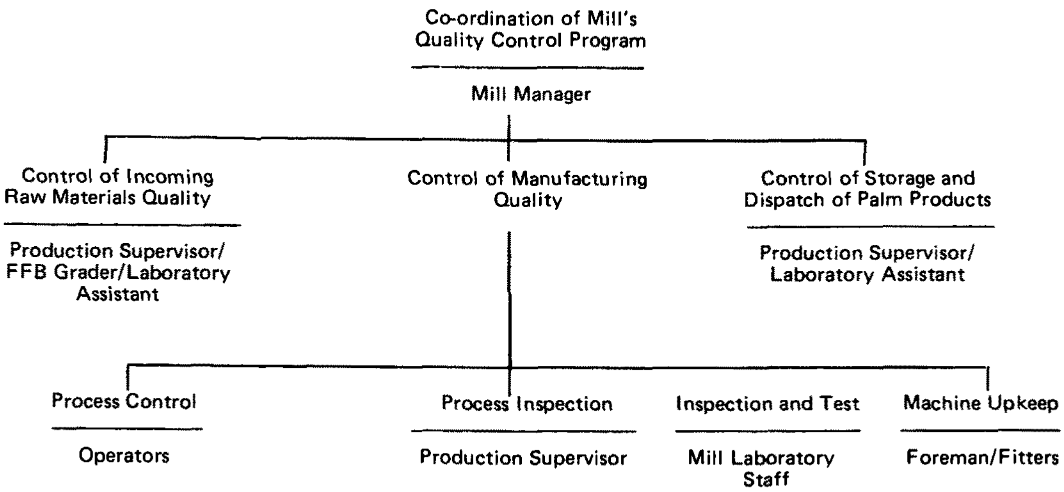

FIG. 1. A common quality-control system in a palm oil mill.

1). This consists of performing the following activities:

- Control of incoming raw materials quality (i.e., palm fruit quality),
- Control of manufacturing quality,
- Control of storage and dispatch of palm products,
- Quality coordination.

Control of incoming raw material quality

Since the quality of the final products (i.e., palm oil and palm kernel) is influenced by the quality of the incoming raw material (i.e., fruit bunches), controls are established at this stage of processing to assure that the required characteristics are present in the incoming raw materials.

Control is normally achieved by visual inspection of crop quality according to ripeness standards (an example of the inspection is shown in Table I), MPD (material passing to digester) analysis and bunch composition analysis (in mills with testing facilities).

Grading of fruit bunch quality is normally done by the mill worker (or bunch grader) under the supervision of mill production supervisors while MPD and bunch composition analysis are done by the laboratory personnel.

Control of manufacturing quality

The acid test of the adequacy of a quality control program comes during actual product manufacture. Control of manufacturing quality provides the mechanism for this phase of quality control.

Definite routines are operated by members of the quality control organization to assure that the product control activities are an integral part of the manufacturing operations. Because of the wide variety of operations in a palm oil mill, the routines cover a number of different control conditions that can be grouped under the following categories: Process control, process inspection, inspection and test and machine maintenance.

Process control The production of good-quality palm product and the prevention of excessive production losses are best served by effective process control.

At the mill level, the only people who can produce correct work are those who actually run the machines (i.e., the operators). It is of utmost importance to successful quality control that the operators be guided in a skilled, conscientious and quality-minded fashion. To achieve good quality, the operator must be provided with the means for knowing what he is supposed to do, the means for knowing what he is doing and the means for regulating what he is doing.

In order for the operator to know what is expected of him, training sessions on quality should be given periodically. These training sessions reinforce management's commitment to a quality product. During the training sessions, time can be allocated for presentations by field personnel, for discussions concerning the sources of quality variations, for methods of improving quality and variations and so on. The primary objective of the sessions is to develop an attitude of "quality mindedness."

Process inspection Having ensured that the operators are trained and provided with all the materials, equipment and information they need, it is important to see that they continue to work correctly throughout the milling process.

Since the production supervisor is the person who has the most influence for good or bad over the worker, he is responsible for seeing that the workers operate the machines/plant correctly through the following quality control activities:

- Constantly comparing the conformance of the processing conditions and product quality to the laid-down standards, and
- Seeing that corrective action is started and completed

TABLE I

FFB Quality Analysis

Fruit Inspection Results:

Estate	Year Planted	Date of Inspection	Date Harvested	No. of Bunches Examined	% Ripeness Category				Poor Fruit-Set	Diseased Bunches	Pest Damage	Empty Bunches	Rotten Bunches	Long Stalks
					Ripe	Over Ripe	Under Ripe	Unripe						

when the standards are not met.

The production supervisor is the key to the manufacture of a quality product. Since this individual is considered by operators to represent management, his ability to convey quality expectations is critical for good employee relations. A production supervisor who is enthusiastic in his commitment to quality can motivate the employees to build quality into every part and thus into the final unit. It is the supervisor's responsibility to provide the operators with the proper tools for the job, to instruct them in the proper method of performing the job and the quality expectations of the job, and to inform them when those expectations are achieved and when they are not.

Inspection and test Even with the best planning and prevention activity, it is obvious that errors will occur during the milling process. The detection of these errors and the feedback of the information for correction of the basic cause of the errors are vital links in assuring the production of good quality palm products at minimum material losses. The act of determining conformance or nonconformance of the process product characteristics to required specifications is the function of the mill laboratory.

At the mill level, inspection and test will consist of:

- Sampling,
- Testing,
- Comparing measured values with required specifications,
- Judging conformance,
- Feedback of inspection data to production division/mill management, and
- Recording the data obtained.

In a palm oil mill, the assessment of how well objectives are being achieved is normally done by sampling materials from appropriate parts of the milling process and by performing simple tests on samples so taken. Since most of the assessments are based on the composition of material passing through the process, the need for obtaining a representative sample for testing must not be overlooked, and strict measures must be adopted so as to ensure that representative samples are obtained as best as possible. Sampling is normally assigned to the sampling boy.

Testing of samples is carried out as fast as possible in the mill laboratory. The laboratory is normally equipped with basic equipment such as ovens, analytical balances and oil analysis apparatus to perform basic tests such as free fatty acid (FFA), peroxide value (PV), moisture (VM), impurities, admixture and oil content. Some mill laboratories are able to test for anisidine value (AV), iodine value (IV), bleachability, carotene, UV, Totox and tocopherols content.

The types of tests performed by the mill laboratory vary from mill to mill depending on the requirements and needs of each mill management. Most mill laboratories do routine testing for quality assurance and process efficiency checks of mill processes.

Machine maintenance The original quality capability of processes, machines and plants is established by process capability studies and trial runs. Thereafter these capabilities must be maintained through adequate and regular maintenance of the machines and plants.

There can be no effective quality control if there are frequent breakdowns of machines due to inadequate maintenance. Breakdowns result in loss of production as well as the waste of labor and materials. They can also create hazardous situations which may lead to more catastrophic events. Upkeep and maintenance of machines and plants are the responsibilities of the mill foreman and his crew.

Control of storage and despatch of palm products Unless the palm products are delivered to the customer in a satisfactory condition, the mill's quality job has not been carried to completion. Palm products, being perishable items, can deteriorate tremendously if adequate measures are not taken during storage. Quality control plays an important role in assuring that adequate measures are taken to protect palm products from deteriorating during storage and handling.

Quality coordination Quality-control activities in the mill are scattered among numerous separate departments, each of which is engaged in meeting multiple goals. The various people involved have departmental and personal goals which may take priority over product quality and may even become antagonistic to product quality.

Hence there is a need to provide a positive mechanism for orchestrating the various quality control activities into a harmonious optimum result. This mechanism is provided in the form of the manager.

The mill manager is responsible for coordinating the mill's quality-control activities among the various organizational units in the mill. In fulfilling his role as the mill's quality coordinator, the mill manager will perform the following functions:

- Initiate corrective action with estate management when crop supplied by the estates are not of an acceptable quality level,
- Initiate corrective action on out-of-control conditions and related quality problems,
- Conduct follow-up to assure that corrective action is accomplished in a timely manner,
- Assure that products dispatched by the mill conform to quality requirements.

For big plantation companies in Malaysia, where each company may have more than one mill, a wider scope of quality-control activities such as quality audit, quality planning, quality improvement and quality motivation, is undertaken by a special department (normally called the Quality Control Department or Oil Technology Department). This department is either based at the company's head office or at the company's research center. Figure 2 shows an example of the quality control system generally adopted by big plantation groups in Malaysia. The quality control department will generally undertake *quality audit* and *quality improvement* in conjunction with the mill management.

Quality audit In order to assure that the mill's process, quality and assurance control systems are operating effectively, an independent review is conducted occasionally to compare some aspect of quality performance with a standard for that performance.

Quality audit is performed by the quality control department staff with the following goals:

- To assure that the systems and procedures governing the activities of quality functions are, in fact, being followed by the mills,
- To determine the effectiveness of the systems and procedures governing the activities of quality functions in identifying conditions requiring corrective action, and securing such action in a timely and effective manner,
- To assure that the quality of products dispatched by the mill conforms with that reported by the mill's laboratory.

Quality improvement Any quality-control system will be incomplete if quality improvement is absent. Quality improvement can be defined as the attainment of a new level of performance that is superior to any previous levels. Quality improvement is undertaken by the quality control

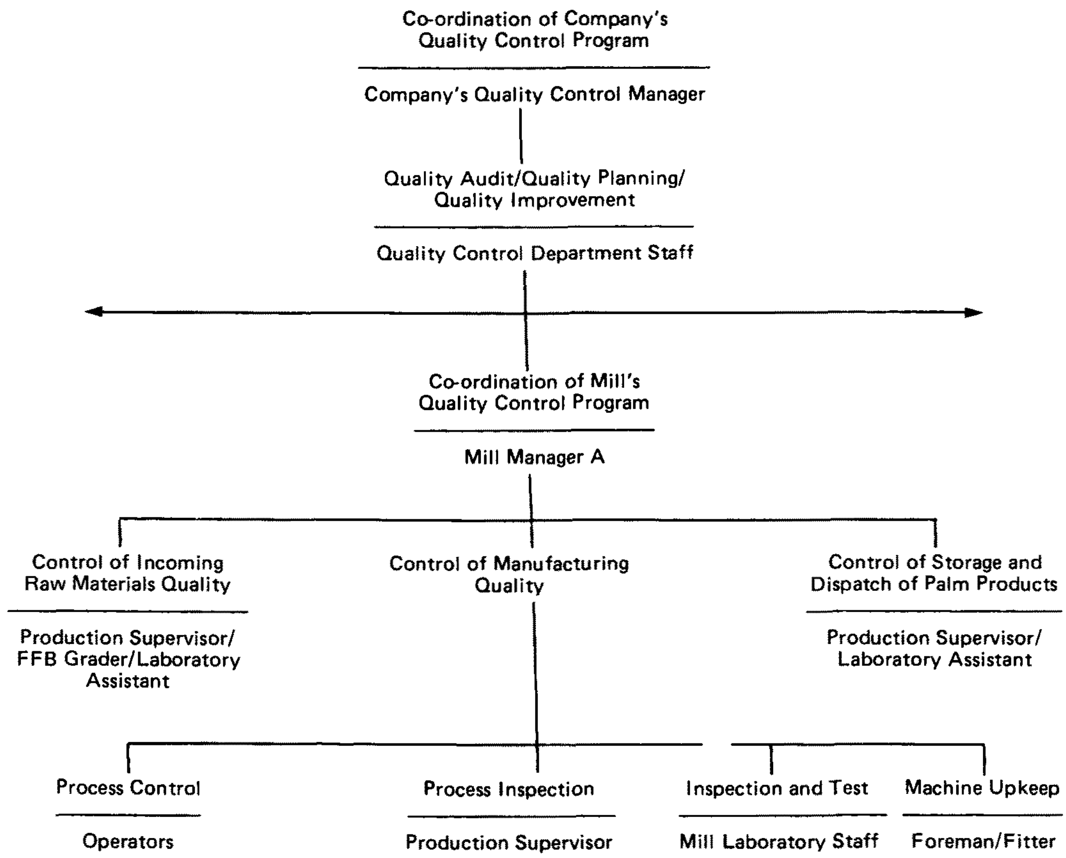

FIG. 2. Quality-control system in a big plantation group.

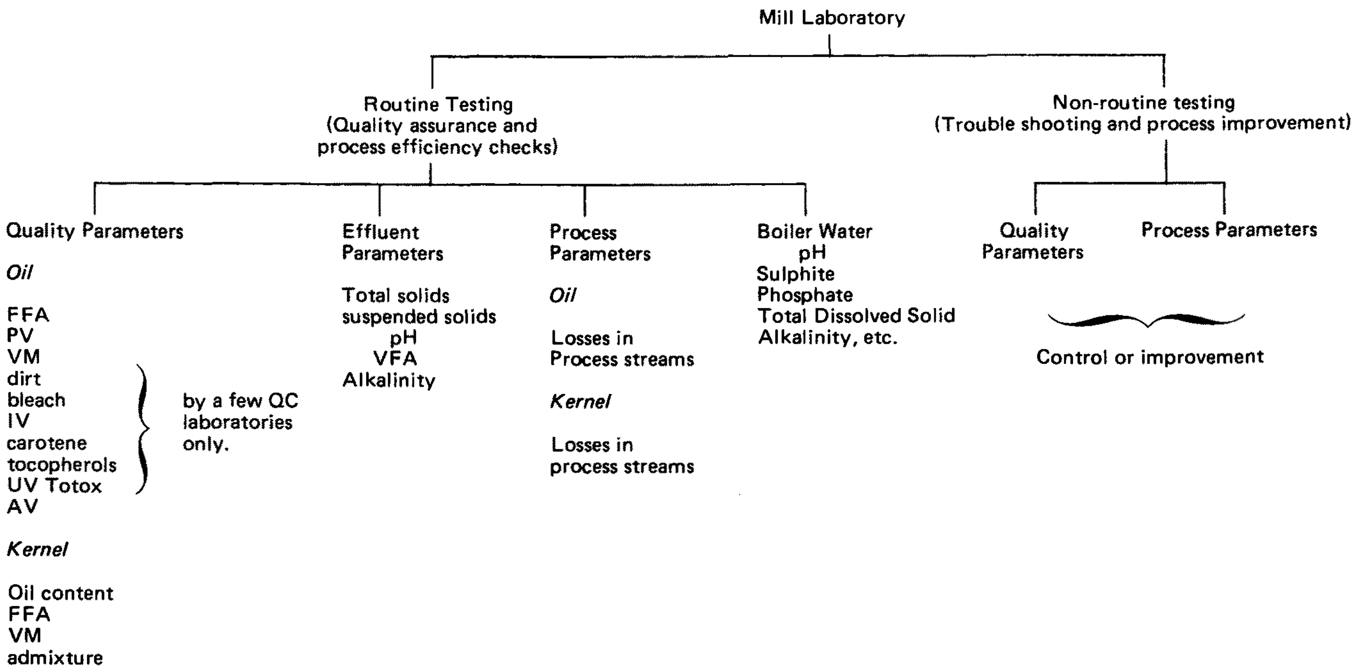

FIG. 3. Types of tests performed by mill laboratories belonging to big plantation groups (1).

department to establish objectives for breakthrough and to take steps to attain the objectives thus established by designing and making experiments involving changes in process, instrumentation, etc.

In making quality improvements, the mill laboratory will be required to undertake nonroutine tests apart from the routine tests. Thus, in a mill which practices quality control and quality improvement, the mill laboratory will need to perform the various tests shown in Figure 3.

Quality control management Because quality is everybody's job, it may become nobody's job. To safeguard against this occurrence, in big plantation groups, an individual is assigned to be responsible for coordinating the quality improvement and quality maintenance activities of the various organizational units in the company.

In fulfilling this responsibility, the individual will perform the following functions:

- Advising mill management on quality-control activities.
- Training and maintaining competent staff to do the functions of quality control.
- Advising management in the quality aspects of the establishment of new machines and manufacturing areas.
- Assisting management in stimulating workswide appreciation of the importance of quality mindedness.
- Conducting special quality studies such as surveys and process capability analysis.
- Research into improved quality control methods.
- Participating in activities on quality control organized by outside professional organizations.

THE EFFECTS OF FIELD FACTORS ON THE QUALITY OF FRESH FRUIT BUNCHES AND PALM OIL

The quality standard achieved by a mill is initially dependent on the quality of the bunches arriving at the mill. The mill cannot improve upon this quality, but can only prevent or minimize further deterioration.

The field factors which can affect the composition and final quality of palm oil are genetic, age of palm, agronomic, environmental, harvesting technique and handling and transport of the bunches. In this section only the effect of harvesting, handling and transport operations on bunch and oil quality are reviewed.

Harvesting

In the early stages of fruit formation, the oil content of the fruit is very low. The formation of oil increases rapidly to about 50% of mesocarp weight as the fruit approaches maturity.

In a fresh, ripe, unbruised fruit, the FFA content of the oil is below 0.3%. However, in the ripe fruit, the exocarp becomes soft and is more easily attacked by lipolytic enzyme especially at the base when the fruit becomes detached from the bunch, resulting in an increase in the FFA of the oil through enzymatic hydrolysis. If the fruit is bruised, the FFA in the damaged part of the fruit increases rapidly to 60% within an hour (2). There is therefore great variation in the composition and quality within the bunch.

Besides FFA, bleachability of the extracted oil was found to be adversely affected by bruising of fruit (2) and by overripe or rotten fruit (3). Kernel color was also found to be affected by the ripeness of the fruit, with darker color being found with overripeness (4).

Optimum ripeness is judged to have been reached when the fruit becomes detached from the bunch. Ideally only ripe fruit should be harvested to maximize oil yield. In actual practice this is impossible because the fruits in the bunch ripen at different times. Furthermore, FFA of the oil increases linearly with the percentage of detached fruit in the bunches (5).

The bunch ripeness standard set for harvesting must therefore strike a balance between the FFA of the oil and the extraction rate. In practice, the bunch ripeness is controlled by varying the minimum bunch harvesting standard and the harvesting interval.

The minimum bunch harvesting standard controls the minimum ripeness of the bunches while the harvesting interval controls the spread of ripeness levels. Smaller spread of ripeness levels are obtained with low harvesting intervals compared with high intervals. For a given minimum bunch harvesting standard, the higher the harvesting interval, the higher will be the average degree of ripeness and the higher the FFA. If harvesting intervals are high, FFA can be controlled by reducing the minimum bunch harvesting standard.

The actual standards adopted by individual companies or even individual estates vary depending on such factors as labor availability, type of oil to be produced (e.g., standard quality, special quality, SPB), etc. Minimum bunch harvesting standards recommended vary from 1 detached fruit per bunch to 4 detached fruit per kilogram of bunch weight and the normal harvesting interval from 5 to 15 days (6,7,8,9).

Handling and Transport of Bunches

Between harvesting and processing at the mill, the bunches are subjected to a series of handling and transport during which damage to the fruit occurs. The rate of increase in FFA of the fruit is a direct function of the severity of damage to the bunches which is in turn related to the amount and method of transport and handling of the bunches (11). The increase in FFA is also dependent on the time lapsed between harvesting and sterilization (7,11).

Pickup of soil, sand and stones during harvesting and transport operations is inevitable. Such "dirt" can cause accelerated wear on process equipment resulting in contamination of the oil with iron which is a pro-oxidant (8). In this respect, rotten bunches will tend to pick up a larger amount of dirt (12).

To reduce quality deterioration to a minimum, care is taken to minimize bruising and pickup of dirt during harvesting, handling and transport of bunches. Fruit bunches are transported to the mill as soon as possible after harvesting for immediate sterilization and processing.

THE EFFECTS OF MILL PROCESSING ON OIL AND KERNEL QUALITY

In mill processing, operating conditions which maximize the product recovery efficiency may not necessarily yield the best product quality. Mill operations are generally run under compromised conditions to obtain both an acceptable recovery efficiency as well as a reasonable product quality. The main areas where quality of oil and kernel are affected by processing are reviewed below.

Reception Ramp

While mills aim to sterilize all bunches upon receipt at the mill to inactivate enzymatic hydrolysis and stop further rise in FFA, this is not always possible. During peak crop periods, bunches are often left for many hours on the reception ramp before sterilization, with resultant buildup in FFA. It is also often normal practice in many mills to maintain a backlog of one to two hours' crop at the end of the day to start the next day's processing. This would also contribute to FFA increase.

Sterilization

The aims of sterilization are mainly to inactivate the fruit enzymes and to loosen the fruit from bunches in preparation for the subsequent stripping operation. During sterilization it is important to ensure evacuation of air from the sterilizer. Air not only acts as a barrier for heat transmission, but oil oxidation increases considerably at high temperatures; hence, oxidation risks are high during sterilization.

It has been shown that both sterilization without proper deaeration and over-sterilization lead to poor bleachability (2). Sterilization is also the chief factor responsible for discoloration of palm kernels. Discoloration adversely affects the bleachability of the extracted kernel oil and reduces the protein value of the cake. Discoloration also results in oxidation as shown by the higher benzidine values of oil from discolored kernels (4).

Oil recovered from sterilizer effluent is heavily contaminated with iron and is oxidized. Such oil should not be recycled to mix with normal production oil.

Digestion

In the digestion process, the rotating digester arms mash up the fruit, breaking the oil cells with release of oil particles. Digestion is normally done at high temperatures with live steam or steam jackets.

The digestion stage was found to have the highest rate of metal wear in the milling process. As a result, the contamination from iron is greatest during digestion. The wear rate is increased if bottom drainage of the digester is used (13). It has also been reported that there is deterioration in the bleachability of the oil as a result of digestion (2).

In order to maintain the temperature of the mash in the digester, from the quality point of view live steam injection was found to be better than heating by steam jacket as there is more risk of localized overheating with the latter (2).

Pressing

Moderate metal wear occurs during the pressing operation, which is therefore also a source of iron contamination. The rate of wear depends on the type of presses, method of pressing, nut to fiber ratio, etc. (13). High pressing pressures were reported to have an adverse effect on the bleachability of the extracted oil (3).

Clarification

Clarification affects quality insofar as prolonged air contact at high temperatures leads to oxidative degradation. The oil settled out in the clarification tank is passed through an oil purifier to remove moisture and impurities. The oil is then further dried in an oil drier. Two types of oil driers are generally used, one involving atmospheric drying and the other involving drying under vacuum.

Although no significant differences have been reported in the oxidative status of oils dried by the two systems, drying in open atmosphere at relatively high temperatures significantly increases the risk of oxidation, especially in the event of overdrying.

To prevent increasing FFA through autocatalytic hydrolysis of the oil, the moisture content of the oil must be reduced to below 0.1% (2). It has also been reported, however, that moisture levels of 0.15% to 0.25% reduce oxidative deterioration considerably (14,15).

Oil Storage

The purified and dried oil is transferred to a tank for storage prior to dispatch from the mill. Since the rate of oxidation of the oil increases with the temperature of storage, the oil is sometimes passed through an oil cooler to reduce the temperature to about 50 C before storage, to improve oxidative stability.

During storage the oil is normally maintained at 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 inert protective coating.

Kernel Recovery

In the kernel recovery process, the nuts contained in the cake discharged by the presses are separated from the fiber in a depericarper. They are then dried and cracked in centrifugal crackers to release the kernels. The kernels are normally separated from the shell using a combination of winnowing and hydrocyclones. The kernels are then dried in silos to a moisture content of about 7% before packing.

During the nut-cracking process some of the kernels are also broken. The rate of FFA increase is much faster in broken kernels than in whole kernels (16,17). Breakage of kernels should therefore be kept as low as possible given other processing considerations.

Drying of kernels is normally done using hot air, and provided the temperature of the air does not exceed 80 C, no discoloration of the kernels occurs (16). Insufficiently dried kernels have shown a much higher rate of increase in FFA. Steam sterilization of the wet kernels for several minutes prior to drying was reported to reduce the rate of FFA increase in the kernels on storage (17).

PROGRESS OF QUALITY CONTROL IN PALM OIL FRUIT PROCESSING

Field Practices

Introduction of the weevil, *Elaeidobius kamerunicus*, in Malaysia in 1981 has increased the fruit set, resulting in heavier and more densely packed bunches. This has necessitated a reassessment of harvesting strategy to ensure that bunches of acceptable ripeness continue to be harvested without unduly affecting the FFA.

The rise in FFA as a result of damage to the fruit during harvesting, handling and transport of the bunches, and the possibility of contamination from pro-oxidant metals from dirt picked up with and by the fruit are by now generally known to the industry. Care is taken to minimize bruising during harvesting. Nets are used in many estates to minimize damage and to reduce the collection of dirt with the bunches and fruit. Transport systems which minimize handling are increasing in use. This includes use of lorries or tractor/trailer units to collect bunches for direct transport to reception ramps in the field, and dispatch of sterilizer cages to the field.

Mill Practices

The effectiveness of sterilization in relation to stripping of the bunches was adversely affected by the more compact weevil-pollinated bunches. To overcome the poor stripping, many mills have adopted multiple-peak sterilization procedures, often at higher pressures. This is expected to have adverse effects in respect to discoloration of kernels. However, the improved deaeration obtained with multiple peak sterilization will reduce the risk of oxidation during sterilization.

The importance of producing oil with low acidity levels has always been appreciated, and early processing of incoming bunches continues to be the aim of all mills.

There is generally increased awareness of the need to produce an oil with good oxidative stability. Significant progress has been made in this area with efforts being directed at two main aspects:

- Improved handling and protection of the oil from oxidation, and
- Reduction and elimination of contamination by the

pro-oxidant metals, copper and iron.

To reduce the risk of oxidation through contact with air, most mills have organized their pipeline layout so that the oil is transferred into tanks through bottom loading to avoid splashing. Some mills have installed floating lids in their clarification tanks to minimize oil contact with air. For similar reason, vacuum driers are increasingly being used for drying the oil. Some mills cool the oil after the drying stage to improve the oxidative stability of the oil. Some producers protect their high-quality oils either by sparging with an inert gas or by providing floating lids inside the tanks.

As a further protection against oxidation many producers are now drying their oil to a moisture content of 0.15 to 0.25%. Although the high moisture content would, in theory, lead to a rise in FFA through autocatalytic hydrolysis, in practice, the rise in FFA, if any, is marginal due to the short storage period before shipping to refineries.

The detrimental effects of copper and iron have been well documented. Strenuous efforts have been made to eliminate the contamination of oil through the use of copper or copper alloy components in oil processing equipment. The success of these efforts is reflected in the fact that the copper levels in a recent survey of oil received by refineries were in the range of the natural levels normally present in the oil (15).

Contamination from iron is to some extent unavoidable, and efforts have generally been to reduce the contamination to a minimum. The use of wear-resistant material and stainless steel in machinery parts which are in contact with oil, e.g., pumps, pipes and tanks, ensures the lowest possible levels of iron in the oil. The provision of magnetic traps in the pipeline before the storage tanks by some producers would further reduce the iron contamination (18). Some mills coat their mild steel storage tanks with an inert protective coating for protection of the oil from iron contamination during storage.

Introduction of an automatic control system in various areas in some mills has resulted in better control over the process and quality of the product. Examples of use of automatic control systems include those for the control of the sterilization cycle, for control over the pressing operation and to control the heating of oil in the storage tank. Automation is used by some mills to provide better sampling for monitoring both the process and quality of the products.

FUTURE TRENDS

In the past, one of the major setbacks to quality control in a palm oil mill is that the results produced by the mill laboratory are not fast enough to initiate corrective action, i.e., by the time the results are known the process has already changed and nothing much can be done about it.

Another setback is that some mill managers feel doubtful about the results produced by the laboratories whenever unfavorable results are obtained. Very often they claim that the unfavorable results are due to sampling error rather than to process malfunction, since they feel that the sample collected was not sufficiently representative or reliable.

These two major problems can be overcome through the use of rapid moisture and oil analysis equipment and automatic sampling systems. In fact many mill laboratories are now equipped with microwave ovens (for VM analysis), Fosslet or Soxhtex (for oil analysis) and even Infra-analyzer for rapid moisture and oil analysis in order to improve the speeds of analysis. Some mills are now installing automatic sampling systems for all mill processes in order to improve the reliability of sampling.

Many mills which have adequate testing facilities and mill instrumentation nowadays do not confine the responsibility for quality to the mill laboratories. Since quality control is everyone's job, they are now using the laboratories for effective quality control and quality improvement in mill operations through proper coordination and interaction among the laboratory staff, production staff and mill management. Table II illustrates how quality control (QC) and quality improvement (QI) are affected in these mills.

TABLE II

Illustration of an Effective Quality Control System (1)

QC team	Uses	QC tools	for	QC and QI
Process engineers Process supervisors		Laboratory Statistical Techniques		In mill operations.
Process operators Laboratory staff Sampling staff		Instrumentation		

Some mills also have formed quality improvement committees to establish quality improvement plans and to ensure that key events described in the quality improvement plans are being implemented successfully and in accordance with established time tables. An example of a quality improvement plan is shown in Table III. In the establishment of the quality improvement plan, the committee normally takes the following steps:

- The committee will define a project or accepts one given by management. It will then set a goal to be achieved and proceed to analyze the problem.
- The committee will investigate the reasons for failures and the causes of the conditions accounting for failures will be studied.
- Suggestions for improvement will be developed and alternatives compared.
- A specific course of action will be chosen and implemented.
- When the project is completed, the committee will summarize the project and the results achieved in a report and present it to top management.

Some mills are now establishing quality control circles (QCC) to increase employee skills and to increase employee participation in planning, problem analysis, cost reduction, solution generation and communication with management.

All these new aspects of quality control are introduced into the mills with the main objective of getting all mill personnel involved in quality control and becoming responsible for the quality requirements which are within their power to control. This ultimately will result in the production of good quality products at minimum costs.

However, since the quality of the products produced by the mill, especially palm oil, is very dependent on the quality of the fruit bunches supplied to the mill, it is vitally important that the suppliers of fruit bunches to the mill should also be involved in the quality control work. It should be the objective of the fruit bunch suppliers (or vendors) to deliver fruit bunches of good quality so that the mill is able to use the produce without the need for incoming inspection or for corrective procedures. To attain these objectives there is a need for fruit bunch suppliers and millers to have proper coordination and interaction to strengthen and improve past weaknesses. The areas that need to be improved are:

- *Vendor relations quality policy:* Matters such as

TABLE III

Quality Improvement Plan for Mill A

Basic Task

To reduce oil losses in sludge and the amount of sludge produced per ton FFB processed.

Objective

To install in the mill an effective integrated quality control system resulting in reduced oil losses in sludge and amount of sludge produced per ton FFB processed.

Goals

(A) To reduce oil losses in sludge from 1.02% on FFB to 0.70% on FFB by end of 1982.
(B) To reduce mixed raw effluent produced from 90% on FFB to 70% on FFB by end of 1982.

Responsibility

Mill Manager Mill A (MM)
Production Controller, Zone x (EPT)
Quality Controller, Zone x (QC)
Quality Controller, HQ. (QC,HQ)

Problem	Key Events	Completion By	Assigned To	Progress To date
1. High oil loss in sludge due to excessive draining as a result of frequent chokage of sludge separators.	(1) To overhaul the four units of vibrating screen (VS) under the press.	31/10/81	EPT	
	(2) A PM system for VS is to be devised and to maintain the VS in good condition at all times once the new VS are installed.	31/10/81	MM	
	(3) To rectify both stork separators and put back into operation together with Alfa-Laval separators.	31/10/81	EPT & MM	
2. Excessive amount of sludge produced per ton FFB processed (a factor of 0.90)	(1) Correct operation of Alfa-Laval separators with the least possible addition of make-up water. This can only be done if VS are corrected.	15/11/81	MM	
	(2) To instill in operators to reduce unnecessary water usage in oil room eg. a). To close water valves when stork separators are not operating. b). To avoid unnecessary washing and close valve after washing. c). To wheel-barrow the tailings from VS in oil room instead of splashing with excessive amount of water with intention of washing it into sludge trap.	–	MM	

mutual respect and cooperation, contractual understanding, agreed methods of evaluation, agreed plans for settling disputes, exchange of essential information;

- *Two-way communication:* Matters such as supplying essential information, providing performance data, identifying troubles which arise, stimulating corrective action, improving the ability of both parties to work together;
- *Detection and remedying deviations:* Inspection at the fields or at the mill.

ACKNOWLEDGMENT

The authors thank Felda Mills Corporation and the General Manager of Socfin Co. Bhd. for permission to publish this paper.

REFERENCES

1. Lim, K.H., Palm Oil Mill Quality Control Laboratories, PORIM Workshop on Quality in the Palm Oil Industry, Kuala Lumpur, 2-3 August, 1983.
2. Jacobsberg, B., The Influence of Milling and Storage Condition on the Bleachability and keepability of Palm Oil, ISP Conference on Quality & Marketing of Oil Palm Products, 1969.
3. Olie, J.J., Some Factors Influencing the Bleachability of Palm Oil, Ibid.
4. Thieme, W.L. and J.J. Olie, Discolouration of Oil Palm Kernels in Relation to Processing Temperature and Time, Ibid.
5. Southworth, A., Harvesting, in Oil Palm Research, edited by R.H.V. Corley, J.J. Hardon, & B.J. Wood, Amsterdam: Elsevier Scientific Publishing Company, 1976, pp. 469-477.
6. Gray, B.S. and J.W.L. Bevan, Field Factors Affecting the Quality of Palm Oil. ISP Conference on Quality & Marketing of Oil Palm Products, 1969.
7. Ng, K.T. and A. Southworth, Optimum Time of Harvesting Oil Palm Fruit, in Advances in Oil Palm Cultivation, edited by R.L.

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

H.K. JORGENSEN, Unitata BHD, Teluk Intan, Malaysia.

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.