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6 March 1972

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United Nations Industrial Development Organization

Expert group meeting on pre-investment
considerations and technical and economic
production criteria in the oilseed processing industry
Vienna, Austria 16 - 20 October 1972

SUMMARY

TECHNICAL AND ECONOMIC ASPECTS OF THE OIL PALM FRUIT PROCESSING INDUSTRY 1/

BY

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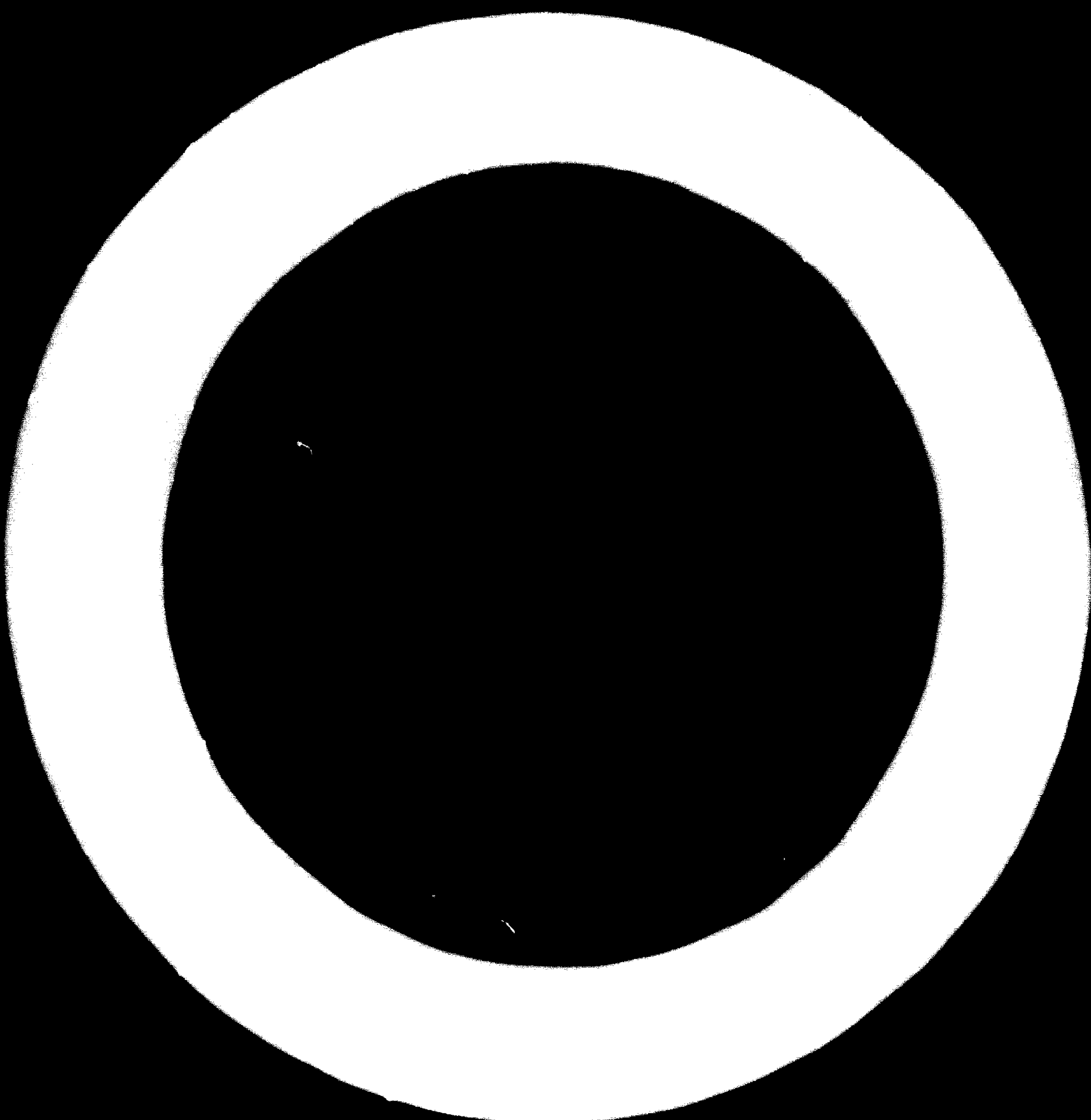

The dynamic oil palm planting programme by the Malaysian Plantation Industry and the Federal Land Government Authority over the last 10 years has made Malaysia the world's leading producer of palm oil, and it is significant to observe that the production of palm oil in Malaysia will reach two million tons within the present decade : -

Under the chapter of harvesting the aspects of controlling the yield in relation to quality is brought under review, and it is interesting to observe that the main factor responsible for the development of F.F.A. is bruising of the F.F.B. A relevant graph shows how quickly the acidification develops after bruising has taken place. The graph under Fig. II indicates a very slow build up of F.F.A. in unbruised fruit and this shows that it is much more important to avoid bruising than to arrange for quick transport to the factory.

The merits of rail and road network collection systems are analysed in Chapters VI & VII. It appears that the rail network is the more expensive to establish but substantially cheaper in operation.

Under Chapter VIII the importance of proper sterilisation is emphasised. The author expresses the opinion that oxidation does not take place as long as the oil is inhibited in the mesocarp and application of vacuum prior to admission of steam does not seem to indicate any pronounced difference in respect of oxidation of the palm oil. Application of vacuum showed only moderate increase of temperature when compared with the standard sterilisation.

Tests carried out in respect of pressure variation during sterilisation seem to indicate that nuts can be conditioned for direct cracking from the depericarper and this will be tried on a commercial basis during 1972.

Under Chapter IX it is observed that Threshing Machines coping with 40 tons of sterilised F.F.B. are in operation. The empty bunches represent approximately 25% of the weight of F.F.B., and burning of such bunches in an incinerator can produce 0.3 to 0.5% of potash to F.F.B. Re distribution to the field of empty bunches also seems to have a beneficial effect on yield and soil conditions.

Chapter X discloses interesting tables referring to the effect of wear and tear in relation to absorption of iron in the oil during processing. It appears that the iron absorption is least when screw presses are used as medium of extraction.

The importance of keeping the correct temperature of the digested mash is clearly recorded in Table No. 7 from where it can be observed that the power consumption can be reduced by 30% if the temperature is raised from 70°C to 95°C. The effect if having bottom discharge from a digester is readily observed from table No. 8, and the writer expresses the opinion that bottom discharge from the digester of the automatic hydraulic press is responsible for the extraordinary heavy wear and tear indicated by the average working life of the digester spares as depicted at page 32.

Table 9 depicts the comparative oil loss in respect of various extraction units operated under identical conditions, it also shows the advantages offered by screw presses in respect of capital outlay and power requirement.

Under kernel recovery plant Fig. 5 discloses an interesting proposal for a depricarper cum nut cracking station being tried on a commercial basis during 1972.

Table No. 12 indicates the advantage of sterilising the kernels prior to storage. It is significant to observe that oil from broken and unsterilised kernels reaches an acid value of 64.21% within 8 weeks compared with an acid value of 14.70% in respect of sterilised broken kernels.

Under Chapter XI it is of interest to observe the high bio-chemical oxygen demand of the factory efficient from a palm oil factory. This problem is now subjected to much attention.

The importance of reducing the contact of hot oil with air during purification is emphasised, and sealed purifiers are recommended in order to ensure production of high quality oil.

Under Chapter XII Table No. 13, gives a clear indication of how to work out a crop projection in order to establish the factory throughput as shown in Table 14.

The fuel balance in relation to the evaporation of steam is shown in Table 15 while Table 16 gives interesting information in respect of the calorific value of the fuel used in a palm oil factory. The steam consumption of 0.4 ton/ton of FFB processed gives a practical rule of the thumb for calculating the steam requirement of a palm oil factory. It is also noticed that a single stage impulse turbine use more steam than a compound steam engine. However, the possibility of using wet steam for turbines makes it now possible to achieve a reduction of the cost of the power plant required for a palm oil factory.

Table 20 gives a realistic picture of the power requirement at various rates of throughput.

From Chapter XIV it can be observed that the oil storage space for preference should be not less than 30% of the annual production in order to maintain the free bargaining capacity with the buyers. This is a most pertinent advice in view of the expanding production.

From Chapter XV it appears that the control of marketing Malaysian palm oil now has been transferred from London to Kuala Lumpur, from where the West Malaysian Palm Oil Producers' Association will maintain close contact with world trading centres.

From page 53 it is obvious that the production of palm oil will represent an increasing percentage of the world production of edible oils and fats, and the writer expresses the opinion that palm oil must acquire a greater share of the world market by making high quality oil available at the door steps of the consumers.

Table 23 depicts a realistic projection of the cost of establishing a palm oil estate and the relevant production cost/ton of oil. It is of interest to observe that a price of $500/ton of oil is marginal in respect of profit, and when the development costs are high as has been the case in recent years particularly so in Sabah a price level of $500/ton is not profitable.

Chapter XVI describes the necessity of employing bulk tankers in future in order to compete on equal terms with other edible oils. The importance of storing Malaysian palm oil in tank farms under a gas blanket in various parts of the world is emphasised.

The coating of tanks with Epoxy resin and control of thermal treatment to which palm oil is exposed is given particular importance in relation to prevention of oxidation.

Chapter XVII indicates the versatility of palm oil, and fractionation of palm oil by separating the mixture of tri-glycerides and thereby obtaining a solid and liquid fraction seems to offer additional flexibility and scope for the use of palm oil.

Table Nos. 24 and 25 clearly indicate the benfit of keeping to total oxidation of palm oil at a low level, and there can be no doubt that the future demand for the S.P.B. quality of palm oil will rapidly raise.

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TECHNICAL AND ECONOMIC ASPECTS OF THE OIL PALM FRUIT PROCESSING INDUSTRY [1]

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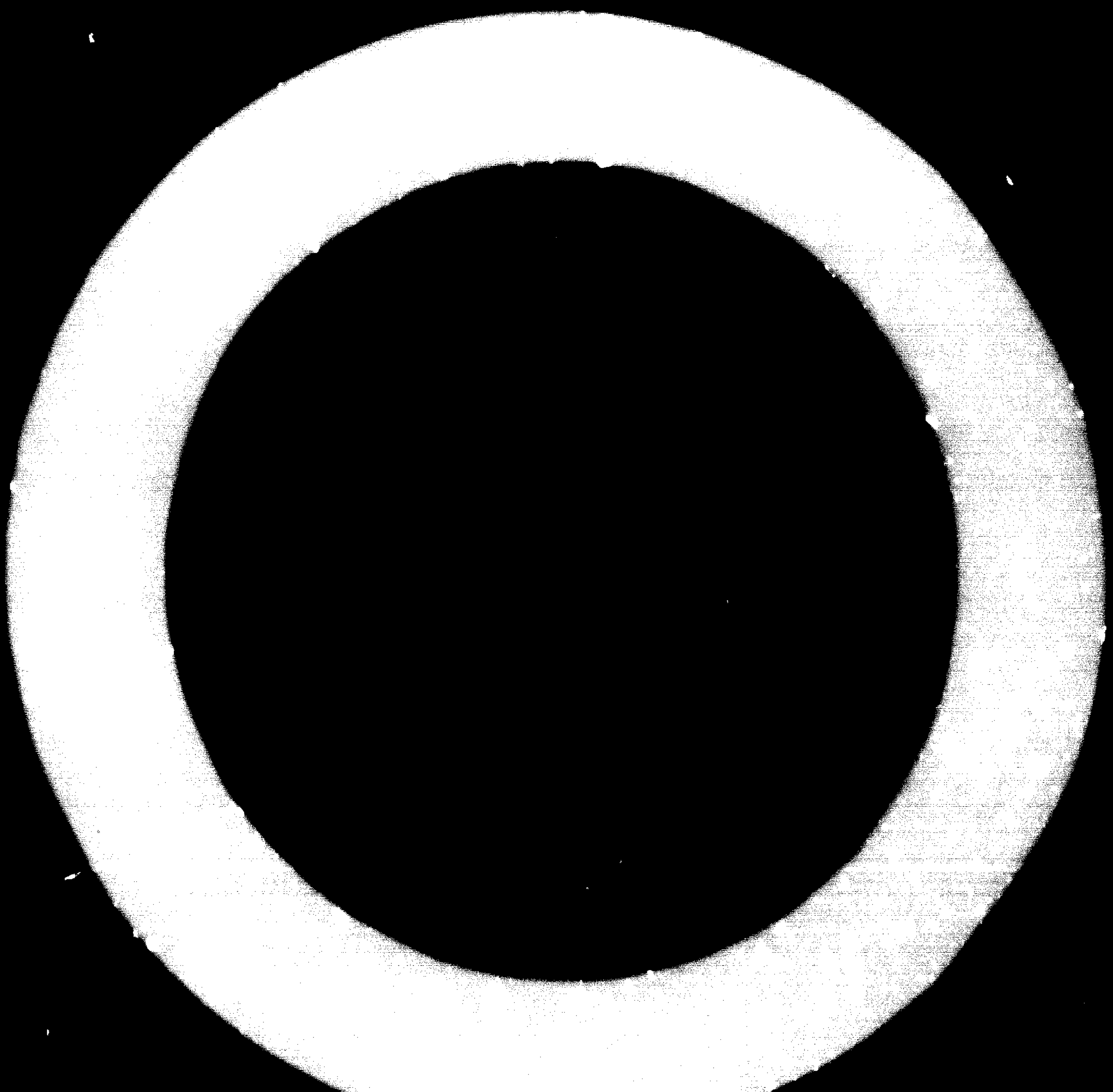


LIST OF CONTENTS

Approximately 15 colour slides will be shown at the meeting.

I. INTRODUCTION :

1. By the middle of the 19th century the palm oil trade was well established between the United Kingdom and African areas with more than 20,000 tons of palm oil being handled in the port of Liverpool in the year of 1856. About this time, or more specifically in the year 1848, four oil palms (Elaeis Guinsensis) were planted in the Buiterzorg Botanical Gardens in Java, and although oil palms were introduced into Malaya in 1875 from Peradeniya, probably through the Royal Botanic Gardens, Kew; and planted in the Botanic Gardens, Singapore, it is generally accepted that the Deli oil palms in the Far East all originate from these four palms.

2. The development of the palm oil industry in Malaya, however, did not commence before 1917 when Tennamaram Estate, Batang Berjuntai, became the pioneer oil palm plantation in this country. However, it was not until 1926 that oil palms started to be cultivated in the earnest on a commercial basis. This expansion of the area under oil palms was interrupted by the second World War, and by 1962 less than 150,000 acres had been planted with oil palms, placing Malaysia, at that time, behind Nigeria, Belgian-Congo and Indonesia.

3. The Malaysian Plantation Industry recognised the increasing demand for edible oil, and this factor together with the strong appearance of synthetic rubber in the world market sparked off a replanting programme with rubber being replaced by oil palms where the soil and growth conditions were suitable.

4. About the same time the Malaysian Government through the Federal Land Development Authority commenced a most

dynamic planting programme, resulting in substantial jungle areas being cultivated with selected oil palms. It is, therefore, not surprising that Malaysia has now become the world's leading producer of palm oil, and the following statement indicating the estimated production up to 1976 clearly manifests Malaysia's position as the World's leading producer of palm oil during the seventies :-

	Recorded Planted Acreage	Palm Oil (tons)	Kernels (tons)
1972	1,054,683	767,594	119,576
1973	1,182,085	971,815	252,672
1974	1,285,492	1,157,968	301,072
1975	1,377,123	1,363,380	354,479
1976	1,418,064	1,533,925	398,821

5. New areas are still being planted up, and with yields reaching about 2.5 tons of palm oil/acre on alluvial clay soil, it will not be too optimistic to predict a Malaysian production of two million tons of palm oil and about 500,000 tons of kernels before the end of the present decade.

6. The question of quality production, freight and distribution in a highly competitive edible oil market is subject to continuous attention by Malaysian Producers and although the oils from annual crops such as soyabean, rapeseed, sunflower, cottonseed and groundnut represent formidable sources of supply, there can be no doubt that the oil palm, being the highest potential yielder of oil per acre, in conjunction with new technical development in the field of oil technology, will capture an increasing percentage of the edible oil market in years to come.

II. HARVESTING, COLLECTION AND STORAGE OF FRESH FRUIT BUNCHES (F.F.B.) :

1. It is generally accepted that the harvesting of F.F.B. is the most important factor in relation to the economic and qualitative aspects of processing of F.F.B. This can be more specifically expressed by stating that the standard of ripeness of the bunch to be harvested in turn will influence the rate of extraction as well as the level of free fatty acid in the oil extracted. It is of course desirable to achieve the highest possible extraction of oil, while the F.F.A. of such oil should be as low as possible. In practice these aims are conflicting because the riper the fruitlets are on a palm bunch, the more easily they become bruised and this in turn causesthe F.F.A. to develop in an undesirable manner. It is therefore of interest to analyse the following problems which arise when optimum efficiency is the declared aim :-

i) Harvesting in relation to extraction
ii) Free Fatty Acid (F.F.A.)
iii) Collection and transport.

III. HARVESTING IN RELATION TO EXTRACTION :-

1. The whole process of efficient oil extraction is closely integrated. It is, however, correct to say that it starts right in the field at the palm to be harvested, because without close field supervision of the harvesting, which should be as homogeneous as possible, the efficient extraction of high quality oil is not possible.

2. The method of harvesting depends upon the area being harvested. In young areas an axe or a chisel fixed to a wooden handle is used, whereas in old areas with palms

reaching a height of about 45 feet, long bamboo poles fitted with a sickle-shaped knife and weighing about 35 lbs. are used by skilful harvesters.

3. The question of when to cut the bunch should be clearly laid down to the harvesters, who normally enter the same area on a 6 to 8 days harvesting round. If a bunch is cut prematurely, i. e. while it still has a red-bluish shine and no loose fruitlets the photosynthesis converting the carbo-hydrates into fat has not been completed and the oil content of the mesocarp is often as low as 35%, whereas the oil content in the mesocarp from well ripe fruitlets normally reaches 50% to 55%. It is therefore obvious that substantial oil losses can occur if the F. F. B. is cut prematurely. In fact, experiments carried out have indicated a loss of 8% of the total oil and it is interesting to observe that tests have shown the following average specific gravity in respect of fruitlets from F. F. B.

Ripe fruitlets	1.06
Unripe fruitlets	1.12

4. The explanation seems to be that the fat (specific gravity 0.90) form a greater part in ripe fruitlets than is the case in unripe fruitlets. Naturally, the oil content is at its maximum level when the fruitlets loosen themselves from the bunch. Unfortunately, there is a variation of about 14 days in maturation of the 800 - 900 fruitlets contained within an average bunch; consequently it is never possible to obtain optimum condition in respect of all fruitlets at time of harvest. The outer fruitlets are bigger and better developed than the inner layers of fruitlets and it has been established by laboratory analysis that oil formation in the pericarp ceases as soon as a fruitlet becomes loose from

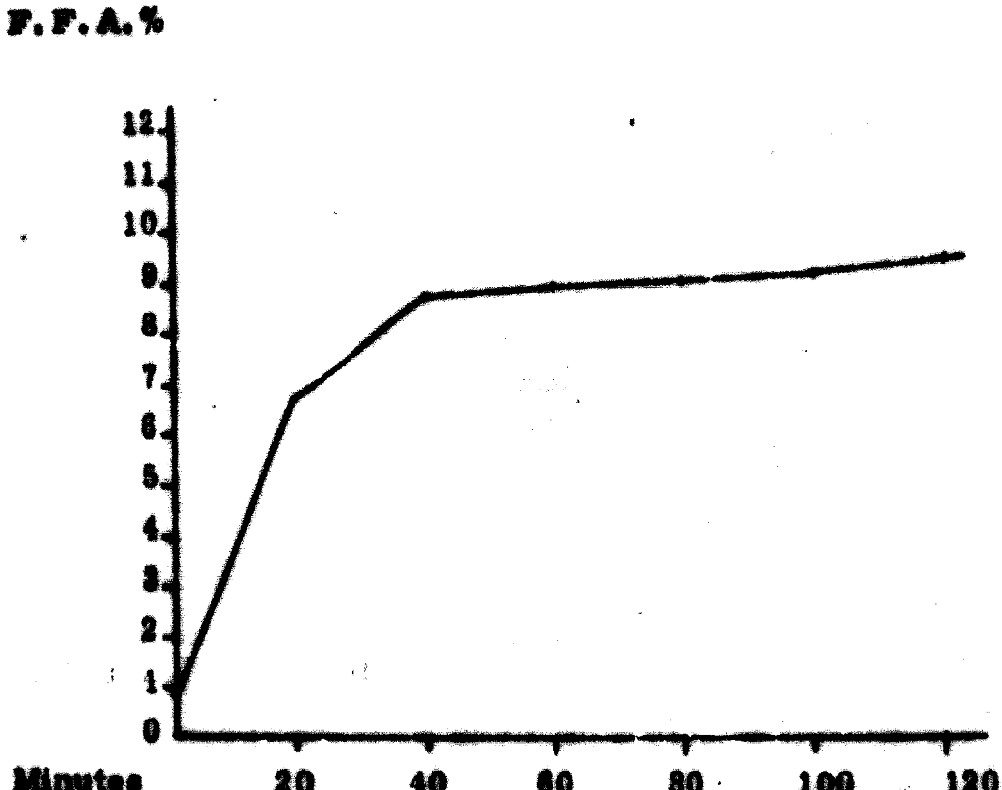
the stalk. Also within a further four days, the oil begins to decompose and this deterioration of the oil content is even quicker when the fruitlets have been bruised. It is therefore not desirable to let too many fruitlets fall to the ground before the bunch is cut, and the general rule within the Writer's organisation is to have one fruitlet/lbs. of bunch weight on the ground before the bunch is cut. With due flexibility, and allowance for rainy days, the height of palms to be harvested (harvesting of younger palms can be better supervised) and the interval between harvesting rounds, this ripeness standard gives good results for both Dura and Tenera palms.

IV. FREE FATTY ACID (F.F.A) :

1. As mentioned above the aims of high extraction and a low F.F.A. of the extracted oil are of a conflicting nature because the producers can easily lose substantial revenue if the fruit is cut prematurely in order to ensure a low F.F.A. It must however, always be borne in mind that a low F.F.A. is the first characteristic to which edible oil refiners pay attention, and although the existing standard contract provides for a premium or penalty of one percent of the sales price per percent below or above 5% Free Fatty Acid, there can be no doubt that palm oil, such as the Stabilised Prime Bleachable (SPB) which has made its entry into the world market over the last few years, will be sold in greater quantities than are at present available. The vast areas of young palms coming into bearing will facilitate the production of palm oil with a low F.F.A. which, together with the fact that a consistent supply of such oil in great volume will be available, should enhance the competitive position of palm oil in the world market.

2. Before going further it might be of interest to state the various factors encountered and confirmed by practical experience in respect of the development of F.F.A. The formation of F.F.A. in the fruit starts with the destruction of the cells which contain, in addition to oil, a protoplasm rich in liplytic enzymes. **THE ACIDIFICATION IS LIMITED TO THE CELLS DESTROYED AND IT IS MOST VIOLENT DURING THE FEW MINUTES IMMEDIATELY FOLLOWING THE BREAKAGE, AND THE NEAR MAXIMUM FATTY ACID CONTENTS IS, AS SHOWN BELOW, REACHED WITHIN 40 MINUTES.**

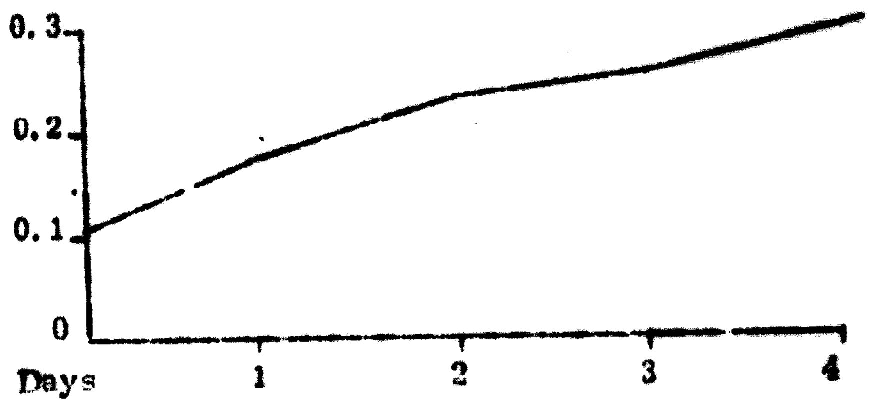
Fig. 1



3. The view has been expressed that rapid transport of F.F.B. to the oil mill will help to maintain the F.F.A. at a low level. The above results, which have been confirmed time and again, clearly show that the most important anti-F.F.A. measure which can be taken under practical working conditions on an Oil Palm estate is <u>TO REDUCE HANDLING AND BRUISING OF THE F.F.B. TO THE ABSOLUTE MINIMUM.</u> This rule, which must be law if high quality oil is to be produced, is confirmed by a substantial number of tests made with unbruised fruitlets stored over a period of four days, the analysis results of which are recorded hereunder :-

<u>Fig. II</u>

F.F.A.



From the above it can be observed that the increase in the F.F.A. of the oil from unbruised fruitlets came to less than 0.2% in the course of four days.

4. The breakage of the cell walls may be due to two completely different causes, either mechanical or micro-biological. The former constitutes by far the most frequent cause of bruising and this will be further considered under the following heading.

V. COLLECTION, TRANSPORT AND STORAGE :

1. The method of collection, transport and storage of F.F.B. varies from estate to estate. During the early period of development of oil palms in Indonesia and Malaysia, most estates were established on flat, alluvial clay soil, which was conveniently suited to carry a light railway network for fruit collection. The post-war period has seen a rapid development of various types of tractors, trailers and tipping lorries, which coincided with the trend of planting oil palms on undulating inland soils, where a light railway network cannot be establised except at prohibitive cost.

2. The capital outlay, in respect of a light railway system, which must be established at a density of .005 miles/acre in order to serve efficiently, is substantially higher than the capital cost of a road network for tractors and trailers, or lorries. However, there can be no doubt that the railway network is the more efficient and economical to operate, in particular if due consideration is given to the aspects of handling the F.F.B. in relation to the development of F.F.A.

3. The following examples of two 10,000 acres estates, having an annual yield of 100,000 tons of F.F.B. which is hauled an average of 7 miles, should give a realistic comparison of costs between systems of road and rail transport.

VI. RAILWAY COLLECTION AND TRANSPORT SYSTEM :

1. The present cost of laying one mile of 20 lbs/yd. rail track will be: -

One mile of track ex estate	\$15,500
2,112 pieces impregnated [illegible]	\$ 2,500
Laying and packing material	\$ 5, 00
Provision for field bridges & levelling	\$ 2,000
Total cost/mile of track	\$25,000

2. The cost of a 5-tons Diesel Locomotive ex estate will be about \$30,000 at today's ruling price. As a general rule it will be necessary to provide storage capacity for not less than 70% of the daily crop of F.F.B. during a peak month which can be 12% of the annual total

i.e. $\frac{100,000 \text{ tons} \times 12\% \times 70\%}{25 \text{ days}}$ = 336 tons

It will therefore be necessary to provide fruit cages and underwaggons to cater for 336 tons of FFB with $2\frac{1}{2}$ tons cages, the total requirement will be as follows :-

$\frac{336}{2.5}$ = 134 cages

The cost of such a cage and under waggon would be about \$1,700 per set.

3. Tractors and Trailers would have to be employed in the fields for carrying the cages to and from the field for loading at the railway, which is done by the medium of the hydraulic power take-off attached to the tractor.
On a 6 days harvesting round five tractors and a similar number of special trailers will serve 10,000 acres in this manner together with five hydraulic gantries.

The cost of a suitable tractor cum trailer for a fruitcage is at present $15,000 ex estate, and a gantry can be provided at $6,000 ex estate.

4. Total Capital Cost of a Railway collection system :

50 miles of track	$1,250,000
60 miles of secondary roads	$ 240,000
10 Five tons Diesel Locomotives	$ 300,000
134 cages and trucks	$ 227,000
5 Tractors and trailers	$ 75,000
5 Gantries	$ 30,000
5 Platform trollies	$ 6,000
1 Tank waggon	$ 6,000
Total cost	$2,134,000

With return cargo such as estate supply, diesel oil to outer divisions, ash from the boilers etc. the total tonnage transported will be approximately 130,000 tons/annum.

The average cost of maintenance and operation would be as follows:

Rail Transport & Upkeep Locomotives	$ 55,000
Upkeep Rail Track	$ 25,000
Upkeep Rolling Stock	$ 10,000
Total average annual cost of operation	$ 90,000

Cost per ton/mile of goods moved before depreciation would be as follows: -

$$\frac{90,000 \times 100}{130,000 \times 7} = 10 \text{ cents.}$$

The following interest and depreciation charges will also have to be included in the cost of operating a railway network:-

5% on 50 miles rail track $1,250,000	=$ 62,500
5% on 60 miles secondary roads $24,000	=$ 12,000
7½% on Rolling Stock $269,900	=$ 20,325
10% on Locomotive $300,000	=$ 30,000
8% interest on Capital $2,134,800	=$170,784
Annual cost of operation	=$ 90,000
Total annual cost operation & capital	=$385,609

Actual cost per ton/mile of goods moved :-

$$\frac{385,609 \times 100}{130,000 \times 7} = 42 \text{ cents.}$$

VII. COLLECTION AND TRANSPORT BY ROAD NETWORK :

1. To establish an efficient road network on inland soil is cheaper than to establish a similar system on alluvial coastal clay; however, since there can be no justification for establishing a rail network on inland soil, it will be of interest only to make a comparison of the capital cost and operations of road and rail network on coastal clay.

2. The road network on two substantial coastal estates has a density of one chain/acre. 70% of the road network consists of all weather roads with mining metal as ballast and the cost is about $10,000/mile, 30% of the road network consists of secondary roads costing $4,000/mile only. A total of 87 miles of all weather roads and 38 miles of secondary roads will be required therefore to give the desired density of one chain/acre on a 10,000 acres estate.

3. The transport equipment required/1,000 acres in this case, is one special, heavy tractor at $27,000 together with two 6-tons trailers costing $6,000/unit.

4. The storage of 70% of the crop is catered for by a 100 tons loading ramp and one hundred $2\frac{1}{2}$ tons cages with special steriliser underwaggons.

5. Total Capital cost of a road network collecting system :

87 miles of all-weather roads	$ 870,000
38 miles of secondary roads	$ 152,000
Loading Ramp & Shunting area	$ 100,000
100 Fruit cages & underwaggons	$ 120,000
10 Tractors	$ 250,000
20 Trailers	$ 120,000
	$1,612,000

6. The average cost of maintenance and operation would be as follows :-

Upkeep 125 miles of roads @ $5/chain	$ 62,500
Upkeep Tractors & Trailers	$ 25,000
Tractor Operating costs	$ 50,000
Total average annual cost of operation	$ 137,500

Cost per ton/mile of goods moved before depreciation

$$\frac{137,500 \times 100}{130,000 \times 7} = 15.1 \text{ cents.}$$

7. The following interest and depreciation charges will also have to be included in the cost of operating a road network :-

5% on roads $1,022,000	=$ 51,100
5% on loading ramp $100,000	=$ 5,000
10% on cages & under waggons $120,000	=$ 12,000
15% on tractors & trailers $370,000	=$ 55,500
8% interest on capital $1,612,000	=$128,960
Annual cost of operation	=$137,500
Total annual cost capital & operations	=$390,060

Actual cost per ton/mile of goods moved :

$$\frac{390,060 \times 100}{130,000 \times 7} = 42.8 \text{ cents.}$$

Table No. 1

Summary of Transport System.	Capital Cost per Acre (10,000 ac.)	Cost per ton/mile Operational	Cost per ton/mile Including Deprecn.
Rail Network	$ 213	10 cents	42.0 cents
Road Network	$ 165	15.1 cents	42.8 cents

VIII. STERILISATION :

1. The first process to which the Fresh Fruit Bunches are subjected is sterilisation, the aim of which is three fold, namely :-

   i) To inactivate the lipase or fruit enzyme, which is thermolabile.

   ii) To coagulate the nitrogenous and mucilagenous matters, in order to prevent the formation of emulsions in the crude oil during purification.

iii) To improve extraction by proper stripping of the bunches as well as the breaking up of the oil carrying cells of the mesocarp.

2. Sterilisation is normally carried out by means of horizontal or vertical sterilisers constructed to withstand a working pressure of 3 atmosphere or about 43 psig.

3. In the horizontal steriliser the FFB is contained in a mild steel fruit cage of either $1\frac{1}{2}$ tons capacity or $2\frac{1}{2}$ tons capacity. The sterilising cage is generally constructed with two cylindrical carrier rings facilitating the lifting and smooth discharge of the fruit into the threshing machine.

4. The vertical steriliser is generally used for a smaller factory throughout and the FFB is normally discharged direct into the steriliser by means of a bunch Elevator. The discharge from the vertical steriliser is carried out manually by workers raking the sterilised fruit to a conveyer feeding the threshing machine.

5. The steam consumption per ton of FFB sterilised is the lowest in respect of the vertical steriliser as shown hereunder in Table No. 2. However, the oil loss in the condensate is the highest in respect of the vertical steriliser and the additional brushing of the FFB during charging of the steriliser also aggravatesthe development of the FFA.

Table No. 2

Steriliser	Steam consumption per ton of FFB	Oil loss to FFB in condensate	Loss of moisture due to desiccation.
Horizontal	280 lbs	0.45%	8 - 12%
Vertical	230 lbs	0.55%	6 - 10%

6. The treatment to which the FFB is subjected during sterilisation is most important because it has a pronounced influence on the overall extraction efficiency and quality of the oil and kernels extracted. The enzymatic hydrolysis causing the acidification of the palm oil will cease when the FFB is exposed to a temperature of about 60°C. However, the destruction of the oil carrying cells which is accelerated by desiccation require a much higher temperature, and although the time required for the loosening of the fruitlets from the stalk vary with the size and ripeness of the FFB it is possible to achieve good sterilisation within one hour at a pressure of 43 psig. If the sterilisation is prolonged beyond 60 minutes discolouration of the kernels will be aggravated.

7. Tests carried out at Ulu Bernam have confirmed that sterilisation at 38 psig, with intermitten fall of pressure to 25 psig, by blowing out steam to other sterilisers, has a beneficial effect in respect of discolouration of kernels, desiccation and nut cracking. The tests were carried out with several samples, each of 5 tons of FFB and harvested from identical palms in respect of age and origin. The average results were recorded as shown below at Table 3.

Table No. 3

Details	43 psig	38 to 25 psig
Desiccation	10%	12%
White Kernels	83%	96%
Discoloured Kernels	17%	4%
* Cracking Efficiency	89%	94%

* Cracking of 50 lbs nuts samples direct from the depericarper.

The higher percentage of desiccation no doubt was caused by the fall in pressure which could create flash evaporation from the bunches in the event the temperature of same would be higher than the steam temperature at 25 psig. The percentage of white kernels clearly illustrate the beneficial influence obtained by the reduction of pressure. The increased cracking efficiency is explained by the effect pressure variation have on the nuts, which in this case was of Dura origin.

8. The possibility of conditioning the nuts during sterilisation for direct cracking from the depericarper, has led to the construction of a new type of nut cracking station which will be tried on a commercial basis during 1972.

9. The question of how to ensure the best possible sterilisation has been subject to much attention of theoritical as well as practical nature.

10. Various views are held with reference to the effect of air in the steriliser in respect of temperature and oxidation of the oil. In particular there seems to be a conflict of opinion as regards the development of peroxide during sterilisation. Consequently in order to meet the demand for high quality palm oil such as SPB an extensive research programme was implemented at the Ulu Bernam Palm Oil Factory of United Plantations, the details of which can be studied from various papers submitted to the Symposium on "Quality and Marketing of Oil Palm Products" sponsored by the Incorporated Society of Planters, and held in Kuala Lumpur 6th to 8th November, 1969.

11. The standard sterilising procedure is to allow slow admission of steam well-distributed at the top of the steriliser, while the bottom discharge valves are left open to allow air to discharge for about 5 minutes or until wet steam is visible at the discharge point. Such procedure makes it possible to drive out a high percentage of the air without use of power or extra equipment. When the main valve has been closed a one inch valve controlling a by-pass, can be left partly open to allow for further escape of air during the sterilisation which normally has a cycle of one hour. This is the method recommended and used widely within the industry. However, in order to establish a comparison of results a vacuum pump giving 80% vacuum within 12 minutes was attached to one of the sterilisers, and the average results in respect of temperature and peroxide development are shown hereunder in Fig. No. III. & IV.

Fig. No. III

Vacuum applied- Average Temperature 273°F

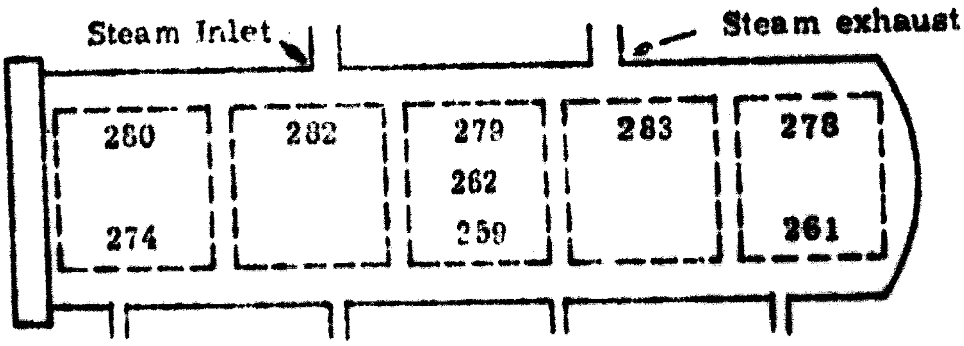
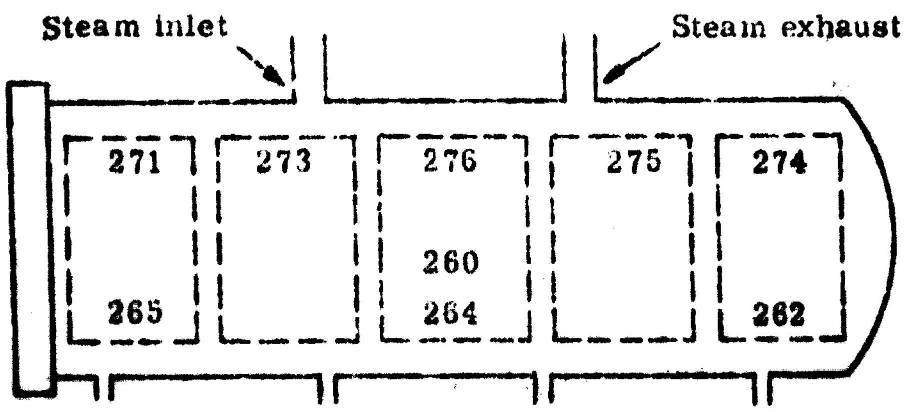


Fig. No. IV

No Vacuum - Average Temperature 269°F



12. It will be ooserved that the average temperature in respect of the steriliser exposed to a vacuum of 80% was recorded at 273°F against 269°F for the steriliser without application of vacuum. A temperature difference of 4°F at this level is equal to a difference of steam pressure of about 4 lbs. only, which really is insignificant under practical conditions. Since the stripping of the bunches in each case was excellent it was concluded that the temperature difference obtained by application of vacuum did not improve the sterilisation to any noticeable degree.

13. As regard the risk of oxidation during sterilisation Table No. 4 shows no convincing difference between the vacuum and none vacuum sterilisation. Subsequent production of SPB oil on a large scale has confirmed our original finding in this respect, which indicate that the oil does not oxidise while inhibited in the mesocrap. This view seems to be confirmed by the fact that the oil which exudes from the fruit during sterilisation has a high degree of oxidation in respect of peroxide and benzidine value.

Table No. 4

Oil Sample	Days FFA %	Moisture %	21	28	35	42	49	56
			Peroxide Value mmole/kg oil					
A	1.37	0.064	0.00	0.18	0.74	0.99	1.11	1.37
B	1.42	0.067	0.00	0.21	0.72	1.02	1.17	1.42

Peroxide tests on fresh oil and stored samples
Steriliser A with vacuum B with air release.

14. The only part of processing of FFB which is not on a continuous basis is the sterilisation. The problem of handling the waste volume of FFB on a continuous basis without additional brushing represents a formidable problem. It is nevertheless, correct to say that continuous sterilisation would be a most desirable feature to add to the processing of F.F.B.

IX. STRIPPING :

1. The second treatment to which the fruit bunches are subjected is stripping of the fruitlets from the bunch. This operation normally takes place in a drum threshing machine with a diameter of about 6'6" operating at 23 R.P.M. The length of the drum varies according to the throughput and with an automatic bunch feeder the throughput of a threshing machine with a drum's length of 18 feet can handle the sterilised bunches from 40 tons of F.F.B./h.

2. The sterilised bunches are lifted by means of an overhead crane, which is fitted with a device turning the fruit cage 180° in order to discharge the contents of the cage. It is important to ensure a rapid conveyance of the fruit from the steriliser yard to the digester in order to preserve the heat of the fruit. Well co-ordinated handling will ensure the fruit reaching the digester at a temperature of not less than 75°C.

3. Assuming proper harvesting standard and sterilisation of the F.F.B. the percentage of unstripped bunches should be between 4 to 6% only. Unstripped bunches must be recollected and sent back for sterilisation a second time. The volume of unstripped bunches is less than half the volume of F.F.B.

4. The stripped bunches represent approximately 25% of the incoming FFB expressed in terms of weight. It therefore represents a handling problem which can be dealt with as follows:

i) The empty bunches are returned to the fields where they are distributed in the inter-rows between the palms. The mulching effect as well as the nutrition value of such bunch application, at the rate of 40 tons per acre, is most beneficial and our records indicate the effect to last over a period of three years.

ii) The empty bunches can also be conveyed directly to an incinerator where a slow and controlled fire will ensure a supply of potash representing 0.3 to 0.5% to F.F.B. Such potash is redistributed to the field where it is readily absorbed by the palms. The average composition of the ash has a range as shown in Table No. 5.

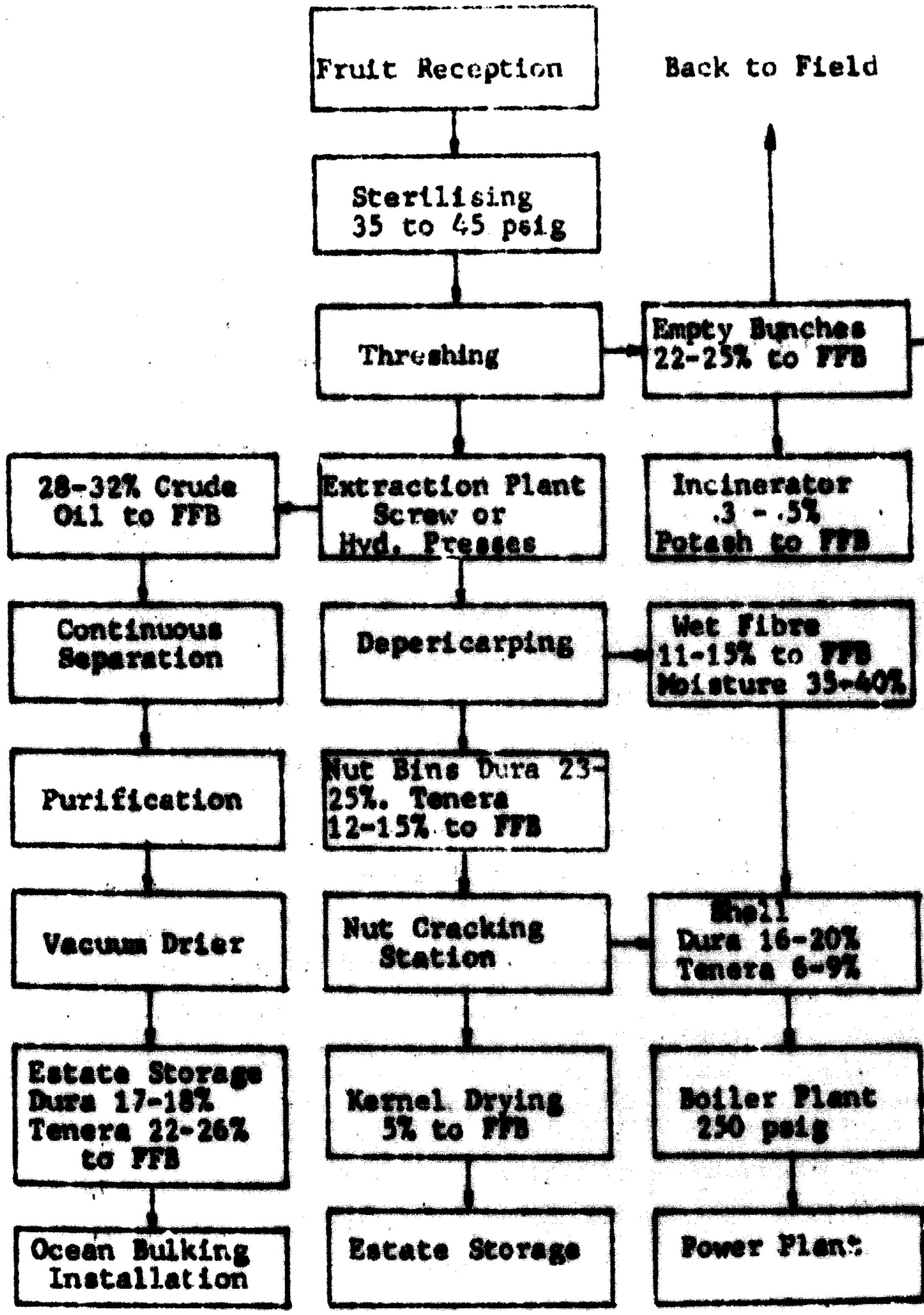
Table No. [illegible]

Analysis of Bunch Ash		Average	Normal Range
Phosphorous	(P)	1.2%	0.9 - 1.7%
Potassium	(K)	26.7%	15.0 - 40.0%
Calcium	(Ca)	2.3%	1.6 - 3.7%
Magnesium	(Mg)	3.6%	2.7 - 4.8%

The ash from one ton of empty bunches contain the equivalent of about 15 lbs. ammonium sulphate, 2½ lbs. of rock Phosphate and 20 lbs. of Potassium sulphate when burnt in an Incinerator. The construction of an incinerator can therefore be considered an economical proposition. In fact approximately 400 tons of concentrated fertilizer can be produced from 25000 tons of empty bunches, and this represents approximately S$100,000 at ruling prices.

iii) During the early stage of operation of a new factory, the fuel supply of fibre and shells sometimes falls below the requirement due to the fact that the power units are geared to a greater throughput. In such cases the empty bunches are sometimes used as additional fuel. However, in view of the high moisture contents as well as an undesirable element of sulpher contained in the empty bunch, it is not considered an attractive fuel substitute.

FLOW SHEET RELATING TO PROCESSING
OF
FRESH FRUIT BUNCHES



X. THE OIL EXTRACTION PLANT:

1. The extraction of edible oil from seeds or other material low in oil contents is now normally carried out by means of solvent extraction leaving less than 1% oil in the meal against from 6 - 8% in respect of the residue from expellers or presses.

2. The palm fruit by containing two widely different oils, namely palm oil and palm kernel oil, represents problem in so far as solvent extraction is concerned, because it would be necessary first to sterilise the bunches in order to loosen the fruitlets as well as to control the development of F.F.A. The separation of the mesocarp and nuts would also be necessary in order to retain the two different oils and such process would involve a pre-pressing. Consequently the residual oil in the fibre should justify the capital investment required for a solvent plant, and this seems to be the stumbling block to such process, which would extract a low quality oil from the fibre containing phosphatides and other non-glyceride impurities.

3. The industry have therefore hitherto been confined to mechanical extraction begining with the centrifuges followed by hydraulic presses and now screw presses. The centrifuge is too inefficient to justify its containing existence and with the increasingly higher oil contents in the pericarp from the Tenera strain, the efficient extraction by means of hydraulic presses becomes more and more problematic. Consequently the continuous screw press is now the most frequently used medium of extraction in the palm oil industry; not only because it can cope more efficiently with a higher oil content in the mesocarp, but

equally much so because the mechanical and economical advantages offered by this method of extraction is superior to any other method of extraction known to the market at the present moment.

4. The efficiency of the extraction unit regardless of type depends very much upon the process of digesting, the aim of which is to break up the oil carrying cells of the pericarp by means of stirring arms rotating with vertical shaft. The size of the digester is normally equal to a volume of 2,500 l. However, with the introduction of the continuous screw press the size has been increased in order to allow sufficient retention time to separate the nuts from the pericarp, and digesters with a volume of up to 4000 l. is now in commission within the Malaysian Palm Oil Industry.

5. When used in conjunction with hydraulic presses, the digester is normally provided with a steam jacket allowing the temperature of the mash discharged into the press to reach 95°C. Digesters for screw presses are sometimes without a steam jacket and in such case live steam is injected in order to let the mash reach a discharge temperature of 95°C. However, tests have shown the desirability of retaining the steam jacket in order to reduce the moisture contents of the fibre going to the boiler platform.

6. Some digesters are operated with bottom discharge in order to pre-condition the mash for the extraction unit. However, practical tests have shown that such method of operation is not desirable as regard the wear

and tear as well as the consequent higher absorption of iron by the palm oil. The importance of reducing the absorption of heavy metal, copper or brass will be shown under the heading "Palm Oil Purification Plant".

7. During 1964 it was decided to embark on a Research Programme the aim of which was to establish how to produce a high quality oil in connection with efficient and economical operation. This policy led to the employment of highly qualified chemical engineers to be in charge of quality control. Experimental research with existing and new machinery and equipment finally produced the agreeable result which made the production of high quality S.P.B. oil on a big scale a reality. The details of the quality aspect of such oil can be observed from the chapter describing the purification of palm oil.

8. The experimental research with existing and new machinery and equipment eventually made the factories controlled by United Plantations unique in the sense that it became the only known centre in the world, where six different types of Palm Oil extraction units were subjected to comprehensive tests under identical conditions over several years, covering not only the performance but also the aspect of wear and tear and relevant economics.

9. It is a well known fact that Iron and heavy metals such as brass and copper have a catalytic effect in respect of oxidation of oil. It was established that the oil from steriliser fruit contained from 0.6 to 0.8 ppm of iron, and 0.06 to 0.18 ppm of copper. The contents of iron in palm oil from South East Asia normally range between 5 ppm to 12 ppm, whereas the copper contents has been

recorded to be between 0, 15 to 0, 4. It is therefore apparent that iron and heavy metal is absorbed during processing, and Table No. 6 indicates the calculated iron absorption in lbs per ton of F. F. B. based upon the loss of iron due to wear and tear over 1000 hours operation.

Table No. 6

	Standard hydraulic	Automatic hydraulic	Usine de Wecker
Digesters:			
Exposed inner shell	8, 32	-	10, 04
Wear plates	40, 20	137, 06	44, 90
Bottom plates	73, 31	90, 85	98, 75
Square shaft	7, 85	9, 76	8, 20
Beater arms	28, 07	36, 20	33, 90
Discharge arms	10, 41	14, 07	11, 30
Mounting blocks	12, 22	13, 74	9, 52
Total loss	181, 38	301, 68	213, 61
Press units:			
Press plates (5)	9, 00	-	-
Press cage	34, 72*	20, 45+	28, 60#
Screw (2)	-	-	22, 63
Extension shafts (2)	-	-	14, 00
Pressure cones (2)	-	-	9, 56
Total loss	43, 72	20, 45	74, 79
Combined total loss :	225, 10	322, 13	288, 40
FFB processed (tons)	3000	55000	100000
Total loss per hour (lb)	0, 225	0, 323	0, 288
Loss per ton f. f. b. (lb)	0, 075	0, 059	0, 028

* Solid drawing steel. + Spebial cast iron.

\# Special steel 95-100 kg per sq. m. m.

10. By choice of extraction unit as well as by preventive measurements it is possible to reduce the iron contents of the production oil to around 2 ppm whereas the copper contents can be kept at about 0.2 ppm. In view of the detrimental effect such metal has on the oil, it is obvious that the storage property of high quality oil is superior and this is why the S.P.B. quality of palm oil is becoming more and more popular with edible oil refiners.

11. From Table No. 7, which includes the recorded power consumption of a digester fitted with one-third extra beaterarms (23 r.p.m.) and seven sets of angle iron stop bars, it can be seen that a temperature raise from 71°C to 95°C caused the power consumption to be reduced from 22 k.w. to 14 k.w., i.e. the rise in temperature promoted a very substantial fall in frictional losses. Consequently, apart from the power requirement which can be substantially reduced if the digesters are operated at the ideal temperature of 95°C, the wear and tear, and thereby absorption of iron, can also be kept at a lower level by use of the correct temperature. It is also interesting to observe how the level of fruit in the digester can influence the extraction efficiency by a significant margin. It appears that a digester for a standard hydraulic press should never be less than three-quarters filled, while maintaining a temperature of approx. 95°C.

Table No. 7. Digester tests with different levels of fruit and temperature

Fullness of Digester	Temp. of digested mash, start-end	Kw electric motor before -after filling press cage	Moisture	Oil loss	Oil on dry basis
1/4	71-72	6-4	47.708	8.213	15.707
1/4	71-70	6-4	46.795	7.690	14.455
1/4	71-71	6-4	46.487	8.487	15.303
1/2	71-71	11-9	45.904	6.572	12.150
1/2	72-71	11-9	45.557	6.403	11.762
1/2	71-70	11-9	45.904	6.572	12.150
3/4	70-70	16-13	45.318	5.749	10.516
3/4	71-70	16-13	44.928	5.665	10.288
3/4	72-72	16-13	45.165	5.805	10.587
Full	69-69	22-18	44.900	5.539	10.053
Full	71-70	22-18	45.245	5.922	10.817
Full	71-70	22-18	46.181	5.786	10.752
Full	95-94	14-12	41.273	5.989	10.198
Full	95-96	14-12	44.496	6.031	10.866
Full	95-95	14-12	41.194	6.212	10.564

Note difference in power consumption between 70°C and 95°C and moisture contents in fibre. Also difference in oil loss on dry basis between one-half and three-quarters-filled digesters.

12. In order to establish whether it would be advantageous to drain digesters while processing D X D fruit, several tests were carried out. The total oil losses from a digester with bottom drainage and a digester without bottom drainage are shown in Table 8. This has been calculated on the basis of the following figures, generally applicable when processing mature D X D fruit; oil extraction, 18%; nuts to fruit, 21-23%-less 14% moisture-say 18%; dry fibre and residue to fruit 11%.

13. From Table 8, it is obvious that although the amount of oil on dry basis in fibre can be improved by having bottom perforation, the total oil loss is higher due to the higher n.f.p.q. and, in particular, due to the higher ratio of oil loss on nuts. An explanation is that bottom drainage with D X D fruit will cause too many cavities between the nuts due to the absence of dry matter; consequently, some of the nuts are visibly wet with oil. It is also significant to observe that, by applying bottom drainage, the power requirement increased by about 30%; hence the frictional losses are greater and the oil consequently contain a higher proportion of iron.

14. The percentage of smashed nuts and kernels becomes substantially higher with bottom drainage. This feature is amplified by severe drainage which, for instance, is required when a digester is working in conjunction with the automatic hydraulic press. However, when processing Tenera fruit in standard presses, experience has been that moderate drainage from the digester bottom plate is a desirable feature in improving the extraction efficiency.

Table No. 8 Typical analysis results recorded from digesters with (A) & without (B) bottom drainage

Press cake (A)*	Oil loss on nuts	Split nuts	Free kernels	Free shell	Whole nuts	Smashed nuts	% of Cake: Nuts	% of Cake: Fibre	Fibre Residue: Moisture	Fibre Residue: Oil	Fibre Residue: Residue	Oil on dry basis
Top	1.02	1.424	0.083	0.432	93.556	4.510	70.908	29.092	42.601	6.216	51.183	10.830
Middle	1.11	6.144	0.224	0.781	85.957	6.894	71.080	28.920	41.721	5.379	52.900	9.230
Bottom	1.26	5.388	0.378	1.602	80.420	12.412	75.206	24.794	40.189	4.886	54.925	8.169
Average	1.13	4.585	0.228	0.938	86.644	7.606	72.380	27.620	41.504	5.493	53.003	9.409
Press cake (B)*												
Top	0.71	0.122	0.042	0.181	98.762	0.893	61.830	38.170	42.931	6.519	50.550	11.424
Middle	0.63	0.300	0.059	0.298	96.707	2.636	53.644	46.356	40.590	5.[illegible]	53.588	9.800
Bottom	0.65	2.353	0.091	0.452	91.776	5.328	58.882	41.118	41.411	5.065	53.523	8.645
Average	0.66	0.925	0.064	0.310	95.748	2.953	58.118	41.882	41.644	5.803	52.553	9.956

	A: Moisture	A: Residue	A: Oil	A: Oil on dry basis	B: Moisture	B: Residue	B: Oil	B: Oil on dry basis
Crude Oil	44.490	7.401	48.109	-	45.064	5.206	49.730	-
Sludge water	95.782	3.829	0.389	9.236	96.784	3.009	0.207	6.435
Oil loss in fibre to boiler (kg)			=0.818				0.904	
Oil loss in residue to sludge separator (kg)			=0.254				0.124	
Oil loss on nuts (kg)			=0.203				0.119	
Total oil loss per 100 kg f.f.b.			1.275				1.147	

* H.p. consumption 27 (A) and 20 (B). Fruit D x D; digester temp. 96°C: 30 r.p.m. maximum pressure 350 kg per sq. cm for 4 min.

15. The overall extraction efficiency, as depicted in Table 9, indicates that the efficiency of screw presses equals, or is even greater than, that of hydraulic presses. No doubt the early results were most unfavourable in respect of the screw presses due to the much higher n.f.p.q. However, improvements in design have brought the n.f.p.q. of the screw presses close to that of the automatic hydraulic press, and the use of better screening and thermal treatment, as well as the introduction of more efficient separators, have made the problem of n.f.p.q. much less important, since the losses on dry basis in the sludge are now nearing the level of the losses in fibre. It is therefore probably correct to predict that the more efficient extraction unit will be the one able to produce the lowest percentage of oil in the fibre from the press, and this will be more pronounced the higher the percentage of oil in the incoming fruit. Table 9 also indicates the capital cost per ton of F.F.B. throughput capacity as well as the relevant maintenance cost of the various presses. In this connection it must be mentioned that screw presses also offer savings in respect of capital outlay for buildings and power plant.

16. The wear & tear of a digester with provision for bottom discharge can be very severe in particular so if the fruit is contaminated with sand. The average life of various components has been recorded as follows:

Digester beater arms and expeller arms	4 - 6 months
Side wall wear plates, 3/8 in thick	6 - 7 months
Bottom wear plate, $\frac{3}{4}$ in thick, mild steel	9 - 12 months
Press cage (approx)	10000 h, equal to 50-55000 tons of f.f.b.

Table No. 9 - Average loss of oil (in kg/100 kg f.f.b) using various extraction units and additional data

	48 in centrifugal	Standard hydraulic	Automatic hydraulic	Usine de Wecker screw press	Speichim screw press'3000'	Krupp Screw Press
Loss in:						
steriliser condensate	0.040	0.040	0.040	0.040	0.040	0.040
empty bunches	0.450	0.450	0.450	0.450	0.450	0.450
press residue	1.400	0.874	0.701	0.606	0.614	0.438
nuts	0.148	0.124	0.150	0.152	0.146	0.160
sludge water	0.054	1.107	0.192	0.231	0.271	0.427
Total oil loss	2.092	1.595	1.533	1.479	1.521	1.515
Total oil recovered (%)	17.441	17.938	18.000	18.054	18.012	18.018
Overall extraction efficiency(%)	89.28	91.83	92.15	92.42	92.21	92.12
Oil on dry basis, fibre (%)	14.91	9.821	8.315	7.274	7.579	7.349
Oil on dry basis, sludge (%)	3.35	5.092	7.481	8.674	9.315	11.868
N.f.p.g	14.6	19.1	23.3	24.2	26.4	32.73
Iron loss per ton f.f.b. (lb)	-	0.075	0.059	0.028	0.027	0.030
Unit capacity (tons f.f.b./h)	4	3	4.5-6.5	5-14	7-11	10-18
Maintenance cost per ton f.f.b (¢)	-	45	50	35	49	32
Required h.p. per ton f.f.b.	10-12	8-9	6-7	3-4	4-5	3-4
Capital outlay per ton ffb capacity	$20000	30000	32000	12000	12000	10000
Annual cost of capital/ton ffb/h *($)	3600	5400	5760	2160	2160	1500

* Assuming 10% depreciation and 8% interest.

X. KERNEL RECOVERY PLANT :

1. The efficient kernel recovery commences during sterilisation, at which time the nuts can be preconditioned for the cracking at a later stage. However, the separation of the nuts from the press residue starts at the press cake conveyer, which is heated by a steam jacket suitable for a pressure of 45 psig. The object of the press cake conveyer is to condition the press residue for separation of the nuts from the fibre. This is done by means of a paddle shaft , rotating at about 50 r.p.m. The application of heat assists, the separation of the fibre from the nuts by reducing the moisture of the fibre before the press residue is discharged into the depericarper.

2. Several types of depericarpers are in use ranging from open mechanical screens to pneumatic separating columns or a combination of the pneumatic columns and a cleaning drum. The later mentioned type which is shown below in Fig. 5 is the latest type introduced to the industry in Malaysia, and the simple design ensures reliable and efficient operation at a power requirement of about 1 H.P./ton of FFB processed.

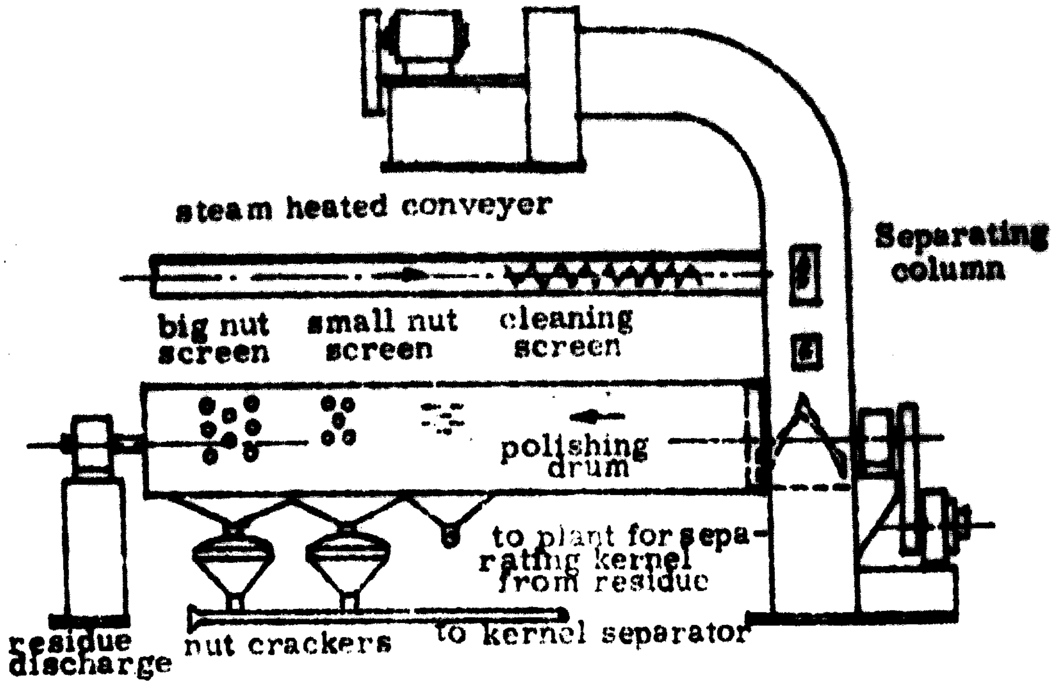


Fig. 5 - New U.P. Type Depericarping cum Cracking Station.

A powerful fan (30 H. P.) sucks the fibre away before the nuts reach the rotating drum which then polishes and separates away further fibre that otherwise could cause trouble during separation of the cracked mixture.

3. After the depericarper the nuts are conveyed to the nut bins either mechanically or pneumatically. In the nut bins the nuts are conditioned for cracking by reducing the moisture content from about 16% to between 10 to 12%, at which level the desiccation has caused the kernel to shrink away from the shell thus facilitating cracking of the nuts without cracking the kernels. Proper drying prior to cracking also reduces the loss of kernels during separation, because with insufficient dried nuts, pieces of shell will stick to the kernels thus causing the kernels to be discharged with the shell fraction going to the boiler.

4. Drying can be achieved by natural drying in the bins for about 6 days, or by artificial drying by means of a heat exchanger in conjunction with a ventilation fan. Tests carried out with a heating oven in order to find the optimum cracking condition gave the results as shown in Table No. 10. The ideal condition would of course be to crack the nuts direct from the depericarper because this would ensure less capital out-lay as well as a better kernel quality.

5. The conventional cracking plant consisted of a top grading screen with two or three separating screens, the aim being to separate the nuts into size prior to cracking and screening. This method called for an elaborate structure without ensuring the desirable efficiency. This is particularly so when a mixture of Dura and Tenera nuts are to be cracked in the same plant.

Table No. 19

Moisture in nut, shell and kernel of fresh Tenera nuts which have been dried from 0.5 hours at 80°C (summary of the mean values)

No. of hours of Drying	M. in S. in % of F.N.	M. in K. in % of F.N.	M. in N. in % of F.N. (a)	% Loss in Wt of Nut (b)	(a) + (b)	No. of Minutes for Cracking 20 Nuts.
0	9.10	14.80	23.90	0	23.90	-
1	4.65	11.99	16.64	5.63	22.27	9.90
2	3.70	11.21	14.91	7.64	22.55	6.40
3	3.38	10.21	13.59	9.11	22.70	4.70
4	2.85	9.17	12.02	10.91	22.93	3.10
5	2.61	7.93	10.54	12.49	23.03	2.60

Reference:

F = Fresh K. = Kernel
N = Nut M = Moisture
S = Shell

6. A new cracking plant was introduced by Messrs. United Plantations during 1968/69. The advantage of this plant is based on the replacement of the top grading screens as well as the consequential separating drums by one single screening drum, which allows for the recycling of uncracked nuts while separating to the boiler all shell pieces below 10 min. This plant has simplified the cracking station and proved to be reliable and efficient. However, as mentioned earlier, an even more simplified plant has now been designed and will be ready for commissioning on a commercial basis during 1972.

7. The separation of the cracked mixture into fractions of kernels & shells takes place by means of either clay bath separators or hydrocyclone separators. The claybath separator is simple and efficient if the proper clay is available, and a plant for a throughput of 5 tons nuts/h can be operated by means of 5 H.P. Nevertheless it requires a continuous supply of suitable clay at a rate of about 0.1 ton per ton of kernels produced. Tests on the gravity of the kernels have shown the variations as shown in Table No. 11. It is therefore advisable to operate the clay-bath with a specific gravity of 1.18 to 1.20 in order to get near 100% recovery. However, with the "tail" peculiar for Tenera nuts a high percentage of shell pieces are carried over with the kernels at such specific gravity. A special winnowing plant cleaning the cracked mixture as well as the dried kernels can overcome this problem.

Table No. 11

Specific Gravity	Test with Salt Solution			
1.06	All kernels remained submersed			
1.07	10% came to the surface			
1.08	30%	"	"	"
1.09	60%	"	"	"
1.10	80%	"	"	"
1.12	90%	"	"	"
1.16	100%	"	"	"

Recommended S.G. for Clay-Bath 1.18 - 1.20

8. The Hydrocyclone Separator can be nearly as efficient as a clay-bath separator, and it does not require a continuous supply of a separating media such as the clay-bath separator. It is quite sensitive to wear and tear of the separating cones in relation to efficiency, and the Power consumption at 30 H.P. is substantial. It is more clean in operation than a clay bath separator, and therefore more agreeable to operators. The cost of maintenance and operation is more or less identical.

9. After the separation the kernels must be washed and conveyed to the kernel drier where the wet kernels will be dried down to a moisture content of between 7 to 8% in order to prevent serious development of F.F.A. during storage and shipment. Tests have shown that oil from cracked kernels show a much higher development of FFA than does oil from whole kernels. This is explained by the fact that cracked kernels expose greater surface area to microbiological attack than is the case with whole kernels which are well protected by the skin of the kernel.

10. To examine the effect of kernel sterilisation on quality, four bags were filled with a mixture of whole and broken kernels selected randomly from fifty bags of stored kernel. These were then sorted into whole and broken kernels. One-half of each group was steamed for 5 min. in an open container provided with live steam distribution pipes and then sun-dried to 7% moisture. The comparative results in respect of oil extracted at two weeks intervals are shown in Table No. 12.

11. It is quite obvious that sterilisation prior to storage has a most salutary effect on the extracted kernel oil, which is closely akin to coconut oil in its fatty acid composition, and therefore eminently suitable for the manufacture of edible fats and soaps, and as the extraction of oil from kernels is now done on a great scale in Malaysia, it should be possible to offer better kernel oil to the consumers in terms of FFA thereby reducing the refining losses, and thus making palm kernel oil more competitive.

12. The sterilisation of the kernels also has a beneficial effect in respect of preventing growth of mould on the residual cake, which although somewhat low in proteins, has a content of essential amino acids, together with a favourable calcium to phosphorous ratio, making it a valuable contribution to the protein build up of a compound animal food.

Table No. 12 - Effects of Kernel Sterilisation on Storage and Quality.

Time (weeks)	Non-sterilised whole kernel f.f.a. (%)	Non-sterilised whole kernel acid value	Non-sterilised whole kernel colour*	Non-sterilised broken kernel f.f.a. (%)	Non-sterilised broken kernel acid value	Non-sterilised broken kernel colour*	Sterilised whole kernel f.f.a. (%)	Sterilised whole kernel acid value	Sterilised whole kernel colour*	Sterilised broken kernel f.f.a. (%)	Sterilised broken kernel acid value	Sterilised broken kernel colour*
0	1.40	3.93	-	4.44	12.48	-	0.96	2.70	-	3.35	10.82	-
2	3.88	10.90	-	11.31	31.78	-	1.23	3.46	-	3.95	11.10	-
4	5.38	15.12	-	15.36	43.16	-	1.71	4.81	-	4.34	13.60	-
6	6.18	17.37	-	19.52	54.85	-	2.02	5.68	-	4.99	13.92	-
8	6.89	19.36	10Y,2.0R	22.85	64.21	20Y,2.3R	2.28	6.41	3.8Y,1.0R	5.23	14.70	1[illegible].5Y, [illegible].3R
10	7.10	19.95	9Y,1.7R	22.92	64.41	24Y,7.0R	2.32	6.52	4Y,1.1R	5.65	15.88	15Y,3.4R

* Lovibond tintometer yellow and red readings with 5¼ in. cell.

XI. PALM OIL PURIFICATION :

1. The pre-war purification of palm oil was frequently carried out by means of a sludge tank placed at ground level. The crude oil was conveyed into such tank and from there was skimmed off by a few gutters delivering the oil to a sump from where it was pumped to one or several decanting tanks. The oil was then exposed to heat treatment by live steam in order to coagulate the mucilagenious matters, and then left for natural separation for several hours. Such method was cumbersome and inefficient measured by the standard of present day purification plants.

2. The need for quality products and efficiency, has promoted the introduction of various solutions to quick recovery of the palm oil from the crude oil as expelled by the extraction units. The purification of palm oil commences immediately after the crude oil has been extracted from the digested mash by leading it over a vibrating screen of 30 to 40 mesh removing the major part of the fibre and residue expelled through the press cage. The residue passing over the screen is immediately recycled to the digester.

3. The crude oil discharged into a suitable reception tank preferably made of stainless steel, and crude oil pumps then convey the press liquid to a continuous separating tank at a temperature of about 90°C. Fig. No. VI shows a popular recovery system patented by Bernam Oil Palms in 1939. Approximately 80% of all the oil is recovered within 25 minutes after having reached the continuous tank, as shown, and from there it is lead direct to a holding tank prior to being admitted to a sealed purifier.

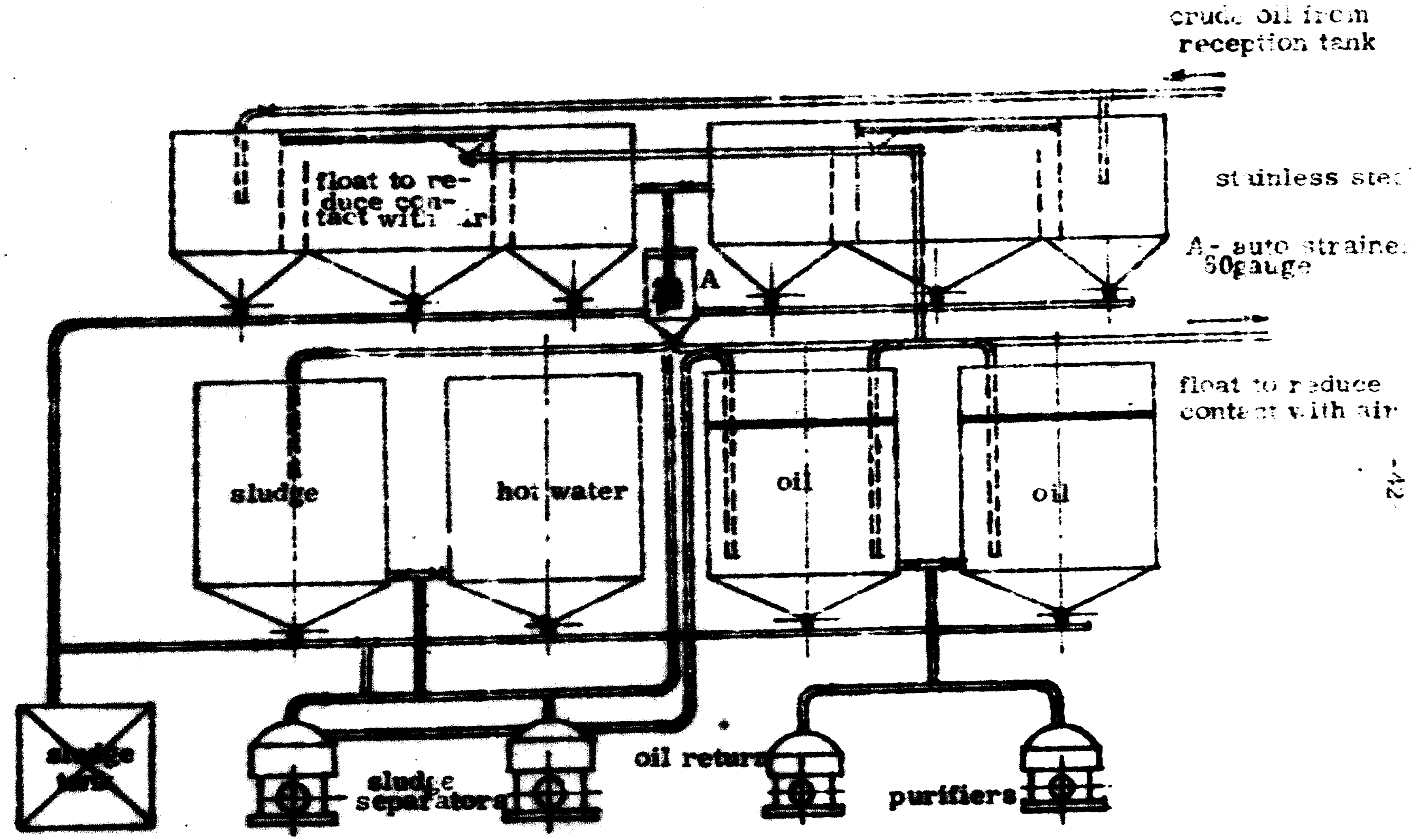


Fig. No. VI- B.O.P. Patent Continuous Palm Oil Separating Plant.

4. The remaining 20% oil together with the sludge , flow by gravity to a rotary screen with a mesh of from 0.6 to 1 mm. The screened sludge oil then goes to a boiling tank where the liquid is heated to about 100°C before being admitted to a sludge separator together with a mixture of hot water at a ratio of 1:1. The oil recovered is transferred to the continuous tank, and the sludge having a biochemical oxygen demand of above 20,000 is conveyed to a fat pit. The oil contents of the sludge water on dry basis is normally from 8 to 10% at a well run installation.

5. After purification the oil is pumped into a vacuum tank where the moisture is reduced to a level of below 0.1%. The oil is then cooled down to about 45°C and pumped to the oil storage tank where it remains at ambient temperature until shipment takes place at a temperature of about 55°C.

6. In the event that oil is conveyed to the Bulking Installation by road tanker, modern factories have comparatively small elevated despatch tanks, normally two of 50 tons each. The oil is discharged direct into the road tanker without pumping or further heating up. Such methods help to reduce the oxidation of the oil.

7. Comprehensive tests have shown that the formation of total oxidation popularly described as TOTOX=2 x pV + BV, commences when the oil has been extracted from the digested mass and exposed to the atmosphere at temperatures above 40°C. It is therefore of great importance to reduce the contact with air while the oil is hot, and from Fig. No. V, it will be noticed that floats have been fixed in the tanks in order to minimise surface contact during purification.

8. Tests carried out have disclosed that the conventional open purifier causes oxidation of the oil due to the fact that palm oil is discharged in small droplets at a high temperature and collected by the surrounding receptacle. In fact it has been found that one lb. of oil atomised by such open centrifuge gives a surface enlargement of 215,000 sq. inch. This is of course good for evaporation of moisture but it aggravates the development of the peroxide value, hence such purifiers should be replaced by sealed purifiers in order to facilitate the production of high quality oil.

XII. POWER PLANT AND THERMAL CONSUMPTION AT A PALM OIL MILL :

1. A palm oil mill consumes a relatively large quantity of steam for motive power and thermal treatment. It is therefore important during the initial stage of planning to establish a proper relationship between the F.F.B., available fuel such as fibre and shells, and the size of boilers and power units suitable for the ultimate capacity. From practical experience we know that the crop of F.F.B. during any one peak month can reach about 12% of the annual total. It is therefore necessary to establish a crop projection in relation to the areas under cultivation or those intended to bring into cultivation. This can be done as shown below in table No. 13.

Table No. 13

Year of Planting		Year of Cropping				
Year	Acres	1975	1976	1977	1978	etc
1969	1,000	3,000	6,000	8,000	10,000	
1970	1,000		3,000	6,000	8,000	
1971 etc	1,000			3,000	6,000	
Tons of F.F.B.		3,000	9,000	17,000	24,000	

2. Having established a crop projection it is possible to plan a factory throughput table based upon one or two shifts operation up to 20 hours/day as indicated in Table No. 14.

Table No. 14

Tons FFB. Per:	Annum	Peak month	Peak day 25 days per mth.	Hour at daily processing as indicated hereunder		
				8 hrs	16 hrs.	20 hrs.
1972	3000	360	14	1.75	0.88	0.70
1973	9000	1080	43	0.53	0.26	0.10
1974	17000	2040	81	1.01	0.50	0.40
1975	24000	2880	96	1.20	0.60	0.45
1980	100000	12000	480	60.00	30.00	24.00

3. When the factory throughput table has been established it becomes possible to calculate the fuel available for the boilers. Based upon the fact that Deli Dura fruit yield 12 to 14% fibre to F.F.B. (35 - 40% moisture) and 15 to 18% shells to F.F.B. (10 to 15% Moisture) Tenera fruit yield an identical percentage of fibre but only 6 - 10% shell to F.F.B. It is therefore obvious that the risk of having too little fuel during the initial stage, for which the boiler and motive power units are overdimentioned cannot be ignored. However, with the introduction of the screw press it is now possible to provide more fuel in relation to the capital outlay than was possible when only hydraulic presses were used. When based upon 18% fuel to F.F.B. with a net B.T.U. of 5500/lb. giving about 3.5 lbs. of steam per hour per lb. of fuel at a Thermal efficiency of 65% the following fuel and steam balance will materialise.

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2 OF 2

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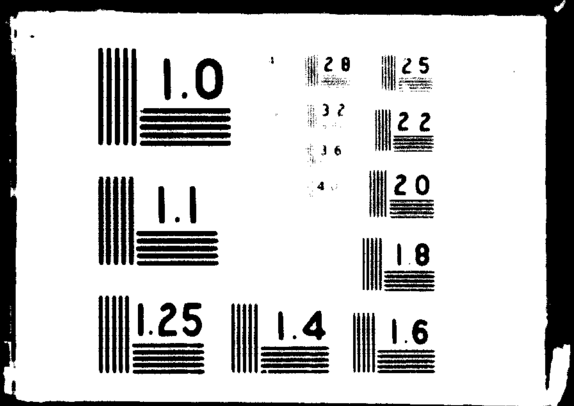

Table No. 15.

	Fuel Available/h.	Steam Evaporation/h.
10 tons of F.F.B./h	4032 lbs.	14112
20 " " "	8064 "	28224
30 " " "	12096 "	42336
40 " " "	16128 "	56448
50 " " "	20150 "	60560
60 " " "	24192 "	74672

4. The calorific value of the fibre and shell have been established by various laboratories, and the following tables Nos. 16 & 17 represent a fair average of semi-dried fuel :

Table No. 16 - Fibre :

Gross B.T.U./lb.	Dried Fuel	As Received	Dry Ash Free
Calorific Value	8.860	8.090	9.560
Proximate Analysis			
Moisture		8.7%	
Volatile Matter	72.7%	66.4%	78.4%
Fixed Carbon	20.0%	18.2%	
Ash	7.3%	6.7%	
	100%	100%	
Ultimate Analysis			
Sulphur	0.44%		

Table No. 1[illegible] - [illegible]

Gross B.T.U/lb.	Dried Fuel	As Received	Dry Ash Free
Calorific Value	9,190	8,450	9,480
Proximate Analysis			
Moisture		8.1%	
Volatile Matter	76.4%	70.2%	78.8%
Fixed Carbon	20.5%	18.8%	
Ash	3.1%	2.9%	
Ultimate Analysis			
Sulphur	0.04%		

5. The shells contain less sulphur than the fibre. However, the silica contents of the shell is quite high, and since the silica deposits itself on the furnace walls thereby causing spalding of the firebricks it is advisable not to use too much shell if it can be avoided. Table No. 18 indicates the analysis results recorded in respect of boiler slag freed from firebrick fragments after continuous firing for three months with 50% palm shells mixed with the fuel.

6. A great variety of boilers such as Water Tube, Lancashire, Cornish, Firetube and Underfired suspension boilers are in use within the palm oil industry. Pre-war, most boilers were operated in conjunction with a steam engine with direct exhaust to the atmosphere. This system gave a consumption of about 0.6 ton steam/ton of FFB treated. The great demand for thermal treatment with steam of low pressure such as sterilisation, treatment of crude oil with live steam and heat transfer through a steam jacket eventually induced the acceptance of the 45 psig back pressure system working in conjunction with a boiler pressure of about 250 psig. The consumption with such a system is generally about 0.4 to 0.45 ton of steam/ton of FFB treated.

Table No. 1 [illegible]

Silica	SiO_2	64.0%
Alumina	Al_2O_3	7.8%
Iron Oxide [illegible]	Fe_2O_3	2.0%
Calcium Oxide	CaO	4.3%
Magnesium Oxide	MgO	6.4%
Potassium Oxide	K_2O	10.8%
Sodium Oxide	Na_2O	0.2%
Sulphate	SO_3	0.9%
Phosphate	P_2O_3	3.1%

	Semi Reducing Atmosphere	Oxidising Atmosphere
Initial deformation Temp. ^0C	1020	1070
Fushion Temp. ^0C	1230	1250
Fluid Temp. ^0C	1320	1340

7. In the past most oil mills were provided with either horizontal or vertical steam engines with a steam consumption ranging from about 32 lbs. to 42 lbs/I.H.P.H. In later years the single stage impulse turbine has found a growing market due to the low initial capital outlay. The fact that single stage turbines can now be operated successfully with up to 4% wet steam without detrimental effect if the right material is used in conjunction with a good steam separator, opens the door for greater utilisation of turbines which require less space and foundation work.

8. The steam consumption of comparatively small turbines such as used in a Palm Oil Mill is higher than the consumption in respect of steam engines, particularly under partial load

conditions. However, fitting of automatic nozzle group valves can improve the steam economy quite substantially. Table 19 indicates the relevant steam consumptions in respect of a 500 KW alternator set driven by a steam engine or a turbine with and without automatic nozzle group valves.

Table No. 19

Steam Consumption	Compound Steam Engine	Turbine	Turbine with Nozzle valves
Load 500 KW	24300	32800	33100
Load 350 KW	20500	26500	23000
Load 225 KW	17000	21000	16000

XIII. POWER REQUIREMENT :

1. The power requirement for a factory initially constructed for a single production line of 30 tons of F.F.B./h., but with allowance for a final capacity of 60 tons of F.F.B./h in two production lines will be approximately as shown in Table 20.

2. Two 400 K.W. turbines would be able to cope with the requirements in conjunction with three boilers of 20,000 lbs. steam/h. for a working pressure of 250 psig.

Table No. 29

	Tons of F.F.B./Hour				
	10	20	30	40	60
Kernel Plant	25	30	30	50	60
Capstan	5	15	15	15	15
Overhead Cranes	15	30	30	45	45
Strippers	15	15	15	30	30
Empty Bunch Conveyer	5	5	5	7.5	7.5
Fruit Elevator	3	5	5	10	10
Fruit Conveyer	4	4	8	8	8
Extraction Units	40	80	120	160	240
Steam Heated Conveyers	5	5	7	14	14
Depericarper	35	35	35	70	70
Conveyers & Elevators	15	15	20	35	35
Nut Bins	15	30	30	45	60
Vibrating Screens	4	4	6	8	8
Crude Oil Transfer Pumps	3	6	6	9	9
Sludge Separators	15	15	30	45	45
Purifiers	7	14	14	21	21
Boiler Fans	15	30	30	45	45
Water Transfer Pumps	6	6	8	10	10
Factory Light	12	15	15	20	20
Workshop	20	20	20	30	30
Miscellaneous	20	20	25	30	40
Total :	297	419	504	747.5	872.5
With 0.8 Load Factor :	238	335	403	598	698

XIV. STORAGE :

1. Having produced the palm oil the question of storage arises, and with particular reference to the estimated production figures depicted on page No. 3, it is obvious that the existing storage capacities at the Oil Mills and Bulking Installations must be expanded in line with the production and preferably ahead of the production. Failing this, the producers will loose the free bargaining capacity with the buyers. Nobody can beat the market on a continuous basis, but the producers can be beaten by the market if they fail to secure sufficient storage space to withstand periods of slack trading. The importance of maintaining adequate storage space at all times cannot be too strongly emphasised.

2. It is generally accepted that the combined mill and bulking storage capacity should be not less than 30% of the annual production. Accepting this dictum would call for a total storage space of about 250,000 tons by the end of the current year, and tank builders in Malaysia will be busy to provide sufficient capacity for the industry within the next four years.

3. The impressive growth rate of the industry will no doubt call for further bulking installations at various points, preferably close to the production centres. The installations must be of greater capacity than has hitherto been the general rule; and although flexibility must be maintained in order to handle special types and qualities of oil, storage tanks of about 5,000 tons must appear on the scene in order to cater for the future requirements, in respect of shipping by bulk tankers direct from Malaysian Bulking Installation to tank farms in Europe and the U.S.A. in lots of 20,000 tons or more.

4. The cost of a Palm Oil Bulking Installation will vary according to ground conditions and size. As a general guide it can be stated that a modern installation with a capacity of 10,000 tons and having facilities for efficient handling of quality products will cost about $$150/ton of storage capacity.

XV. MARKETING:

1. The marketing of Malaysian Palm Oil was done by the joint selling committee of the Palm Oil Pool seated in London until the end of 1971. From the 1st of January 1972, the West Malaysian Palm Oil Producers Association, based in Kuala Lumpur, has assumed control of the general marketing policy of the producers oil, through managing and sales committees representing the producers as well as Bulking installations. Close liaison is maintained with world trading centres and daily contact between the sales committee members and selling agents should ensure a flexible marketing policy.

2. The storage, selling and shipping of palm oil is a somewhat complex business, and a strong producers association should represent a united front against buyers playing off one producer against another, thus making it possible to obtain a better price and more agreeable terms and conditions of contracts than individual producers can hope to obtain on a continuous basis.

3. A strong body also makes it possible to secure better terms in respect of freight rates by co-ordination of shipment and storage on a world wide basis. Research, quality control, and sales promotion by a strong body is also more likely to bring lasting benefit to the industry as a whole, and these aspects of marketing will be of increasing importance in view of the rapidly expanding productions of palm oil from Malaysia.

4. The world production of edible oils and fats reached approximately 34 million tons during 1971. This compares with a production of palm oil of about 1.6 million tons or 4.7%. By 1976 it is estimated that the total production of oils and fats will reach approximately 42 million tons of which palm oil will represent 3.5 million tons or 8.3%. In other words palm oil will almost double its share of the world's production of oil and fats, and since by far the bigger volume of this increment will be exported, palm oil will reach a substantial percentage in respect of the world exports of oils and fats.

5. The percentage increment of the total world production shown by palm oil by 1976, will exceed the relevant increment of world population, which by 1976 is estimated to exceed four billion and it is therefore obvious that palm oil must acquire a greater share of the market by improving the quality and broadening the base for its distribution and availability at the door steps of the consumers. This can only be achieved by having storage facilities at the consumption centres in Europe and the U.S.A. and such storage tanks must be equipped with facilities for blanketing the oil, with an inert gas such as nitrogen, in order to prevent oxidation during storage. Experiments with storage under such conditions have shown encouraging results and have clearly shown the effect of gas blanketing as an anti-oxidant.

Table No. 21

Effect of surface area on oxidation of palm oil samples * heated for 4 days at 75°C and stored with and without an atmosphere of carbon dioxide.

Container	Surface area exposed (sq. cm)	P.V. (mmole/kg) Days			
Wide-mouth glass dish	236	0.00	8.28	8.78	10.25
Narrow neck 500 ml boiling flask	7	0.00	1.17	1.65	2.28
Conical flask 600 ml with CO_2	0	0.00	0.00	0.00	0.52
Control (unheated corked bottle)	0	0.00	0.00	0.85	2.22

* Initial impurity levels for all samples were: f.f.a. 1.83%, moisture 0.054%, residue 0.003%, iron 3.5 p.p.m. and copper 0.06 p.p.m.

6. Improved nutrition and standard of hygiene in the developing countries will no doubt also increase the consumption in excess of the growth of population. However, the greatest source of promoting the sale of palm oil will be technical development exploiting the versatile fat palm oil really is, and it is encouraging to observe that palm oil will be made available in various fractions and qualities in increasing quantities in the near future. Furthermore the absence of lauric glycorides allows palm oil, unlike coconut oil to be used for frying on account of its low-foaming properties. Also of importance among the non-glycerine components are

the carotenoids, which gives crude palm oil its distinctive colour. Indeed new development might see this valuable vitamin preserved in its natural form eliminating the need for colour and vitamin addition to margarine and other edible products.

7. The comparatively high contents of tocopherols which are natural anti-oxidants also gives palm oil a stability not enjoyed by many of the competing oils. The greater awakening to the importance of quality has placed Malaysian Palm Oil on the map with margarine producers, many of whom are now increasing the percentage of palm oil used for the production of better table margarines.

8. The rapid increment of the production of palm oil makes it all the more important that producers make the effort to supply the edible oil refiners with a standard product of high calibre in respect of free fatty acid content as well as should the oil be able to bleach without difficulty. Several methods for testing the bleachability are in use. However, a good number of the methods are too complicated for exact and quick check at the point of production. Three test methods were subjected to tests at the U.P. quality control laboratory namely the Hobum, the Unilever and the Bernam method. The Hobum test was found not to be sensitive enough to differentiate a standard oil from the S.P.B. quality oil. The Unilever method was found to be somewhat more complicated than the Bernam method, and there was no corelation between a high Totox value (Totox = 2 x pv + Bv) and the colour removal when measured by means of a one inch Lovibond cell. The Bernam method as can be seen from the table No. 22 showed good corelation between the total oxidation and colour removal whether measured by a one inch cell or a five and a quarter inch cell. There is no doubt that the future marketing of palm oil will pay increasingly more attention to the stability factor,

COMPARATIVE ANALYSIS OF UNILEVER AND BERNAM BLEACHABILITY METHODS

TABLE [illegible]

No.	F.F.A.	Moisture %	Peroxide Value meq/kg	Anisidine Value	Totox	CHARACTERISTICS OF CRUDE OIL — COLOUR 1" Cell	COLOUR 5¼" Cell	RESIDUAL COLOUR 1" CELL Unilever Method	1" CELL Bernam Method	5¼" CELL Unilever Method	5¼" CELL Bernam Method	[illegible]	[illegible]	[illegible]
1	[illegible]	[illegible]	[illegible]	[illegible]	2.18	[illegible]R [illegible]Y	IN 68R [illegible]Y	0.4R [illegible]Y	.7R [illegible]Y	[illegible]R [illegible]Y	1.[illegible]R	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	.42	6.46	26R [illegible]Y	IN 68R [illegible]Y	0.4R 5Y	0.3R 3Y	1.4R [illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	.74	11.82	2[illegible]R [illegible]Y	IN 68R [illegible]Y	.4R 4Y	0.4R 5Y	2R [illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	14.64	26R [illegible]Y	IN 68R [illegible]Y	0.5R [illegible]Y	0.7R 10Y	[illegible]R 6Y	7.3R [illegible] IN	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]1.3	26R [illegible]Y	IN 67R [illegible]Y	0.5R 6Y	1.2R 15Y	[illegible].4R 2[illegible]Y	4.[illegible]R 4[illegible] IN	[illegible]	[illegible]	[illegible]
6	[illegible]	0.0[illegible]4	10.18	5.60	25.96	25R 2[illegible]Y	IN 67R [illegible]Y	0.6R 6Y	1.8R 18Y	[illegible].7R [illegible]7Y	[illegible].5R 6[illegible]Y IN	[illegible]	[illegible]	[illegible]
7	2.[illegible]1	0.0[illegible]1	12.12	6.46	30.70	24R [illegible]4Y	IN 66R [illegible]4Y	0.7R 6Y	2R 20Y	2.8R [illegible]0Y	6.2R [illegible]Y IN	[illegible]	[illegible]	[illegible]
8	2.[illegible]1	0.046	14.08	6.81	34.97	23R 24Y	IN 64R 54Y	0.8R 6Y	2.1R 24Y IN	3.[illegible]R [illegible]Y	[illegible].4R [illegible]Y IN	44.4[illegible]	[illegible]	[illegible]
9	2.[illegible]2	0.041	16.18	7.20	39.56	23R 23Y	IN 62R 50Y	0.8R 6Y	2.2R 2[illegible]Y IN	3.4R [illegible]Y	[illegible]R [illegible] IN	[illegible]	[illegible]	[illegible]
10	2.[illegible]	0.034	20.22	8.10	48.54	23R 21Y	IN 62R 48Y	0.8R 7Y	2.4R 25Y IN	3.6R 36Y	[illegible]R [illegible] IN	[illegible]4.[illegible]	[illegible]	[illegible]
11	2.5[illegible]	0.039	24.16	8.54	56.86	22R 20Y	IN 60R 50Y	0.8R 8Y	2.5R 24Y ON	4.2R 4[illegible]Y	6.8R 7[illegible]Y IN	[illegible]3.[illegible]	[illegible].47	[illegible]
12	[illegible].53	0.03[illegible]	28.08	9.10	65.26	21R 19Y	IN 56R 48Y	0.9R 8Y	2.6R 22Y IN	4.7R [illegible]	7.2R 70Y IN	92.[illegible]7	[illegible]	[illegible]
13	2.63	0.03[illegible]	32.34	9.92	74.50	20R 19Y	IN 54R 48Y	0.9R [illegible]Y	2.8R 24Y	5.2R 54Y	7.6R [illegible]Y IN	91.78	[illegible]	[illegible]

and it is for this reason that United Plantations has taken the initiative to offer high quality oil on a guaranteed figure of total oxidation. The table show clearly indicate the importance of maintaining a low Totox of the palm oil.

9. The cost of palm oil like all other primary commodities is subject to frequent fluctuations, and it may be of general interest for the readers to gather an idea of the profitability of a palm oil estate, and in view of the fact that certain markets harbour the idea that palm oil can be produced at S$250/ton it might be appropriate to submit realistic figures based upon the average yield over 20 years in respect of an estate of 10,000 acres. It is obvious that there will be deviations up, and down from the average figures shown. The table No. 23 below nevertheless indicates a fair average of the overall production cost.

<u>Table No. 23</u>

Cost of estate to maturity	$11,000,000
Cost of Road Collection system	$ 1,700,000
Cost of Oil Mill 30 tons of FFB/h.	$ 4,000,000
Cost of Staff & Workers quarters	$ 1,500,000
Cost of Administrative centres	$ 200,000
Total Establishment cost	$18,650,000
<u>Annual Cost of Capital :</u>	
5% Depreciation on $13,000,000	$ 650,000
10% Depreciation on $5,650,000	$ 565,000
8% Interest on Capital $18,650,000	$ 1,492,000
Total Annual Cost of Capital	$ 2,707,000

With [illegible] production [illegible] oil over 20 [illegible] the cost [illegible] oil in respect of capital comes to	$ 170.00
Cost/ton Upkeep and Cultivation	$ 65.00
Cost/ton Harvesting and Collection	$ 55.00
Cost/ton Manufacture	$ 20.00
Cost/ton General Charges	$ 95.00
Cost/ton Forwarding	$ 17.00
Cost/ton Bulking Installation	$ 8.00
Cost/ton Duty price $500	$ 63.75
All in cost per ton F.O.B.	$ 493.75

From the above it appears that a price of S$500 is marginal for most producers, and where development cost such as in Sabah has been higher than in Malaysia a price of $500/ton would represent a loss to the producer.

XVI. SHIPMENT:

1. The expansion of the production of palm oil in Malaysia is now reaching explosive proportions, and there can be no doubt whatsoever that future shipments of palm oil to overseas destinations must be undertaken by bulk tankers carrying 20,000 tons or more. Deep tanks in cargo vessels may still be a practical size of consignment for a specific destination, it is, however, important that palm oil must be evacuated on terms equal to other edible oils and fats and the answer is BULK TANKERS from one safe berth to another in Europe or the U.S.A.

2. The oil must be stored in large tank farms preferably under a blanket of nitrogen right from Malaysia to the destination of storage which must cater for various fractions and qualities

of palm oil. [illegible] shipment and storage that the Malaysian Palm Oil Industry can compete on equal terms with other edible oils and fats.

3. The cheaper rate of shipments bulk carriage should make possible, should be able to finance the storage of palm oil at tank farms under agreeable conditions. Consequently Malaysian Palm Oil must be made equally well available to a refiner or soap maker anywhere in the world, as is soya oil, sunseed oil, rapeseed oil, fish oil and lard or tallow. Only then will the refiners or soap makers appreciate the excellence of palm oil.

4. The detailed distribution in Europe or U. S. must be done by coastal vessels or big road tankers under strict supervision in respect of cleanliness and quality aspects such as oxidation.

5. The tanks of the carriers as well as storage tanks should for preference be treated with Epoxy resin costings, and all means of heating should be thermostatistically controlled and set at a maximum temperature of 55°C. Thermograph recorders should be installed in order to furnish the customers with a record of the thermal treatment during the voyage and discharge. Without such facilities high quality oil such as S.P.B. cannot achieve the acclaim it rightly deserve.

6. Cleaning of tanks and testing for leakages must be strictly supervised by ship officers and operator of bulking installations alike, and all concerned must be made aware that excessive heating is anathema as well as is it unacceptable to expose palm oil to copper, brass, rust and water.

[illegible] the oil should be [illegible] in order not to absorb oxygen [illegible] down. The oil should also be filled as [illegible] of the hatch coaming in order [illegible] the volume of air space above [illegible] temperature falls off during the [illegible] at the shipping temperature [illegible].

8. [illegible] rate of pumping at the Bulking Installation [illegible] doubt, must reach 500 tons/h. It may also [illegible] time of loading [illegible] protection against oxidation [illegible].

XVII. REFINING:

1. Palm oil [illegible] vanaspati, shortening [illegible]. The oil must therefore be refined before it [illegible] of an edible product. Refining [illegible], it is therefore important for its competitive position that palm oil reaches the consumer [illegible] oxidation and F.F.A., therefore [illegible] are relatively cheap to refine.

2. The refining is concerned with the minimisation of oil losses, which depend on the initial F.F.A. and method of neutralisation [illegible] the type of plant used, and finally the skill of the operators [illegible] play an important part. Generally it is correct to say that the refining losses or Wesson losses will be about 1.5 times the level of F.F.A. in the crude oil. The [illegible] resulting from alkali refining [illegible] split into acid oil. In [illegible] the refining [illegible] represent a depreciation in value in relation to [illegible] crude palm oil.

3. The bleaching of the palm oil which takes place after refining is done under vacuum and high temperature with admission of bleaching earth which is subsequently removed by filtering. The bleachability of palm oil is directly corelated to the Totox. It is therefore understandable that the S.P.B. Oil carries a premium of approximately four pounds/ton. Tables Nos. 24 and 25 clearly show the difference between the S.P.B. quality and ordinary palm oil. It is in particular interesting to observe the difference in Totox iron contents and bleachability.

4. Fractionation of palm oil opens up new fields of utilisation by separating the mixture of triglycerides which melts at different temperatures. Various methods for effecting the fractionation are in existence, and it is too early to accept any known method as perfect. It is nevertheless, correct to state that the olein fraction of palm oil with a melting point of about 16°C might open new fields for the use of palm oil in competition with more expensive oils.

5. Palm oil has a relatively simple glyceride structure comprising trisaturated 5 - 10% disaturated 45 - 50% monosaturated 35 - 45% triunsaturated 3 -10%, giving a fat with a soft texture and fairly long plastic range, which makes it satisfactory for blending in substantial amounts in margarine and shortening fats for domestic use and for commercial baking and biscuit manufacture. In fact this versatile fat can be transformed into a bland, colourless, stable edible product with an agreeable shelf life if it appears at the refiners plant as high grade crude palm oil

Table No. 24

QUALITY CONTROL ON SHIPMENTS FROM JENDARATA

S.P.B. OIL ARRIVAL AT BULKING INSTALLATION

% FFA	% Mois-ture	% Dirt	PV	A.V.	Totox	Caro-tene ppm.	Iodine Value	Iron ppm Fe	BLEACHABILITY 150 C/[illegible] w/3%EARTH Cru-de	Oil	Col-our	Blea-ched	Oil	Col-[illegible]	% [illegible]
[illegible]	[illegible]	[illegible]	2.32	[illegible]	[illegible]	540	52.8	[illegible]	25R	25Y	IN	0.5R	6Y		[illegible]
[illegible]	[illegible].045	0.[illegible]	1.61	2.30	7.[illegible]	5[illegible]0	53.[illegible]	2.[illegible]	25R	25Y	IN	[illegible]	7Y		[illegible]
[illegible]	[illegible]	[illegible]	1.3[illegible]	3.22	5.36	545	52.4	3.[illegible]	25R	25Y	IN	0.4R	6Y		[illegible]
[illegible]	[illegible].046	[illegible].005	1.45	3.09	5.[illegible]	564	52.6	[illegible].4	25R	25Y	IN	[illegible]	[illegible]		[illegible]
[illegible]	[illegible].047	0.005	0.57	[illegible].08	4.22	564	52.8	2.6	25R	25Y	IN	0.3R	4R		[illegible]
1.03	[illegible].067	0.005	1.61	3.01	6.23	574	52.6	2.2	25R	25Y	IN	0.4R	4Y		[illegible]

Table No. 25

QUALITY CONTROL ON SHIPMENTS FROM OUTSIDE ESTATES

ORDINARY PALM OIL ARRIVAL AT BULKING INSTALLATION

% FFA	% Moisture	% Dirt	PVe	E.V.	Totox	Carotene ppm.	Iodine Value	Iron ppm Fe	BLEACHABILITY 150°C/1hr/3% EARTH Crude Oil		Colour	Bleached Oil		Colour	% Colour Removed
2.01	0.068	0.005	5.53	4.68	15.74	56[illegible]	52.6	5.2	27R	27Y	IN	1.1R	14Y	IN	[illegible]
1.92	0.010	0.005	6.08	4.7[illegible]	16.88	586	52.6	5.0	28R	27Y	IN	1.2R	15Y	IN	[illegible]
2.55	0.067	0.005	6.68	5.19	18.55	584	52.6	5.[illegible]	27R	27Y	IN	1.6R	16Y	IN	[illegible]
2.[illegible]0	0.041	0.005	6.09	5.54	17.[illegible]2	586	52.8	5.5	28R	27Y	IN	1.4R	18Y	IN	[illegible]
3.06	0.085	0.005	5.78	5.82	17.38	575	53.0	6.4	28R	27Y	IN	1.3R	1[illegible]Y	IN	[illegible]
2.78	0.049	0.005	6.34	4.99	17.67	582	52.9	5.7	28R	27Y	IN	1.4R	18Y	IN	[illegible]
3.33	0.072	0.005	4.34	5.98	14.66	569	53.0	6.3	26R	26Y	IN	1.1R	11Y	IN	[illegible].31

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