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Palm Oil Quality Related to Processing and Shipping

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팜유의 제조공정 및 수송에 있어서의 품질

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High quality and consistent standard is the main objective and concern of the Malaysian palm oil industry. The quality deterioration of palm oil is mainly due to oxidation process between unsaturated fatty acids with oxygen which is enhanced by prooxidants such as trace metals and to excessive hydrolysis of the oil. These will result in poor bleachability and poor keepability of palm oil.

This paper will give a short account of current research carried out at PORIM on palm oil quality related to certain aspects of milling operation, refining process and shipping.

Effect of milling operation

When compared normal palm oil mills constructed entirely of mild steel with a mill where stainless steel was used in pipework and selected parts of machinery, the later mill showed significant decrease in iron content at various sampling points (Table 1). Installation of magnetic trap at the end of milling process has been proved to be an effective means of removing particulate iron from the crude palm oil. The effectiveness of such alternative milling procedures and the effects of reduced iron levels on crude palm oil quality were shown in Table 2. The three crude palm oils were sampled from different sources, but the initial carotene and tocopherol contents were very similar. However, the initial totox value of the sample from a normal mill showed an undesirable level of oxidation. During the period of experiment, dissolved iron contents of all samples increased. After 20 days, totox values of all 3 samples were already high but only the normal mill sample was difficult to bleach at this stage. After a further 10 days, the two special-mill samples were still bleachable.

Table 1. Comparison of iron content (ppm) of crude palm oil from normal and stainless steel mills

Samples	Normal mills	S.steel mill
After sludge centrifuge	2.7~4.9	–
After purifier	2.9~6.1	0.6
After vacuum drier	3.2~5.6	0.9
From storage tank	2.6~5.5	1.2

Since the specification of original oils were different, it was possible that some unmeasurable factors have contributed to the difference in the keepability. Nonetheless there is a strong indication that reduction in iron content has had an important effect on quality of palm oil (Fig. 1).

Most of the iron contamination in crude palm oil is therefore avoidable by suitable mill construction, and

Table 2. Effect of iron content on quality of crude palm oil

Storage Period (Days)	Tempe-rature	Mill	Fe (ppm)		β-Carotene (ppm)	Total tocopherols (ppm)	Totox value	SCOPA bleach test red (5 ¼″)
			Unfiltered	Filtered				
0	Ambient	Normal	6.2	3.6	501	503	20.6	–
		S. steel	2.2	1.1	582	501	9.3	1.1
		Magnetic trap	2.2	1.5	533	469	4.3	0.9
20	55℃	Normal	6.5	5.3	321	211	61.8	4.2
		S. steel	2.4	2.4	533	383	41.7	2.5
		Magnetic trap	2.3	1.6	475	508	27.5	1.9
30	55℃	Normal	6.3	4.9	215	116	69.6	5.0
		S. steel	2.4	2.5	453	309	61.8	3.1
		Magnetic trap	2.4	1.9	385	319	60.2	3.0

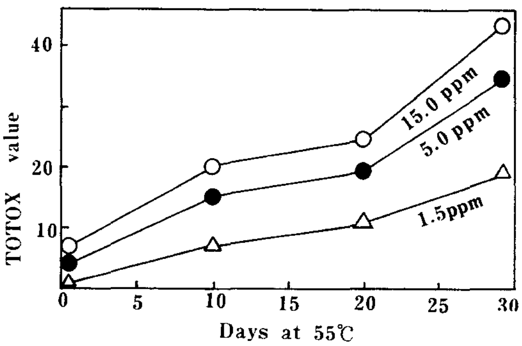

Fig. 1. Effect of iron content on oxidation of palm oil

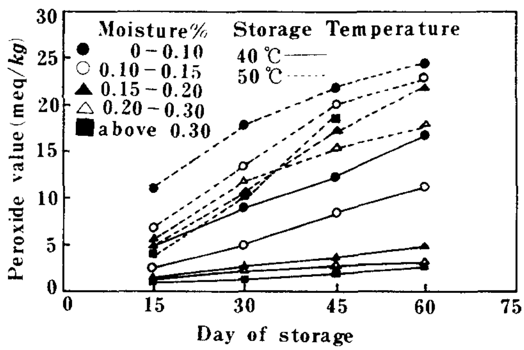

Fig. 2. Effect of iron moisture content on peroxide value increase during storage of crude palm oil

if it does occur, most of the iron particles can be removed before dissolved in the oil.

It is interesting to note that crude palm oil having a residual moisture content of 0.2-0.3% develops peroxides more slowly during storage than oil with lower moisture contents (Fig. 2). However, since these higher moisture levels promote hydrolysis, a compromise is usually achieved by reducing the moisutre content to about 0.15% in the crude palm oil.

Effects of antioxidants

Total tocopherols and tocotrienols concentration in crude palm oil is in the range of 635-1000 ppm, about 80% of which is tocotrienols which have stronger antioxidant activities than tocopherols. Retention of such natural antioxidants is important in ensuring oil stability.

In our survey, about 29-72% and 32-99% of natural antioxidants remained in the refined palm oil by the alkali and physical refining, respectively (Table 3). It was also observed that a certain physical refineries operating with a particular type of deodorizers involving relatively higher temperatures (270 °C) resulted in substantial loss of tocopherols and tocotrienols in the refined oil in most cases. We believe that the percentage of retention of tocopherols and tocotrienols depends on the processing conditions such as temperature, plant design, etc. and further studies on the factors affecting natural antioxidant retention are in progress.

It is well known that oxidative stability of palm oil and palm oil fractions could be improved by the addition of synthetic antioxidant such as butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), propyl gallate (PG) and tertiary butyl hydroquinone (TBHQ) although such applications are subjected to

Table 3. Percentage of tocopherols and tocotrienols retained after physical refining

Refinery	RBD palm oil	RBD palm olein	Refiner	RBD palm oil	RBD palm olein
A	60		N		71
B	99		O		71
C		65	P	40	
D		43	Q		78
E		56	R	68	
F		68	S	47	
G		76	T	32	
H	78		U	33	
I	72		V	36	
J	58	58	W	52	
K		73	X		·88
L	58		Y	38	
M	62		Z		73

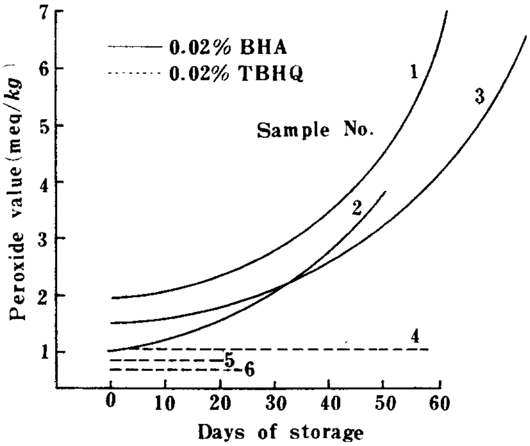

Fig. 3. Effect of antioxidants on plam olein in bulk storage

legislation from one country to another. TBHQ (0.02%) was very effective and lasting antioxidant for palm oil (Fig. 3). Together with citric acid, there was a synergistic enhancing effect. Addition of citric acid improves the bleachability and keepability of palm oil.

Bleachability of palm oil

There appears to be two major factors affecting the bleachability of crude palm oil. The first is a more dramatic effect caused by the accumulation of oxidation products due to deterioration of crude palm oil during storage and transport and the second is intrinsic in the composition of certain fresh crude palm oil in which their contents of trace constituents and impurities overloaded the bleaching capacity.

A new established analytical procedure, DOBI (Deterioration of Bleachability Index), was a useful indication for crude palm oil bleachability. Malaysian commercial crude palm oil usually has DOBI values between 2 and 4. Crude palm oil with DOBI less than 2 will have some difficulty in bleaching. Sludge palm oils received from mill effluent have DOBI of less than 1 and are suitable for technical uses only.

Table 4 illustrates the first type of factor. The analyses are of 32 crude oil samples from the survey of crude palm oil production at a mill in Sabah from June 1981 to February 1982. As shown in Table 4, there were increases in free fatty acid contents and higher color values and obtained after standard SCOPA bleaching test procedure. There is also a correlation in these samples between increasing free fatty acid and increasing phosphorus content while the changes in carotene and oxidation parameter are not significant.

Results shown in Table 4 suggest that even commercial crude palm oil with high DOBI values show differences in bleachability possibly because of variation in other minor constituents. Apparently there is an indirect relationship between bleachability and free fatty acids in fresh crude palm oil. Perhaps free fatty acids help to solubilize important trace components and impurities in crude palm oil. One can also correlate bleachability with

Table 4. Analyses of crude palm oil samples from a Sabah mill production survey (June 1981 – Feb. 1982)

Period of sampling	Sets of examples	Carotene (ppm)	DOBI index	FFA (%)	Phosphorus (ppm)	SCOPA red
6 ~ 9 / 1981	6 × 2	611±34	3.5±0.1	2.3±0.3	14± 2	1.0
9 ~ 12 / 1981	6 × 2	604±31	3.1±0.2	3.4±0.3	23± 2	1.2
1 ~ 2 / 1982	4 × 2	615±10	3.0±0.2	4.3±0.2	28± 4	1.6
Mid 11 / 1981	1 × 2	654	3.5	4.6	32	2.2

changes of phosphorus content under conditions where oxidative deterioration is not the dominant factor.

These investigations are also being extended to the behavior of minor components during fractionation of palm oil, and extented to the bleachability problems of crude palm stearin.

Palm oil quality and refining process

It is part of PORIM research programs to study the unit operations of refining in view of improving the quality of refined oil. The final quality such as color of the fully refined or RBD palm oil is dependent on the efficient operation of all steps at the refinery and the quality of crude palm oil received.

The phosphorus "slip" during physical refining is considered an important criterion of quality and specification of less than 4 ppm of phosphorus in a fully processed palm oil has been proposed as a commercial standard. Fig. 4 shows the detailed analyses of RBD

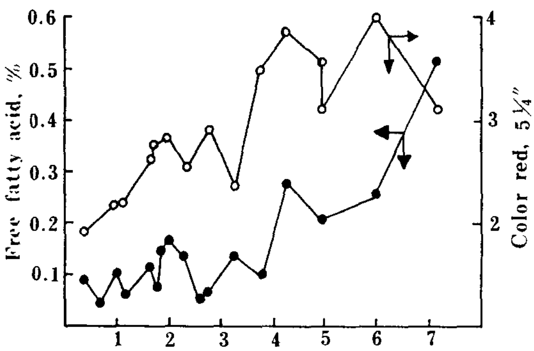

Fig. 4. Effect of residual phosphorus on landed oil quality

palm oil received by a USA refiner. There is definitely a strong correlation of both free fatty acids and color development with the residual phosphorus content of the landed oil. Therefore, instead of using the activated bleaching earth to remove the added phosphoric acid as in the present refinery practice, it was decided to investigate alternative treatments.

In our laboratory scale treatment, washing with hot water has been found to be very efficient at removing not only all the added phosphoric acid, but water-washing at 90°C also results in the partial removal of the phosphorus containing and other gum initially present in the crude palm oil.

It has been a common refinery practice to use calcium carbonate addition either before or after earth bleaching to neutralize the excess phosphoric acid. There is, however, from our extensive laboratory trials, no experimental evidence to prove the addition of calcium carbonate as effective means for the avoidance of phosphoric acid "slip".

It is obvious that improving or modification of refining unit operation requires a more detailed understanding of the chemistry of relevant minor and trace components in crude palm oil.

Palm oil quality during shipping

As has been mentioned above, trace metals such as copper should be avoided in the handling of vegetable oils, but, in our recent study on handling and shipping, we have found that copper or its alloys are still in current use in sampling instruments, thermometers, coupling connections to mild steel heating coils, valves and hose connections on road tankers. Some new vessels commissioned two years ago for vegetable oil cargo were found to have heating coils made of aluminium-copper alloy.

The Technical Advisory Service (TAS) Unit of PORIM also supervizes and monitors palm oil quality during shipping. Although it is a feature of most contracts that they are based on quality defined at time of loading, it is undoubtedly in everyone's interest to narrow the gap between loaded and received quality as much as possible.

Table 5 shows the free fatty acid contents of some shipment of RBD palm olein to an oversea destination. Much of the oil is used for large scale frying and can be used without reprocessing only if it arrives in good conditions.

Table 5. Free fatty acid content (% palmitic acid) at bulk storage

Days	1981			1979		
Storage	1	2	3	1	2	3
0	0.04	0.05	0.05	0.07	0.07	0.09
10	0.05	0.06	–	0.08	–	0.10
20	0.05	–	–	0.09	–	0.11
30	–	–	0.06	–	0.08	–
40	–	0.06	–	–	–	–
50	–	–	–	–	0.10	–
60	0.05	–	0.06	–	0.11	–

The survey demonstrates that oils arriving with free fatty acid content at or below 0.05% are stable while those with higher free fatty acids (as shown by the 1979 shipments) are highly unstable.

The reports of free fatty acid increase during shipment have been received from USA, Australia and New Zealand. The results of 40 such shipments were summarized in Table 6.

Table 6. Effect of initial free fatty acid content on landed content

Country	Loaded≦0.05%		Loaded>0.05%	
	Landed<0.1	Landed>0.1	Landed<0.1	Landed>0.1
Australia	–	1	1	4
U. S. A.	9	4	3	9
New Zealand	6	–	–	3
Total	15	5	4	16
Arrival within specification	75%		20%	

It is clear that a free fatty acid content above 0.05% ex-Malaysian refinery is conductive to the development of free fatty acids thereafter. This is important for two reasons. Firstly, oils have to be stored before shipment and they may go out of specification before loading. Secondly, for certain applications, in particular frying and hydrogenation, the presence of free fatty acid above 0.1% may necessitate costly reprocessing and therefore may affect adversely the economics of using palm oil.

0.05% of free fatty acids seems to be an empirical level and its significance is now being investigated by PORIM.

Conclusion

Better awareness of effects of trace metals and minor components on the quality of palm oil during milling, processing and shipping is essential. In order to produce a better and more consistent refined palm oil, it is important also to understand the factors affecting bleachability and color changes of palm oil and to improve or modify refining operations.

References

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본 총설은 팜열매에서의 추출에서부터 공정을 거쳐서 수송할 때까지의 팜유에 함유되어 있는 철, 구리와 같은 중금속과 미량성분들이 팜유의 품질에 미치는 영향을 추적 조사한 것으로 국내 유지업계에 직접적으로 도움을 줄 수 있을 것으로 생각하여 게재한다.

(편집 간사 주)