PALM OIL technical bulletin

Vol. 1 No. 5 May 1995

FFB YIELD CAN REACH 49 TONNES/HA/YEAR

- PORIM has succeeded in developing a variety of oil palm which can produce up to 49 tonnes/ha/year of fresh fruit bunches in PORIM's own experimental fields. Under commercial conditions the variety achieved 30 - 40 tonnes/ha/year : the present average yield of FFB in Malaysia is around 25 tonnes/ha/year.

In This Issue..

CAROTENES AND PALM OIL

by

Dr Ooi Cheng Keat

Palm oil, like other edible oils, consists mainly of triglycerides, but it contains about 1% of a mixture of minor components which includes carotenoids, vitamin E (tocopherols and tocotrienols), sterols, phospholipids, glycolipids, triterpenic and aliphatic hydrocarbons, and other trace substances (*Table 1*). Carotenoids and vitamin E are the principal minor components and they are known to possess important nutritional and physiological properties.

TABLE 1. MINOR COMPONENTS OF PALM OIL (Ooi, *et al.*, 1990)

Component	Content (ppm)
Carotenes	500 - 700
Tocopherols and Tocotrienols	600 - 1000
Sterols	326 - 527
Phospholipids	5 - 130
Triterpene alcohols	40 - 80
Methylsterols	40 - 80
Squalene	200 - 500
Aliphatic alcohols	100 - 200
Aliphatic hydrocarbons	50

CAROTENOIDS

Carotenoids form one of the most important groups of natural pigments and are found in nearly all families of the plant kingdom. Carotenoids derived their name from *Daucus carota*, the carrot, in which β-carotene was discovered in 1831 (and at first called 'carotin'). There are two major classes of carotenoids: carotenes and xanthophylls. Carotenes are long-chain, conjugated, unsaturated hydrocarbons, while xanthophylls are oxygenated carotenes. The carotenoids of palm oil are mainly carotenes.

A Publication of the Palm Oil Research Institute of Malaysia (PORIM)
P.O. Box 10620, 50720 Kuala Lumpur, Malaysia

It is estimated that more than 100 million tonnes of carotenoids are produced annually in nature. However, almost all of them occur in low concentration and are not commercially extracted except for small amounts from carrot, some algae and palm oil. Most of the commercially available carotenoids are synthetic. The demand for carotenoids, particularly natural ones, is increasing every year. The global production of commercial carotenes in 1989 was estimated at 300 tonnes, with a value of about US$100 million. Natural carotenes accounted for approximately 10% of the total market, and the demand for natural carotenes appears to exceed supply.

CAROTENES IN PALM OIL

Palm oil owes its orange-red colour to a mixture of carotenes : in fact the oil is one of the richest sources of natural carotenes. The amount of carotenes present ranges from 400 to 4600 ppm, depending on the species of palm. The oil obtained from the *tenera* variety of *Elaeis guineensis*, the usual commercial planting material in Malaysia, has a carotene content of 500-700 ppm, while that from *Elaeis oleifera*, the South American species, was found to contain about 4600 ppm. The carotene content of oil from hybrid palms, produced by the cross breeding of the two species of *Elaeis*, lies between those values (*Table 2*).

TABLE 2. CAROTENE CONTENT OF PALM OIL FROM DIFFERENT SPECIES (Choo *et al.*, 1989)

Species	Carotene Content (ppm)
Elaeis guineensis (dura, D)	997
Elaeis guineensis-(pisifera,P)	428
Elaeis guineensis-(tenera,DxP)	673
Elaeis oleifera	4592
Hybrid - *E.guineensis* (P) x *E.oleifera*	1430
Hybrid - *E.guineensis* (D) x *E.oleifera*	2324
Hybrid - *E.guineensis* (DxP) x *E.oleifera*	896

There are 13 different types of carotenes in palm oil (Choo *et al.*, 1989), the major being α- and β-carotenes, which together make up 90% of the total. The others are phytoene, phytofluene, cis-β-carotene, cis-a-carotene, β-carotene, β-carotene, β-carotene, neurosporene, β-zeacarotene, α-zeacarotene and lycopene (*Table 3*).

The potential availability of natural carotenes from Malaysian palm oil amounts to about 4500 tonnes per annum, with an estimated value of US$ 1.5 billion. At present the carotenes are destroyed during the refining process to produce a light coloured oil (although a process in which the carotenes are retained in the refined oil has been devised and is in limited use). Various methods for extracting the carotenes from palm oil have been developed. These include saponification, adsorption, precipitation, selective solvent extraction, molecular distillation and transesterification followed by separation. However only the last process has been further developed for production on a commercial scale. PORIM has already developed such a process which will soon be ready for commercialization. It involves the conversion of palm oil into methyl esters and the removal of these by distillation, giving a carotene concentrate which is then purified (Ooi *et al.*, 1991; Ooi *et al.*, 1994).

TABLE 3. CAROTENE COMPOSITION OF PALM OIL (TENERA)(Choo *et al.*, 1989)

Carotene	Percentage
α-carotene	35.2
β-carotene	56.0
cis-α-carotene	2.5
cis-β-carotene	0.7
τ-carotene	0.8
δ-carotene	0.3
ζ-carotene	0.7
Phytoene	1.3
Phytofluene	0.1
Neurosporene	0.3
α-Zeacarotene	0.2
β-Zeacarotene	0.7
Lycopene	1.3

IMPORTANCE OF CAROTENES

β-Carotenes, and to a lesser extent α-carotene, act as pro-vitamins, being converted in the body to Vitamin A (retinol). Palm oil has 15 times more retinol equivalent than carrots, and 300 times more than tomatoes (*Table 4*). Studies have also shown that carotenes have an anti-atherosclerotic effect and appear to be protective against certain cancers such as those of the mouth, throat, lung, stomach and colon (Mathews-Roth *et al.*, 1987; Metlin, 1984; Norman *et al.*, 1988; Suda *et al.*, 1986). One important recent finding was that α-carotene is 10 times more potent as an anti-cancer agent than β-carotene (Murakoshi *et al.*, 1992; Murakoshi *et al.*, 1989). Both α- and β–carotenes are present in palm oil, as already noted. β-Carotene is also associated with the prevention of cataract formation (Cutler, 1989; Jacques, 1989) apart from its pro-vitamin A role in the prevention of night blindness. Besides α- and β-carotenes, like phytoene and lycopene some of the less well known ones, have also been reported to have anti-cancer properties, with the latter being a more efficient singlet oxygen quencher than β -carotene.

TABLE 4. RETINOL (VITAMIN A) EQUIVALENT OF PALM OIL AND OTHER FOODS

Source	μg Retinol Equivalent/100g edible portion
Crude Palm Oil (CPO)	30 000
Carrots	2 000
Leafy Vegetables	685
Apricots	250
Tomatoes	100
Bananas	30
Oranges	8

APPLICATIONS OF CAROTENES

Carotenoids are widely used in various industries for their natural colour and nutritional value. In the food industry, they are used mainly to impart colour to products. They are also incorporated into poultry and fish feed where they act as a source of vitamin A and as pigmentation agents. When carotenoids are ingested by poultry they are stored mainly in the liver, eggs, body fat, skin, feathers, beak and shank. The carotenoids are not all equally effective pigmentation agents. Some of the effective ones are cryptoxanthin, β-apo-8'-carotenol, zeaxanthin, lutein and canthaxanthin. β-carotene is not an effective *in vivo* pigmenter for poultry as it is efficiently converted to vitamin A (Goodwin, 1954), but with the dairy cow β-carotene is both a pigmenter and a potent vitamin A source. Ingested β-carotene that is not converted to vitamin A is both stored in the fatty tissues of the body and in the butterfat of milk, so that it appears in milk products such as cheese (Goodwin, 1954). In the pharmaceutical and cosmetic industries, carotenoids are widely used to make products look more attractive and to distinguish one product from others. Some of the products are tablets, syrups, suppositories and gelatin capsules. β-Carotene is also sold as a nutritional supplement, either alone or in combination with vitamins C and E. In the cosmetic industry, the main use is to replace synthetic colquring materials, since the safety of certified colours has been a great concern to the industry. Carotenoids are used in fat-based cosmetics such as emulsions, creams and lipsticks. In the medical field, carotenoids, particularly β-carotene, have been applied successfully for the treatment of photosensitivity diseases in human beings (Mathews-Roth, 1964; Mathews-Roth, 1970). Studies on carotenes as anti-cancer agents are relatively recent but, as already indicated, the results are promising, and a vigorous research effort is continuing.

REFERENCES

1. *Oil World Annual* (1994)
2. *Statistics on Commodities* (1994), Ministry of Primary Industries, Malaysia
3. OOI, C K (1990) *et al.*, PORIM Project Report CT161/88

3a. CHOO, Y M *et al.*, (1989). *Proceedings AOCS World Conference of Edible Fats and Oils*, Basic Principles and Modern Practices, Maastricht, The Netherlands, pp 436 - 440.

4. OOI, C K *et al.*, (1991). *US Patent*, 5019668
5. OOI, C K *et al.*, (1994). *J.Am. Oil Chem. Soc.* 71:423
6. MATHEWS-ROTH, M M and KRINSKY, N I (1987). *Photochem.* 46:507
7. METLIN, C (1984). *Adv. Nutri. Res.* 6:47
8. NORMAN, J T and TAPAS, K B (1988). *Nutri. Res* 8:685
9. SUDA, D *et al* .,(1986). *Carcinogenesis*, 7:711
10. MURAKOSHI, M *et al.*, (1992). Cancer Res. 52:6583
11. MURAKOSHI, M *et al.*, (1989). *Natl. Cancer Inst* 81:1649
12. CULTER, R G (1989). Paper presented at *Conf. on Antioxidants.Vitamins and β-carotene in Disease Prevention*, October, London.
13. JACQUES, P F (1989). Paper presented at *Conf. on Antioxidants, Vitamins and β-carotene in Diseases Prevention*, October, London.
14. GOODWIN, T W (1954). *Carotenoids, Their Comparative Biochemistry*, Chem. Pub. Co., New York
15. GOODWIN, T W (1952). *The Comparative Biochemistry of Carotenoids*, Champman and Hall, London
16. MATHEWS-ROTH, M M (1964). *Nature* 203:1092
17. MATHEWS-ROTH, M M *et al* .,(1970). *N. Engl. J. Med.* 282:1231.

NEUTRON ACTIVATION ANALYSIS (NAA) FOR DETERMINATION OF TRACE ELEMENTS IN PALM OIL

by
M Rasid M Jaais and T.T. Sue

The chemical composition and properties of palm oil undergo various changes during the latter stages of fruit development; harvesting and damage to fruit bunches cause further changes. Also, the method used to extract oil from the fruit can affect the level of impurities in it, including iron and copper and other trace elements. These metallic components are often undesirable: one of the main quality factors affecting the use of palm oil for edible purposes in developed countries is its mineral content. As indicated by the Codex Standard, the mineral content of palm oil for edible use should be as low as possible, especially in Fe, Cu, Pb and As. (*Table 1*).

Many importing countries have standards for palm oil limiting the maximum content of iron and copper. *Table 2* shows some of the standards governing palm oil for Jordan, Syria and Saudi Arabia. As can be seen, the maximum permitted values for CPO are 5 ppm for iron and 4 ppm for copper, and the standards for processed palm oil are more stringent.

TABLE 1. PERMISSIBLE LIMITS OF METAL CONTAMINATION IN VEGETABLE FAT PRODUCTS

Contaminating Metal	Maximum Permitted Level (ppm)
Iron (Fe)	1.5
Copper (Cu)	0.1
Lead (Pb)	0.1
Arsenic (As)	0.1

Source : Codex Standard, CODEX STAN 157-1987

TABLE 2. STANDARDS FOR PALM OIL AND ITS DERIVATIVES APPROVED BY JORDAN, SYRIA AND SAUDI ARABIA

Contaminating Metal	Maximum Permitted	Level (ppm)
	Processed Oil	Crude Oil
Iron (Fe)	1.5	5.0
Copper (Cu)	0.1	4.0
Lead (Pb)	0.1	-
Arsenic (As)	0.1	-

Source : Standards of Palm Oil for Jordan, Syria and Saudi Arabia

Measured values for the iron and copper content of crude and refined palm oil from many sources were recorded by Cornelius (*Table 3*).

Trace metals, particularly iron and copper, enter the oil as a result of wear and tear on machinery during processing and also later during storage of the oil. Initially they are present as minute particulates but during storage they react with the free fatty acid (FFA) present, forming metallic

TABLE 3. IRON AND COPPER IN PALM OIL (PPM)

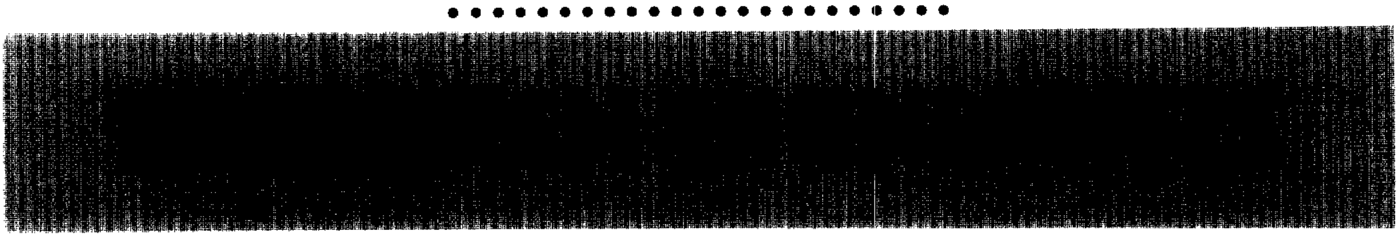
Metal	Palm Oil	
	Crude	Fully Refined
Iron	3.5 max	1.5
Copper	0.05 max	0.02

Source : Cornelius J.A. 1977

soaps which dissolve in the oil. Iron and copper have been shown to be powerful catalysts of the oxidation of edible oils; this produces peroxides which break down into various compounds causing off-flavours. To minimize such deleterious effects the iron particulates can be removed by filtration immediately after the processing of the oil. Alternatively, the use of stainless steel for the equipment in contact with the oil during milling can reduce the iron content to below 5 ppm. Copper, lead and arsenic are not likely to be present in substantial amounts in palm oil although no definitive studies have been made.

Iron and copper in palm oil can be determined by colorimetry and atomic absorption spectrophotometry (AAS), as described in PORIM Test Methods. AAS is also used to determine lead. Neutron Activation Analysis (NAA), a modern technique complementary to AAS, is also eminently suitable for elemental analysis. Sensitivity is extremely high for most elements and NAA could be used especially for the detection of As and Cu. The lower limit of detection for these metals, under interference free conditions, is 0.001 micrograms in both cases. In general, results with NAA are accurate to within ±2% of the true value, even at the sub-ppm level. The technique also avoids the problems of contamination often encountered with conventional analytical methods, so that it is suitable for both qualitative and quantitative analysis of trace elements in palm oil.

The equipment for NAA is now commercially available at a cost which is not prohibitive for the industry. It is hoped that palm oil analysts will not overlook NAA in their development of methods for trace element determination.



Oil Palm Research in Universities and Research Institutions

A seminar on Oil Palm Research in Universities and Research Institutions organized by PORIM was held on 20-21 March 1995 at PORIM Headquarters, Bandar Baru Bangi, Selangor. The objectives of the seminar were :-

- to review the progress of R & D on oil palm and its products in the public sector
- to chart the future direction of R & D on oil palm ; and
- to discuss the commercialization of relevant research findings.

Staff from five local research institutions and five universities took part in the seminar.

The papers presented and discussed covered a wide range of subjects, from oil palm breeding, agronomy, pathology and biotechnology to the utilization of by-products such as trunks, fronds, *etc.* by conversion into value-added products. Some of the papers dealt with novel topics, *eg.* the one entitled 'Use of Palm Oil Products for Roads and Highways' which is highlighted in the next item, below.

A study by Mr. Mustapha Kamal Abdul Aziz of the Technological University of Malaysia on 'Process Design and Modelling of Physical Refining' was also particularly interesting. The aim of this work was to improve the current refining process using thin liquid film phenomena of falling film and packed column to enhance separation performance in deodorization of oil.

Contributed by Johari Minal

Palm Oil Products for Roads and Highways

Ir Dr Hasanan Md. Nor of the Technological University of Malaysia has opened a new vista for palm oil in non-food applications with his discovery that palm olein and palm kernel oil are suitable for the modification of propane precipitated asphalt (PPA) and the rejuvenation of recycled asphalt pavements. In his study, Grade 80/100 bitumen (the bitumen normally used in Malaysia) was compared with PPA and PPA blended with palm olein and it was found that the blended PPA had better properties than either PPA or Grade 80/100 bitumen alone. Dr Hasanan also found that bitumen extracted from milling waste can be recycled after blending with palm olein. In fact, the bitumen blend showed better working properties than 80/100 bitumen.

Contributed by Johari Minal

Palm-Based Metallic Soaps for Rubber Compounding

A study by Dr Hamirin Kifli of PORIM and Dr. Ong Eng Leong of the Rubber Research Institute of Malaysia on the use of palm-based metallic soaps has shown that they are suitable as processing aids for rubber formulations.

Processing aids which are in common use, can play one or more roles when incorporated into a rubber compound such as speeding up the rate and controlling the degree of polymer breakdown, helping to disperse the other compounding ingredients, helping to reduce 'nerve' in the compound, reducing shrinkage during subsequent processing and imparting building tack to the compound.

According to Dr Hamirin Kifli and Dr. Ong the metallic soaps have proven effective in reducing viscosity, mastication and mixing energy, and the extrusion stress of both unfilled and filled unvulcanized natural rubber compounds during the extrusion process; they also improve the surface smoothness of the extrudates and have no adverse effects on the properties of vulcanizates of typical carbon black-filled formulations.

Contributed by Johari Minal

Oil Palm By-Products as Sources for Animal Feeds

A lot of work is being done on the conversion of oil palm by-products into value-added goods so as to maximize the use of local resources from the oil palm industry and at the same time actualize the zero-waste concept. Such studies include the production of animal feeds from palm by-products.

Oil palm trunks, fronds and empty fruit bunches are useful sources of fibre or roughage for animals, especially in the total mixed rations of ruminants, according to Mr Abu Hassan Osman of the Malaysian Agricultural Research and Development Institute.

'Oil palm trunk chips can be incorporated in the feeds at an optimum percentage of 50% as silage or dried components,' he said, adding that they can also be further processed into pellets for commercial exploitation.

Mr Abu Hassan, who said that oil palm fronds have already been widely used by farmers in Malaysia, has also investigated the possibility of using empty fruit bunches for animal feeds. He found that incorporation of 20-30% of empty fruit bunch material into animal feeds was also possible.

Contributed by Johari Minal

Polyunsaturated Oils and Asthma

Researchers reporting in the *Australia and New Zealand Journal of Medicine* say that rising consumption of polyunsaturated oils and margarines may be responsible for the increasing incidence of childhood asthma. They cited polyunsaturated oils from sunflower and safflower seeds as being particularly high in fatty acids deemed 'pro-inflammatory'. They postulate that the growing prevalence of childhood asthma — in Australia and elsewhere — is related to the simultaneous five-fold rise in consumption of polyunsaturated oils and a switch from butter to margarine.

Contributed by Dr B A Elias and J R Santhiapillai.

Cold Stability Studies on Blended Palm Olein

Palm olein tends to crystallize partially and become cloudy at low temperatures for instance during winter in temperate countries. Cloudiness can be avoided by blending the oil with 'soft' oils such as sunflower seed, soya bean and rapeseed (canola) oils.

Several studies to determine the best proportion of palm olein to polyunsaturated oils have been conducted by PORIM. Some of the results are summarized in *Table 1* .

These results can be used as a guide in formulating suitable blended oils for specific temperatures. However before a blended oil can be commercialized or marketed in a specific locality the formulation will have to be retested since all natural oils varies somewhat in chemical properties and hence also in physical properties.

TABLE 1. COMPOSITION OF BLENDS OF POLYUNSATURATED OILS (PVO) WITH PALM OLEINS OF DIFFERENT IODINE NUMBERS

Temperature [a]	PUO	Ratio (PUO : Palm Olein)			
		IV58	IV60	IV62/63	IV65
0°C	Soyabean Sunflower	-	-	90:10	-
5°C	Soyabean	-	90:10	90:10	-
	Sunflower		90:10	85:15	-
10°C	Soyabean	90:10	80:20	70:30	
	Sunflower	90:10	70:30	70:30	70:30
15°C	Soyabean	85:15	70:30	70:30	
	Sunflower	-	70:30	70:30	70:30
20°C	Soyabean	-	70:30	60:40	30:70
	Sunflower	-	30:70	30:70	30:70
	Canola	70:30	50:50	-	-

[a] The respective blends all remained clear for more than three month at the temperatures indicated.

Source : Teah Y K & Ahmad, 1991; Palm Oil Developments No. 15

Nor'Aini Idris et al 1993; PORIM International Palm Oil Conference, Kuala Lumpur

Johari et al 1994, Palm Oil Developments No. 21

Contributed by Johari Minal

New Prospects for Palm Olein in Turkey

In Turkey, the restaurant and hotel industry is looking for frying media which will perform better while being economical and nutritious. In order to meet these criteria manufacturers have come out with a tailor-made frying medium. This is a pourable shortening or pourable margarine which is basically a blend of RBD palm olein with partially hydrogenated soya bean or sunflower oil. Palm olein is the major component.

PORIM has been promoting this product within the Turkish oils and fats industry, and two manufacturers have started commercial production of such a frying medium, packed in 30-kilogramme drums fitted with a pouring outlet and a detachable top for institutional use. So far the product has been well received, and demand in the hotel and restaurant industry is increasing rapidly.

Future Contract for Palm Oil at CBOT

It is reported by Oils and Fats International that the Chicago Board of Trade (CBOT) is considering launching a palm oil future contract - - possibly in conjunction with the Kuala Lumpur Commodity Exchange (KLCE), which already has a contract of limited volume, denominated in local currency. Chicago analysts say that palm oil traders are still basing their operations on the CBOT's established soya bean oil future contract — even though its price correlation with palm oil is poor.

Palm Oil Contract by AVOC

The ASEAN Vegetable Oil Club, developed the AVOC Common Contract in 1994 for trading palm and coconut oils. AVOC represents producers of these oils from Malaysia, Indonesia and the Philippines, who together supply 40% of the oils traded in the international market. AVOC has launched a new campaign for the trade to use its contract in future.

• • • • • • • • • • • • • • • • •

We invite readers to send in comments, suggestions and technical news which could be published in this newsletter.

For more information please contact :
Dr. Hamirin Kifli
Tel : 03-8259155/775
Tlx : MA 31609
Fax : 03-8259446