ELAEIS OLEIFERA PALM FOR THE PHARMACEUTICAL INDUSTRY

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INTRODUCTION

Tenera (T) is the major commercial oil palm progeny planted in Malaysia. It is a cross between the dura and pisifera varieties, (DxP),belonging to the *Elaeis guineensis* family originating from West Africa. The crude palm oil extracted from this Tenera variety consists of an equal proportion of saturated (50%) and unsaturated (50%) fatty acids which is high in monounsaturates (~39%). Crude palm oil consists of 1% minor components. The major ones are carotenoids, Vitamin E (tocopherol and tocotrienols) and sterols. Their concentrations have been found to be 500 - 700 ppm, 600 - 1000ppm and 250 - 620ppm respectively (Goh *et al.*, 1985). The major carotenes present are α- and β-carotenes which constitute about 90% of the total carotenoids (Choo, 1994). Palm oil is unique as most of the Vitamin E present are in tocotrienol forms (70 - 80%) which have recently been reported to possess interesting physiological properties. Among the sterols present, β-sitosterol is the major constituent.

Figure 1(a). Elaeis oleifera *oil palm tree*

Over the years, oil palm breeding has been actively carried out in Malaysia and elsewhere primarily to improve the oil yield by intercrossing within the *E. guineensis* species. The main objective was to increase the oil yield in the fresh fruit bunches. More recently the possibility to alter the fatty acid composition and to increase the iodine value (IV) (Tan, 1995) of palm oil to meet the present and future market requirements have been vigorously pursued.

The objective in breeding research in order to increase the level of unsaturated fatty acids content in palm oil has been made possible by the availability of another oil palm species, *E. oleifera* (or Melanococca)(*Figures 1 [a]–[c]*). However, this particular species has not been commercially exploited simply because of its extremely low oil yield. Oil from *E. oleifera* has been found to contain a higher level of unsaturated fatty acids (*Table 1*) and this oil palm has slow, yearly height increments and also shows great resistance to certain oil palm diseases. Palm oil from *E. oleifera* has also been found to have higher carotenes, Vitamin E (tocopherol and tocotrienols) and sterol contents (*Tables 2, 3* and *4*) as compared to oil from *E. guineensis* (Choo *et al.*, 1995). Thus, it is believed that this oil as produced coupled with some pretreatment can be encapsulated for pharmaceutical applications.

ECONOMIC VIABILITY

Although more than 600 carotenoids occur in nature, only about 50 possess Vitamin A activity. Among those present in crude palm oil having these properties are α-carotene, β-carotene, γ-carotene and β-zeacarotene.

TABLE 1. FATTY ACID COMPOSITION (%)OF OILS FROM VARIOUS OIL PALM SPECIES

	E. guineensis (E. G.)			*E. oleifera (E. O.)*	*E.G. x E.O.*			*Albescens**
	Tenera (T)	*Pisifera (P)*	*Dura (D)*		*E.O. xP*	*E.O. xD*	*E.O.DxP*	
C12:0	0.3	-	-	-	-	-	-	< 0.1
C14:0	1.2	1	1.8	0.2	0.5	0.5	1.6	0.6
C16:0	44.3	42.3	54.6	18.7	32.2	35.4	43.1	42.3
C16:1	-	-	-	1.6	0.3	0.1	0.2	0.2
C18:0	4.3	4.8	2.5	0.9	3.2	4.1	3.6	4.8
C18:1	39.3	40.2	30.1	56.1	51.8	45.1	34.4	40.3
C18:2	10	11.5	10.5	21.1	10.8	13.7	16.5	9.6
C18:3	0.4	0.4	0.4	1	0.5	0.5	0.5	1.2
C20:0	0.3	tr	0.1	tr	0.4	0.4	0.1	0.4

* Choo *et al.*, unpublished data

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Vitamin A Equivalents of *E. oleifera* Palm Oil

Malaysian Recommended Daily Allowance (RDA) for Vitamin A: 750 µretinol (vitamin A) equivqlent or 2500 IU of vitamin A activity (Teoh, 1975).

Calculation:

From *Table* 2, it can be seen that:

Carotene content of *E. oleifera* palm oil = 4300 ppm
Composition of carotenes: α-carotene = 40 - 50%
β-carotene = 40 - 54%
Others = <10%
(with γ-carotene = 0.08%, and β-zeacarotene = 0.57%)

(*Note*: α- , β-, and γ- carotenes and β-zeacarotene are provitamin A carotenes)
Using the information from *Table 5*

Vitamin A equivalents of *E. oleifera* palm oil containing
4300 ppm of carotenes : about 500 µg/g oil or 1 665 IU/g oil
Capsule size : 0.75 g

Thus, dosage of two capsules of *E. oleifera* palm oil/day would meet the daily requirement for Vitamin A. For cancer patients, it is recommended to consume more.

Commercial Product

Commercial Capsule: Natural β-carotene from Algae

50 capsules (each contains 6000 µg b-carotene or 1000 µg of retinol equivalent or 3330 IU of Vitamin A) cost RM18.90 (retail price). Thus each capsule costs RM0.38.

**It is worth noting that the capsule also contains natural palm-based Vitamin E and β-sitosterol besides natural palm carotenes.*

Figure 1(b) & (c) Elaeis oleifera Oil Palm Fruit

Each capsule contains 3300 IU of Vitamin A. Recommended dosage for adult: one capsule per day.

For palm oil carotene capsule

1.5 gramme of *E. oleifera* palm oil containing 2 500 IU of Vitamin A is able to meet the daily Vitamin A requirement.

Assuming one gramme of such oil can fetch RM0.10, then one tonne of *E. oleifera* palm oil would fetch 1 000 000 x RM0.10 = RM100 000.

For *Tenera* Palm

One hectare of Tenera palms can yield 4 - 5 tonnes of oil/ year. At a current palm oil price RM1 400 per tonne, the revenue would be RM5 600 - 7 000/ha/ year.

For *E. oleifera* Palm

The oil yield is lower, where one hectare of *E. oleifera* only produces 0.5 tonnes of oil/year.

At an assumed price of RM100 000 per tonne of *E. oleifera* palm oil, the expected revenue is RM50 000/ha/year.

TABLE 2. COMPOSITION (%) OF CAROTENES OF PALM OILS DERIVED FROM *E. guineensis*, *E. oleifera* AND THEIR HYBRIDS

	E. guineensis (E.G.)			*E. oleifera* (E.O.)	*E.G. x E.O.*			*Albescens*
	Tenera (T)	*Pisifera* (P)	*Dura* (D)		*E.O. x P*	*E.O. x D*	*E.O.D x P*	
Phytoene	1.27	1.68	2.49	1 . 12	1.83	2.45	1.3	1.1
Cis-β-Carotene	0.68	0.1	0.15	0.48	0.38	0.55	tr	0.9
Phytofluene	0.06	0.9	1.24	tr	tr	0.15	0.42	0.3
β-Carotene	56.02	54.39	56.02	54.08	60.53	56.42	51.64	61.1
α-Carotene	35.06	33.11	24.35	40.38	32.78	36.4	36.4	29.8
Cis-α-Carotene	2.49	1.64	0.86	2.3	1.37	1.38	2.29	3.1
ξ-Carotene	0.69	1.12	2.31	0.36	1.13	0.7	0.36	0.7
γ-Carotene	0.33	0.48	1.16	0.08	0.23	0.26	0.14	0.3
δ-Carotene	0.83	0.27	2	0.09	0.24	0.22	0.19	0.2
Neurosperene	0.29	0.63	0.77	0.04	0.23	0.08	0.08	0.3
β-Zeacarotene	0.74	0.97	0.56	0.57	1.03	0.96	1.53	1
α-Zeacarotene	0.33	0.21	0.3	0.43	0.35	0.4	0.52	0.2
Lycopene	1.3	4.5	7.81	0.07	0.05	0.04	0.02	1
Total (ppm)	500 - 700	300-500	900 - 1000	4300 - 4600	1250 - 1800	1200 - 2400	800 - 900	90 - 110

TABLE 3. COMPOSITION (%) OF TOCOPHEROL AND TOCOTRIENOLS OF PALM OILS DERIVED FROM *E. guineensis, E. oleifera* AND THEIR HYBRIDS

	E. guineensis (E. G.)			*E. oleifera (E. O.)*	*E.G. x E.O.*			*Albescens*
	Tenera (T)	*Pisifera (P)*	*Dura (D)*		*E.O. x P*	*E.o x D*	*E.O.DxP*	
α-Tocopherol	21	24	31	15	19	24	11	25
α-Tocotrienol	23	38	21	27	28	22	31	20
γ-Tocotrienol	45	32	40	54	42	49	51	40
δ-Tocotrienol	11	6	8	4	15	5	7	15
Total (ppm)	**600 - 1000**	**600-800**	**800-1000**	**700 - 1500**	**600 - 1600**	**800-1700**	**700- 900**	**700- 750**

TABLE 4. COMPOSITION (%) OF STEROLS OF PALM OILS DERIVED FROM *E.guineensis, E. oleifera* AND THEIR HYBRIDS

	E. guineensis (E. G.)			*E. oleifera (E. O.)*	*E.G. x E.O.*			*Albescens*
	Tenera (T)	*Pisifera (P)*	*Dura (D)*		*E.O. x P*	*E.O. x D*	*E.O.D x P*	
β-Sitosterol	60	54	55	64	59	61	58	70
Campesterol	13	17	25	19	20	22	20	20
Stigmasterol	24	22	14	15	16	13	19	8
Cholesterol	3	7	6	2	5	4	3	2
Total (ppm)	**250 - 620**	**1500 - 2000**	**2000 - 2500**	**3500 - 4000**	**1100 - 1250**	**1200 - 1400**	**700 - 800**	**500 - 600**

Alternatively, the palm oil producer can invest in the finished product which will require putting up the encapsulation plant. The targeted price for E. oleifera palm oil containing 2500 IU of vitamin A activity RM0.38. Thus, 1.5g (two capsules)is worth RM0.38 or RM0.26 per gm of oil.

IMPORTANCE OF CAROTENES, VITAMIN E AND β-SITOSTEROL

Carotenes

Increasing evidence have shown that carotenes, in particular β-carotene, besides providing Vitamin A activity, also possess anti-cancer properties for certain types of cancers, such as oral, throat, lung, stomach and colon cancers (Mathews-Roth and Kinsky, 1987; Metlin, 1984; Norman and Tapan, 1988; Peto *et al.*, 1989; Suda *et al.*, 1986; Sundram, 1989). What is more interesting is the latest finding on α-carotene which has been demonstrated to be ten times more potent as an anti-cancer agent than β-carotene (Murakoshi *et al.*, 1992; Murakoshi *et al.*, 1989). Both of these carotenes are present in palm oil. β-Carotene is also associated with prevention of aging process and cataract formation (Culter, 1989; Jacques, 1989). It also possesses anti-atherosclerotic effect (Graziano, 1990). It is worth noting that among other carotenes present in palm oil, phytoene and lycopene have also been reported to possess anti-cancer properties with the latter being recently reported to be a more efficient singlet oxygen quencher than β– carotene. Thus, palm oil presents a very important potential source of α–carotene, β-carotene, lycupene and other carotenoids which are important for human health.

TABLE 5. RETINOL EQUIVALENT (TEE, 1992)

1 retinol equivalent	=	1μg of retinol
	=	6μg of β-carotene
	=	12μg of other pro-vitamin A carotenes
	=	3.33 IU of vitamin activity from retinol
	=	10 IU of vitamin activity from β-carotene

Vitamin E (Tocopherol and Tocotrienols)

Tocopherol and tocotrienols have been shown to be excellent chain-breaking antioxidants (Serbinova *et al.*, 1993), which and important for the protection of unsaturated lipid peroxidation particularly in biomembranes (Scott, 1976). Numerous studies have also shown that the tocopherols and tocotrienols have protective effect against some of the diseases (Kato *et al.*, 1985; Qureshi *et al.*, 1986; Qureshi *et al.*, 1991; Rim *et al.*, 1993). For instance α-tocopherol and α-tocotrienol have been reported to have anti-cancer properties in experimental animals(Kato *et al.*, 1985; Qureshi *et al.*, 1991). α-Tocotrienol has also been shown to be able to suppress the elevation of the cholesterol level in blood (in some hypercholesterolemic subjects) and δ-tocotrienol has been reported as being able to prevent aggregation of platelets in blood as well (Holub *et al.*, 1989).

β-Sitosterol

β-Sitosterol has been reported to have the beneficial effect of being hypocholesterolemic.

METHODS OF EXTRACTION

The oil from *E. oleifera* can be extracted using normal screw press, (oil yield of *E. oleifera* 5%), food grade solvents such as n-hexane, or supercritical fluid extraction (SFE). In the third method, no solvent residue would be present in the oil. Odoriferous components and FFA are selectively removed, leaving oils containing carotenes and Vitamin E (certain fractions contain enriched fraction of carotenes and Vitamin E). Nevertheless, this process requires investment of SFE. Though capital cost is high, sale of high value health product will offset the capital investment. The absence of hazardous solvent and effluent will be other added advantages.

CONCLUSION

Thus, it is PORIM's wish that the industry will consider expand-the growing of *E. oleifera*, for its high carotene oil (an extraction technology using SFE is being developed by PORIM) and encapsulate it for pharmaceutical application (for Vitamin A and E supplement). Also, since Malaysia has the largest oil palm germplasm collection in the world, the industry should consider growing other hybrid palms (select those high in carotenes and Vitamin E content) and extracting the oil again for pharmaceutical application. In this respect, SFE can be used to concentrate the fractions enriched with carotenes and Vitamin E.

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