Utilization of Malaysian Palm Oil and Palm Kernel Oil for Fatty Acids and Derivatives

ROY J. de VRIES, Acidchem (Malaysia) Sdn. Berhad, PO Box 123, Butterworth, Province Wellesley, West Malaysia

ABSTRACT

Malaysia produces ca. 65% of the world's palm oil, or (in 1982) ca. 3,500,000 metric tons. By 1985, this will increase to 80% of world production, or ca. 4,800,000 metric tons. Palm oil products are refined, bleached and deodorized oil for edible purposes, palm olein for edible use, palm stearin for edible or industrial use, and the acid oil or fatty acid distillate for industrial uses. The Malaysian processors naturally want to upgrade the products as much as possible.

PALM OIL AVAILABILITY

In 1870, the oil palm '*Elaeis guineensis*' was introduced into Malaysia as an ornamental plant and, in 1917, commercial planting took place. Today, Malaysia is the world's largest grower of oil palm which competes with natural rubber as one of the country's largest agricultural products. On many plantations the crops are grown side by side. A subtropical climate, with high rainfall and a consistent temperature of ca. 35 C, stimulates the growth of the palm which produces all year round. The fruit is harvested continually and the fresh fruit bunches are transported to local mills for extraction of the oil (crude palm oil) and separation of the kernels which are transported to other mills for recovery of the palm kernel oil and the proteinaceous 'expeller cake' which is exported for use in animal feeds. A metric ton of fresh fruit bunches yields ca. 200 kg of crude palm oil and 40 kg of palm kernels, which in turn yield almost 20 kg of oil. Thus, the production of palm to palm kernel oil is about ten to one.

In 1982 (Table I), producing in excess of 3.5 million metric tons of palm oil, Malaysia achieved 64% of the world's estimated production of 5,445,000 metric tons. In the case of palm kernel oil, Malaysian production of 350,000 metric tons was more than 50% of the world's estimated production. By the end of the century, with projected production of 6.5 million metric tons of palm oil and 702,000 metric tons of palm kernel oil, Malaysia is expected to produce more than 80% of total world production of both these oils.

EFFECT OF '*Elaeidobius kamerunicus* Faust'

Poor pollination among oil palms in Sabah and Sarawak and particularly among young palms in Peninsular Malaysia has led to an extensive research program into pollination. In June 1980, the Department of Agriculture in Peninsular Malaysia imported 1,044 '*E. kamerunicus*' pupae into Malaysia for a 6-month study period. Following evaluation, permission for release of the weevil was obtained in November of that year. Although the weevil has caused some problems regarding the processing of fresh fruit bunches in the mills, in general its introduction has been acclaimed because of its extremely beneficial effects on oil yields. Table I also indicates the effect of the weevil as it shows Malaysia's potential increase in crude palm oil production by 800,000 tons in 1985 because of the effect of the weevil. The effect on the production of palm kernel oil is even more significant. With or without the weevil, Malaysia is the world's largest producer of palm and palm kernel oils and, by the end of the century, production will be formidable.

Today, the majority of Malaysia's crude palm oil is refined locally and exported as refined, bleached and deodorized palm oil. In fact, Malaysia currently has more refining capacity than raw materials.

Like most countries, Malaysia's policy is to upgrade and add value to the raw material it exports. In the case of oil palm, it must identify oil-based products with potential markets and also find uses for the byproducts resulting from its refinery operations. It must also recognize that in the case of edible products, it is competing with materials such as soybean oil. In the case of oleochemicals, however, it is competing with materials such as tallow, coconut oil and tall oil, which are less expensive than soybean oil. Thus, Malaysia has to accept a double set of raw material economic standards.

RAW MATERIALS FOR OLEOCHEMICALS PRODUCTION

Malaysia refines palm oil for edible purposes both by the physical and alkali refining processes. The alkali process extracts a multiple of 1.7 times the free fatty acid (FFA) from the oil, whereas the physical process extracts a multiple of 1.2 times the FFA. The physical process is therefore more economical and the trend is to the physical process.

Using the total Malaysian production figures for crude palm oil (3,500,000 metric tons), acid oil (113,000 metric tons), and deodorizer distillate (64,000 metric tons) (euphemistically called fatty acid distillate), and assuming that 85% of the crude palm oil reflected refinery residues and that the average FFA was 4%, one can estimate that 55% of the refining operations were alkali and 45% physical. Assuming that by 1990 all of Malaysia's refining is physical and

TABLE I

Production of Crude Palm Oil and Palm Kernel Oil (1977-82) Including Projected Growth to the Year 2,000 (thousand metric tons)

	1977	1978	1979	1980	1981	1982	1985	1990	2000
Crude palm oil, world	2,899	3,118	3,628	4,156	5,063	5,445	6,000	6,900	8,000
Crude palm oil, Malaysia	1,613	1,786	2,189	2,573	2,823	3,500	4,000	5,000	6,500
Weevil effect on crude palm oil, Malaysia						3,509	4,800		
Palm kernel oil, world	520	488	557	604			800	920	1,000
Palm kernel oil, Malaysia	142	142	196	222	243	350	411	540	702
Weevil effect on palm kernel oil, Malaysia						374	493		

Source: Hewin International, Porim Occasional Paper I, Palm Oil Update.

that 85% of the projected 4 million metric tons of crude palm oil are refined from an FFA of 4%, one would expect to have 163,200 metric of distillate available.

Crystal separation of palm oil is done in a number of plants in Malaysia to produce liquid palm olein and solid palm stearin fractions. Palm olein sells at a premium as a liquid edible oil, whereas the palm stearin is discounted as much as US$40/metric ton below the price of crude palm oil. Thus, palm stearin is another raw material available to the oleochemical manufacturers.

Table II lists the raw materials available in Malaysia together with actual and relative prices. It can be seen that crude palm stearin sells at ca. 90% of the crude palm oil cost, and the acid oil and deodorizer distillate sells at 75%. Refined, bleached and deodorized (RBD) palm oil sells at 15% above the price of crude palm oil.

The oleochemical producer in Malaysia, as elsewhere, has to decide which raw material will most economically produce his required sales mix without producing too many unsalable byproducts. Glycerine has come to be the byproduct that wags the dog, fetching a better price than almost anything the fatty acid producer makes.

RBD palm oil is ideal from all points of view other than price. It gives excellent glycerine and fatty acid yields, good throughput and makes it easy to meet specifications. Acid oil costs 75% of the price of crude palm oil but has only half the glycerine and is difficult to process.

Deodorizer distillate has virtually no glycerine – it does not need splitting but can be hydrogenated and distilled to form an acceptable rubber grade stearic acid.

TABLE II

Average Malaysian Local Delivered Price of Palm Oil and Palm Oil Products for the Year 1982 (US$/metric tons)

	Actual price	Relative price
Crude palm oil	359	100
Acid oil	276	75
Fatty acid distillate	275	75
Crude palm stearin	334	90
Palm kernel oil	393	
RBD Palm oil	418	115

Source: Acidchem's purchasing department.

PRODUCTION CAPACITY

Table III indicates that Malaysia has in excess of 150,000 metric tons of fatty acid "design" capacity, requiring some 180,000 metric tons of raw materials. Early strategy suggested that Malaysia's fatty acid capacity would operate solely on the byproducts of the refining industry. It is perhaps fortunate that byproduct availability does not support this, nor do prices of the byproducts make them particularly attractive. Otherwise, the Malaysian oleochemical manufacturer might be branded a poor quality producer, whereas he is able to fractionate lauric acid to 99%.

RAW MATERIAL COMPOSITION

Apart from tall oil, some 70% of the world's fatty acids are produced from tallow and 30% from coconut oil. From Table IV it can be seen that, particularly with the alternative of hydrogenating palm oil, one can produce the whole tallow fatty acid range and even the historic single-, double- and triple-pressed stearics. Palm oil also has the advantage in that, because of its vegetable source – provided due care is taken in selection of the raw material – the resultant fatty acids are food grade, Kosher and Halal.

Palm kernel oil (Table V) is also suitable for the total range of fatty acids produced from coconut oil. It also has the advantage that it has a lower C_8-C_{10} content, i.e., 7% compared to coconut's 15%.

PRODUCT DIFFERENCES

Oleic acid is produced in Malaysia by fractional distilla-

TABLE III

Approved Fatty Acid Plants in Malaysia

Company	Licensed capacity (metric tons)	Status	Type of plant
Felda	3,000	On-stream	Hydrogenation and distillation
Acidchem	30,000	On-stream	Fatty acids: splitting, fractionation, distillation, hydrogenation, flaking. Glycerine: pretreatment, evaporation, distillation, bleaching to 99.5% concentration.
Unichema	30,000	On-stream	Fatty acids: splitting, distillation, hydrogenation. Glycerine: no refining, only produce glycerine of 88% purity.
Southern	30,000	On-stream	Fatty acids: splitting, fractionation, distillation, hydrogenation, flaking. Glycerine: pretreatment, evaporation, distillation, bleaching to 99.5% concentration.
Pacific	30,000	On-stream	
Henkel	30,000	On-stream end of 1983	
Godrej	N/A	–	–
Bestex	N/A	–	–
Sawit	N/A	–	–
Glychem	N/A	–	–

N/A = not available.

TABLE IV

Palm Oil Composition Compared to Tallow

Product	Sap. no.	Iodine value	Titer (C)	Fatty acid composition C12	C14	C15	C16	C17	C18	C20	C14:1	C16:1	C18:1	C18:2	C18:3
Palm oil	190-202	51-55	40-47	0.1	1.0		43.7		4.4	0.3		0.1	39.9	10.3	trace
Tallow	192-202	40-56	40-47		3.0	0.5	25.0	1.5	21.5	0.5	0.5	2.5	42.0	3.0	

TABLE V

Palm Kernel Oil Composition Compared to Coconut Oil

Product	Sap. no.	Iodine value	Titer (C)	Fatty acid composition C6	C8	C10	C12	C14	C16	C18	C16:1	C18:1	C18:2	C18:3
Palm kernel oil	240-255	16-20	20-28	trace	3.7	3.3	48.0	15.3	7.7	1.7		15.6	2.7	0.3
Coconut oil	250-264	7-12	20-24	trace	7.6	7.3	48.2	16.6	8.0	3.8	1.0	5.0	2.5	

TABLE VI

Palm-Derived Oleic Acid Compared to Tallow-Derived Oleic Acid

Product	Titer (C)	Iodine value	Acid value	Sap. no.	Color % trans 440/550 nm min	Color 5¼" Lovibond	Unsap. % max	Fatty acid composition C12	C14	C15	C16	C17	C18	C14:1	C16:1	C18:1	C18:2	C18:3
Palm oleic acid	29	94-98	195-203	197-205		10Y-1.5R					0.5		7/9			70/74	17/18	1 max
Tallow oleic acid	8-11	89-93	199-204	201-206	2/30		1.5	trace	3	trace	6	1	1	2	6	73	8	1

tion rather than the solvent separation and hydrophilification techniques used in the West. Resulting from this is a product with a titer of ca. 29 C rather than the 6-8 C normally associated with oleic acid (Table VI). This is almost certainly due to the high stearic acid content of 8% but, in spite of the high titer, this oleic acid is successfully being used for food esters where its vegetable origin is an advantage.

MARKETS AVAILABLE TO MALAYSIAN OLEOCHEMICALS

Malaysia has a design capacity of 150,000 metric tons of fatty acids. Thus, with a home market of only 2,000 metric tons, Malaysia has sufficient capacity to supply more than 10% of world consumption – a world consumption that already has more locally available capacity than it requires. Malaysia owns no markets, has no unique technology, but has abundant raw materials.

ADDITIONAL DERIVATIVES PLANNED AND POTENTIAL

There is considerable interest in Malaysia for the production of fatty alcohols and, to date, 6 companies have obtained Government licences for their production (Table VII).

The current economic depression and reduction in petrochemical prices have slowed progress, but it is virtually certain that as world economy improves at least one of the licences will reach the commitment stage.

Fatty acids are the first and poorest relation of the oleochemical industry. Most oleochemical companies view their fatty acids as raw materials to be computed into their more sophisticated operations at cost rather than market price. As a result of this policy, the sole fatty acid manufacturer must look "downstream," be it to esters, dimer acids, fatty amines or whatever. Fatty acids, dimer acids, metal stearates, etc., can be produced to supply local ASEAN and South East Asian Markets.

Nitrile could be produced to ship to the major markets of Europe, the USA and Japan, while a portion could be reserved for conversion to the whole range of cationics, nonionics and amphoterics for the small but rapidly increasing local markets.

TABLE VII

Approved Fatty Alcohol Licences in Malaysia

Company	Capacities (metric tons/yr)
Henkel (J.V. with Jomalina & Socoil)	40,000
Albright & Wilson	30,000
Kao Corporation	30,000
Unichema	30,000
Palmco	18,000
Comcraft	10,000
Total	158,000

PROBLEMS

The Malaysian oleochemical manufacturers must learn that finished products and the cost of producing them bear a direct relation to the quality of the raw materials.

Malaysia must learn that, for oleochemicals, it is competing with different raw materials to those it competes with in the food industry. The Malaysian Government must ensure that Malaysian raw materials are preferentially available to Malaysian manufacturers.

The world wants Malaysia's alkyl chain. Should it take it as the triglyceride, the acid group, the methyl ester, the alcohol, the nitrile or whatever?

Malaysia would like to add as much value as possible and export as complex a molecule as possible. The rest of the world would prefer to finish its own raw materials. Fatty acids could be shipped in bulk to the major ports in the USA, Europe and Japan.

The West eventually must reliquish its simpler operations to be carried out at the raw material source.

Structural Determination and Uses of Jojoba Oil

THOMAS K. MIWA, The Jojoba Society of America, 2086 East La Jolla Drive, Tempe, AZ 85282

ABSTRACT

The predominating molecular species in jojoba oil is *cis*-13-docosenyl *cis*-11-eicosenoate (erucyl jojobenoate), ranging from 31% to 45% of the extracted seed oil. Other alcohol/acid combinations contribute to the C_{42} molecular chain length so that this fraction constitutes a low of 41% to a high of 57% of the total wax esters. The positions of the exclusively *cis* ethylenic bonds in the alcohol and acid moieties of the wax esters are 99% ω-9 and 1% ω-7. Only 2% of the alcohol and acid moieties were saturated when analyzed after saponification of the oil. Triglycerides were detected by gas chromatography in all of the more than 200 natural jojoba oil samples tested, a few of which had substantially more than the normal 1%. Among the many uses of jojoba oil cited here, the two most promising are the sulfurized oil as extreme-pressure/extreme-temperature lubricant additive and the natural or refined oil formulated into cosmetic products.

INTRODUCTION

Jojoba (*Buxus chinensis* [Link 1822], *Simmondsia californica* [Nuttal 1844], or *Simmondsia chinensis* [Schneider 1907]) oil is a liquid wax ester mixture extracted from seeds of a desert shrub native to Arizona, California, Northwestern Mexico and Baja California (1-9). Composition and molecular structure of the oil were determined by gas liquid chromatography (GLC), gas chromatography-mass spectrometry (GC-MS), reversed-phase high pressure liquid chromatography (HPLC), ozonolysis and other analytical techniques (10,11).

Many uses for jojoba have been proposed over the past three decades, and those that are interesting and have been experimented on by this author are listed in the last section of this article.

EXPERIMENTAL PROCEDURES

Extraction of Oil

Jojoba seeds were ground in a Laboratory Wiley Mill, either individually or as a batch, and placed in a Butt extraction