The Chemical and Physical Characteristics of Oleochemicals Produced in Malaysia

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INTRODUCTION

Oleochemicals are products derived from oils and fats. They are often classified into two categories; basic oleochemicals and derivatives. The important basic oleochemicals are fatty acids, fatty esters, fatty alcohols, fatty amines and glycerol, while derivatives are made from basic oleochemicals by various chemical processes. The production of basic oleochemicals in Malaysia, the Pacific Rim and the world as a whole is shown in *Table 1.*

As basic oleochemicals and derivatives are both commonly based on molecules with C12-C14 and C16-C18 chain lengths, both palm oil and palm kernel oil can be used as raw materials for their production. In 1994, 850 000 tonnes of oils (palm oil and palm kernel oil) were used for the production of oleochemicals in Malaysia: 70% of the total was palm kernel oil (crude and processed) (PORLA, 1995).

At present ten companies are producing basic oleochemicals and derivatives in Malaysia. The country's output of basic oleochemicals in 1990 was 83% more than in the previous year, while production in 1995 was 5.6 times that of 1989. It is predicted that by the year 2000, Malaysia will contribute about 20% of the world's production of basic oleochemicals.

In the ASEAN region, Malaysia is the main producer of basic oleochemicals, followed by the Philippines, Indonesia and Thailand. Fatty acids represent the major basic oleochemicals produced in Malaysia, followed by fatty esters, fatty alcohols and glycerol *(Table 2).* In Malaysia and Indonesia the main raw materials used for the production of oleochemicals are palm oil and palm kernel oil while in the Philippines coconut oil is the principal feedstock. It would be interesting to know if the quality of the oleochemicals differs depending on the raw materials used.

The author is conducting a survey to:

- collate information on the quality of oleochemicals produced in Malaysia
- collate information on the quality of oleochemicals produced by other ASEAN countries
- compare and contrast the two preceding items
- propose possible standards or specifications for products, and
- propose areas of specialization or niche products to be made by Malaysia.

The present paper reports on the quality of oleochemicals produced in Malaysia. It is based on the collation of data on products provided by their manufacturers. It is

TABLE 1. PRODUCTION OF BASIC OLEOCHEMICALS (THOUSAND TONNES)

BASIC OLEOCHEMICALS	1990			1995			2000		
	WORLD	PACIFIC RIM	MALAYSIA	WORLD	PACIFIC RIM	MALAYSIA	WORLD	PACIFIC RIM	MALAYSIA
FATTY ACIDS	2130	625	135	2 575	1 033	462.5	2 693	1 223	560
METHYL ESTERS	–	126	63	175	160	5	–	200	70
FATTY ESTERS	450*	10	10	369	67	30	624	97	40
FATTY ALCOHOLS	855	145	30	581	403	168	1575	810	350
FATTY AMINES	425	41	–	491.2	92	30	526	142	60
GLYCEROL	557	94	24.2	300	160	66.45	780	258	120
TOTAL	4 417	1 041	262	4 491	1 915	806.95	6 098	2 730	1 200

SOURCE : World Conference on Oleochemicals, 1990

* = Methyl esters + Other esters

TABLE 2. PRODUCTION OF BASIC OLEOCHEMICALS FROM THE ASEAN REGION (THOUSAND TONNES)

BASIC OLEOCHEMICALS	MALAYSIA			PHILIPPINES			INDONESIA			THAILAND		
	1989	1990	1995	1989	1990	1995	1989	1990	1995	1989	1990	1995
FATTY ACIDS	105	135	462.5	30	30	60	27	27	67	10	10	20
METHYL ESTERS	25	63	50	50.1	63.1	80	–	–	–	–	–	–
FATTY ESTERS	–	10	30	–	–	6	–	–	10	–	–	–
FATTY ALCOHOLS	–	30	168	47.5	55	100	–	30	95	–	–	–
FATTY AMINES	–	–	30	–	5	10	–	–	10	–	–	–
GLYCEROL	13	24.2	66.45	14.77	19.37	30	2.7	5.7	17.5	1	1	2
TOTAL	143	2662.2	806.95	142.37	172.47	286	29.7	62.7	199.5	11	11	22

SOURCE : World Conference on Oleochemicals, 1990

important for readers to note that the Malaysian manufacturers often produce tailor-made products to meet specific requests from clients. The characteristics of such products may vary from the data included in this survey.

The basic oleochemicals and their derivatives have a wide range of applications, the important ones being in the production of surfactants, detergents, cosmetics, toiletries, pharmaceuticals and other industrial chemicals *(Table 3)*.

TABLE 3. AREAS OF APPLICATION OF OLEOCHEMICALS IN THE CHEMICAL INDUSTRY

Product	Area of application
Fatty acids and derivatives	Plastics, metal soaps, washing and cleaning agents, soaps, cosmetics, alkyl resins, dyestuffs, textiles, leather, paper and rubber industries and lubricants
Methyl esters of fatty acids	Cosmetics, washing and cleaning agents
Glycerol and derivatives	Cosmetics, toothpastes, pharmaceuticals, foodstuffs, lacquers, plastics, synthetic resins, tobacco, explosives and cellulose processing
Fatty alcohols and derivatives	Washing and cleaning agents, cosmetics, textiles, leather and paper industries and mineral oil derivatives
Fatty amines and additives	Fabric conditioners, mining, road making, biocides, textile and fibre industries and mineral oil additives

SURVEY OF PRODUCT INFORMATION

A survey was carried out by compiling and analysing information on oleochemical products produced by various manufacturers in Malaysia. The number of manufacturers and the types of oleochemicals covered in the survey were as shown in *Table 4*.

The information was collated according to the following parameters: alkyl composition, colour, acid value, hydroxyl value, saponification value, unsaponifiable matter, iodine value, titre or solidification point.

TABLE 4. NUMBER OF MANUFACTURERS AND TYPES OF OLEOCHEMICALS COVERED IN THE SURVEY

Oleochemicals	Number of Manufacturers
Fatty acids	7
Methyl esters	2
Fatty esters	1
Fatty alcohols	2
Glycerol	8

FATTY ACIDS

The most common method for the production of fatty acids in the oleochemicals industry is fat splitting at high temperature and high pressure. The fatty acids produced are then purified or fractionated by simple or fractional distillation.

Various palm fatty acids have been produced in this country. The main constituents of the products vary depending on the type of raw material *i.e.* on whether it is crude or refined, unhardened or hardened, palm or palm kernel oil or their products.

Some chemical and physical properties of the fatty acids produced by Malaysian manufacturers are shown in *Table 5*.

TABLE 5. CHEMICAL AND PHYSICAL PROPERTIES OF FATTY ACIDS ORIGINATING FROM OIL PALM PRODUCTS

Type of Fatty acid	Fatty Acid Composition (%)									Colour		Acid value	Saponification value	Unsaponifiable matter (%)	Iodine value	Titre (°C)
	C6	C8	C10	C12	C14	C16	C18	C18:1	C18:2	APHA	Lovibond 51/4"					
Distilled palm kernel fatty acids	T	2-5	2-4	46-51	13-17	6-8	1-5	13-20	1-5	–	1R-2R 2.5Y-20Y	242-265	243-266	1	14-28	20-28
Distilled stripped palm kernel fatty acids	–	0-0.5	1-3	40-60	14-20	6-12	1-5	12-22	2-5	–	1R-1.5R 10Y	240-260	246-262	1	14-23	22-28
Hydrogenated palm kernel fatty acids	–	1-5	1.5-4	46-58	13-22	6-14	10-24	0-1	–	–	0.5R-1R 2Y-10Y	246-262	247-260	1	0-1	30-38
Stripped hardened palm kernel fatty acids	–	–	1-3	47-53	15-19	8-11	16-24	–	–	–	0.5R 5Y	248-258	249-259	1	0-1	30-34
Caproic-Caprylic acids	25-35	55-65	<———0-10———>			–	–	–	–	–	2R-10Y	385-420	386-421	–	0-5	–
Caprylic-capric acids	0-6	42-78	10-50	0-15	0.1	–	–	–	–	–	0.5R-1R 3Y-10Y	348-375	349-380	0.5-1	0-1	-2 - 6
Caproic acid	98-100	0-2	–	–	–	–	–	–	–	–	0.2R 1Y	473-482	473-482	2	0-2	-5 - 1
Caprylic ,99% acid	0.5-1	>99	0.5-1	–	–	–	–	–	–	60	0.3R-1R 3Y-5Y	383-392	385-393	0.5	0-0.5	14-18
,98%	0-1	98-100	0-1	–	–	–	–	–	–	–	0.2R 1Y	385-390	385-390	0.5	0.1-0.5	14-16
,95%	0-1	95	0-4	–	–	–	–	–	–	–	0.5R-1R	383-393	394-394	0.5	0.1-1	12-18

Type of Fatty acid	Fatty Acid Composition (%)									Colour		Acid value	Saponification value	Unsaponifiable matter (%)	Iodine value	Titre (°C)
	C6	C8	C10	C12	C14	C16	C18	C18:1	C18:2	APHA	Lovibond 51/4"					
Capric acid, 99%	–	0-1	99min	0-1	–	–	–	–	–	60	0.2R-0.8R 3Y	321-329	322-330	0.5	0-0.5	30-31.5
, 98%	–	0-1	98-100	0-1	–	–	–	–	–	–	0.2R 1Y	324-328	324-328	0.5	0.1-0.5	30-31.5
, 95%	T-1	2-4	95min	1-4	–	–	–	–	–	–	0.3R-1Y 3Y-10Y	320-330	322-330	0.5-1	0.5-1	28-32
Lauric acid, 99%	–	–	0.5-1	99min	0.5-1	–	–	–	–	–	0.2R-0.3R 2Y-3Y	277-282	278-283	0.5	0-0.5	41-44
, 98%	–	–	0-1	98min	0-2	–	–	–	–	40	0.2R-0.3R 1Y-3Y	277-282	278-283	0.2-0.5	0-0.5	41-44
, 95%	–	–	0-4	95	0-4	–	–	–	–	–	0.2R-0.3R 2Y-3Y	277-282	278-283	0.5	0.2-0.5	41-44
, 92%	–	–	2.5	92-94	2-7	–	–	–	–	–	0.2R 2Y	277-281	277-281	0.5	0.1-0.5	41-44
, 70%	-	–	0-2	70-75	22-30	0-4	–	–	–	40	0.2R-0.5R 2Y	267-275	268-276	0.5	0.1-1	32-36
Myristic acid , 99%	–	–	–	1	98.5-99	0-1	–	–	–	40	0.2R-0.3R 2Y-3Y	243-248	244-249	0.5	0-0.5	52-54
, 98%	–	–	–	0-2	98-100	0-2	–	–	–	40	0.2R-0.3R 1Y-3Y	242-247	243-249	0.5	0-0.5	52-54
, 95%	–	–	–	0-5	95	0-5	–	–	–	–	0.2R-0.3R 2Y-3Y	243-248	244-249	0.5	0-0.5	52-55
, 92%	–	–	–	2-5	92-94	2-5	–	–	–	–	0.4R-3R	243-246	243-246	0.5	0.1-0.5	51-52

Type of Fatty acid	Fatty Acid Composition (%)									Colour		Acid value	Saponification value	Unsaponifiable matter (%)	Iodine value	Titre (°C)
	C6	C8	C10	C12	C14	C16	C18	C18:1	C18:2	APHA	Lovibond 51/4"					
Distilled palm fatty acids	–	–	–	0-1	0-3	40-65	3-8	28-48	3-12	FAC1	0.8R-2R 4Y-20Y	190-220	196-221	0.5-1	30-56	42-54
Palm triple pressed fatty acids	–	–	–	0-1	0-2	52-60	38-47	T-1	T	40	0.2R-0.3R 2Y-3Y	205-212	206-203	–	0-1	54.5-56
Palm double pressed fatty acids	–	–	–	0-2	0-3	52-63	35-45	0-4	0-1	–	0.5R 3Y	206-213	207-214	–	0-6	53-56
Palm stearin fatty acids	–	–	–	0-1	0-3	52-70	3-8	20-37	3-10	–	1.5R-3R 10Y-30Y	196-216	202-217	1	28-44	48-55
Hardened palm stearin fatty acids	–	–	–	–	0-3	55-70	27-48	–	–	–	1R 10Y	206-216	205-217	1	0-1	53-57
Food/Cosmetic stearic acid	–	–	–	2-3	2-3	45-63	34-52	0-1	–	–	0.3R-0.5Y 1Y-2Y	204-212	205-214	0.5	0.7-1	53-56

Type of Fatty acid	Fatty Acid Composition (%)									Colour		Acid value	Saponification value	Unsaponifiable matter (%)	Iodine value	Titre (°C)
	C6	C8	C10	C12	C14	C16	C18	C18:1	C18:2	APHA	Lovibond 51/4"					
Single pressed stearic acid	–	–	–	1	2	52-60	27-37	8	–	–	2R 20Y	204-211	205-212	–	<8	52-55
Double pressed stearic acid	–	–	–	T-1	0-2	55-60	32-41	0-5	–	–	0.5R 5Y	204-212	205-213	1	0-4	53-56
Triple pressed stearic acid	–	–	–	0-1	0-3	41-65	33-55	T-1	–	–	0.3R-0.5Y 3Y-5Y	202-213	203-214	0.5	0-1	54-57
Stearic acid stabilizer grade	–	–	–	3	3	54	43	0-1	–	–	0.4R 1.5Y	205-212	206-213	0.5	0-8	54-56
Stearic acid Candle grade	–	–	–	3	3	61	32	5	–	–	0.7R 2.5Y	208-213	209-214	1	9	52-55
Stearic acid rubber grade	<——— NA ———>									–	0.7R-5R 2.5Y-50Y	199-213	200-204	1	0-9	52-57
Palmitic , 98% acid	–	–	–	1	0-2	98-100	0-2	–	–	–	0.2R-0.3R 1.5Y-3Y	216-220	217-221	0.5-1	0-1	58-63
,95%	–	–	–	1	1-2	95	2-3	–	–	–	0.2R-0.3R 2Y-3Y	215-221	216-222	0.5	0.5-1	59-63
,92%	–	–	–	–	2-5	92-94	2-5	–	–	–	0.5R 3Y	216-220	216-220	1	0.3-1	59-60
,90%	–	–	–	1-1.5	3-6	90-95	7	–	–	40	0.2R-0.3R 2Y - 3Y	215-223	216-224	0.5	0-1	58-62

Type of Fatty acid	Fatty Acid Composition (%)									Colour						
	C6	C8	C10	C12	C14	C16	C18	C18:1	C18:2	APHA	Lovibond 51/4"	Acid value	Saponification value	Unsaponifiable matter (%)	Iodine value	Titre (°C)
Palmitic-Stearic acids	–	–	–	0.1	0.3	33-64	33-67	T-8	–	–	0.3R-5R 2.5Y-20Y	195-214	208-214	0.5-1	0.5-10	52-61
Stearic , 98% acid	–	–	–	–	1	0-2	95-100	0-2	–	60	0.5R-2R 6Y-20Y	193-198	193-199	1.5	0-2	54-69
, 95	–	–	–	–	–	3-5	95-98.5	0-2	–	–	0.3R-0.5R 2Y-5Y	196-199	197-200	–	0-2	66-68
, 92	–	–	–	–	–	6-8	92-94	0-1	–	–	1R-10Y	188-196	188-196	1	1-3	65-66
, 90	–	–	–	–	–	3-8	90-94	0-2	T	60	0.3R-0.5R 3Y-5Y	195-202	196-203	–	0-2	64.5-69
, 85	–	–	–	–	T	5-15	85-95	T	–	–	0.5R-5Y	194-205	194-206	0.5	0-1	65-69
, 70	–	–	–	1	0-2	25-32	67-75	0-1	T	50	0.3R-0.5R 3Y-5Y	199-207	200-208	2	0-1	57-63
, 65	–	–	–	T	1-2	20-36	62-66	T-1	–	–	0.5R-1R 5Y-10Y	197-209	198-210	1	0-1	57-61
, 60	–	–	–	0-1	0-5	27-35	60-73	T	–	–	0.3R-3Y	200-208	202-208	0.5	0-1	56-62
, 50	–	–	–	1	2	42-48	50-56	1	T	50	0.3R 3Y	204-210	205-211	–	0.5	55-57
Oleic acid, 80	<————		<6		————> >			80	<14	–	1.5R 10Y	194-204	195-205	–	94-102 (melting point)	< 9
, 75	<————		<12		————> >			75<	12.5	–	1R 8Y	195-205	197-207	–	88-95 (cloud point)	< 7
, 72	<————		<13		————> >			72	<13-18	–	2R 15Y	195-205	197-205	–	88-95	< 8
, 70	–	–	–	–	–	0-2	8-10	70-77	14-18	–	1.5R 10Y	195-203	197-205	1	92-100	< 30

T = Trace

FATTY ACIDS FROM PALM KERNEL OIL

Palm kernel oil (PKO) is used as a source for C8 to C14 fatty acids but it also contains other fatty acids, notably oleic. If it is not fractionated before splitting, the mixture of fatty acids obtained will obviously have a composition very close to that of the parent oil.

TABLE 6. COMPOSITION (%) OF FATTY ACID MIXTURES FROM UNFRACTIONATED OILS

	From PKO	From hardened PKO
C12	40-60	48-58
C14	13-20	13-22
C16	6-12	6-14
C18	1-5	10-24
C18:1	12-22	0-1
Iodine value	14-28	0-1

Unless the C6-C10 fatty acids originally present in the parent oil are stripped off by distillation under reduced pressure, there will be 4-9% of them in the fatty acid mixtures.

The stripped C6-C10 fatty acids can be sold as they are, under the name caproic-capric acid mixture or partially fractionated to give caprylic-capric acid mixture, or fractionated completely to give pure caproic, caprylic and capric acids. Similarly the fatty acid mixtures from palm kernel or hardened palm kernel oil can be partially fractionated or fully fractionated into pure acids after stripping. The chemical characteristics of the acids obtained will naturally vary with the extent of fractionation and the process used.

Pure palm kernel fatty acids have acid values and saponification values decreasing with increasing number of carbon atoms in their molecules. Titre values increase with increasing number of carbon atoms. The colours and iodine values of various types of pure fatty acids from palm kernel oil are not very different: colours range from 0.2R to 1R and 1Y to 10Y and iodine values from 0 to 2.

The ranges for the acid values and saponification values of capric acid 98% and lauric acid 92% given in *Table 5* are narrower than for compounds of higher purity. This is because the information on these acids was obtained from a single manufacturer.

FATTY ACIDS FROM PALM OIL

The principal fatty acids of palm oil are palmitic and oleic together with smaller amounts of stearic and linoleic acids. The palm oil fatty acids, like those from PKO, can be fractionated to varying degrees, *e.g.* to give the products known as single, double or triple pressed 'stearic acid'. The oleic acid content of these materials decreases with each pressing (from about 8% to a trace in the triple-pressed fraction) while the 'true' stearic acid content increases (from 27% to 55%).

Another type of fatty acid product derived from palm oil is a crude preparation of a single acid, usually palmitic or stearic, each acid containing some of the other, along with some oleic acid. Palmitic acid preparations may reach 90-98% purity, with virtually no oleic acid whilst stearic acid preparations contain 50-98% of the acid with low amounts of oleic. The purity of oleic acid produced ranges from 70-80% with lesser amount of linoleic acid.

Table 7 lists the main fatty acid products made from palm kernel oil and palm oil.

FATTY ESTERS

Fatty esters can be synthesized by various routes, the commonest being esterification of fatty acids and alcoholysis of triglycerides. Such esters may be derived from mono, di or polyhydric alcohols. They are used in various industries such as those dealing with textiles, cosmetics, lubricants, plastics, pharmaceuticals and food. The most important fatty esters are methyl esters. As with fatty acids, fatty esters produced by Malaysian manufacturers range from unfractionated mixtures to pure compounds.

TABLE 7. MAIN FATTY ACID PRODUCTS FROM PALM KERNEL OIL AND PALM OIL

Fatty acid products from palm kernel oil		Fatty acid products from palm oil	
Distilled palm kernel fatty acids		Distilled palm fatty acids	
Distilled stripped palm kernel-fatty acids		Palm double pressed fatty acids	
Distilled Hydrogenated palm-kernel fatty acids		Palm triple pressed fatty acids	
Stripped hardened palm kernel-fatty acids		Palm stearin fatty acids	
Caproic-caprylic acid mixture		Hardened palm stearin fatty acids	
caproic acid	25-35%	Stearic acid, single pressed	
caprylic acid	55-65%	Stearic acid, double pressed	
Caprylic-capric acid mixture		Stearic acid, triple pressed	
caprylic acid	42-78%	Stearic acid, food/cosmetic grade	
capric acid	10-50%	Stearic acid, stabilizer grade	
Caproic acid	98%	Stearic acid, rubber grade	
Caprylic acid	99%	Stearic acid, candle grade	
	98%	Palmitic acid	98%
	95%		95%
Capric acid	99%		92%
	98%		90%
	95%	Palmitic-stearic acid mixture	
Lauric acid	99%	palmitic acid	33-64%
	98%	stearic acid	33-67%
	95%	Stearic acid	98%
	92%		95%
	70%		92%
Myristic acid	99%		90%
	98%		85%
	95%		70%
	92%		65%
			60%
			50%
		Oleic acid	80%
			75%
			72%
			70%

They are made mostly from palm kernel oil, palm oil, or their products such as palm stearin, palm olein and pure fatty acids.

METHYL ESTERS

The chemical and physical characteristics of some fatty methyl esters are set out in *Table 8*. These characteristics vary depending on the raw materials and processes used in their preparation.

METHYL ESTERS FROM PALM KERNEL OIL

The main constituents of fatty methyl esters prepared from palm kernel oil are methyl laurate, myristate, oleate and stearate with methyl caprylate, caprate and linoleate as minor components. The colour values of these methyl esters are approximately 0.3R and 3Y. The acid value and unsaponifiable matter are low at 0.5-1.0 and 0.5, respectively. Saponification values are in the range of 230-248.

TABLE 8. CHEMICAL AND PHYSICAL CHARACTERISTICS OF FATTY METHYL ESTERS

Type of Methyl ester	Alkyl Composition (%)									Water	Colour APHA	Colour Lovibond 51/4" Max	Acid value	Saponification value	Unsaponifiable matter (%)	Iodine value	Titre (°C)
	C6	C8	C10	C12	C14	C16	C18	C18:1	C18:2								
Mixed methyl esters from palm kernel oil	0-1	1-5	1-5	45-50	14-18	7-10	1-3	12-19	2-4	–	–	0.3R 3Y	1.0	238-248	0.5	14-19	Ca.-9
Mixed methyl esters from stripped palm kernel oil	–	0-0.5	0-3	47-53	15-19	8-11	1-3	12-20	2-4	–	–	0.3R-3Y	0.5	230-240	0.5	14-20	Ca.-7
Mixed methyl esters from palm kernel oil for sulphonation	–	0-0.5	0-3	47-53	15-19	8-12	16-28	–	–	–	–	0.3R 3Y	0.5	230-240	0.5	< 0.5	Ca.15
Methyl caprylate	0-2	98-100	0-2	–	–	–	–	–	–	–	–	0.2R 2Y	0.3	352-358	0.5	0.5	Ca.-55
Methyl caprylate-caprate	2-6	50-78	18-35	0-15	–	–	–	–	–	–	–	2.5R 5Y	1.0	325-345	1.0	1.0	Ca.-28
Methyl laurate, 98%	–	–	0-2	98-100	0-2	–	–	–	–	0.1	25	0.2R 2Y	0.5	255-265	0.5	0.3-0.5	Ca.5
, 92%	–	–	2-5	92-94	2-7	–	–	–	–	–	–	0.2R 2Y	0.5	257-265	0.5	0.3	1-4
, 70%	–	–	0.2	70-75	22-30	0-2	–	–	–	–	–	0.2R 2Y	0.5	250-260	0.5	0.5	Ca. 4
Methyl myristate, 98%	–	–	–	–	>98	–	–	–	–	0.1	25	–	0.5	229-236	–	0.5	–
, 92%	–	–	–	2-5	92-94	2-5	–	–	–	–	–	0.2R 2Y	1.0	227-236	0.5	0.5	15-18

Type of Methyl ester	Alkyl Composition (%)										Colour						
	C6	C8	C10	C12	C14	C16	C18	C18:1	C18:2	Water	APHA	Lovibond 51/4"	Acid value	Saponification value	Unsaponifiable matter (%)	Iodine value	Titre (°C)
Mixed methyl esters from palm oil	–	–	–	0-1	0-3	40-50	4-7	35-44	6-12	max.0.1	–	1R 10Y	0.5	195-203	1	42-56	Ca.14
Mixed methyl esters from palm stearin	–	–	–	0-1	0-3	55-70	3-7	20-30	5-10	–	–	0.5R 5Y	0.5	196-208	1	22-45	Ca.21
Mixed methyl esters from palm stearin for sulphonation	–	–	–	0-1	0-3	55-70	27-48	–	–	–	–	0.3R 3Y	0.5	195-205	1	< 0.5	25-30
Mixed methyl esters from palm olein	–	–	–	–	–	0-2	8-10	70-77	14-18			1R 10Y	1.0	186-196	1	85-95	Ca.5
Methyl palmitate, 92%	–	–	–	–	2-5	92-94	2-5	–	–	–	–	0.2R 2Y	1.0	203-209	0.5	1.0	Ca.25
Methyl stearate, 92%	–	–	–	–	–	6-8	92-94	–	–	–	–	0.2R 2Y	1.0	187-191	1.0	1.0	Ca.36
, 70%	–	–	–	–	0.1	25-32	67-75	–	–	–	–	0.2R 2Y	1.0	195-203	1.0	1.0	Ca.30

A preparation containing 98% methyl caprylate is produced which has methyl caprate as the minor component. A mixture of methyl caprylate and caprate is available with a lesser amount of methyl laurate.

Methyl laurates with purities of 70%, 92% and 98% are produced: the minor components present are usually methyl myristate and methyl caprate.

Methyl myristate preparations range from 92 to 98% in purity, with methyl laurate and palmitate as the minor components present.

METHYL ESTERS FROM PALM OIL

The major constituents of fatty esters from palm oil and palm stearin are methyl palmitate and oleate, with methyl stearate and linoleate as minor components. Methyl esters from palm stearin meant for sulphonation contain mainly palmitate and stearate. Palm olein methyl ester contains mainly oleate, with stearate and linoleate as minor components.

The colour of methyl esters from palm oil is in the range of 0.3R-1R and 3Y-10Y. The acid values of palm oil methyl esters, and their content of unsaponifiable matter, are low not normally above 1.0. The iodine values of methyl esters from palm stearin, palm oil and palm olein are 22-45, 42-56 and 85-95 respectively. The saponification values range from 186 to 208.

A preparation containing 92% methyl palmitate is produced which has methyl myristate and stearate as the minor components. Methyl stearates of purity 70% and 92% are available with palmitate as the minor component.

All the pure methyl esters produced from palm oil have a low iodine value (1).

FATTY ESTERS

Besides methyl esters the alkyl esters produced include:-

Isopropyl myristate 99%, isopropyl myristate 98%, isopropyl palmitate 90%, glycerol tricaprylate 55-65%, glycerol tricaprylate- tricaprate mixture and glycerol monostearate (36% alpha or 40% alpha).

Some of the chemical and physical properties of these esters are listed in *Table 9.*

The saponification values of fatty esters decrease with increasing number of carbon atoms in the chain. All acid values and iodine values for fatty esters are low, less than 3.5 and 3 respectively. Most of the water content of the fatty esters produced are close to 0.1 percent.

Table 10 lists fatty esters produced from oil palm products.

FATTY ALCOHOLS

Fatty alcohols are commonly produced by hydrogenation of fatty methyl esters at high temperatures and pressures using copper-chromite catalyst in a fixed-bed reactor. If some of the unsaturation present in the molecule is to be maintained then a catalyst containing zinc (Zn) is used.

Fatty alcohols themselves have limited direct use. More than 90% of the world-wide out put of fatty alcohols is used for the production of more valuable derivatives such as fatty alcohol sulphates, fatty alcohol ethoxylates and fatty alcohol ether sulphates. These are extensively used in the manufacture of washing and cleaning products.

The fatty alcohols produced in Malaysia (mainly from palm kernel oil, palm oil and palm oil products) range from mixtures to pure compounds. They include octyl alcohol, decyl alcohol, a mixture of octyl and decyl alcohols, lauryl alcohol, myristyl alcohol, a mixture of lauryl and myristyl alcohols, cetyl alcohol, octadecyl alcohol and a mixture of cetyl and octadecyl alcohols. The chemical and physical characteristics of

TABLE 9. CHEMICAL AND PHYSICAL CHARACTERISTICS OF FATTY ESTERS

Type of Fatty ester	Alkyl Composition (%)									Water	Colour		Acid value	Saponification value	Hydroxyl value	Iodine value	Soap content
	C6	C8	C10	C12	C14	C16	C18	C18:1	C18:2		APHA	Lovibond 5 1/4"					
Isopropyl Myristate ,99%					> 99					0.1	10		0.1	206-211		0.5	
Isopropyl Myristate , 98%					> 98					0.1	20		0.1	206-211		0.5	
Isopropyl Myristate					NA					0.1	30		0.5	206-211		1.0	
Isopropyl Palmitate, 90%				N.A.		> 90				0.1	20		0.5	185-191		1.0	
Isopropyl Palmitate, 60%						> 60				0.1	20		0.5	180-186		1.0	
2-ethyl hexyl Palmitate		–	–	N.A.	–	–	–	–	–	0.1	30		0.2	150-155		–	
Butyl stearate										0-1	30-50		0.2	167-177		1	
2-ethyl hexyl stearate	–	–	–	N.A	–	–	–	–		0.1	30		0.2	144-152		1	

Type of Fatty ester	Alkyl Composition (%)									Colour							
	C6	C8	C10	C12	C14	C16	C18	C18:1	C18:2	Water	APHA	Lovibond	Acid value	Saponification value	Hydroxyl value	Iodine value	Soap content
Glycerol tricaprylate	–	> 98	–	–	–	–	–	–	–	0.15	50		0.1	340-360	5	0.5	–
Glycerol tricaprylate-tricaprate	–	55-65	30-45	–	–	–	–	–	–	0.15	50		0.1	325-360	5	0.5	–
Glycerol Monostearate	Alpha Monoglyceride, 40% min									2	–	IR 3Y (1")	3	168-184	F.G.2	3	0.3
Glycerol Monostearate	Alpha Monoglyceride, 36% min									2	–	1R 4Y (1")	3.5	–	F.G.7	2	3.5

TABLE 10. FATTY ESTERS PRODUCED FROM OIL PALM PRODUCTS

Fatty esters from palm kernel oil		Fatty esters from palm oil	
Mixed methyl esters from palm kernel oil		Mixed methyl esters from palm oil	
Mixed methyl esters from stripped palm-kernel oil		Mixed methyl esters from palm stearin	
Mixed methyl esters from palm kernel-oil for sulphonation		Mixed methyl esters from palm-stearin for sulphonation	
Methyl caprylate	98%	Mixed methyl esters from palm-olein	
Methyl caprylate-caprate		Methyl palmitate	92%
caprylate	50-78%	Methyl stearate	92%
caprate	18-35%		70%
Methyl laurate	98%	Isopropyl palmitate	90%
	92%		60%
	70%	2-ethyl hexyl palmitate	
Methyl myristate	98%	Butyl stearate	
	92%	2-ethyl hexyl stearate	
Isopropyl myristate	99%	Glycerol monostearate	40%
	98%		36%
Glycerol tricaprylate	98%		
Glycerol tricaprylate-tricaprate			
glycerol tricaprylate	55-65%		
glycerol tricaprate	30-45%		

these fatty alcohols are shown in *Table 11.*

The purity of the fatty alcohols produced and their content of minor components vary with the raw materials used. All single component fatty alcohols have purities higher than 97 percent.

The hydroxyl value is a parameter that can clearly distinguish fatty alcohols from fatty acids or esters. For C8 to C18 alcohols the hydroxyl values range from 430 to 210 mg KOH/g, *i.e.* the hydroxyl values decrease with increasing chain length. The solidification points of fatty alcohols, on the other hand, increase with increasing chain length. Acid, saponification and iodine values are low and more or less the same for all the fatty alcohols produced.

Table 12 lists fatty alcohols produced from oil palm products.

GLYCEROL

Glycerol is obtained by concentration and purification of 'sweet-water' (10-30% glycerol in water), produced during the hydrolysis, saponification, or alcoholysis of oils or fats.

Glycerol has several applications such as in pharmaceutical products and cosmetics, as a heat transfer agent and in hydraulic fluids. It is also used to produce other types of chemicals that are used as explosives, greases or lubricants, polyurethanes, food emulsifiers, *etc.* The chemical and physical characteristics of glycerol are shown in *Table 13.*

In Malaysia glycerol is produced by eight manufacturers with five different concentrations, *i.e.* 84-86%, 88%, 99.5%, 99.7% and 99.8%. The only chemical and physical data available on the 84-86% glycerol are

TABLE 11. CHEMICAL AND PHYSICAL CHARACTERISTICS OF FATTY ALCOHOLS

Chemical Descriptions	Alkyl Composition (%)									Hydrocarbon content (%)	Water (%) (max)	Colour APHA (max)	Acid value (max)	Saponification value	Hydroxyl value	Iodine value	Solidification point (°C)
	C6	C8	C10	C12	C14	C16	C18	C20	C18:2								
Fatty alcohols																	
Octyl		98	(0.1)								0.1	10	0.1	0.2	424-430	0.1	–
Decyl		0.1	97	0.3							0.1	10	0.1	0.2	341-353	0.1	–
Octyl-decyl	0.5	50-66	30-45	0-5						1.5	0.5	10	0.1	1.5	385-410	0.5	ca. -11
Lauryl				98	0.2						0.1	10	0.1	0.2	298-302	0.1	22-25
Myristyl				0.5	97	1.0					0.1	10	0.1	0.2	257-263	0.1	37-39
Lauryl-Myristyl			0-2	67-78	20-30	0-2				1	0.1	20	0.1	0.5	285-295	0.3	17-23
Cetyl					0.5	97	0.2				0.1	10	0.1	0.2	225-235	0.1	48-50
Octadecyl						0.2	98				0.1	10	0.1	0.2	205-209	0.1	57-60
Cetyl-Octadecyl					0-3	22-32	66-76	0-3		0.5	0.3	20	0.1	1.0	210-220	0.5	50-54

TABLE 12. FATTY ALCOHOLS PRODUCED FROM OIL PALM PRODUCTS

Chain length of alkyl group			Hydroxyl value
C8		98%	424-430
C8-C10 :	C8	50-66%	385-140
	C10	30-45%	
C10		97%	341-353
C12		98%	298-302
C14		97%	257-263
C16		97%	225-235
C16-C18 :	C16	22-32%	210-220
	C18	66-76%	
C18		98%	205-209

relative density (1.221-1.232), refractive index (1.449-1.450), colour (less than 10 [APHA]), boiling point (approximately 130°C) and melting point (-12 to -5°C). The only information available on 86% glycerol is its ash content at the level of 1.0 percent.

The chemical and physical data on the fine grades of glycerol, *i.e.* 99.5%, 99.7% and 99.8% purity, differ very little. The highest grade of glycerol (99.8%), contains lower levels of chloride, organic chloride and total heavy metals than the lower grades (99.5 and 99.7%).

TABLE 13. CHEMICAL AND PHYSICAL CHARACTERISTICS OF GLYCEROL

Quality Parameters	Glycerol				
	84% - 86%	88%	99.5%	99.7%	99.8%
Relative Density (20/20°C)	1.221 – 1.232	–	1.262-1.2636	–	1.2631
Specific Gravity (25/25°C)	–	–	1.2607-1.262	1.2612	–
Refractive Index N^{20}	1.449-1.450	–	1.4731-1.4750	1.4734	1.4737
Colour (APHA)	<10	–	5-20	5-10	5
Chloride (ppm)	–	–	2-10	10	
Organic chloride (ppm)	–	–	5-30	30-35	5
Sulphated Ash (%)	–	–	0.01	–	0.01
Sulphates (ppm)	–	–	20	20	
Ash %	–	1.0	0.01	0.01	–
Arsenic (ppm)	–	–	1-2	1-5	–
Lead (ppm)	–	–	1.0	–	–
Total heavy metals (ppm)	–	–	1-5	5	1.0
Fatty acid esters eq. (ml of 0.5N NaOH)	–	–	0.35-2	1-2	–
Residue	–	–	0.01	0.1	–
Boiling point (°C)	Approximately 130	–	–	–	–
Melting point (°C)	-12° to -5°	–	–	–	–
Sugar	–	trace	–	–	–
Water	–	–	–	–	
Acidity (ml of 0.1N NaOH)	–	–	0.2 max	–	

For glycerol to be certifiable as of British Pharmacopoeia Grade it should possess the following characteristics (British Pharmacopoeia, 1988):-

Content	:	98-101%
Acidity	:	Less than 0.2ml of 0.1M NaOH
Refractive Index	:	1.470-1.475
Heavy Metals	:	5 ppm
Chloride	:	10 ppm
Water	:	Less than 2%

From *Table 13,* it can be seen that glycerol of purity higher than 99.5% may comply with the standard and therefore may be considered as Pharmacopoeia Grade.

CONCLUSION

Currently Malaysia has the capability and capacity to produce various types and grades of fatty acids, fatty alkyl esters, fatty alcohols and glycerol. The author is aware of a company producing fatty nitrogen compounds in Malaysia but no data on the products are available yet.

Besides manufacturing basic oleochemicals, the industry has gradually ventured into downstream activities such as producing glycerol mono and di-stearate and medium chain triglycerides.

The raw materials used for the production of these oleochemicals can usually be predicted from the carbon number, *i.e.* C6 —> C14 from palm kernel oil and C12 —> C18 from palm oil. Unless stated by the manufacturers, it is difficult to distinguish products derived from palm oil and palm stearin.

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