EXTENSION

Properties of Palm Oil

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Nurhan Turgut Dunford
Extension Specialist for Oilseed Chemistry

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Introduction

Although, the oil palm tree (*Elaeis guineensis*) is native to West Africa, today, Malaysia and Indonesia account for about 90% of the palm oil world trade and about 26% of the global oil production. Oval shaped palm fruits or drupes embedded in spikelets growing on a main stem are referred to as bunches. Each bunch weighs about 20-30 kg and holds 1500-2000 fruits. The fruit kernel or seed is enclosed in pericarp, which is comprised of a hard shell (endocarp), oil bearing tissues (mesocarp) and skin (exocarp). Two distinct types of oil are obtained from palm fruits: palm oil from the mesocarp and palm kernel oil from the seeds. Mature fruits contain about 50% oil based on mesocarp weight.

Fruit Processing and Oil Extraction

Fresh fruits arrive at the mill from the field as bunches or loose fruits. First, fruit bunches are heat treated or sterilized. The latter process facilitates loosening and easier detachment of the fruits from fresh fruit bunch stalks, inactivates enzymes called lipases that breakdown triacylglycerides (TAG) generating Free Fatty Acids (FFA) in the oil (see Fact Sheets FAPC-196 Lipid Glossary and FAPC-197 Edible Oil Quality for definitions), softens the mesocarp for digestion to release oil, and conditions nuts to minimize kernel breakage. Palm mesocarp is the tissue that contains the highest amount of lipase in the fruit. Steam at a pressure of 40 psig is used for heat treatment of the fruits in autoclaves for 60-90 minutes. Newer facilities use continuous sterilizers that enhance the process efficiency.

Sterilized fruits are fed into a rotating drum to detach fruits from the bunch. The latter process is referred to as stripping. The bunch stalks do not contain any oil. They are often incinerated to produce heat for boilers and the remaining ash, which is rich in potassium, is used as fertilizer. After stripping, the fruits are reheated in a steam-heated vessel equipped with a rotating shaft to loosen the pericarp from the nuts.

There are two types of oil extracted from palm fruits, palm oil from mesocarp and kernel oil from nuts. Either a wet or dry process can be used for palm oil extraction. Water is commonly used to extract oil from the digested fruits in a wet process. A hydraulic press (batch process) or a screw press (continuous process) is employed for oil extraction in the dry process. About 5-6% of oil remains in the mesocarp fiber after pressing. When pressing is done at lower pressures to avoid cracking of palm nuts, residual oil in the solid residue is higher, 10-12%.

For palm kernel oil extraction, first, nuts are separated from the digested and pressed fruits. Then, nuts are conditioned at about 60 °C, dried, cracked and kernel and shells are separated. The kernel is then dried in silos with hot air to a moisture content of less than 7%. Oil is expelled from palm kernel via pressing or hexane extraction.

Crude oil extracted from the fruit mesocarp by pressure contains a considerable amount of water and solid particles which are removed by screening, centrifugation or in settling tanks. The oil is dried to 0.1% moisture content. Crude palm oil goes through a refining process that is similar to that used for other vegetable oils (see Fact Sheet FAPC-160: Oil and Oilseed processing III: Crude Oil Refining and Preparation for Biodiesel Production) to obtain edible grade oil.

Oil Properties

Quality of the crude oil depends on the quality of bunches arriving at the mill. Variety and age of the tree, agronomic, environmental, handling and transportation conditions and harvesting technique used have also significant effects on oil properties.

Both palm mesocarp and kernel oils are known as tropical oils. Similar to the coconut oil, palm kernel oil is classified as a lauric fat, because of its high content of lauric acid (see Table 1). Crude palm oil has a deep orange color due to the presence of carotenoid pigments and has a characteristic “sweetish” or “nutty” odor. The oil is semi-solid at ambient temperatures. TAGs are the major constituents of palm oil, over 95%. Monoglycerides (MAG), diglycerides (DAG), free fatty acids (FFA), phosphatides, sterols, pigments, tocopherols and metals are the minor components of oil.

The major fatty acids in palm oil obtained from the mesocarp are palmitic, oleic and linoleic acids (Table 1). The ratio of palmitic/stearic acid in palm oil may vary depending on the geographical conditions. Saturated fatty acids comprise over 50% of the total fatty acids present in palm oil, majority being the palmitic acid. Palm kernel oil is more saturated, above 80%, than palm oil. In general, DAG content of palm oil is 4-5%, but some oils may contain 10-11% DAG. Solid fat content of vegetable oils is an important factor determining their functional properties. Melting profile of palm oil and palm kernel oil are considerably different. Palm kernel oil is significantly harder at temperatures below 20°C but melts faster above room temperature than palm oil. Melting point of kernel oil is about 10°C lower than that of palm oil.

Phospholipid content of crude palm is relatively lower than that of many other vegetable oils (Table 2). Phosphatidylcholine, phosphatidylethanolamine, phosphatidylinositol and phosphatidylglycerol are the main phospholipids in crude palm oil. Sitosterol, campesterol and stigmasterol are the major phytosterols present in palm oil (Table 3). Many scientific studies have shown that phytosterol intake may lower LDL (Low Density Lipoprotein) levels in blood. Minor amounts of cholesterol are also found in palm oil. The amounts of tocopherols and tocotrienols in palm oil vary significantly with variety. γ-Tocotrienols, α-tocopherols and δ-tocotrienols are the major tocols found in palm oil (Table 3). Tocopherols, specifically α-tocopherol, are important antioxidants with high vitamin E activity. Deep red color of crude palm oil is due to the high concentration of carotenoids (500–2000 mg/kg oil) in crude palm oil. About 90% of the total carotenes are β- and α-carotenes, remaining being γ-carotene, lycopene and xanthophylls. β-Carotene exhibits the highest pro-vitamin A activity. However, most of the phytonutrients present in crude palm oil, carotenoids, tocopherols, tocotrienols and phytosterols are either degraded or removed during the refining process. Phytonutrient content of kernel oil is significantly lower than that of palm oil.

Palm oil which has an iodine value (IV) (see Fact Sheet FAPC-196: Lipid Glossary) of 51-53 is usually fractionated to obtain stearin and olein fractions that have very different physicochemical properties than the native palm oil and designed for use in specific applications. For example, olein fraction with IV of 56-59 is liquid at temperatures below 25 °C and suitable for frying applications. Today, higher value products such as super stearin (IV of 12-14), soft stearin (IV of 40-42), hard palm (IV of 32-36), and super olein (IV of 64-66) are produced for various food applications. Super stearin which contains about 90% saturated fatty acids, mainly palmitic acid, is very hard below 40-45°C and melts at 65-70°C. The latter product is an excellent substitute for partially hydrogenated fats and can be used in the formulation of zero or low trans margarines and shortenings. Soft stearin can be used as an ingredient in margarines and shortenings and as a dairy replacer fat. The hard palm fraction is used for manufacturing cocoa butter equivalents. Super olein is suitable as salad oil.

Palm kernel oil is a good feedstock to produce confectionery fats because of its high content of medium chain fatty acids lauric and myristic acids (Table 1). The fats designed to substitute cocoa butter must have a very fast/steep melting profile to release flavor and resist blooming in confectionary products. Palm kernel olein with IV of about 28 can be used in nondairy ice cream, as coating fat and filling creams, toffee and caramel formulations and as basestock for interesterification which is a process used to modify structure and functionality of fats and oils to reduce saturated fatty acids and trans fatty acids in the final product.

Health Effects

Highly saturated tropical oils such as palm oil have been linked to higher risk of cardiovascular problems. There are significant amounts of scientific data indicating that excessive consumption of saturated fats increases LDL also referred to as "bad cholesterol" and triacylglycerides levels in blood, both of which are risk factors for heart disease. After the US Food and Drug Administration ban on trans fats (see Fact Sheet FAPC-133: Trans Fats, Health and Nutritional Labeling of Foods) many food manufacturers and restaurants have switched to palm oil to substitute partially hydrogenated solid fats in their food formulations increasing the saturated fat intake of the consumers.

Table 1. Fatty Acid Composition of Various Palm Oil Types*.

Fatty Acid Name	**Content (%)**			
Oil Type	**Palm Oil[1]**	**Palm Kernel Oil[2]**	**Palm Stearin**	**Palm Olein**
Caprioc (C6:0)	-	0.1-0.8	-	-
Caprylic (C8:0)	-	0.9-16	-	-
Capric (C10:0)	-	0.8-2.6	-	-
Lauric (C12:0)	0-0.4	29-55	0.1-0.4	0.1-0.5
Myristic (14:0)	0.2-2	6-26	1.1-1.8	0.9-1.4
Palmitic (16:0)	19-55	4-10	48.4-73.8	38.2-42.9
Palmitoleic (16:1)	0.6-2	-	0.05-0.2	0.1-0.3
Stearic (18:0)	1-5.5	1.3-4	3.9-5.6	3.7-4.8
Oleic (18:1)	30-56	12-26	15.6-36	39.8-43.9
Linoleic (18:2)	10-21	1-8	3.2-9.8	10.4-13.4
Linolenic (18:3)	0-0.5	-	0.1-0.6	0.1-0.6
Arachidic (20:0)	0.1-1	0-0.3	0.3-0.6	0.2-0.6
Eicosenoic (20:1)	0-0.2	-	-	-
Lignoceric (24:0)	0-0.2	-	-	-

*Adapted from "David Firestone. 1999. Physical and chemical characteristics of oils, fats and waxes. American Oil Chemists Society Press." The range is for: 1) *Elaeis guineensis Dura, Elaeis olleifera Elaeis* and *Elaeis guineensis*, 2) *Elaeis guineensis*, *Buttia capitata, Aiphanes acanthophyllla* and *Elaeis olleifera* palm varieties.

Table 2. Major Phytonutrients Present in Crude Palm Oil.

Phytonutrients	Concentration (g/kg)
Carotenoids (α-carotene, β-carotene, lycopene, phytoene)	500-1,000
Tocopherols/tocotrienols	600-1,000
Phytosterols (sitosterol, stigmasterol, campesterol)	300-620
Phospholipids	20-100
Squalene	250-800

Table 3. Phytosterol and Tocol Content of Palm Oil Obtained from Mesocarp of *Elaeis guineensis Dura* variety.

Phytosterol	Content (%)
Cholesterol	2-7
Campesterol	19-28
Stigmasterol	8.5-15
β-Sitosterol	50-64
Tocols	**Content (g/kg)**
α-tocopherol	219
α-tocotrienol	178
γ-tocotrienol	245

References

David Firestone. 1999. Physical and chemical characteristics of oils, fats and waxes. American Oil Chemists Society Press

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