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Characteristics of Palm Oil/Palm Olein as a Frying Oil

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INTRODUCTION

Palm oil is extracted from the flesh of the fruit of the oil palm, *Elaeis guineensis*, which is a native of West Africa. In Malaysia, the high-yielding tenera variety of *E. guineensis* is the most commonly cultivated oil palm. *Tenera* is a cross between *dura* and *pisifera*. There are two types of oil produced from the palm fruit: palm oil from the flesh (the orangey fibrous outer layer of the fruit) and palm kernel oil from the white kernel inside the shell of the oil palm fruit. Out of these two oils, many fractions of palm and palm kernel oil can be produced for a variety of food applications. For frying, only palm oil and palm olein (the liquid fraction of palm oil) are commonly used in industrial frying and in the food services industry. Palm olein is also used as a general household cooking oil in tropical countries. Through industrial experiences and scientific studies, the following facts have been established for palm oil/olein as a frying oil: they have high oxidative stability; the frying oil has an extended life span; the fried foods have a longer shelf-life and favourable organoleptic quality; the fryer requires less maintenance; the foods cook faster; there is less oil absorption by the fried foods; and palm oil/olein is naturally stable, that is it does not need hydrogenation or addition of synthetic anti-oxidants to slow down oxidative degradation.

Industrial frying accounts for more than 50% of the total oil used in food applications. Instant noodles, snacks and pre-fried foods, which are industrially produced in bulk need a good frying oil to achieve good organoleptic quality and long shelf-life of the fried foods. The oil used in frying plays an important role in the eating quality of the fried food and its shelf-life. In the past, animal fat, peanut oil, cottonseed oil and hydrogenated fats were the main oils/fats used for frying. These frying fats and oils, due to technical and commercial reasons, were gradually replaced by palm oil and palm olein. Numerous studies revealed that palm oil and palm olein have desirable frying performance, better than or at least comparable to their alternatives (Berger, 2005). Today, palm oil and palm olein are the most consumed oils in the frying industry, while frying is the single largest application of palm oil in the world. Palm oil is also the world's largest traded oil, and it is readily available in most parts of the world.

In recent years, high-oleic oils such as high oleic sunflower, high oleic canola and high oleic soyabean oils have also been used for industrial frying but the availability of these oils are limited. The high oleic version of palm oil is produced in Colombia but its use as a frying oil is still not popular due to its cost and limited supply. Products similar to high oleic palm oil can be obtained by the fractionation process in which palm olein is fractionated to produce palm olein with higher iodine values (IV). These oils are called superoleins. Commonly produced superoleins are those having IV 60, IV 63 and IV 65. Superolein with higher IV is produced only on demand because of its higher cost of production. Superolein is used as a household frying and cooking oil, mainly in tropical countries. It is also blended with soft oils and used as a cooking oil.

Properties of Palm Oil as a Frying Oil

In general, palm oil/palm olein offers the best option as a frying oil. It has excellent frying performance, and because palm oil is produced all year round, there is ample supply throughout the year for the food industry worldwide. As such, it is a lot easier for the food industry to stick to the same product formulations to keep the taste and quality of the food consistent.

Palm oil is resistant against oxidation even at high frying temperatures due to its low content of linoleic acid and the presence of natural antioxidants, *i.e.*, tocopherols and tocotrienols. Palm oil contains about 50% saturated fatty acids and 50% unsaturated fatty acids. The unsaturated fatty acids consist of 10% linoleic acid,

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and a negligible amount of linolenic acid (Department of Standard Malaysia, 2018). Linolenic acid is very susceptible to oxidation because of the presence of the three double-bonds in its fatty acid structure. Thus, palm oil is less susceptible to oxidation because of its low content of linolenic acid compared with polyunsaturated oils, which have excessive amounts of linolenic acid. Linolenic acid can undergo the auto-oxidation process even at ambient temperature. Polyunsaturated oils need to be hydrogenated before they can be used for industrial frying. Unfortunately, the hydrogenation process causes the formation of harmful *trans* fatty acids.

By using the relative oxidation rates of oleic, linoleic and linolenic acids, which are 1, 12 and 25, respectively, the Inherent Oxidative Stability (IOS) of oils and fats can be calculated. The lower the IOS, the more stable the oil is against oxidation. Palm oil, high-oleic sunflower oil, sunflower oil, soyabean oil, corn oil, cottonseed oil, canola oil and coconut oil have IOS of 1.5, 1.7, 7.1, 7.1, 6.5, 5.8, 4.5 and 0.2, respectively, indicating that palm oil and high-oleic sunflower oil are the most stable oils against oxidation compared with the others (Min Hu, 2018).

The presence of tocopherols and tocotrienols in palm oil/palm olein provides greater oxidative stability to the oil. For refined, bleached and deodourised (RBD) palm oil, the range of antioxidants present in the oil is from 280-890 ppm, while for palm olein, the levels are between 560 and 900 ppm (Gapor, 1989). All this contributes to a high oil stability index (OSI) for palm oil and palm olein. OSI is a parameter that measures the relative oxidative stability of edible oils against oxidation, and is determined at elevated temperatures to accelerate the oxidation process. The higher the OSI value, the better the oil is able to withstand oxidation.

Coconut oil has the highest OSI due to its high content of lauric and myristic acids. However, lauric fatty acid causes hydrolysis of the oil, and ultimately rancidity in the food. Thus, coconut oil is not suitable for industrial frying when the fried products need a long shelf-life of between one and two years, depending on the type of fried foods.

Blending palm olein with soft oils will increase OSI of the blend, and at the same time the soft oils will increase resistance to crystallisation of the blend by reducing its cloud point (CP).

parameters such as free fatty acids (FFA), peroxide value (PV), p-Anisidine value (AV), total polar materials (TPM) and total polymeric compounds, and backed by sensory evaluation. Quick tests are available to monitor the quality of the frying oil during frying.

If antioxidants and anti-foaming agents are added to palm oil/palm olein, the oxidative stability of the oil will be excellent. For soft oils, it is necessary to add antioxidants and anti-foaming agents to increase their oxidative stability. Otherwise, the oils should only be used for a very limited number of repeated fryings (Fediol Nutrition Factsheet) and should not be used in heavy duty frying. Consumption of heated polyunsaturated oils can cause cellular damage to the liver and kidneys (Hageman *et al*., 1991).

TABLE 1. FATTY ACID COMPOSITIONS OF SELECTED OILS AND FATS AND THEIR OSI AT 110°C

	SBO	CO	GNO	RSO	SFO	PO	POL	CNO
Lauric							**0.2**	**48.0**
Myristic	0.1	0.1	0.1		0.1	1.0	1.0	18.2
Palmitic	11.0	11.0	11.5	4.3	7.0	46.0	40.6	9.0
Stearic	3.6	2.0	2.0	1.7	4.2	4.0	3.8	2.0
Oleic	24.7	27.0	48.0	59.0	19.5	37.8	42.0	7.0
Linoleic	**53.5**	**58.5**	**31.0**	**27.8**	**68.9**	**10.0**	**11.5**	**2.0**
Linolenic	**6.4**	**0.5**	**1.0**	**8.3**		**0.5**	**0.4**	
OSI (hr,110°C)	5	7	8	7	5	25	24	75

Note: SBO - soyabean oil; CO - corn oil; GNO - groundnut oil; RSO - rapeseed oil; SFO - sunflower seed oil; PO - palm oil; POL - palm olein; CNO - coconut oil; OSI - oil stability index.

Source: Ismail (2019).

Based on the IOS and OSI values above, and by classifying the oils with the highest IOS and lowest OSI values as having poor oxidative stability, the oxidative stability of oils can be summarised as in *Table 3.*

For quality evaluation of a frying oil, OSI should be used in combination with other quality

Soft oils can also be blended with palm olein/superolein to improve its oxidative stability. For example, blending of palm olein with cottonseed oil significantly improved the frying performance of the latter (Fatma Nur Arslam *et al.*, 2017).

TABLE 2. OSI VALUES OF OILS

Oil	OSI (hr,110°C)	Oil	OSI (hr,110°C)
Sunflower oil	3.0-6.0	High-oleic canola oil	12.0-18.0
Soyabean oil	5.0-6.7	Palm oil	20.0-30.0
Canola oil	6.0-8.0	High-oleic soyabean oil	25.0-65.0
Corn oil	7.0-11.0	Partially hydrogenated soybean oil	20.0-85.0

Note: OSI: oil stability index.

Source: Min Hu (2018).

TABLE 3. OXIDATIVE STABILITY OF OILS

Oil	Oxidative stability
Coconut oil	Excellent
Hydrogenated soyabean oil	Good/Excellent
Palm oil	Good
Palm olein	Good
High-oleic sunflower oil	Good
High-oleic canola oil	Fair/Good
Peanut oil	Fair
Cottonseed oil	Fair
Rapeseed/Canola oil	Fair
Corn oil	Poor/Fair
Sunflower oil	Poor
Soyabean oil	Poor

TABLE 4. SPECIFICATIONS FOR DEEP FRYING OILS/FATS

1.	Free fatty acid	£ 0.1%
2.	Odour and flavour	Bland
3.	Colour	Light
4.	Moisture	£ 0.1%
5.	Smoke point	³ 200°C
6.	Peroxide value	£ 1 meq kg^{-1}
7.	Fatty acid composition	
8.	Linolenic acid	£2% (French Legislation) or £3%

Source: Stevenson *et al*. (1984); Binkman (2000).

Palm-based frying oils are available in many forms: as palm shortening, pourable palm oil, palm olein, special quality palm oil/palm olein (low colour with better oxidative stability) and as various grades of superoleins. The various forms of palm-based frying oil provide the food industry with the flexibility to select the most suitable frying oil for a specific application. For example, palm olein is used by the snack food manufacturers throughout the world. In Japan, palm oil is used mainly for instant noodles, snacks and tempura (Kochhar, 1999). In USA, palm shortening is a popular frying medium for doughnuts. In Malaysia, pourable palm oil is used by the fast food chains. The instant noodle industry normally uses palm oil or palm olein as the frying medium. In Vietnam, palm stearin is also used for instant noodle frying. In short, palm oil offers the solution for every type of frying operation; be it shallow or deep frying, continuous or batch frying. At least one or more forms of palm frying oils will fit the required frying operation.

Specifications for Frying Oils

Several chemical reactions take place all at once at accelerated rates during frying. These reactions include hydrolysis, oxidation, ring formation and polymerisation. The consequence of these chemical reactions is degradation of the frying oil as well as the quality of food fried in it. The higher the temperature, the faster the degradation process takes place. Soft oils degrade faster than palm oil/palm olein because of their higher content of polyunsaturated fatty acids. Generally, a good frying oil should comply with the specifications given in *Table 4.*

CONCLUSION

The type of food, nutritional aspects, type of frying operation (either continuous or batch), maintenance cost, oil prices, *etc*. are factors usually considered when selecting a frying oil. For frying purposes, palm oil/olein offers several techno-economic advantages over most other oils and fats in terms of price, availability, frying properties, and nutritional aspects, among others. Experiences in the frying industry have shown that when palm oil/ palm olein is used for frying, productivity is higher, production breakdown and maintenance costs are reduced, there is a slower increase in free fatty acid, polar and polymer formation, and the fried foods have a longer shelf-life (Berger, 2005).

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