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# CHARACTERISTICS OF MALAYSIAN PALM KERNEL AND ITS PRODUCTS

**NUZUL AMRI IBRAHIM***

**ABSTRACT**

*The chemical and physical characteristics of Malaysian palm kernel and its products are discussed in this article. The main products derived from palm kernel are palm kernel oil, palm kernel olein and palm kernel stearin whereas the by-products are palm kernel meal and palm kernel fatty acid distillate. The major composition of the kernel is oil (49%), followed by carbohydrate (26.1%), protein and crude fibre (8% each). The major triacylglycerol content in palm kernel oil and its fraction is trilaurin. Even though palm kernel oil is highly saturated, its melting point (27.3°C-28.0°C) is relatively low due to high proportion of short chain fatty acids. The range of iodine value of palm kernel oil is 16.5 to 18.75, whilst for its fraction, palm kernel olein and stearin, is 20.6 minimum and 8.0 maximum respectively. The residue after mechanical pressing is known as palm kernel meal, contains carbohydrate (50.3%), protein (19.8%), crude fibre (16.7%) and oil (8%), which made it suitable for animal feed application. The major component of palm kernel fatty acid distillate (a by-product of palm kernel oil refining) is total fatty matter (95%). Some insights on the quality requirement of palm kernel products based on Malaysian Standards are also discussed in this article.*

**Keywords:** palm kernel oil, triacylglycerol composition, fatty acid composition, iodine value, solid fat content.

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## INTRODUCTION

Palm kernel oil (PKO) and coconut oil (CNO) are the most common lauric oils traded in the international market. The source of the former is from oil palm (*Elaeis guineensis* Jacq.) while the latter is from coconut palm (*Cocos nucifera* L.) which grow productively in tropical regions of Asia, Africa and Central and South America. Malaysia and Indonesia are the major producers of PKO whilst the Philippines and Indonesia are the major producers of CNO. Even though cohune, babassu, tukum, murumuru and ouricuri are also categorised as lauric oil, however, these oils are only for domestic consumption, and therefore are not readily available in the international market. Those oils are termed as lauric oil due to the high content of lauric acid present in the triacylglycerol backbone of the lipids.

In Malaysia, the production of crude palm kernel oil (CPKO) was merely about 200 000 t $yr^{-1}$ in the 1970s by processing 500 000 t of palm kernels. In 2012, the supply of palm kernel increased tremendously to 4.7 million tonnes, producing 2.16 million tonnes of CPKO and 2.40 million tonnes of palm kernel meal (PKM) (MPOB, 2013). The tremendous increment was partly due to the introduction of the pollinating weevil, *Elaeidobius kamerunicus,* in the early 1980s, and also due to the expansion of oil palm plantations. The national average of PKO extraction rate for 2012 was 45.95%, an increase of 0.11% from 2011 (MPOB, 2012).

* Malaysian Palm Oil Board,
6 Persiaran Institusi, Bandar Baru Bangi,
43000 Kajang, Selangor, Malaysia.
E-mail: nuzul@mpob.gov.my

## PALM KERNEL

PKO is a co-product of palm oil since it is obtained after pressing the mesocarp. As shown in *Figure 1*, the inner part of the fruit is the kernel which is surrounded by the shell. The shell has to be broken in order to get the kernel. The most common nut crackers are the centrifugal type and the ripple mill. Both types consist of a moving part (known as a rotor) and a stationary part. The stationary part for the centrifugal type and the ripple mill is known as a stator ring and a semi-circular ripple plate, respectively. In the centrifugal type cracker, nuts are given velocity by being fed through the rotor and are caused to crack by being flung against the stator ring, while in the ripple mill, the high speed nuts are forced between the ripple plates and the rotor. The performance of the ripple mill is determined by the speed and clearance of the rotor.

The separation of the kernel and shell is achieved by winnowing in a hydrocyclone. Heavy particles are thrown by the centrifugal force to the wall of the cyclone cylinder and exit through the bottom while lighter particles move toward the centre of the cylinder and move upward and leave the system via the overflow tube. As the moisture content of fresh kernels is around 20%, they are susceptible to mould growth and a rapid increase in free fatty acid (FFA). Fresh kernels are kept in a silo and are dried by passing hot air into the silo.

The storage condition and transport handling of the kernels are very important since these would affect the quality of the kernels. An ideal moisture content of the kernel should not be greater than 7% to avoid mould growth and a rapid increase in FFA during storage and transportation. Lorry conditions should also be inspected for cleanliness prior to loading the kernels. According to the Malaysian Standard, palm kernels should be free from musty and/or rancid odour. The kernels also should be free from foreign materials such as insect or fungal infestation when examined with an unaided eye (MS 236:2007). The kernel contains oil, carbohydrate, protein, crude fibre, moisture and ash. The composition is shown in *Table 1.*

*Table 2* shows a comparison between the Malaysian Standard and the Malaysian Edible Oil Manufacturers' Association's (MEOMA) specifications on the requirements for palm kernels. Domestic contracts are usually based on MEOMA specifications. It is possible to request for better quality kernels as per the Malaysian Standard but buyers usually have to pay a higher price. The kernels are of various sizes and it was reported that CPKO extracted from small kernels have a higher iodine value (IV) than large kernels (Siew *et al.*, 1995).

### Palm Kernel Oil and Palm Kernel Meal

CPKO is extracted from the kernels either by mechanical screw pressing or solvent extraction. However, due to poor solvent recovery and the safety issue, solvent extraction is not so common any more and by far, it is outnumbered by the mechanical

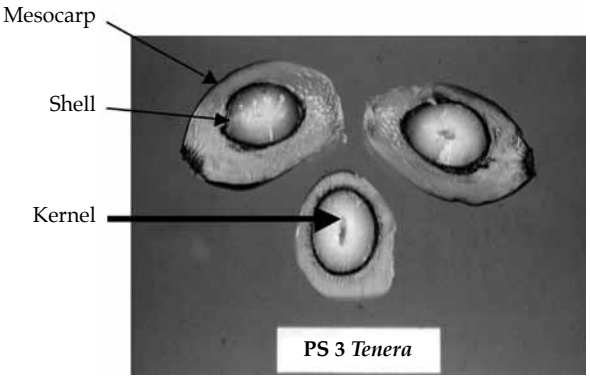



*Figure 1. Cross-section of a palm fruit.*

**TABLE 1. TYPICAL COMPOSITION OF MALAYSIAN PALM KERNEL AND PALM KERNEL MEAL (% by weight)**

| | Kernel | Meal |
|---|---|---|
| Oil content | 49.0 | 7.9 |
| Protein | 8.3 | 14.8 |
| Crude fibre | 8.1 | 16.7 |
| Moisture | 6.5 | 6.4 |
| Ash | 2.0 | 3.9 |
| Carbohydrate | 26.1 | 50.3 |

Source: Tang and Teoh (1985).

**TABLE 2. SPECIFICATION FOR PALM KERNEL**

| Characteristics | MS236 | MEOMA |
|---|---|---|
| Free fatty acids in the extracted oil, as lauric acid | 3% max | 5% max |
| Moisture and volatile matter | 6% max | 7% basis, 10% max |
| Shell and dirt | 3% max | 6% basis, 10% max |

Note: MEOMA - Malaysian Edible Oil Manufacturers' Association.

screw press method. Since the mechanical screw press method is more commonly used than solvent extraction, only the former extraction method will be elaborated.

In the mechanical screw press method, the kernels are subjected to two stages of extraction in order to ensure a good extraction rate. It is a common practice for the kernel crusher to have two assembly lines of screw presses, where the pressed kernel from the first screw press will be conveyed to the second screw press. The oil will drop to the bottom of the screw press, pass through a coarse filter and will subsequently be followed by a filter press, while the PKM will exit through an annular orifice located at the end of the screw press, as illustrated in *Figure 2*. The resultant meal still contains nutrients and protein (*Table 1*) and can be used as animal feed. It is estimated that CPKO is produced at a ratio of 10 to 13 t for every 100 t of production of crude palm oil (Basiron, 2005). CPKO is then delivered to a refinery to get refined, bleached and deodorised (RBD) PKO, which can be fractionated to get RBD palm kernel olein (PKOo) and RBD palm kernel stearin (PKOs).

### Palm Kernel Fatty Acid Distillate

Palm kernel fatty acid distillate (PKFAD) is a by-product of the physical refining of CPKO. It is obtained as a condensate of the volatile matters carried over from the deodoriser by the action of the stripping steam. It consists of 80%-90% of FFA and has often been used as a raw material for soap making, feed compounding and oleochemical feedstock.

## CHEMICAL PROPERTIES

### Triacylglycerol

The major component in PKO is triacylglycerol (TAG), which is about 95%, while the minor components are free acids, monoacylgycerols, diacylglycerols, phospholipids, free and/or acylated sterols, tocols and hydrocarbons such as alkanes, squalene and carotenes. The C36 is the most abundant TAG in PKO, as shown in *Table 3*, mainly trilaurin (21%) due to the high level of the acid, followed by C38 (15%). PKO contains higher amount of long chain TAG (C42-C50) than CNO due to the higher amount of total C18 acids of the former.

Fractionation of PKO yields PKOo (liquid phase) and PKOs (solid phase). The TAG compositions of the two fractions are shown in *Table 3*. PKOo contains higher amount of C32, C34, and C44 - C50:1 than PKOs. The high amount of the long chain TAG in PKOo is due to the distribution of oleic and linoleic acids from PKO into the liquid fraction during the fractionation process while the more saturated fatty acids (lauric and myristic acids) go into the solid fraction (*Table 4*). This eventually leads to the high iodine value observed in PKOo and low iodine value in PKOs.

### Fatty Acid Composition

Ibrahim *et al*. (2003) conducted a one-year survey on the characteristics of CPKO produced in Malaysia and reported some minor differences in the content of caprylic, lauric, myristic and palmitic

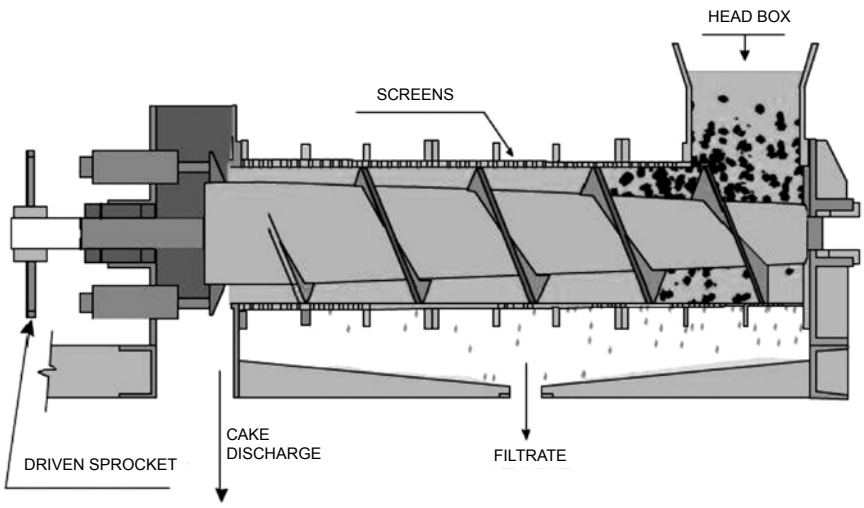



*Figure 2. Cross-section of a screw press.*

**TABLE 3. TRIACYLGLYCEROL (TAG) COMPOSITION, IODINE VALUE (IV) AND SLIP MELTING POINT (SMP) OF PALM KERNEL PRODUCTS**

| TAG ECN* | PKO | PKOo (wt %) | PKOs |
|---|---|---|---|
| C26 | 1.1 | 0.7 | 0.5 |
| C28 | 0.6 | 0.8 | 0.4 |
| C30:2 | - | 0.4 | - |
| C30:1 | - | 0.9 | - |
| C30 | 1.4 | 1.1 | 0.5 |
| C32 | 6.1 | 7.6 | 3.5 |
| C34:1 | 0.5 | 0.7 | - |
| C34 | 8.4 | 9.3 | 6.8 |
| C36 | 21.4 | 18.6 | 28.2 |
| C38:2 | 0.6 | 1.0 | - |
| C38:1 | 0.8 | 1.4 | - |
| C38 | 15.2 | 10.6 | 24.4 |
| C40:2 | 0.9 | - | - |
| C40:1 | 4.6 | 7.6 | 2.7 |
| C40 | 8.6 | 5.4 | 14.3 |
| C42:2 | 0.8 | 1.2 | - |
| C42:1 | 5.1 | 6.7 | 2.4 |
| C42 | 4.1 | 2.7 | 6.7 |
| C44:1 | 3.4 | 4.5 | - |
| C44 | 4.4 | 5.2 | 0.9 |
| C46:2 | 2.4 | 2.1 | 2.0 |
| C46:1 | 1.8 | 2.3 | 2.8 |
| C46 | 2.0 | 2.4 | 0.9 |
| C48:3 | 1.9 | 2.1 | 1.3 |
| C48:2 | 1.8 | 2.2 | 0.5 |
| C48:1 | 1.0 | 1.2 | 0.4 |
| C48 | 0.2 | 0.6 | 0.4 |
| C50:2 | 0.5 | - | - |
| C50:1 | 0.3 | 0.4 | - |
| IV | 17.9 | 23.0 | 7.0 |
| SMP, °C | 27.3 | 23.6 | 32.2 |

Note: *ECN: equivalent carbon number.
PKO – palm kernel oil.
PKOo – palm kernel olein.
PKOs – palm kernel stearin.
Source: Siew (2001).

acids as compared to an earlier survey conducted by Siew (1989). As shown in *Table 5*, CPKO contains 82.6% of saturated fatty acid with lauric acid as the most abundant fatty acid followed by myristic and oleic acids. CPKO is very stable against oxidation due to the high saturation (O'Brien, 2000).

The first Malaysian Standard for CPKO (MS 80:2011) was revised by adopting the fatty acid composition values reported by Ibrahim *et al*. *Table 5* shows a comparison between the revised Malaysian Standard (MS 80:2011) with Codex Standard (2009) where the values of the latter is wider than the former. The main reason is due to the wider range of samples originating from various countries taken into consideration for the Codex Standard while only CPKO from Malaysia were considered for the Malaysian Standard. This is to ensure that the fatty acid composition (FAC) profile stipulated in the Malaysian Standard fits Malaysian CPKO.

## Minor Components

The unsaponifiable matters in CPKO range from 0.32%-0.49% (Tang *et al*., 1995). Upon fractionation of the crude oil to yield olein and stearin, most of the unsaponifiable matters migrate to the former, *i.e*. 0.42%-0.53% and 0.32%-0.40%, respectively as shown in *Table 6*. Sterols, a mixture collectively known as phytosterols for vegetable oils, are a major component in the unsaponifiable matter (985-1228 mg $kg^{-1}$). Sterol contents of CPKO and RBD PKO are shown in *Table 7*. The β-sitosterol is the major sterol present in PKO, followed by stigmasterol and campesterol. Crude palm oil is rich in carotenoids (500-700 mg $kg^{-1}$), however in CPKO, it is merely 3.3-8.1 mg $kg^{-1}$ and not presence

**TABLE 4. FATTY ACID COMPOSITION (FAC) OF PALM KERNEL OLEIN (PKOo) AND PALM KERNEL STEARIN (PKOs)**

| FAC (%) | PKO[a] | PKOo[b] | PKOs[b] | MS 1436[c] | MS 1437[d] |
|---|---|---|---|---|---|
| C6:0 | 0.3 | 0.3 | 0.1 | 0.2-0.4 | 0-0.1 |
| C8:0 | 4.2 | 4.3 | 1.9 | 3.6-5.0 | 1.5-2.6 |
| C10:0 | 3.7 | 3.6 | 2.7 | 3.2-4.5 | 2.5-3.0 |
| C12:0 | 48.7 | 44.7 | 56.6 | 42.0-46.5 | 54.8-58.2 |
| C14:0 | 15.6 | 14.0 | 22.4 | 12.3-15.5 | 21.1-24.1 |
| C16:0 | 7.5 | 8.3 | 8.0 | 7.4-10.6 | 7.2-9.0 |
| C18:0 | 1.8 | 2.3 | 1.8 | 1.8-3.0 | 1.3-2.4 |
| C18:1 | 14.8 | 19.2 | 5.6 | 14.6-21.3 | 4.6-7.2 |
| C18:2 | 2.6 | 3.3 | 0.8 | 2.6-3.8 | 0.6-1.3 |
| C20:0 | 0.1 | 0.1 | 0.1 | 0-0.3 | 0-0.3 |
| IV | 17.9 | 23.0 | 7.0 | 20.6-26.0 | 5.8-8.0 |

Note: PKO – palm kernel oil.
Source: [a] Siew (2001), [b] Tang *et al.* (1995), [c] PKOo, [d] PKOs.

**TABLE 5. FATTY ACID COMPOSITION OF CRUDE PALM KERNEL OIL (%)**

| Fatty acid | Range[a] | Mean[a] | Codex 2009 | MS 80 |
|---|---|---|---|---|
| C6:0 | 0.2-0.4 | 0.3 | ND-0.8 | 0.3 |
| C8:0 | 3.2-4.7 | 3.6 | 2.4-6.2 | 3.6 |
| C10:0 | 2.9-3.5 | 3.3 | 2.6-5.0 | 3.3 |
| C12:0 | 45.4-49.8 | 48.0 | 45.0-55.0 | 48.0 |
| C14:0 | 15.4-17.2 | 16.7 | 14.0-18.0 | 16.7 |
| C16:0 | 7.9-9.3 | 8.5 | 6.5-10.0 | 8.5 |
| C18:0 | 1.9-2.3 | 2.1 | 1.0-3.0 | 2.1 |
| C18:1 | 13.7-17.0 | 14.9 | 12.0-19.0 | 14.9 |
| C18:2 | 2.1-2.9 | 2.5 | 1.0-3.5 | 2.5 |
| Total saturated | - | 82.6 | - | 82.6 |
| Iodine value (Wijs) | 17.0-20.0 | 17.8 | 14.1-21.0 | 17.8 |

Source: [a] Ibrahim *et al.* (2003), Codex Alimentarius (2009) and MS 80:2011.

**TABLE 6. UNSAPONIFIABLE MATTERS IN PALM KERNEL OIL PRODUCTS**

| Sample | | % unsaponifiable matters in oil |
|---|---|---|
| CPKO | Mean (n=3) | 0.39 |
| | Range | 0.32-0.49 |
| RBD PKO | Mean (n=3) | 0.31 |
| | Range | 0.29-0.33 |
| CPKOo | Mean (n=3) | 0.48 |
| | Range | 0.42-0.53 |
| RBD CPKOo | Mean (n=3) | 0.32 |
| | Range | 0.03-0.36 |
| CPKOs | Mean (n=3) | 0.37 |
| | Range | 0.32-0.40 |
| RBD CPKOs | Mean (n=3) | 0.24 |
| | Range | 0.22-0.26 |

Note: CPKO - crude palm kernel oil.
RBD - refined, bleached and deodorised.
PKOo - palm kernel olein.
PKOs - palm kernel stearin.
Source: Tang (1996).

in refined PKO due to the decomposition of the compound during deodorisation. The presence of FFA is of great concern to the industry since it is an important quality indicator. The level for CPKO and RBD PKO should not exceed 5% and 0.1% as lauric acid respectively, in order to comply with MEOMA specification. Generally, crude oils have higher contents of the above-mentioned minor components than refined oils, since most of the compounds are removed during the deodorisation stage while other volatile matters are distilled into fatty acid distillate condensate.

The n-Alkanes with odd carbon numbers ranging from C15 to C33 are naturally present in vegetable oils (McGill *et al.*, 1993). Tan and Kuntom (1994) reported that the range of natural hydrocarbon content in CPKO is 0.6 to 7.1 mg $kg^{-1}$. If exceptionally high level of hydrocarbon is observed, it may indicate contamination from external sources. It is important to take all the necessary measures during handling and transporting the kernels and oil in order to avoid contamination of hydrocarbon and other foreign materials.

**TABLE 7. COMPOSITION OF STEROL AND TOTAL CAROTENOIDS IN CRUDE PALM KERNEL OIL AND REFINED, BLEACHED AND DEODORISED PALM KERNEL OIL (mg $kg^{-1}$)**

| | CPKO | | RBD PKO | |
|---|---|---|---|---|
| | Range | Mean | Range | Mean |
| Sterol* | 985-1228 | 1 104 | 827-906 | 875 |
| Cholesterol | 14.7-20.9 | 18.5 | 12.7-14.3 | 13.7 |
| Brassicasterol | 0-1.2 | 0.8 | 0-1.7 | 0.6 |
| Campesterol | 95.5-125.3 | 106.9 | 76.8-80.6 | 78.9 |
| Stigmasterol | 143.8-179.3 | 158.6 | 118.3-130.5 | 124.3 |
| β-Sitosterol | 658.0-825.2 | 742.5 | 561.5-627.0 | 599.2 |
| Δ5-Avenasterol | 45.0-51.6 | 49.3 | 29.9-38.4 | 33.2 |
| Δ7-Stigmasterol | 2.0-4.9 | 3.1 | 0-2.7 | 1.5 |
| Δ7-Avenasterol | 1.1-2.4 | 1.8 | 0-1.7 | 1.0 |
| Others | 13.8-31.8 | 20.9 | 17.4-30.4 | 23.2 |
| Total (mg $kg^{-1}$) | 985-1228 | 1 104 | 827-906 | 875 |
| Total carotenoids as carotene, mg $kg^{-1}$ ** | 3.3-8.1 | 6.0 | - | - |

Source: * Tang (1996), ** MS 80:2011.

Other minor components present in crude palm kernel oil are tocopherol and tocotrienol, with a total content which range from not detected to 260 mg $kg^{-1}$, as shown in *Table 8* (Codex, 2009). The main type of tocols are γ-tocotrienol and γ- and β-tocopherol while the least is α-tocopherol.

**TABLE 8. LEVEL OF TOCOPHEROL AND TOCOTRIENOL IN CRUDE PALM KERNEL OIL**

| Tocols | Content (mg $kg^{-1}$) |
|---|---|
| α-Tocopherol | ND-44 |
| β-Tocopherol | ND-248 |
| γ-Tocopherol | ND-257 |
| γ-Tocotrienol | ND-260 |
| Total | ND-260 |

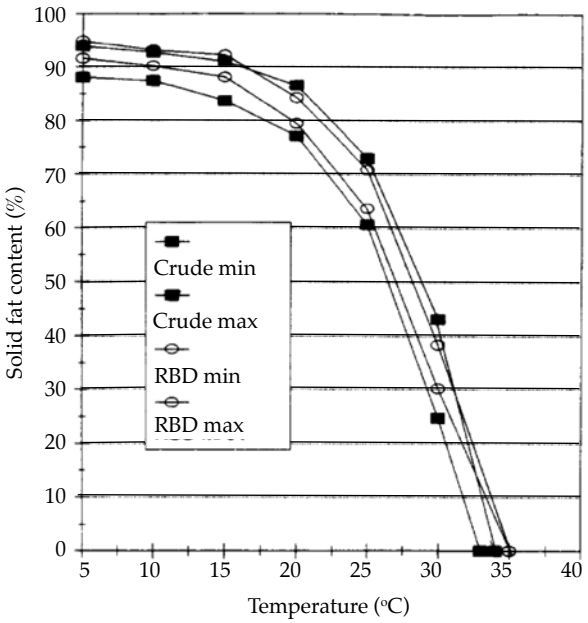
Source: Codex (2009).

## PHYSICAL PROPERTIES

Solid fat content (SFC) and slip melting point (SMP) of PKO products are shown in *Table 9*. SFC of PKO and PKOo show more than 50% reduction when the temperature is raised from 20°C to 25°C and become totally melted at 30°C. PKOs has the highest SFC due to the higher lauric and myristic acids content as compared to the other two oils. The melting profile of PKOs is shown in *Figure 3*, where high solid is observed at 25°C and lower, but sharp melting at above 30°C and totally melted at 35°C.

Speciality fats are used extensively in the food industry for applications where specific physical or chemical properties are essential. Most confectionery products, for example, have a high fat content and as a result, the fat consistency and melting behaviour in the mouth are critical. The sharp melting property of PKO and PKOs made the oils as ideal raw materials for the production of specialty fats and in formulating food products that are expected to melt quickly in the mouth. The steep melting profile can be further improved with fractionation to produce stearin with higher solids and good melting properties. The physical properties of PKOs particularly closely resemble those of cocoa butter, and it is generally acknowledged that the best types of cocoa butter substitute (CBS) are made from this fat.

PKO remains liquid at an ambient temperature in a tropical climate in spite of its high degree of saturation, since many of the saturates are in the form of short chain fatty acids. Ability to maintain




Source: Tang *et al.* (1995).

*Figure 3. Solid fat content of crude and refined, bleached and deodorised (RBD) palm kernel stearin.*

**TABLE 9. SOLID FAT CONTENT AND SLIP MELTING POINT OF PALM KERNEL OIL PRODUCTS BASED ON MALAYSIAN STANDARDS**

| | PKO[a] | PKOo[b] | PKOs[c] |
|---|---|---|---|
| Solid fat content (% by pulsed NMR) at | | | |
| 5°C | 68.0-76.8 | 55.4-71.2 | 88.1-94.6 |
| 10°C | 61.6-71.2 | 43.0-67.0 | 87.5-93.2 |
| 15°C | 50.7-60.0 | 25.1-51.7 | 83.6-92.2 |
| 20°C | 34.2-45.5 | 8.5-32.7 | 77.0-86.0 |
| 25°C | 10.2-21.5 | 0-12.0 | 55.0-76.0 |
| 30°C | melted | melted | 22.0-44.0 |
| 35°C | | | melted |
| Slip melting point, °C | 27.3-28.0 | 21.8-26.0 | 31.3-33.1 |

Note: [a] MS 80:2011, [b] MS1436:2010, [c] MS 1437:2010.
PKO – palm kernel oil.
PKOo – palm kernel olein.
PKOs – palm kernel stearin.

its fluidity despite being saturated oil makes it popularly used in foods that require a long shelf-life.

Other physical characteristics of PKO products are shown in *Table 10*.

**TABLE 10. QUALITY GUIDELINE FOR CRUDE AND REFINED PALM KERNEL OIL ACCORDING TO MALAYSIAN STANDARDS**

| | Crude | Refined |
|---|---|---|
| Free fatty acid (as lauric acid), % | 5 max | 0.1 max |
| Moisture and impurities, wt % | 0.5 max | 0.1 max |
| Colour, 133.35 mm Lovibond | 8 Red max | 1.5 Red max |
| Iodine value (Wijs) | | |
| PKO | 16.5-18.75 | |
| PKOo | 20.6 min | |
| PKOs | 8.0 max | |
| Slip melting point, °C | | |
| PKO | - | |
| PKOo | 26.0 max | |
| PKOs | 34.0 max | |
| Refractive index, nD 40°C | | |
| PKO | 1.4500-1.4518 | |
| PKOo | 1.4514-1.4522 | |
| PKOs | 1.4499-1.4501 | |
| Apparent density, g $ml^{-1}$ at 40°C | | |
| PKO | 0.9040-0.9050 | |
| PKOo | 0.9039-0.9056 | |
| PKOs | 0.9040-0.9059 | |

Note: PKO – palm kernel oil.
PKOo – palm kernel olein.
PKOs – palm kernel stearin.

## QUALITY GUIDELINE

The quality requirement shown in *Table 8* serves as a guideline for trading purposes but it is not mandatory, since sales contracts are normally based on a mutual agreement between buyers and sellers. The values indicated in *Table 8* are applicable to PKO, PKOo and PKOs either in the crude or refined form. FFA and moisture and impurities (M&I) are the most common quality parameters used for trading purposes. The allowable levels of FFA (as lauric acid) content in crude and refined oils are 5% and 0.1% maximum respectively, while for M&I the values are 0.5% and 0.1% maximum respectively. The colour of the refined oils should be lighter than the crude oil, *i.e.* 1.5 Red and 8 Red maximum respectively. The IV of PKO is also an important parameter since it affects the yield of stearin, which is a premium product. PKO with high IV will give a low yield of stearin. Therefore, a low IV PKO will be an advantage to buyers since this will give a higher stearin yield.

The specification of CPKO by MEOMA for domestic contracts is similar to MS 80, however the IV is slightly higher for export, that is 19 maximum at the time of shipment for the MEOMA specification. Another difference is that PKOo and PKOs are not included in MEOMA specification for local contract. Specifications of the two oils are only available for the export contract where the value of each parameter is the same as Malaysian Standards, except for IV of PKOo, which is set at 21.

## CONCLUSION

The major application of PKO and its products (PKOo and PKOs) is for the food industry; while the remaining portion is for the oleochemical industry and other uses. The sharp melting characteristics of PKO and its products make them a suitable alternative for cocoa butter, which are normally used as CBS substitute by confectioners. Their other characteristics such as bland taste, good flavour stability and shelf-life stability make them suitable for use in formulations for margarine, filling cream, ice cream and filled milk. As a replacement for dairy products, they are also suitable for the production of non-dairy cream, non-dairy whipping cream and non-dairy cheese.

PKM, which is a by-product of PKO, is mainly used as animal feed, as it contains nutrients and protein, which are essential components for the growth of ruminants.

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