OCL 2022, 29, 37

https://doi.org/10.1051/ocl/2022030

OCL Oilseeds & fats Crops and Lipids

Available online at:
www.ocl-journal.org

RESEARCH ARTICLE OPEN ACCESS

Evaluation on the quality of Malaysian refined palm stearin

Farah Khuwailah Ahmad Bustamam*, Chee Beng Yeoh, Najwa Sulaiman and Mei Huey Saw

Malaysian Palm Oil Board, 6 Persiaran Institusi, Bandar Baru Bangi, 43000 Kajang, Selangor, Malaysia

Received 7 March 2022 – Accepted 17 October 2022

Abstract – The quality of Malaysian palm stearin was monitored through a twelve-month survey in 2018, by participation of palm oil refineries and oleochemical plants from Peninsular Malaysia and Sarawak. Quality parameters requirement as listed in the Palm Oil Refinery Association of Malaysia (PORAM) specification such as moisture, impurities, free fatty acids, slip melting point, peroxide value and iodine value were determined. Other identity characteristics analyses as detailed in the palm stearin specification namely Malaysian Standard MS 815:2007 and Codex Alimentarius CXS 210-1999 documents were also analyzed, which were apparent density, refractive index, fatty acids composition, triacylglycerols, etc. Results obtained from this survey indicated that the quality of Malaysian palm stearin complied with the requirements specified in MS 815:2007 and Codex CXS 210-1999 documents. The iodine value determined was ranged from 28 g I_2/100 g oil to 48 g I_2/100 g oil, with 60.9% of the palm stearin tested were in the range of 30 g I_2/100 g oil to 35 g I_2/100 g oil. Meanwhile, some deviations are found in the average of parameter such as refractive index, apparent density, slip melting point, oleic and palmitic acids of the palm stearin produced. These deviations could be due to the improvement in current fractionation technologies causing less olein entrainment in stearin products, which resulted of harder stearin fraction in the sample itself, giving a more representative reading of the parameters.

Keywords: palm stearin / quality parameters / MS 815:2007

Résumé – Évaluation sur la qualité de la stéarine de palme raffinée malaisienne. La qualité de la stéarine de palme de Malaisie a été contrôlée lors d'une enquête menée durant 12 mois en 2018, avec la participation des raffineries d'huile de palme et des usines oléo-chimiques de la Malaisie péninsulaire et du Sarawak (un des 2 états de Malaisie orientale, situé sur l'île de Bornéo). Les exigences relatives aux paramètres de qualité listés dans la spécification de la *Palm Oil Refinery Association of Malaysia* (PORAM), tels que l'humidité, les impuretés, les acides gras libres, le point de fusion par glissement, l'indice de peroxyde et l'indice d'iode ont été déterminées. D'autres caractéristiques telles que détaillées dans la norme malaisienne MS 815:2007 et les documents du Codex Alimentarius CXS 210-1999 relatifs à la stéarine de palme, ont également été analysées : densité apparente, indice de réfraction, composition des acides gras, triacylglycérols, etc. Les résultats de cette étude ont indiqué que la qualité de la stéarine de palme de Malaisie était conforme aux exigences spécifiées dans les documents MS 815:2007 et Codex CXS 210-1999. L'indice d'iode déterminé était compris entre 28 g I_2/100 g d'huile et 48 g I_2/100 g d'huile, avec 60,9 % des stéarines de palme testées se situant dans la fourchette de 30 g I_2/100 g d'huile à 35 g I_2/100 g d'huile. Par ailleurs, certains écarts sont constatés par rapport à la moyenne de paramètres tels que l'indice de réfraction, la densité apparente, le point de fusion par glissement, les acides oléique et palmitique des stéarines de palme produites. Ces déviations pourraient être dues à l'amélioration des technologies de fractionnement actuelles entraînant une présence moindre d'oléine dans les stéarines, ce qui conduit à une stéarine plus dure, donnant une lecture plus représentative des paramètres.

Mots clés : stéarine de palme / paramètres de qualité / MS 815:2007

*Corresponding author: fkhuwailah@mpob.gov.my

1 Introduction

Oil palm (*Elaeis guineensis*) was first introduced as an ornamental plant in 1870, and well ahead, it has become the most important commodity crop in Malaysia. The valuable oil derived from oil palm mesocarp is naturally semi-solid at room temperature and has distinct physical and chemical properties after undergoing several fractionation processes. It also possessed distinctive properties of fatty acids and triacylglycerols (TAG) profile making it suitable for numerous food applications. The initial fractionation separates the palm oil into two different fractions, namely palm olein (liquid form) and palm stearin (solid form). Palm stearin is derived from the crystallization process at controlled temperatures, and it is widely used in edible and non-edible applications (Tang and Pantzaris, 2009). In 2021, the palm stearin production in Malaysia recorded was 2.522 million tonnes, and the stearin price has increased up to 64.2% from RM 2801 per tonnes in 2020 to RM 4598 per tonnes in 2021 (Parveez *et al.*, 2022; MPOB, 2022).

The quality of palm stearin produced depends on both crystallization and separation steps. A wider range of stearins are being produced resulted from the developments and technology in crystalliser design, cooling programmes, filtration technology as well as the addition of crystals aids (Saw *et al.*, 2015).

Palm stearin contains more saturated fatty acids and a TAG profile with a higher melting point of 48 °C to 50 °C (Siew, 2011). It is a natural source in providing solid fat functionality without the need for hydrogenation, and hence strengthens oil structure that enhances the plasticity of the products (Kellens *et al.*, 2007; Pande *et al.*, 2012; Siti Hazirah *et al.*, 2012). Further fractionation stage of palm stearin produces palm mid fractions (PMF). Palm stearin is directly used in blends with other vegetable oils to produce suitable functional products such as margarine, shortenings and vanaspati (Ornla-ied *et al.*, 2016; Noor Lida *et al.*, 2017). Moreover, palm stearin plays a significant role in the process of film formation and as a coating substitution material and a useful natural hard stock for making *trans*-free fats (Edy and Rizki, 2020).

Apart from food application, palm stearin also possesses suitable properties for non-edible products such as formulation of soaps and animal feeds (Norliza *et al.*, 2012; Ogan *et al.*, 2015). It is also an excellent feedstock for oleochemicals products, production of biodiesel, and lubricant (Theam *et al.*, 2016; Farhanah and Syahrullail, 2016; John *et al.*, 2021).

Figure 1 shows the fractionation of palm oil, resulted of different type of palm stearin with different iodine value (IV) properties. The IV of palm stearin is varied with a maximum of 48 g I_2/100 g oil, producing of soft stearin and hard stearin category. The IV of soft stearin is found higher (40 to 42 g I_2/100 g oil), while hard stearin normally owned a lower IV (17 to 21 g I_2/100 g oil) (Podchong *et al.*, 2018). Soft stearin fractions are commonly used as the main components in shortening and margarine blended with liquid oils, while the hard palm stearin is the structural fats that act as the backbone of margarine and shortening (Kim *et al.*, 2014). The multiple-step of dry fractionation to manufacture higher added-value products known as super stearin was reported for the production of palm stearin with very low IV (IV 12 to 14 g I_2/100 g oil) (Gibon, 2012). Super stearin is an excellent hard stock to substitute hydrogenated products and is also usable in the formulation of zero or low trans margarine and shortening.

Palm stearin is traded by either mutual contract between buyer and seller or generic-trading specifications following PORAM standard for processed palm oil products (Tab. 1) (PORAM, 2012). In demand to facilitate trade as well as to provide tools for the market to create enthusiasms in improving the overall product quality, the requirements for quality, composition, chemical and physical characteristics of palm stearin were indicated in specifications documents, *i.e.* Malaysian Standard; MS 815:2007 (Department of Standard Malaysia, 2007) and Codex Standard for Named Vegetable Oils; CXS 210-1999 (Codex, 1999).

Malaysian Palm Oil Board (MPOB), as the custodian of Malaysian palm oil, is committed in monitoring the quality performance of palm oil and its products, as well to ensure these products are within the specification requirements. In view of this, a one-year palm stearin survey has been conducted from January to December 2018 to gather the latest information on the characteristics of palm stearin, specifically to refined palm stearin, to ascertain whether the quality is within the specification requirement. A similar survey was previously carried out in last 1992, and hence a new survey was deemed timely for data update (Siew *et al.*, 1992). Therefore, this paper elaborates the results and findings from the quality monitoring of palm stearin activity, which voluntary participated by selected palm oil refineries and oleochemical plants in Malaysia.

2 Materials and methods

2.1 Collection of palm stearin samples

A total of 140 palm stearin samples were obtained from 11 refineries and 3 oleochemical plants in Peninsular Malaysia and Sarawak on monthly basis throughout the survey period. The samples were stored in a cool (~ 5 °C) dry place prior to the analyses.

2.2 Quality parameter analyses

Palm stearin samples were analyzed for quality parameter analyses, namely moisture, impurities, free fatty acids, and peroxide value. The sources of analytical methods used are varies, based on which applicable the best to palm stearin samples. All of the analyses were carried out in duplicate. Palm stearin samples were heated at 60 °C in the oven prior to the analyses and stirred well to ensure samples are fully melted and homogenized.

Moisture content. The moisture content in the palm stearin sample was measured using a volumetric titration Karl Fischer moisture analyzer (Mettler Toledo, Switzerland) according to ISO 8534:2017 method (International Organization for Standardization, 2017a). Samples were dropped into the validated Aqualine® reagent (Fisher Scientific) in which have been certified with standard water solutions over the necessary range.

Impurities content. The impurities were determined using the oven method according to ISO 663:2017 (International Organization for Standardization, 2017b). The palm stearin

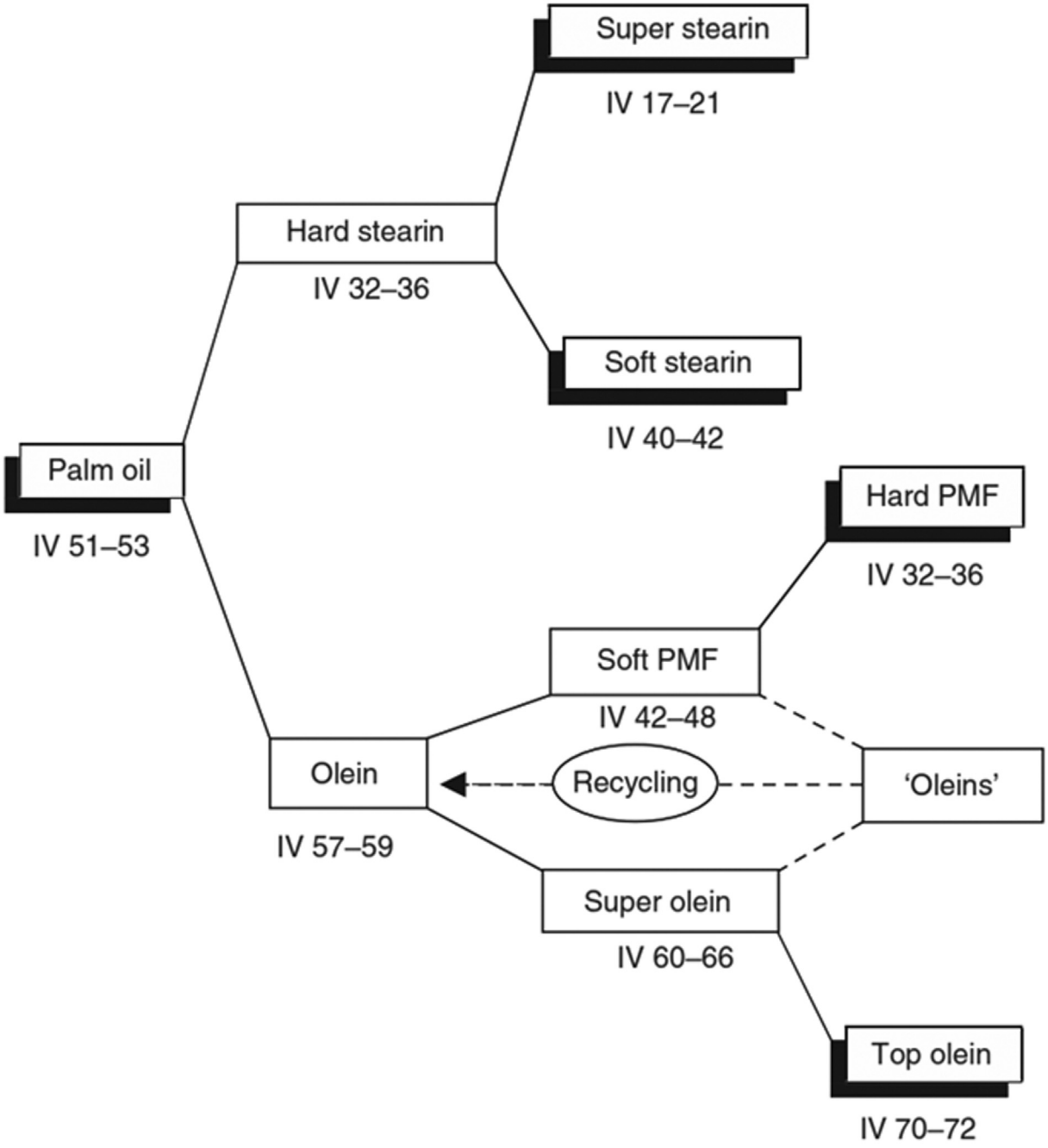

Fig. 1. The schematic diagram of multiple fractionations of palm oil.

Table 1. Specification for refined, bleached and deodorised (RBD)/neutralised, bleached and deodorised (NBD), palm stearin.

Parameter	Requirement		
	PORAM[a]	MS 815:2007[b]	Codex CXS 210-1999[c]
Free fatty acid (% as palmitic), max	0.2	0.2	–
Moisture and impurities (%), max	0.15	0.15	–
Iodine value (g I_2/100 g oil), max	48	48	48
Melting point (°C), min	44	44	–
Colour (5 $^{1/4}$ Lovibond cell), max	3 Red	3 Red	–
Apparent density (g ml^{-1}) (at 60 °C)	–	0.8813–0.8844	0.881–0.885
Refractive index (η_D at 60 °C)	–	1.4482–1.4501	1.447–1.452

[a] PORAM 2012
[b] MS 815:2007
[c] Codex CXS 210-1999.

sample was filtered using Whatman Paper No.4, followed by washing a few times with petroleum ether. The filter paper with the filtrate was then heated in the oven at 103 °C ± 1 °C for 2 h. The residue weight was measured and calculated as percentage.

Free fatty acids content (FFA). FFA content was analyzed according to acid-based titration procedure following American Oil Chemists' Society (AOCS) Official Method Ca 5a-40 (American Oil Chemists' Society, 2017a). Five grams of palm stearin sample was dissolved in neutralised *iso*-propanol and the free acids were neutralised with 0.1 M sodium hydroxide solution. Phenolphthalein was added as an indicator to observe and detect the end point. The FFA was expressed in percentage as palmitic acid.

Peroxide value (PV). PV was determined by titration technique, referring to the acetic acid: *iso*-octane method, ISO 3960:2017 (International Organization for Standardization, 2017c). Five grams of palm stearin sample was first dissolved in a 50 ml mixed solution of acetic acid and *iso*-octane at a ratio of 3:2. Next, approximately 0.5 ml of saturated potassium iodide solution was added into the mixture and gently stirred for 1 min, followed by the addition of 30 ml deionized water. Similar to IV analysis, an automated titration system is used for titration. The mixture was then titrated with 0.01 M sodium thiosulphate ($Na_2S_2O_3$) solution until the equivalence point was reached potentiometrically. The blank sample was determined concurrently in duplicate.

2.3 Identity characteristics analyses

Palm stearin samples were also analyzed for identity characteristics parameter, *i.e.* iodine value, refractive index, apparent density, fatty acids composition, TAG composition, and slip melting point. All of the analyses were carried out in duplicate. Palm stearin samples were heated at 60 °C in the oven prior to the analyses and stirred well to ensure samples are fully melted and homogenized.

Iodine value (IV). The IV of the oil sample was determined using the Wijs method according to ISO 3961:2018 (International Organization for Standardization, 2018). As an alternative to manual titration, an automated titration system T90 (Mettler Toledo, Switzerland) was used for the titration based on potentiometric measurement. About 0.4 g of palm stearin sample was weighed in an amber beaker (300 ml). A mixture of *iso*-octane and cyclohexane (1:1) solvent was added, followed by the addition of Wijs solution. The mixture was then incubated for 60 min. After the incubation period, potassium iodide (10%) solution and 100 ml deionized water was added. The mixture was titrated with 0.1 M thiosulphate solution until the equivalence point is reached. Blank determination was also performed concurrently in duplicate.

Refractive index (RI). RI is measured by using refractometer Abbemat 300 (Anton Paar, Austria) at the temperature of 60 °C according to ISO 6320:2017 method (International Organization for Standardization, 2017d). The refractometer was calibrated against deionized water. A drop of palm stearin sample was introduced onto the measuring prism and the measurement was performed.

Apparent density (AD). The AD of the palm stearin was measured using densitometer DMA 4500 M (Anton Paar, Austria) according to ISO 18301 method (International Organization for Standardization, 2014). The densitometer is equipped with a temperature-controlled heating inlet to ensure the samples are fully melted and well homogenized throughout the measurement process. The densitometer was calibrated against air and water prior to the measurements. Palm stearin sample was introduced to the U-tube cell by using a syringe and the measurement was occurred.

Slip melting point (SMP). SMP was measured according to AOCS Official Method, AOCS Cc 3-25 (American Oil Chemists' Society, 2017b). Palm stearin is solidified in an open capillary tube and tempered at 4 °C to 10 °C for 16 h. Then, the tube is heated in a water bath until the temperature at which the fat column in the tube begins to rise.

Fatty acids composition (FAC). FAC was measured by conversion of the oil sample to their fatty acid methyl esters (FAME) according to ISO 12966-Part 2 (International Organization for Standardization, 2017e). The FAME was prepared by adding 1 ml of hexane into 0.05 g of palm stearin in the vial. Next, 0.2 ml sodium methoxide solution was added and the mixture was vortex for 60 s. The solution was allowed for 5 min before addition of sodium chloride solution. The clear upper layer of FAME was collected into a vial and dried over 0.5 g of sodium hydrogen sulphate. The FAC was determined using a Gas Chromatography (Agilent GC 7890, Agilent Technologies, Germany) equipped with a fused silica capillary column SP^{TM} 2560 (100 m × 0.25 mm film thickness) and flame ionization detector. The column temperature was set at 110 °C and held for 7 min, with temperature increment rate of 4 °C min^{-1} an increment up to 240 °C and hold for further 7 min. Nitrogen was used as the carrier gas with a flow rate of 1 ml min^{-1}.

Triacylglycerols (TAG) composition. TAG composition was determined according to AOCS Official Method Ce 5c-93 by using reversed-phase high performance liquid chromatography (HPLC) (Agilent 1100 Series, Agilent Technologies, Germany), equipped with a refractive index detector and a Lichrospher®100 RP-18 column, 250 mm × 4.6 mm with 5 μm particle size (Darmstadt, Germany) (American Oil Chemists' Society, 2017c). The oil samples were weighed and diluted in acetone for injection into the HPLC column. The mobile phase used was a pre-mixed acetone and acetonitrile with a ratio of 3:1, with the flow rate of 1 ml min^{-1}. Identification of the TAG peaks was based on the reference standard of refined bleached and deodorized palm oil.

2.4 Data analysis

Basic statistical analyses such as mean, standard deviation, the minimum, and the maximum value were calculated using Microsoft Office Excel 2007 (Microsoft Corporation, Redmond, WA). Other statistical analyses such as data distribution were performed using Minitab 16 software.

3 Results and discussion

3.1 Quality parameters

The quality parameters obtained were as shown in Table 2 and compared with the data reported in 1988 (Siew *et al.*, 1988).

Table 2. Palm stearin quality survey data.

Parameter	Siew *et al.* (1988) ($n = 15$)		MPOB 2018 survey ($n = 141$)	
	Average (Standard deviation)	Range	Average (Standard deviation)	Range
Moisture (%)	0.05 (±0.05)	0.01–0.21	0.03 (±0.01)	0.01–0.09
Impurities (%)	–	–	0.005 (±0.003)	0–0.017
Free fatty acid, (% as palmitic)	0.07 (±0.02)	0.05–0.12	0.11 (±0.04)	0.05–0.24
Peroxide value, (meq O_2/kg)	1.03 (±0.96)	0.29–4.12	0.78 (±1.44)	0–9.61

In general, the quality of palm stearin is not much different and was well within the specification indicated in MS 815:2007 document. The moisture content and PV were slightly lower compared to that of the previous survey, while the FFA showed an increase in the average value despite being within the specification. This indicated that the basic product handling and storage procedures in the Malaysian palm oil industry are well practiced (Berger, 2010).

3.2 Trend of palm stearin quality from different states in Malaysia

Figure 2 demonstrated the palm stearin quality at different participated states in Malaysia. From the figure, it clearly showed that the quality characteristic of palm stearin samples from different state, referring to moisture, impuritries, FFA and PV parameters were within the MS 815 requirement as specified in Table 1. However, only the sample from Pahang showed a higher PV; as the number of samples is not equal, no conclusive difference can be made. The PV for that sample could have increased during the transportation process.

3.3 Identity characteristics

Physical and chemical characteristics of the palm stearin indicated the characters, properties and the appearance of the oil, which is unique. It is useful for the purity and identification of the oil. Table 3 showed the identity characteristics of palm stearin with a comparison to the reported survey in 1992. In the current survey, the average AD has declined to 0.8815 g ml^{-1} from 0.8823 g ml^{-1} as reported in the 1992 survey with narrower range, meanwhile, the average RI has decreased from 1.4493 as reported in 1992 survey to 1.4486, respectively. The average of IV was also decreased from 37.9 to 34.3 g I_2/100 g oil. On the other hand, the average of SMP is slightly increased. The upward trends in SMP are due to the appearance of membrane filter presses in the industry allowing effective stearin squeezing, but also to the growing demand for super stearin with a very low IV for specific application, *i.e.* substitutes for hydrogenated products and specialty fats. These four parameters are co-related to each other and mainly associated to the unsaturation properties of the oil. The changes of these parameters are suspected could be due to the changes in fatty acid composition properties, which will be discussed in the separate subtopic. Pearson correlation was applied to identify the presence of a relationship between IV, AD, and RI parameters of the palm stearin samples. Results showed that a fairly strong positive relationship occurred between RI and AD, RI and IV, and IV and AD with the correlation of 0.878, 0.888, and 0.822, respectively. This is in agreement with the observations discussed in the previous chapters.

Iodine value. The IV of palm stearin is diversified to a maximum of 48 g I_2/100 g oil depending on the fractionation process (Deffense, 1985; Gibon, 2012). Data obtained revealed that the IV of palm stearin are diversified from 28 to 48 g I_2/100 g oil, which with mod value of 33 g I_2/100 g oil. Figure 3 displayed the pie chart of the percentage of palm stearin in this survey, which 93.5% are within the IV range from 30 to 45 g I_2/100 g oil, while 5.1% is less than 30 g I_2/100 g oil and 1.4% is more than 45 g I_2/100 g oil. The IV results obtained indicated that palm stearin produced in Malaysia is within the requirement set by the relevant standards, which is maximum of 48 g I_2/100 g oil. The common usage of palm stearin in oleochemicals products has IV ranging from 30 to 35 g I_2/100 g oil, which encountered of 60.9% from the total of palm stearin samples analysed. As the sampling condition for this survey requires the collection of the common production samples, which is refined palm stearin, most of the palm stearin samples obtained are in the soft stearin form. The production of hard (IV < 20 g I_2/100 g oil) or super stearin (IV < 14 g I_2/100 g oil) at lower IV usually needs a special or additional fractionation profile.

Fatty acids composition. A wide variation was seen in the FAC of the palm stearin (Tab. 4). The major saturated fatty acids found in the samples were palmitic (45.2% to 66.4%) and stearic (3.9% to 5.7%) acids and the main unsaturated fatty acids were oleic (22.3% to 39.5%) and linoleic (4.8% to 9.7%) acids. Only a trace amount of linolenic acid was detected (0.1% to 0.5%). Generally, the ranges for the major acids, palmitic and oleic, were fairly similar to those in the previous survey. The upper range of palmitic is slightly decreased; meanwhile the upper range of oleic is slightly increased. However, the range reported were based on individual results, when total up the average of unsaturated acids and saturated acids, it showed that the saturated acids had increased and unsaturated acids had decreased, compared to the previous survey data. This is in agreement with the increase of SMP results, which resulted from the unsaturation that enhance the fluidity of fatty acids (Berg *et al.*, 2002).

Triacylglycerol. TAG are basically structural components of fats, thus, variation in TAG composition will lead to major changes in the characteristics of the functionality of the fats. TAG composition determines the characteristics of the fats with respect to their macroscopic properties such as overall texture,

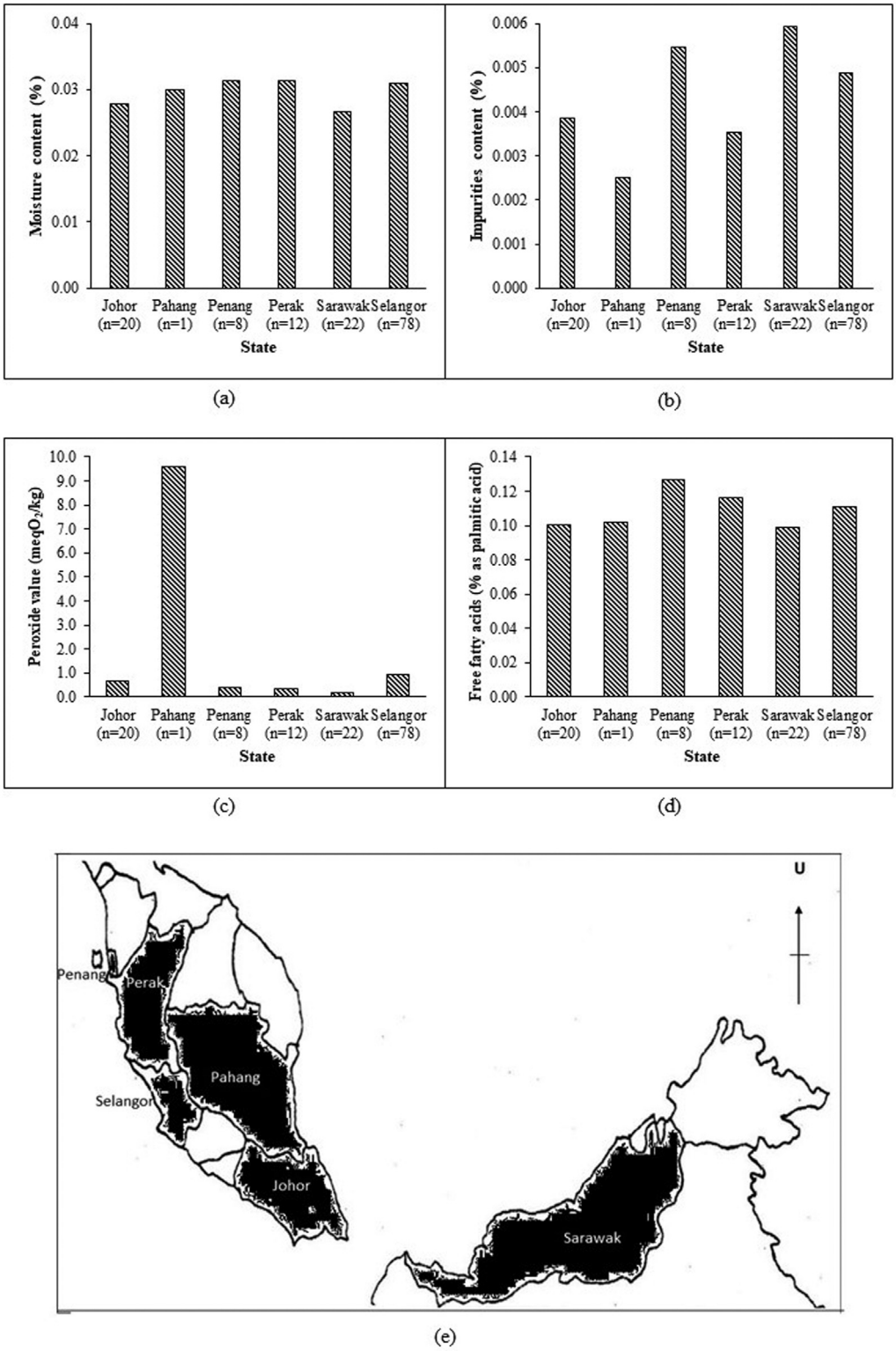

Fig. 2. (a–d) The quality parameters data generated from different states in Malaysia and (e) Malaysia map.

Table 3. Identity characteristics of palm stearin.

Parameter	PORIM 1992 survey[#] ($n = 244$)	MPOB 2018 survey ($n = 141$)
	Average (Standard deviation)	Average (Standard deviation)
Apparent density ($g\,ml^{-1}$), at 60 °C	0.8823 (±0.0005)	0.8815 (±0.0003)
Refractive index, at 60 °C	1.4493 (±0.0019)	1.4486 (±0.0003)
Slip melting point, (°C)	51.3 (±1.3)	52.9 (±1.4)
Iodine value ($g\,I_2/100\,g$ oil)	37.9 (±3.5)	34.3 (±2.7)

[#] Siew *et al.* (1992)

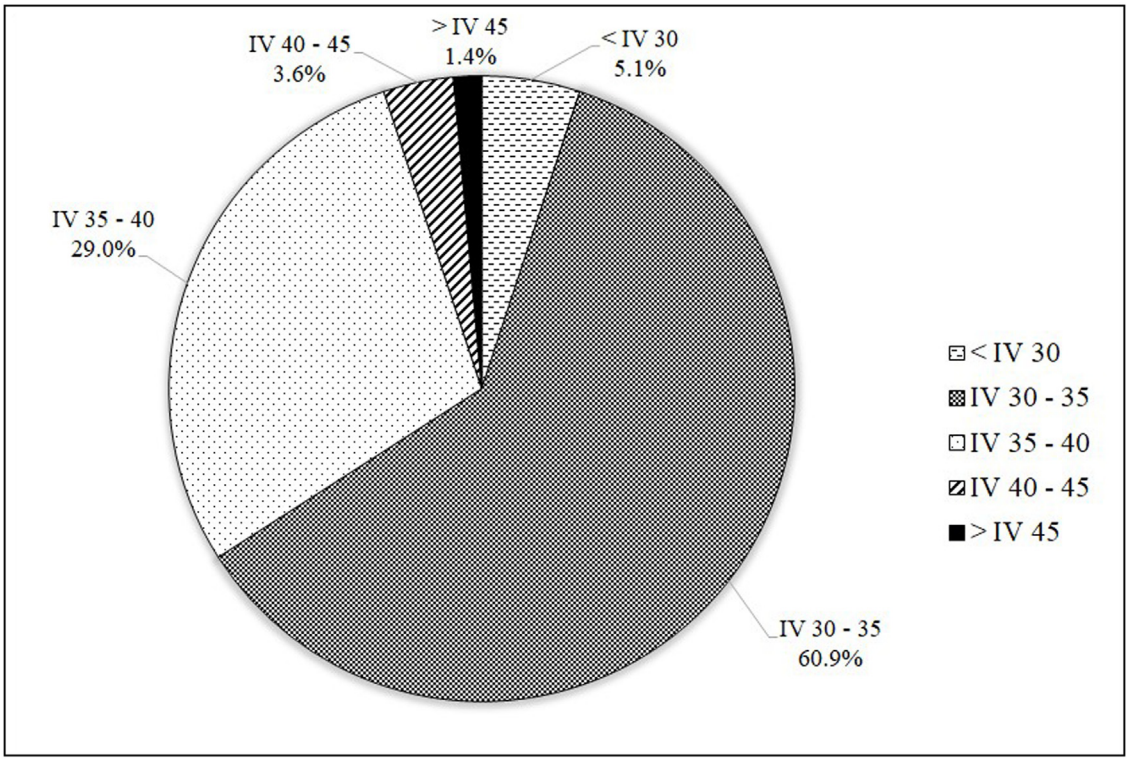

Fig. 3. Percentage of iodine value of palm stearin in 2018 palm stearin survey ($n = 138$).

Table 4. Fatty acid composition (% by weight) by gas chromatography of palm stearin product.

Fatty acid (%)	PORIM 1992 survey[*] ($n = 205$)		MPOB 2018 survey ($n = 140$)		MS 815:2007
	Average (Standard deviation)	Range	Average (Standard deviation)	Range	Range
Lauric; C12:0	0.2 (±0.1)	0.1–0.3	0.1 (±0.0)	0.1–0.2	0.1–0.3
Myristic; C14:0	1.1 (±0.1)	1.1–1.7	1.2 (±0.1)	1–1.3	1.1–1.7
Palmitic; C16:0	56.8 (±3.6)	49.8–68.10	61.0 (±2.4)	45.2–66.4	49.8–68.1
Stearic; C18:0	4.9 (±0.3)	3.9–5.6	4.9 (±0.4)	3.9–5.7	3.9–5.6
Oleic; C18:1	29.0 (±2.7)	20.4–34.4	26.3 (±2.0)	22.3–39.5	20.4–34.4
Linoleic; C18:2	7.2 (±0.8)	5.0–8.9	5.9 (±0.5)	4.8–9.7	5.0–8.9
Linolenic; C18:3	0.1 (±0.1)	0–0.5	0.2 (±0.1)	0.1–0.3	0.1–0.5
Arachidic; C20:0	0.2 (±0.1)	0–0.5	0.3 (±0.1)	0.1–0.5	0.3–0.6

[*] Siew *et al.* (1993)

Table 5. Triacylglycerols composition of palm stearin product.

Triacylglycerols (weight %)	Bangun (2009)	MPOB 2018 survey ($n = 140$)	
		Average (Standard deviation)	Range
Trinunsaturated			
OOO	1.92	2.05 (±0.32)	1.4–3.8
OLO	0.84	1.08 (±0.16)	0.7–1.8
OLL	0.26	0.27 (±0.05)	0.1–0.5
Monosaturated			
PLO	5.53	5.45 (±0.77)	3.8–10.3
POO	15.81	13.36 (±1.81)	9.8–24.5
OOS	1.62	1.44 (±0.19)	1.0–2.3
PLL	1.40	1.40 (±0.23)	0.8–2.7
Disaturated			
MPL	–	0.49 (±0.20)	0.1–0.9
PPL	8.74	7.76 (±0.56)	6.5–10.1
PPO	31.06	29.07 (±2.17)	25.4–37.7
POS	5.60	4.71 (±0.54)	3.6–7.6
SOS	0.79	0.50 (±0.08)	0.3–0.9
Trisaturated			
PPP	20.61	24.85 (±3.95)	6.1–33.1
PPS	5.65	4.96 (±0.75)	1.1–6.3
MPP	–	1.93 (±0.24)	0.7–2.5
PSS	0.68	0.66 (±0.12)	0.18–1.01

Note: M: myristic; P: palmitic; S: stearic; O: oleic; L: linoleic.

which in turn affects the compatibility of the fats into various food systems (Kanagaratnam *et al.*, 2020). The variation of TAG composition gives significant changes to the overall functionality and application of the fats in the final food products. Palm stearin had trisaturated TAG (such as PPP) and monounsaturated TAG (such as POP) as the main constituents. Palm stearin consisted mainly of POP (29.07%), PPP (24.85%) and POO (13.36%) as shown in Table 5. The total monosaturated TAG is 21.65%, with POO is the major content ranging from 9.8% to 24.5%. Meanwhile, the percentage of total disaturated TAG is 42.53%. The total of trisaturated TAG is 32.4%, with the main species of tripalmitoyl-glycerol (PPP) ranged from 6.1% to 33.1%. Data obtained are not comparable as there were no previous survey data are available. However, the TAG data obtained from this survey are not much difference to those reported by Bangun (2009).

4 Conclusion

Data generated from this survey found that most of the palm stearin produced in Malaysia are well within the average and ranges specified in the Malaysian Standard document, MS 815:2007, in terms of quality, physical, and identity characteristics. Most samples of exhibit IV ranging from 30 to 35 g I_2/100 g oil, which represented by 60.9% of palm stearin analyzed. The deviations found in the average of RI, AD, IV, SMP, oleic and palmitic acids of the palm stearin produced could be due to the improvement in current fractionation technologies causing less olein entrainment in stearin products which resulted of harder stearin fraction in the sample itself, giving a more representative readings of the parameters. Data obtained from this study will be useful in updating the relevant standards and specifications for palm stearin, as well as to understand the changes in the quality of palm stearin, in relation to the improvement of processing technology of palm stearin. Further investigations are needed, in order to find the actual factors that contributed to the deviation.

Conflicts of interest

The authors declare that they have no conflicts of interest in relation to this article.

Acknowledgment. The authors wish to thank the Director-General of MPOB for permission to publish this article. The support and advice from the Director of Product Development and Advisory Services Division are highly acknowledged. Technical assistance from the Analytical Quality Development Unit is greatly appreciated.

References

American Oil Chemists' Society. 2017a. AOCS Official Method Ca 5a-40 (Revised 2017). Free fatty acids in crude and refined fats and oils. Official methods and recommended practices of the AOCS, 7th ed. American Oil Chemists' Society.

American Oil Chemists' Society. 2017b. AOCS Official Method Cc 3-25 (Reapproved 2017). Slip melting point, AOCS Standard Open Tube Melting Point. Official methods and recommended practices of the AOCS, 7th ed. American Oil Chemists' Society.

American Oil Chemists' Society. 2017c. AOCS Official Method Ce 5c-93 (Reapproved 2017). Individual triglycerides in oils and fats by HPLC. Official methods and recommended practices of the AOCS, 7th ed. American Oil Chemists' Society.
Bangun PN. 2009. Physicochemical properties of palm stearin and palm mid fraction obtained by dry fractionation. *Agritech* 29: 154–158.
Berg JM, Tymoczko JL, Stryer L. 2002. Biochemistry, 5th ed. Section 12.2: Fatty acids are key constituents of lipids. New York: W. H. Freeman. Available from https://www.ncbi.nlm.nih.gov/books/NBK22497/.
Berger KG. 2010. Recommended practices for storage and transport of edible oils and fats. Malaysian Palm Oil Board, pp. 1–15.
Codex Alimentarius Commission. 1999. Standard for named vegetable oils Codex; CXS 210-1999. Adopted in 1999, Revised and Amended in 2019.
Deffense E. 1985. Fractionation of palm oil. *J Am Oil Chem Soc* 62: 376–385.
Department of Standard Malaysia. 2007. Malaysian Standard, MS 815:2007. Palm stearin – Specification, 2nd revision.
Edy S, Rizki LN. 2020. The recent application of palm stearin in food industry: A review. *Int J Sci Technol Res* 9: 2593–2597.
Farhanah AN, Syahrullail S. 2016. Evaluation of lubricant performance of RBD palm stearin and its formulation under different applied loads. *J Tribol* 10: 1–15.
Gibon V. 2012. Chapter 12: Palm oil and palm kernel oil refining and fractionation technology. In: Lai O-M, Tan C-P, Akoh CC, eds. *Palm oil, production, processing, characterization, and uses*. AOCS Press, pp. 329–375.
International Organization for Standardization. 2014. Animal and vegetable fats and oils – Determination of conventional mass per volume (litre weight in air) – Oscillating U-tube method (ISO Standard No. 18301:2014).
International Organization for Standardization. 2017a. Animal and vegetable fats and oils – Determination of water content – Karl Fischer method (pyridine free) (ISO Standard No. 8534:2017).
International Organization for Standardization. 2017b. Animal and vegetable fats and oils – Determination of insoluble impurities content (ISO Standard No. 663:2017).
International Organization for Standardization. 2017c. Animal and vegetable fats and oils – Determination of peroxide value – Iodometric (visual) endpoint determination (ISO Standard No. 3960:2017).
International Organization for Standardization. 2017d. Animal and vegetable fats and oils – Determination of refractive index (ISO Standard No. 6320:2017).
International Organization for Standardization. 2017e. Animal and vegetable fats and oils – Gas chromatography of fatty acid methyl esters – Part 2: Preparation of methyl esters of fatty acids (ISO Standard No. 12966-2:2017).
International Organization for Standardization. 2018. Animal and vegetable fats and oils – Determination of iodine value (ISO Standard No. 3961:2018).
John CB, Raja SA, Deepanraj B. 2021. Palm stearin biodiesel: Preparation, characterization using spectrometric techniques and the assessment of fuel properties. *Biomass Convers Biorefinery*. https://doi.org/10.1007/s13399-020-01265-0.
Kanagaratnam S, Habi Mat Dian NL, Abd Hamid R, *et al.* 2020. Are characteristics of soft palm stearins similar to soft palm mid fractions? *J Oil Palm Res* 32: 103–116.
Kellens M, Gibon V, Hendrix M, De Greyt W. 2007. Palm oil fractionation. *Eur J Lipid Sci Technol* 109: 336–349.
Kim TT, Nesaretnam K, Kanagaratnam S. 2014. Chapter 18: Trans fats replacement solutions in Malaysia. In: Kodali DR, ed. *Trans fats replacement solutions*. AOCS Press, pp. 385–398.
MPOB. 2022. Refinery: Monthly production of selected processed palm oil for the month of December 2021. Available from https://bepi.mpob.gov.my/index.php/en/production/production-2021/production-of-processed-palm-oil-2021.
Norliza S, Ismail Z, Affandi Yusoff MS, Tahiruddin S. 2012. Fractionated RBD palm stearin as potential rumen bypass supplements. *Malays J Vet Res* 3: 65–70.
Noor Lida HMD, Abd Hamid R, Kanagarathnam S, *et al.* 2017. Palm oil and palm kernel oil: Versatile ingredients for food applications. *J Oil Palm Res* 29: 487–511.
Ogan IM, Marie-José D, Michael N. 2015. Palm oil: Processing, characterization and utilization in the food industry – A review. *Food Biosci* 10: 26–41.
Ornla-ied P, Sonwai S, Lertthirasuntorn S. 2016. Trans-free margarine fat produced using enzymatic interesterification of rice bran oil and hard palm stearin. *Food Sci Biotechnol* 25: 673–680.
Pande G, Akoh CC, Lai OM. 2012. Food uses of palm oil and its components. In: Lai O-M, Tan C-P, Casimir CA, eds. *Palm oil production, processing, characterization, and uses.* AOCS Press, pp. 561–586.
Parveez GKA, Kamil NN, Zawawi NZ, *et al.* 2022. Oil palm economic performance in Malaysia and R&D progress in 2021. *J Oil Palm Res* 34: 185–218.
Podchong P, Tan CP, Sonwai S, Rousseau D. 2018. Composition and crystallization behavior of solvent-fractionated palm stearin. *Int J Food Prop* 21: 496–509.
PORAM. 2012. Handbook – The palm oil refiners association of Malaysia, 7th ed. Malaysia: PORAM.
Saw MH, Chong CL, Yeoh CB. 2015. New developments in palm oil fractionation. *Palm Oil Develop* 62(4-9): 14.
Siew WL, Tan YA, Chong CL. 1988. Stability tests for refined palm oil products. PORIM Report PO (141), pp. 1–88.
Siew WL, Chong CL, Tan YA, Tang TS, Flingoh OHCH. 1992. Identity characteristics of Malaysian palm oil products. *Elaies* 4: 79–85.
Siew WL, Tang TS, Flingoh CHOH, Chong CL, Tan YA. 1993. Identity characteristics of Malaysian palm oil products: Fatty acid and triglyceride composition and solid fat content. *Elaies* 5: 38–46.
Siew WL. 2011. Chapter 2: Palm oil. In: Gunstone FD, ed. *Book vegetable oils in food technology: Composition, properties and uses*, 2nd ed. United States: Wiley-Blackwell, pp. 25–54.
Siti Hazirah MF, Rashid NA, Omar Z. 2012. Effects of chemical interesterification on the physicochemical properties of palm stearin, palm kernel oil and soybean oil blends. *Malays J Anal Sci* 16: 297–308.
Tang TS, Pantzaris TP. 2009. Pocketbook of oil palm uses, 6th ed. Bangi: Malaysian Palm Oil Board, pp. 1–178.
Theam KL, Islam A, Taufiq-Yap YH, Choo YM, Teo SH. 2016. Binary metal-doped methoxide catalyst for biodiesel production from palm stearin. *Res Chem Intermed* 42: 1943–1963.

Cite this article as: Ahmad Bustamam FK, Yeoh CB, Sulaiman N, Saw MH. 2022. Evaluation on the quality of Malaysian refined palm stearin. *OCL* 29: 37.