A Survey on Commercial Palm Olein and Oil Extracted from Snack Products in Selected Asian Countries – Part 1: Assessment of Quality Indices

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INTRODUCTION

Palm oil is one of the 17 major edible oils and fats traded worldwide. It accounts for 30.6% in terms of total production and 57.6% of global exports (Oil World, 2015). The acceptance of palm oil in food applications is not only contributed by its unique characteristics and versatility, but also its consistency in supply and attractive price over other oils and fats. As one of the leading countries in the palm oil industry, Malaysia must make efforts to ensure that her palm oil is of good quality.

One of the major uses of palm oil – particularly its liquid fraction, namely, palm olein – is for frying. This is because the oil generally exhibits inherent properties countering excessive heat with stronger resistance against thermal oxidation compared with most conventional oils and fats (de Marco, 2007; Ismail, 2005). In principle, frying can be distinguished by three techniques; 1) Pan frying, which is applied to flat, wide and relatively thin pieces of food such as omelettes, fillets and patties without the need for stirring; the food is cooked by contact with a small amount of hot oil, usually on one side; 2) Stir frying, which utilises only a small amount of very hot oil for rapid frying with constant stirring, and requires a shorter time to complete and thus there is low oil absorption into the food, and; 3) Deep fat frying, in which the food is immersed in hot oil so that heat can be transferred uniformly over the entire surface of the food (Berk, 2013).

Realising that a significant market for palm olein is for cooking and frying applications, the Malaysian Palm Oil Board (MPOB) therefore conducted a series of case studies to evaluate the quality of cooking oils across Asian countries. In the survey, 24 commercial cooking oils of pure palm olein, comprising eight local brands and 16 samples from overseas, *i.e.* Indonesia (three), Thailand (five), Philippines (three), Vietnam (one), China (three) and Pakistan (one), were analysed for predetermined quality indices. The samples were obtained from retail stores and edible oil processors. In addition, the physico-chemical properties of lipid extracts from nine commercial snack products obtained from China were analysed. The products were classified as expanded, fabricated, chips and stick products. In order to protect the interest of the food processors, the information pertaining to brand and/or processing conditions was not disclosed but were assigned to codes.

CASE STUDY 1: COMMERCIAL PALM OLEIN IN SELECTED ASIAN COUNTRIES

The content of free fatty acids (FFA) is considered a relatively fast and reliable measurement to monitor the acidity of edible oils as a result of hydrolysis. *Table 1* shows that the FFA level did not exceed 0.1% for two-thirds of the total samples

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tested. The samples collected from Indonesia, Philippines and Vietnam had lower FFA values, while two samples from Malaysia and one sample from Pakistan contained FFA of about 0.2%. The remaining four samples yielded acidity values between 0.3% and 0.4%. According to Basiron (2005), the legislative limit for acidity of Malaysian refined palm olein is 0.1%.

The formation of FFA is inversely correlated to the transition in the smoke point (SP). The majority of the samples demonstrated SP values of not less than 200°C except for two samples from Thailand and the sole sample from Pakistan (*Table 1*). It is anticipated that lower SP in the samples from Thailand is likely due to the higher level of FFA. Nevertheless, significantly lower SP for the sample from Pakistan was unexpected because the acidity of that oil was fairly low (0.2%). In industrial frying, SP is essentially used as a safety measure to select oils for frying. For instance, oils are considered suitable as frying media when SP is above the typical frying temperature of 180°C (Ismail, 2001).

The oxidative behaviour of cooking oils was also investigated from the following perspectives; 1) primary oxidation, which is normally expressed as the peroxide value (PV); and 2) secondary oxidation, which is measured by the formation of aldehydes and ketones, and denoted by the *p*-anisidine value (AnV). From the survey, the differences in PV were high, varying from 1.5 to 15.6 meq O_2 kg^{-1} depending on the origin of the sample (*Table 1*). All Malaysian samples exhibited PV below 6 meq O_2 kg^{-1}. The oxidative values of Malaysian refined oils were lower and generally there was less deterioration upon storage and transportation. Surprisingly, AnV for all oil samples was below 2 units (*Table 1*). The measurements of AnV appeared to be more important than PV because aldehydes have greater thermal resistance compared with peroxides (Ahmad Tarmizi *et al.*, 2013).

Tocols – which consist of tocopherol and tocotrienol homologues – are essential antioxidants that are inherently present in edible oils (Ahmad Tarmizi and Ahmad, 2015). Unlike most vegetable oils, palm olein contains significant amounts of tocotrienols; hence, this oil dominates the total share of tocols content. The level of tocols across the samples varied considerably as evidenced in *Table 1*. The highest concentration of tocols for Malaysian processed palm olein was 773 mg kg^{-1} whereas the samples from Indonesia, Thailand and Philippines gave the highest tocols contents of 787, 603 and 684 mg kg^{-1}, respectively. Oil samples obtained from Vietnam contained the lowest amount of tocols (492 mg kg^{-1}) whilst the sample from Pakistan, surprisingly, yielded the highest tocols amongst all the others (859 mg kg^{-1}).

The induction period (IP) principally describes the degree of oil resistance against oxidation at high temperatures (Matthäus, 2006). This parameter is considered a dynamic indicator when compared with PV and AnV which are static measurements (Aladedunye *et al.*, 2014). The variation of IP between samples was considerably large, hovering between 18 hr and 36 hr (*Table 1*). Nonetheless, almost 80% of all the samples exhibited typical IP values of 21 hr to 26 hr. It was also observed that one of the samples from Thailand had a significantly high IP (36.7 hr) although its tocols content was just below 600 mg kg^{-1}. It is plausible that this sample may have contained additives that enhanced its oxidative stability.

The iodine value (IV) indicates the extent of unsaturation of the oil by determining the number of double bonds present in the oil structure. This measurement can be used to show the tendency of an oil to oxidise (Ahmad Tarmizi *et al*., 2008a). Indeed, IV correlates well with the composition of fatty acids. From *Table 1*, it was observed that 19 samples gave IV within the range of 56 to 59, while the remaining two samples, which originated from Indonesia, showed higher values. It is established that single-fractionated palm olein – which comprises the bulk of refined palm olein – has IV of 56 to 59 while IV for double-fractionated palm olein ranges from 60 to 67 (Ahmad Tarmizi *et al*., 2008b).

Quantification of the total polar compounds (TPC) is recognised as the most objective method to identify the deteriorative effect in oils (Mohamed Sulieman *et al*., 2006). The TPC content of all the samples fell within a narrow range of 6% to 9% regardless of their origin (*Table 1*). The results were expected because significant amounts of diacylglycerols are naturally present in palm olein (Berger, 2005). In some cases, TPC

TABLE 1. PHYSICO-CHEMICAL PROPERTIES OF COMMERCIAL PALM OLEIN SAMPLES FROM SELECTED ASIAN COUNTRIES

Country	Quality indices							
	FFA (%)	SP (°C)	PV (meq O_2 kg^{-1})	AnV (unit)	Tocols (mg kg^{-1})	IP (°C)	IV (Wijs)	TPC (%)
Malaysia								
MY1	0.10 ± 0.00e	202 ± 1de	2.72 ± 0.19cd	1.78 ± 0.11e	699 ± 8l	23.07 ± 0.12f	58.4 ± 0.6de	7.14 ± 0.15b
MY2	0.05 ± 0.00b	217 ± 1i	4.10 ± 0.40e	1.44 ± 0.17bcd	662 ± 5j	23.88 ± 1.90f	57.5 ± 0.5c	7.78 ± 0.14efgh
MY3	0.05 ± 0.00b	217 ± 1i	5.52 ± 0.03f	1.14 ± 0.33ac	545 ± 6d	18.69 ± 2.06abc	58.4 ± 0.2de	7.66 ± 0.16defgh
MY4	0.34 ± 0.00m	209 ± 1f	2.27 ± 0.10b	1.64 ± 0.17de	513 ± 6c	21.92 ± 0.55d	57.4 ± 0.3c	8.17 ± 0.12i
MY5	0.15 ± 0.00h	199 ± 1c	2.68 ± 0.07c	1.42 ± 0.32acde	694 ± 9kl	23.88 ± 1.90fg	58.1 ± 0.2de	7.37 ± 0.03c
MY6	0.12 ± 0.00f	209 ± 1f	2.18 ± 0.12b	1.04 ± 0.08a	545 ± 5d	25.34 ± 2.48gh	56.2 ± 0.1b	6.29 ± 0.19a
MY7	0.18 ± 0.00i	200 ± 1cd	3.03 ± 0.11d	1.30 ± 0.09bc	773 ± 12m	21.47 ± 2.85bcdefg	58.6 ± 0.2e	7.45 ± 0.10cdefgh
MY8	0.10 ± 0.00e	203 ± 1e	1.53 ± 0.03a	1.07 ± 0.21a	656 ± 4j	21.42 ± 1.87bcdefg	56.2 ± 0.3b	7.18 ± 0.02b
Indonesia								
ID1	0.14 ± 0.00g	201 ± 1cde	10.10 ± 0.02l	1.23 ± 0.15ac	697 ± 3l	23.34 ± 0.85fg	58.1 ± 0.1de	7.65 ± 0.14defg
ID2	0.06 ± 0.00c	209 ± 1f	7.25 ± 0.13g	0.86 ± 0.24a	787 ± 5m	23.00 ± 0.35fg	62.3 ± 0.1g	8.03 ± 0.56hij
ID3	0.08 ± 0.00d	206 ± 1g	12.63 ± 0.18n	1.20 ± 0.37ac	567 ± 5e	22.64 ± 0.12e	59.5 ± 0.3f	7.82 ± 0.04g
Thailand								
TH1	0.27 ± 0.00g	203 ± 1e	9.77 ± 0.15k	1.53 ± 0.11cd	427 ± 3a	21.10 ± 1.07cde	57.4 ± 0.3c	8.18 ± 0.17i
TH2	0.14 ± 0.00g	208 ± 1f	4.42 ± 0.21e	1.22 ± 0.27acd	593 ± 2f	36.17 ± 1.70j	57.7 ± 0.3cd	6.01 ± 0.18a
TH3	0.10 ± 0.01e	203 ± 1e	11.60 ± 0.24m	1.13 ± 0.21ac	603 ± 4g	22.70 ± 0.72de	57.2 ± 0.2c	7.97 ± 0.04i
TH4	0.35 ± 0.00m	184 ± 1b	8.26 ± 0.12i	1.29 ± 0.20acd	488 ± 5b	22.67 ± 0.14e	57.8 ± 0.2c	8.27 ± 0.08i
TH5	0.28 ± 0.00l	199 ± 1c	7.89 ± 0.10h	1.37 ± 0.13bcd	616 ± 5h	23.97 ± 0.59fg	58.0 ± 0.4d	7.90 ± 0.17g
Philippines								
PH1	0.08 ± 0.00d	212 ± 0h	15.63 ± 0.30p	1.81 ± 0.24e	597 ± 6fg	19.49 ± 0.35ab	56.4 ± 0.4b	8.55 ± 0.34i
PH2	0.12 ± 0.00f	209 ± 1f	8.52 ± 0.25ij	1.82 ± 0.12e	684 ± 4k	26.95 ± 0.15h	55.7 ± 0.1a	8.87 ± 0.19k
PH3	0.08 ± 0.00d	212 ± 0h	8.70 ± 0.10j	1.80 ± 0.19e	628 ± 3i	26.11 ± 0.14h	55.6 ± 0.6ab	8.45 ± 0.14j
Vietnam								
VT1	0.04 ± 0.00a	219 ± 1j	13.18 ± 0.12o	1.46 ± 0.15bcd	492 ± 6b	21.56 ± 0.39d	55.4 ± 0.3a	7.92 ± 0.09gh
Pakistan								
PK1	0.20 ± 0.00j	169 ± 1a	5.57 ± 0.12f	1.03 ± 0.09a	859 ± 7n	27.99 ± 0.52i	58.0 ± 0.1d	6.32 ± 0.12a

Note: Means within a column for each quality index marked with different lowercase letters are significantly different from one another ($P < 0.05$).

content may lead to a misleading perception of the quality aspect of palm olein even when the oil has not been subjected to heating treatments.

CASE STUDY 2: GRADES OF PALM OLEIN FROM CHINA

Three grades of palm olein with different melting points (MP) – *i.e.* 5°C, 8°C and 18°C – were evaluated for their FFA, SP, PV, AnV, tocols, IP, IV and TPC as summarised in *Table 2*. The FFA content for all the samples was considerably low, following the legislative limit set for refined edible oils (Basiron, 2005). Samples containing lower FFA content gave higher SP of more than 200°C. PV was remarkably high in all the samples, particularly in the palm olein with the highest MP (18°C). This can be explained from the basis of transportation and storage of the samples. In terms of secondary oxidation, AnV averaged within a narrow range of 2 to 3 units. The variation in tocols content among the samples was obvious; palm olein with higher MP appeared to have a reduced level of tocols. By comparing samples from other countries, as discussed in the previous case study, IP for the samples from China was very low, with the maximum MP registering at the lowest value of 10.62 hr. As was expected higher MP yielded palm olein with lower IV as a result of a higher proportion of saturated fatty acids (SFA). Irrespective of MP, the TPC content was somewhat identical (8% to 9%) with that of palm olein from other countries.

CASE STUDY 3: COMMERCIAL SNACK PRODUCTS FROM CHINA

In order to investigate the frying media used for processing snack products in China, nine commercial products were purchased and evaluated for selected quality tests. The samples were; 1) two expanded products, 2) four fabricated products, 3) two chips products; and 4) one stick product. Lipids were extracted from all samples and determined for their tocols content (including the homologues, tocopherols and tocotrienols), SFA, monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA). Furthermore, the products were assessed for their proximate properties such as oil content (OC) and moisture (MC).

Based on the results in *Table 3*, one can conclude that OC in expanded products was significantly lower when compared with that of other processed products (fabricated, chips and stick products) which ranged from 26% to 33% of oil. It was expected that the latter products were fried for a longer time whereas expanded products may only require less than 60 s of frying. Frying time appeared to influence the amount of oil absorbed into the products. In the case of fabricated, chips and stick products, MC fell within the range of 1% to 2%; while expanded products demonstrated a slightly higher MC (2.5% to 4.5%). It is worth mentioning that the recommended MC for commercial snack products is 1% to 3% (Ahmad Tarmizi and Niranjan, 2013).

Despite the difference in tocols retention across the extracted lipids, the ratio between the tocopherols and tocotrienols homologues indicates that palm olein was essentially used as a frying media. In order to strengthen the hypothesis, the lipids were further evaluated for their fatty acids composition and IV. The ratios between SFA, MUFA and PUFA as well as IV confirmed that the lipids were palm olein.

CONCLUSION

In general, most commercial cooking oils (palm olein) from Malaysia and other Asian countries are of good quality. Significant development of peroxides (which is expressed as PV) in some samples from overseas likely occurred during transportation to Malaysia. As most of cooking oils are utilised for frying, it is crucial to ensure that their physico-chemical properties meet the recommended specifications of frying oils, for instance; 1) FFA not greater than 0.2%; 2) PV less than 4 meq O_2 kg^{-1}; 3) SP above 200°C; and 4) IP more than 15 hr. In consideration of the above findings, the oil processors should be able to improve their production of cooking oils by closely monitoring the quality attributes throughout processing (*i.e.* milling and refining) and supply chains (*i.e.* packaging, transportation and storage). Indeed, the production of good quality cooking oils is essential because significant amounts of the oils become part of the cooked food.

TABLE 2. ASSESSMENT OF DIFFERENT GRADES OF PALM OLEIN FROM CHINA

Sample	Quality indices							
	FFA (%)	SP (°C)	PV (meq O_2 kg^{-1})	AnV (unit)	Tocols (mg kg^{-1})	IP (°C)	IV (Wijs)	TPC (%)
Palm olein MP 5°C	0.08 ± 0.01a	218 ± 1b	11.99 ± 0.99a	2.82 ± 0.10b	731 ± 11c	15.00 ± 0.40b	71.28 ± 0.22c	8.73 ± 0.07b
Palm olein MP 8°C	0.09 ± 0.01a	212 ± 1a	11.02 ± 1.23a	2.27 ± 0.11a	561 ± 2b	16.48 ± 0.58c	64.88 ± 0.11b	9.18 ± 0.16c
Palm olein MP 18°C	0.10 ± 0.01a	214 ± 1a	21.19 ± 1.49b	3.21 ± 0.09c	427 ± 5a	10.62 ± 0.26a	58.59 ± 0.13a	8.15 ± 0.14a

Note: Means within a column for each quality index marked with different lowercase letters are significantly different from one another ($P< 0.05$).
The abbreviation MP refers to melting point.

TABLE 3. CHARACTERISATION OF LIPID EXTRACTS IN SNACK PRODUCTS FROM CHINA

Product	Quality indices							
	OC (%wb)	MC (%wb)	Tocopherols (mg kg^{-1})	Tocotrienols (mg kg^{-1})	SFA (%)	MUFA (%)	PUFA (%)	IV (Wijs)
Expanded								
EP1	16.01 ± 0.19a	2.56 ± 0.04f	32 ± 2 (25%)b	96 ± 4 (75%)b	48	42	10	54.8 ± 0.2a
EP2	15.77 ± 0.78a	4.47 ± 0.07g	24 ± 0 (27%)a	64 ± 3 (73%)a	47	42	11	55.6 ± 0.1b
Fabricated								
FP1	28.37 ± 0.78c	1.04 ± 0.08a	60 ± 3 (31%)c	133 ± 10 (69%)b	48	42	10	55.1 ± 0.3a
FP2	29.91 ± 0.58d	2.26 ± 0.10e	115 ± 2 (29%)f	279 ± 6 (71%)f	46	43	11	57.4 ± 0.1d
FP3	32.59 ± 0.42e	1.77 ± 0.05d	100 ± 1 (30%)e	236 ± 1 (70%)e	46	43	11	56.3 ± 0.1c
FP4	28.49 ± 0.15c	2.28 ± 0.05e	87 ± 1 (33%)d	177 ± 1 (67%)d	46	42	12	57.3 ± 0.1d
Chips								
CP1	31.98 ± 0.83e	1.28 ± 0.04b	120 ± 2 (31%)g	268 ± 5 (69%)f	46	43	11	57.0 ± 0.3d
CP2	32.80 ± 2.27de	1.43 ± 0.05c	195 ± 5 (34%)i	385 ± 5 (66%)g	45	43	12	58.1 ± 0.0e
Stick								
SP1	26.08 ± 1.01b	1.75 ± 0.13d	118 ± 2 (30%)fg	274 ± 4 (70%)f	46	43	11	57.4 ± 0.1d

Note: Means within a column for each quality index marked with different lowercase letters are significantly different from one another ($P< 0.05$).

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