

Sensory and Physicochemical Qualities of Palm Olein and Sesame Seed Oil Blends during Frying of Banana Chips

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Abstract

Palm olein and sesame seed oil were blended at varying ratios; changes in their physicochemical and sensory characteristics were determined. Increasing amounts of SSO (from 10 to 20, 30 and 40%) and decreasing amounts of PO (from 90, 80, 70 and 60%) in the blends, results in increase in the degree of unsaturation. FFA increased from 0.25% (90 PO: 10 SSO) to 0.65%. (60 PO: 40 SSO). Blending altered FA composition of palmitic and linoleic acids, which results in a significant change in trilinolein, dioleoyl-linoleoyl-glycerol, dipalmitoyl-3-linoleoyl glycerol and dipalmitoyl-3-oleoyl glycerol contents. A pleasant nutty flavor was imparted. Melting and crystallization temperatures shifted to lower values from 12.65 to 11.03, 10.44 and 9.74°C and from -6.31 to -6.99, -7.38 and -8.31 °C, respectively. Sensory quality of banana chips fried in the oil blends showed no acceptability differences between them. All blends received high scores for all sensory attributes tested and overall acceptability.

Keywords: Blending, Physicochemical and sensory characteristic, Palm olein and sesame seed oil

1. Introduction

Most native oils and fats have limited applications in their unmodified forms, imposed by their triacylglycerol (TAG) and fatty acid (FA) compositions. It is widely known that the physical and chemical properties of oils are a strong function of the TAG and FA composition. By changing the natural physical and chemical characteristics of a fat or oil, it offers greater functionality for a large number of product formulations. Fats and oils applications can be widened by modifying them through blending, fractionation, interesterification, hydrogenation, or combinations of these processes (Petrauskaite *et al.*, 1998).

Blending has long been used to modify oils and fats to improve the fat functionalities and thus optimize their application in food products. It modifies the physicochemical properties of oils without changing their chemical composition (Chu and Kung, 1997). With the rising demand of natural products and emphasis on nutritional enrichment, blending of vegetable oils and fats has emerged as an economical way to produce edible oils devoid of any chemical treatment and which possess natural flavor and characteristics as well as nutritional value. The nutritional properties of importance are based on essential fatty acids content, omega 3 to omega 6 ratio, saturated to unsaturated ratio, contents of monounsaturated and polyunsaturated fatty acids (PUFA) (Kochhar, 2002).

Sesame seed oil (SSO); which is derived from sesame seeds (seeds of *Sesamum indicum* L.) is conventionally extracted by pressing roasted seeds without further refining. It is very popular in Chinese, Korean and Japanese cooking because of its pleasant nutty flavor (Kochhar, 2002). SSO is highly resistant to oxidation and displays several medicinal effects (Kochhar, 2000). The oil is very stable due to the presence of a number of antioxidants such as sesamin, sesamol and sesamol. Therefore, it has a long shelf life and can be blended with less stable vegetable oils to improve their stability and longevity. It also contributes the pleasant nutty flavor and linoleic acid content to the oil blends (Kochhar, 2002).

Palm olein' (PO) the liquid fraction of palm oil has been shown as highly monounsaturated oil, which is rich in oleic acids (Nor Aini *et al.*, 1993), is currently touted to be oxidatively stable. PO, besides being marketed as liquid oil, can be promoted for blending with other edible oils (Lin, 2002). This is because its moderately low linoleic acid content is admirably suited for blending with oils of high PUFA content. Ideal edible oil is one in which the ratio of saturated, monounsaturated and PUFA fatty acids is close to 1: 1: 1 (Grundy, 1988). By blending PO with high PUFA oils in proper proportions, one can achieve such a ratio. The aim of this work is to produce an ideal blend of sesame and palm olein suitable for frying application.

SSO, which is expensive, is a candidate for oil blending. Blends of PO with more unsaturated vegetables oils, resulted in blends that are more stable (do not crystallize easily) at low temperatures. The blends stay clear for a longer period of time (Nor Aini *et al.*, 1992, Mahmood *et al.*, 1996). Therefore proper blending of PO and SSO in the optimal proportion can produce oil blends with improved stability, nutritional value and flavour characteristics. In this paper the physicochemical and sensory characteristics of PO and SSO blends were investigated and their frying stability during the frying of banana was determined.

Frying Material

Edible larger banana species also known as plantain (*Musa x paradisiaca*) are very popular for making banana chips and for cooking in South East Asian countries. It belongs to the genus *Musa spp* and is widely grown in many tropical countries all around the globe. This specie is larger and angular in shape. Before fully ripe plantain is normally cooked or fried and seldom consumed as raw even after ripening. In Malaysia and other South East Asian countries and in tropical Africa, it is commonly fried and consumed as snacks.

2. Materials and Methods

2.1 Materials

Two different edible oils of plant origin were used in this study. Refined, bleached and deodorized (RBD) palm olein (PO) and unrefined sesame seed oil (SSO) were purchased from a local supermarket. Frying material; banana (plantain) was purchased from a local market around Universiti Putra Malaysia. All chemicals and solvents used were either of analytical or (HPLC) grade purchased from BDH laboratories (Poole, England) and Merck (Darmstadt, Germany). Fatty acid methyl esters and triacylglycerol (TAG) standards were obtained from Sigma Chemical Co (St. Louis, MO, USA).

2.2 Blends Preparation

PO was blended with SSO in varying proportions. The following PO: SSO (% v/v) blends were prepared; 100: 0 (control), 90: 10, 80: 20, 70: 30 and 60: 40. The oil blends were mixed at 60 °C in an oven prior to initial analysis.

2.3 Color Determination

Color was determined using a Lovibond tintometer Model E (Salisbury, England) according to PORIM test method (p4.1). The blended oil samples were placed into 1 inch cell and the color was determined at 30°C by achieving the best possible match with the standard colour slides of red and yellow indices.

2.4 Determination of Viscosity

The apparent viscosity of samples was determined by a rheological measurement using RheoStress 600, Haake, Karlsruhe, Germany. A cone sensor (C35/2° Ti; 222-1632; 35 mm diameter, 2° angle), with 0.100 mm gap and a measuring plate cover (MPC 35; 222-1549) were used. Measurement was performed at 25°C at various shear rates (from 10:00 to 40:00 s⁻¹) and duration of 60 seconds, the temperature used is commonly considered to the one obtained during product utilization. The equipment was driven through the Haake software, Rheowin Job Manager Version 3.1

2.5 Standard Chemical Analyses

Standard methods were used to determine the following: iodine value (method: Cd 1-25/93), free fatty acid content (FFA) (method: Ca 5a-40/93), peroxide value (PV) (method: Cd 8-53) and p-anisidine value (p-AV) (Ca Sa-40/93) (AOCS, 1989). Total oxidation (TOTOX value) was derived using the formula $TOTOX = 2PV + p-AV$ (Shahidi and Wanasundara, 2002).

2.6 Determination of Fatty Acid (FA) Composition

The fatty acid composition was determined by conversion of oil to fatty acid methyl esters prepared by adding 950µL of *n*-hexane to 50µL of oil followed by 50µL of 1M sodium methoxide using the method of (Cocks and Van Rede, 1966). The mixtures were vortexed for 5 seconds and allowed to settle for 5 min. The top layer (1µL) was injected into a gas chromatograph (Model GC- Clarus 500 Perkin Elmer Incorporate, Massachusetts, USA) equipped with a flame ionization detector and a polar capillary column ELITE-5(30m x 0.25mm ID x 0.25 µm,

Perkin Elmer, USA) to obtain FA methyl ester peaks. The detector temperature was 240°C and column temperature was 130°C held for 0.5 min and increased at the rate of 10°C/min to 240°C and held for 5 min and a run time of 20.50 min. Individual peaks of FA methyl esters were identified by comparing their retention times with those of standards. Individual FA composition was calculated using the peak areas of the FA species that appear in the chromatogram as a relative percentage of the total peak areas of all the FA in the oil sample.

2.7 Determination of Triacylglycerol (TAG) Profile

TAG profile was obtained by reverse phase high performance liquid chromatography (HPLC) using a Waters Alliance HPLC, Waters, USA equipped with separation module (Waters 2695), an auto-injector, and refractive index detector (Waters 2414, Waters Corporation, Milford, Massachusetts, USA). The chromatogram was processed using an Empower Software (Milford, Massachusetts, USA). The TAG were separated using a commercially packed RP-18 column (250 × 4 mm) with a particle size of 5µm (Merck, Darmstadt, Germany) and was eluted from the column with a mixture of acetone/acetonitrile (63.5: 36.5 v/v) at the flow rate of 1 mL/min, and the TAG peaks were detected with a refractive index detector (Water, 2414). 10 µL of sample [6% concentration in chloroform (w/w)] was injected into the HPLC. The total run time was 1 hour. TAG peaks were identified based on the retention time of TAG standards. Peak areas produced by the data integrator were used to quantify the components based on relative percentages. In calculating the relative percentage of the TAG all the peaks that appears after 12 min (time at which the first TAG peak appeared) in the chromatograph were included (Ghazali *et al.*, 1995a).

2.8 Thermal Analysis

The melting and crystallization behavior of the oil samples was determined using a Perkin- Elmer Diamond DSC (Shelton, CT, USA). The instrument was calibrated using indium and zinc. The purge gas used was 99.99% nitrogen with a flow rate of 100 mL/ min and a pressure of 20 psi. Samples of 5- 7 mg were weighted into aluminium pans to the nearest 0.1 mg, and covers were hermetically sealed. An empty, hermetically sealed aluminium pan was used as reference. Prior to analysis of samples, the baseline was obtained with an empty, hermetically sealed aluminium pan. The oil samples were subjected to the following temperature program. Frozen oil samples were heated at 60°C in an oven until completely melted, and 5- 7 mg were placed in individual aluminium volatile pans. Each sample was cooled to – 60°C at the rate of 10°C/min and held for 2 min at – 60°C. It was then subjected to the heating procedure ramped from – 60°C to 60°C at the rate of 10°C/min (Abdulkarim *et al.*, 2007, Naghshineh *et al.*, 2010). The heating and cooling thermograms were recorded and the onset, peak and offset (end) temperatures were tabulated. These values provide information on the temperature at which the melting and crystallization process starts, the temperature at which most of the TAG have melted, or crystallized and the complete melting and crystallization temperature of the oil respectively.

2.9 Sensory Evaluation

Sensory evaluation was conducted on the banana chips fried with (90PO:10SSO), (80PO:20SSO), (70PO:30SSO) and (60PO:40SSO) oil blends by using 9- point hedonic scale by 50 untrained panellists. Peeled bananas approximately 1.75 mm in thickness were sliced using a mechanical slicer (Italimport SRL, Model 90915, China). Two litre of each oil blend sample was used as frying medium to fry banana chips (batches of 100g) at 180 ± 5 °C for 3 minutes. The banana chips kept at room temperature for 5 min, placed on kitchen rolland paper towels to remove surplus oiland later stored in an air tight glass bottles and labeled. The sensory quality of the banana chips was evaluated based on their appearance or color, aroma, flavor and overall acceptability. The results of sensory evaluation were analyzed to determine the preference and significant difference among the four oil blends.

2.10 Statistical Analysis

All statistical analyses were carried out on triplicate evaluations and the means and standard deviations were determined using by MINITAB 14. The data were compared using one-way analysis of variance (ANOVA) followed by Tukey's tests and multivariate descriptive statistics method used to prepare the biplots by using SAS version 9.13. Significance was based on 5% level in all cases.

3. Results and Discussion

3.1 Changes in Color and Viscosity

TABLE 1 shows changes in color and viscosity of PO, SSO and their blends. PO was light yellow whereas SSO was yellowish brown color. After blending PO with SSO, the color was not significantly ($P>0.05$) changed. But as the SSO ratio was increased in the blends, it resulted in a reddish brown color. Most of the consumers prefer clear and light yellow oil color so the color of the blends with low ratio of SSO was acceptable. Lovibond was used to measure the oil color, widely used in the edible oils industry (Belbin, 1993). When the amount of SSO was

increased in the blend, the viscosity significantly ($P < 0.05$) decreased. This may be due to an increase in the unsaturated linoleic acid and the viscosity of the blends was lowered. Santos *et al.* (2005) reported that vegetable oil's viscosity depend on fatty acids composition. The results obtained were similar to previous finding that viscosity decreased with increased in PUFA (Fasina *et al.*, 2006). Viscosity is one of the most important parameters required to determine the quality and stability of food system. The viscosity has a direct relationship between some chemical characteristics of the vegetable oils.

3.2 Fatty Acid Composition

The fatty acid compositions of the original and blended oils are shown in TABLE 2. The most prominent fatty acids in PO were palmitic (38.39%) and oleic (45.77%) acid, while SSO has abundance of oleic (40.52%) and linoleic (46.03%) acids. Blending of PO with SSO caused the content of palmitic acid to decrease and linoleic acid to increase in the blends. The FA composition thus was changed by blending. Blending of PO with SSO in proportions of 90:10, 80:20, 70:30 and 60:40 resulted in the reduction of palmitic acid content from 38.39 to 35.98, 33.13, 29.60 and 27.03% respectively. Linoleic acid content increased from 12.16 to 14.92, 18.24, 22.45 and 25.00% following the above blending ratios. But there was no significant change in the oleic acid content. It is also noticed that the proportion of polyunsaturated/mono-unsaturated fatty acid ratios were significantly ($P < 0.05$) decreased and hence, increased the oxidative stability of the blends. FA ratio was significantly changed in the blends with decreasing PO and increasing SSO ratios.

3.3 Changes in Free Fatty Acids Content (FFA)

FFA contents of oil blend are shown in TABLE 3. SSO had significantly ($P < 0.05$) higher initial FFA value (1.25 %) than PO (0.18%). This is due to the conventional extraction method used in SSO, which is done by pressing the roasted seeds without further refining to remove the FFA. This extraction method helps to retain the natural antioxidants and nutty flavor in SSO. For PO, the low FFA (0.18%) was due to the refining process it undergone. According to the palm oil refiners association of Malaysia, the standard trading specification for palm olein should be lower than 0.1% FFA (Tan, 1994). As expected, the increase in FFA in the blends occurs as the SSO amount was increased. The increment were from 0.25% (90PO:10SSO) to 0.65% (60PO:40SSO). Apart from the effect of the higher FFA content on the quality of oil, it also means higher diacylglycerol (DAG) and monoacylglycerol (MAG) contents. Higher proportion of these additional oil types will affect rate of crystallization and cause cloudiness in oil at low temperature storage condition (Siew, 1996, Siew, 1999). However, it has been observed that blending palm olein with vegetable oils with higher degrees of unsaturation, resulted in blends that are more stable (do not crystallize easily) at low temperatures. The blends stay clear for a longer period of time (Nor Aini *et al.*, 1992, Mahmood *et al.*, 1996).

3.4 Changes in Iodine Value (IV)

TABLE 3 shows that the IV contents significantly ($P < 0.05$) increased from 90PO:10SSO (64.38 g I₂/100g oil) to 60PO:40SSO (77.55 g I₂/100g oil). The Increase was due to an increase in the predominance of MUFA and PUFA groups. Blending has a significant influence on IV where linoleic acids from SSO tend to migrate into oil blends. SSO was characterized by high unsaturation and its difference from PO was reflected in its higher IV. PO is made up of about 58.03% unsaturated FA (MUFA and PUFA) whereas a substantial amount of unsaturated FA 86.55% was found in SSO. The IV of the oil blends was therefore improved by blending of PO with SSO. The iodine value is a measure of the unsaturation of the oils. It is one of the parameters used to measure the oil quality (Haryati *et al.*, 1998).

3.5 Changes in PV, p-AV and TOTOX Value

Results of PV, p-AV and TOTOX value are shown in TABLE 3. SSO and PO have relatively the same PV values (1.98 and 1.99 meqO₂/Kg) respectively, which is less than 10 meqO₂/Kg, and therefore within the acceptable value range for fresh oil (Codex, 2003). Even in aged SSO, its high saturated content ensures its stability against oxidative rancidity. Unsaturated fatty acids easily react with oxygen to form peroxides (Marina *et al.*, 2009). p-Anisidine value is a better indication of the freshness of oil. PV and p-AV both measure specific oxidation values, which represent only two specific quality parameters of oil. Results showed that the p-AV of all the oil blends were not significantly ($P > 0.05$) different. The total oxidation or TOTOX value calculated as: TOTOX = 2PV+ p-AV gives a better indication of the oxidative state of the oil. The results of TOTOX value of PO and SSO oil blend were 6.36, 6.64, 6.84 and 7.00. These low values obtained for the blends indicate that they are stable.

3.6 Triacylglycerol Profile

The change in the TAG content of the oil blends is shown in TABLE 4. The percent of the some species of the TAG in the original PO were found to increase after blending with the SSO at PO: SSO (90:10, 80:20, 70:30 and 60:40) as follows: trilinoleoyl glycerol (1.31, 2.69, 4.62 and 5.69) (, olein-2,3 dilinoleoyl glycerol (2.77, 5.05, 8.24

and 10.03), palmitoyl-2,3 dilinoleoyl glycerol (3.13, 3.73, 4.52 and 5.28), dioleoyl-3, linoleoyl glycerol (3.83, 5.57, 7.62 and 9.52) and trioleoyl glycerol (5.64, 6.09, 6.50 and 6.85), respectively. This was due to the high amounts of linoleic acid in the SSO. These changes are also highlighted in the TAG profiles in FIGURE (1c, 1d, 1e and 1f). Changes in TAG profiles will normally affect the physical characteristics of the oils such as the thermal behavior. Due to the increased in the percentage of low melting TAG, it means that the oil will have a lower melting and crystallizing temperatures, a characteristic that is desirable in oils for good storage and functionality.

3.7 Changes in Thermal Behavior of Oil Blends

The change in thermal behavior of the oil blends is shown in TABLE 5. Melting and crystallization curves are illustrated in FIGURE 2a and 2b. Melting and crystallization points were determined as the end set temperature values of the last melting and crystallization peaks, respectively. Melting temperature of the PO:SSO (90:10, 80:20, 70:30 and 60:40) blends were 12.65, 11.03, 10.44 and 9.74°C, respectively. Results shown in Figure 2a indicated a shift in the melting peaks from higher temperature of PO towards lower temperatures as the proportion of SSO increases in the blends. The oil blends have a range of melting temperature of between 9 to 12°C depending on the proportion of the two oils in the blend. The melting temperature of the blends indicates that the liquidity of oil can be maintained at environments with low ambient temperatures, which is a desired characteristic.

3.8 Sensory Evaluation of PO and SSO Blends

Results of the sensory test on banana chips fried in the blended oils (FIGURE 3a) indicate that the mean scores for crispness, aroma, flavor and overall acceptability (assessed using a 9 point hedonic scale, where 1= dislike extremely and 9= like extremely) are high. The moderate to high frequencies of scores between 5 to 7 for all the sensory attributes is a measure of acceptability by the panelists of the product fried in the oils. No significant differences ($P>0.05$) were found in the sensory attributes across the oil blends. In overall acceptability, the control 100% PO and (90PO:10SSO) oil blend have the same sensory score. Also, for aroma and flavor, scores for the (90PO:10SSO) blend were higher than the other blends. Blend (90PO:10SSO) was found to be closest in degree of liking to the control (palm olein) fried banana chips.

Biplot of the hedonic data (FIGURE 3b) showed the distinction among the oils in the individual attributes tested, as well as, the mean ratings of the banana chips samples for four attributes (crispness, aroma, flavor and overall acceptability). Sample E (90PO:10SSO) blend scored highest in aroma, and flavor while G(70PO:30SSO) had the highest score for crispness and control (100%PO) had the highest score for overall acceptability, although none of the differences were statistically significant.

4. Conclusions

The blend of oils that results from the combination has a good frying and acceptable sensory qualities. As requirements for fat products become more sophisticated, simple blending of natural fats and oils can help to achieve desired characteristics without resorting to drastic methods such as chemical or enzymatic modifications, which often are expensive and time consuming. The advantages of using blending as a means of modifying oils is that it is easy and costs less. More importantly blending oils serves to improve and enhance the nutritional and functional qualities of the oils by combining the good attributes of the two oils into one, by this therefore improving commercial viability.

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Table 1. Color, viscosity and refractive index of original oils and blended oils

Oil sample	Color		Viscosity
	Red unit	Yellow unit	
Palm olein(PO)	0.60±0.28 ^E	9.60±0.57 ^E	78.20±0.17 ^A
90PO:10SSO	1.15±0.21 ^D	9.90±0.14 ^E	77.76±1.10 ^B
80PO:20SSO	1.55±0.21 ^D	10.80±0.28 ^D	76.58±0.71 ^C
70PO:30SSO	2.70±0.14 ^C	12.75±0.35 ^C	76.10±0.16 ^C
60PO:40SSO	3.25±0.35 ^B	14.60±0.57 ^B	73.95±0.16 ^F
Sesame oil (SSO)	8.55±0.21 ^A	16.65±0.49 ^A	69.73±1.46 ^G

Values in the table are means and standard deviations of triplicate analysis.

Mean values within each column followed by different superscript letters

(A, B, C, etc) are significantly ($P < 0.05$) different.

Abbreviations: 90PO:10SSO means PO 90% and SSO 10% (v/v)

80PO:20SSO means PO 80% and SSO 20% (v/v)

70PO:30SSO means PO 70% and SSO 30% (v/v)

60PO:40SSO means PO 60% and SSO 40% (v/v)

Table 2. Fatty acid composition of original and blended oils

Fatty acid ^a	Palm olein	PO90:SSO10	PO80:SSO20	PO70:SSO30	PO60:SSO40	Sesame oil
C _{12:0}	0.13	ND	ND	ND	ND	ND
C _{14:0}	0.91	0.70	0.62	0.53	0.35	ND
C _{16:0}	38.39	35.98	33.13	29.60	27.03	7.96
C _{18:0}	2.49	2.69	3.36	3.75	4.21	5.42
C _{18:1}	45.77	45.68	44.60	43.63	43.36	40.52
C _{18:2}	12.16	14.92	18.24	22.45	25.00	46.03
C _{18:3}	0.10	ND	ND	ND	ND	ND
C _{20:0}	0.06	ND	ND	ND	ND	ND
C _{24:0}	ND	0.02	0.03	0.04	0.05	0.07
FA ratio	0.15	0.18	0.23	0.31	0.36	0.95

ND, not detected

^a FA ratio = $(C_{18:2} + C_{18:3}) / (C_{18:1} + C_{16:0})$

Table 3. Chemical properties of original and blended oils

Oil sample	FFA %	IV g I ₂ /100g oil	PV meqO ₂ /Kg	p-AV	TOTOX value 2PV+ p-AV
Palm olein (PO)	0.18±0.00 ^I	57.13±0.14 ^J	1.99±0.00 ^D	2.37±0.12 ^G	6.35±0.12 ^G
90PO:10SSO	0.25±0.00 ^H	64.38±0.23 ^H	1.98±0.00 ^D	2.42±0.13 ^F	6.36±0.24 ^G
80PO:20SSO	0.37±0.01 ^G	68.51±0.59 ^F	1.98±0.05 ^D	2.68±0.01 ^D	6.64±0.13 ^G
70PO:30SSO	0.53±0.01 ^F	74.27±0.89 ^D	1.98±0.01 ^D	2.88±0.15 ^C	6.84±0.01 ^G
60PO:40SSO	0.65±0.00 ^E	77.55±0.04 ^C	1.98±0.01 ^D	3.04±0.24 ^B	7.00±0.45 ^F
Sesame oil (SSO)	1.25±0.02 ^B	108.41±0.17 ^A	1.98±0.00 ^D	3.72±0.12 ^A	7.68±0.91 ^F

Results in the above table represent the means and standard deviation of triplicate analysis. Mean values within each column followed by different superscript letters (A, B, C, etc) are significantly (P < 0.05) different.

Table 4. Area percent of TAG peaks (PO:SSO)

Sample	MPL	LLL	OLL	PLL	OOL	MMP	PLO	PPL	OOO	POO	PPO	OOS	PSO
PO	2.06	-	-	-	0.39	2.25	14.43	10.14	4.94	31.69	26.89	2.89	4.32
90:10	0.32	1.31	2.77	3.13	3.83	0.39	13.61	8.11	5.64	28.51	25.29	2.97	4.12
80:20	0.29	2.69	5.05	3.73	5.57	0.32	13.56	6.62	6.09	27.94	21.50	2.93	3.71
70:30	0.22	4.62	8.24	4.52	7.65	0.27	13.46	5.40	6.50	25.45	17.65	2.84	3.17
60:40	0.13	5.69	10.03	5.25	9.52	0.24	12.88	5.00	6.85	23.08	15.93	2.56	2.84
SSO	-	13.66	23.22	7.94	18.53	-	11.42	1.26	9.33	5.36	5.87	3.00	0.39

Abbreviations: PO, palm olein; SSO, sesame oil; m, myristic; P, palmitic; S, stearic; O, oleic; L, linoleic.

Table 5. Thermal properties of blended oils

Oil sample	Heating profile			Cooling profile		
	On set	Peak	End set	On set	Peak	End set
PO	-12.43±0.02 ^A	4.78±0.00 ^C	13.63±0.18 ^A	4.36±0.00 ^A	2.92±0.00 ^A	-4.76±0.01 ^D
90PO:10SSO	-18.48±0.04 ^D	6.42±0.00 ^A	12.65±0.01 ^B	3.59±0.00 ^B	0.67±0.00 ^D	-6.31±0.02 ^E
80PO:20SSO	-19.60±0.05 ^E	4.51±0.09 ^C	11.03±0.02 ^C	2.46±0.00 ^D	-0.48±0.00 ^F	-6.99±0.07 ^E
70PO:30SSO	-20.81±0.01 ^F	4.47±0.00 ^C	10.44±0.01 ^D	1.18±0.00 ^E	-0.43±0.00 ^F	-7.38±0.07 ^F
60PO:40SSO	-21.00±0.02 ^G	2.50±0.00 ^D	9.74±0.01 ^E	0.97±0.00 ^F	-1.17±0.00 ^G	-8.31±0.25 ^G
SSO	-26.02±0.09 ^I	-21.49±0.00 ^F	-3.56±0.09 ^F	-6.15±0.00 ^G	-7.58±0.00 ^H	-11.11±0.05 ^H

Values presented are means and standard deviation of triplicate analysis. Mean values within each column followed by different superscript letters (A,B,C, etc) are significantly (P<0.05) different.

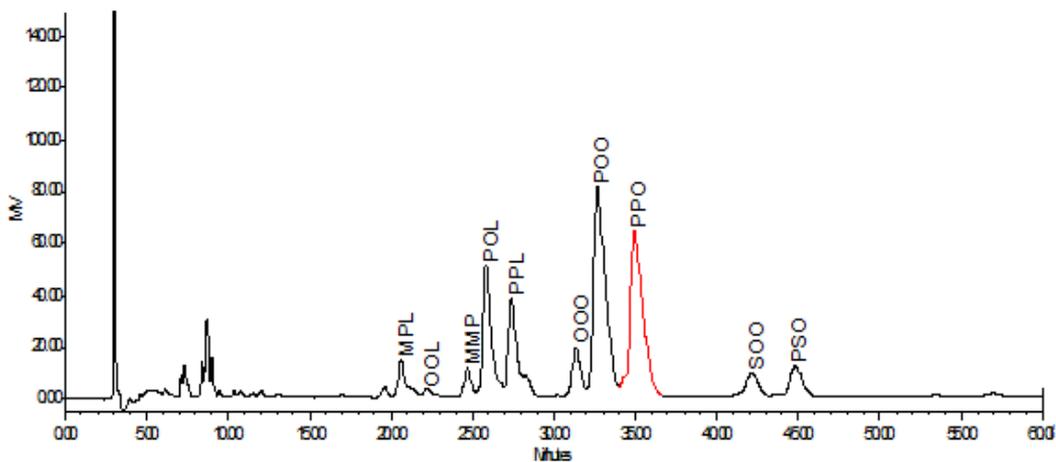


Figure 1a. HPLC chromatogram of palm olein

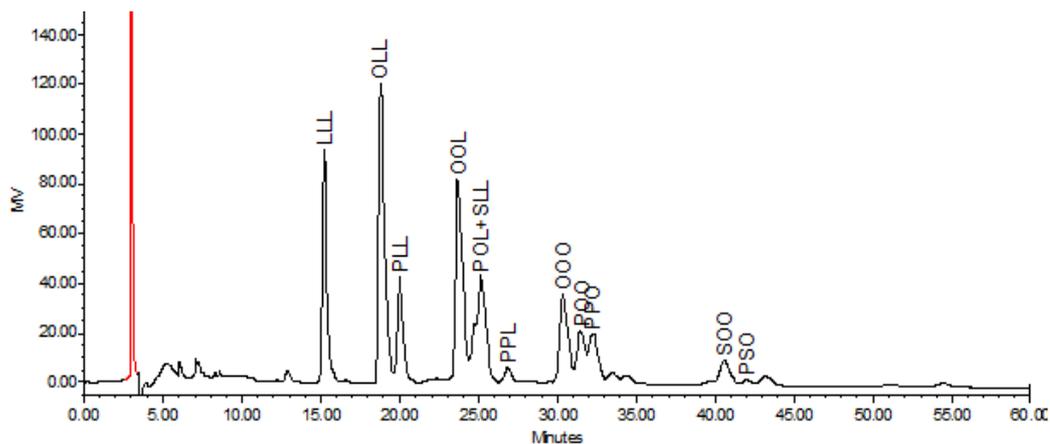


Figure 1b. HPLC chromatogram of sesame oil

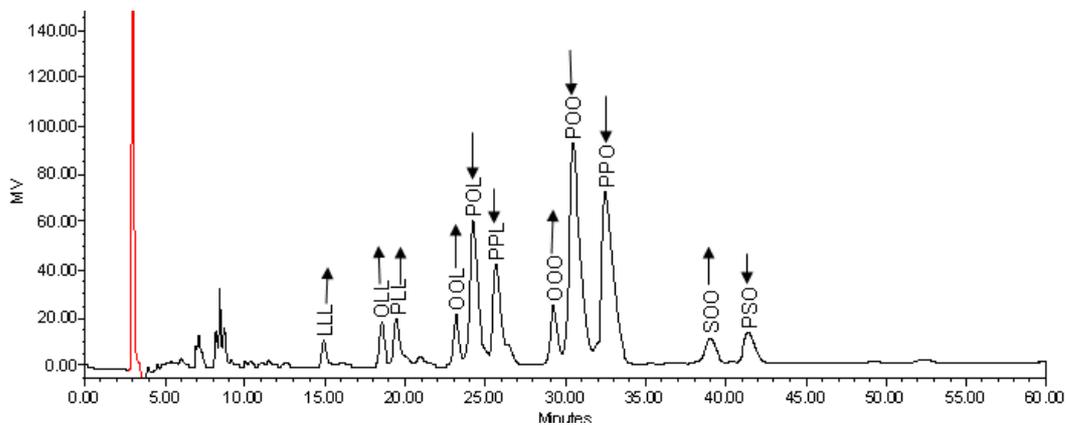


Figure 1c. HPLC chromatogram of 90PO:10SSO

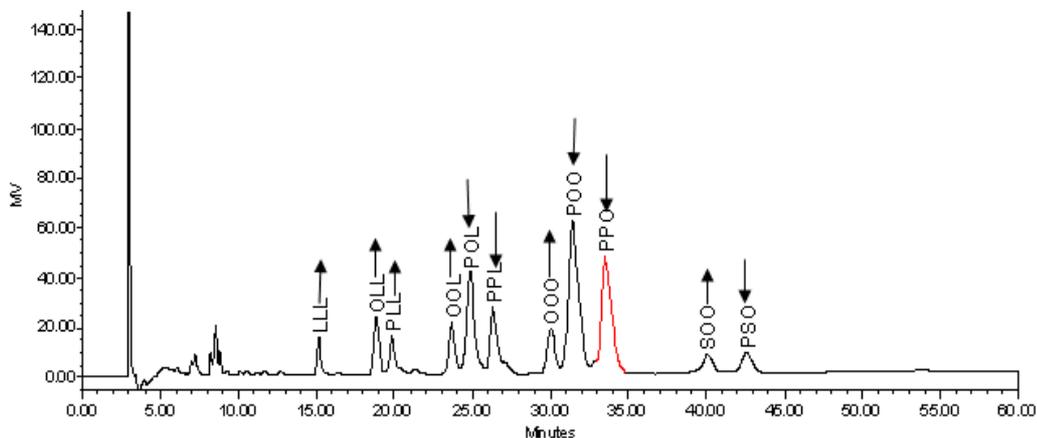


Figure 1d. HPLC chromatogram of 80PO:20SSO

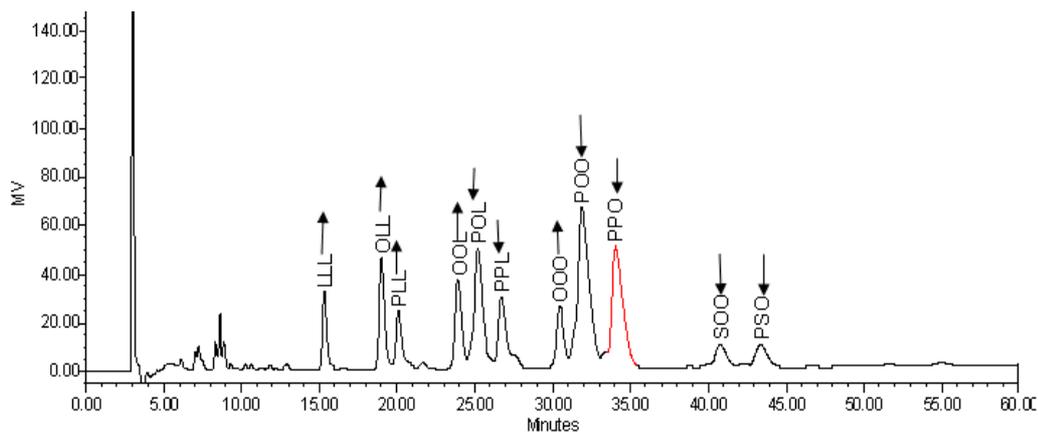


Figure 1e. HPLC chromatogram of 70PO:30SSO

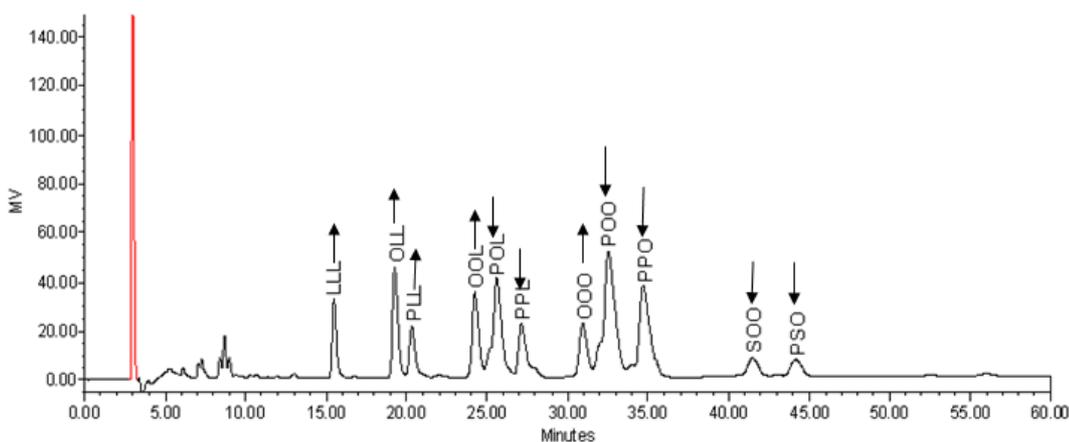


Figure 1f. HPLC chromatogram of 60PO:40SSO

(Abbreviations: Arrow up indicates increases in concentration relative to palm olein while arrow down indicates the opposite trend).

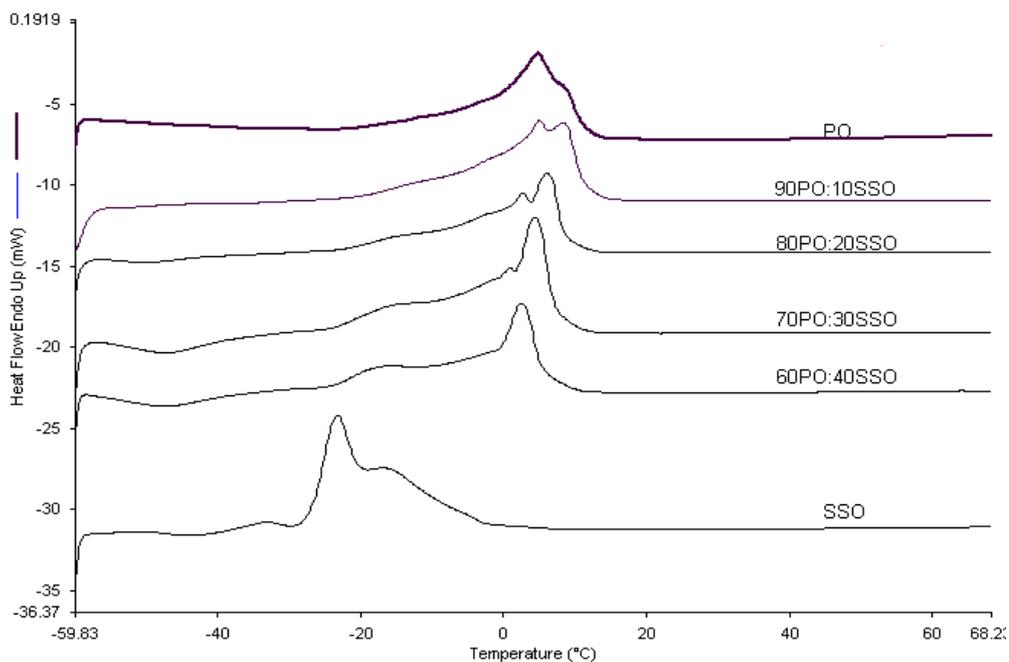


Figure 2a. DSC heating profile of PO and SSO blends

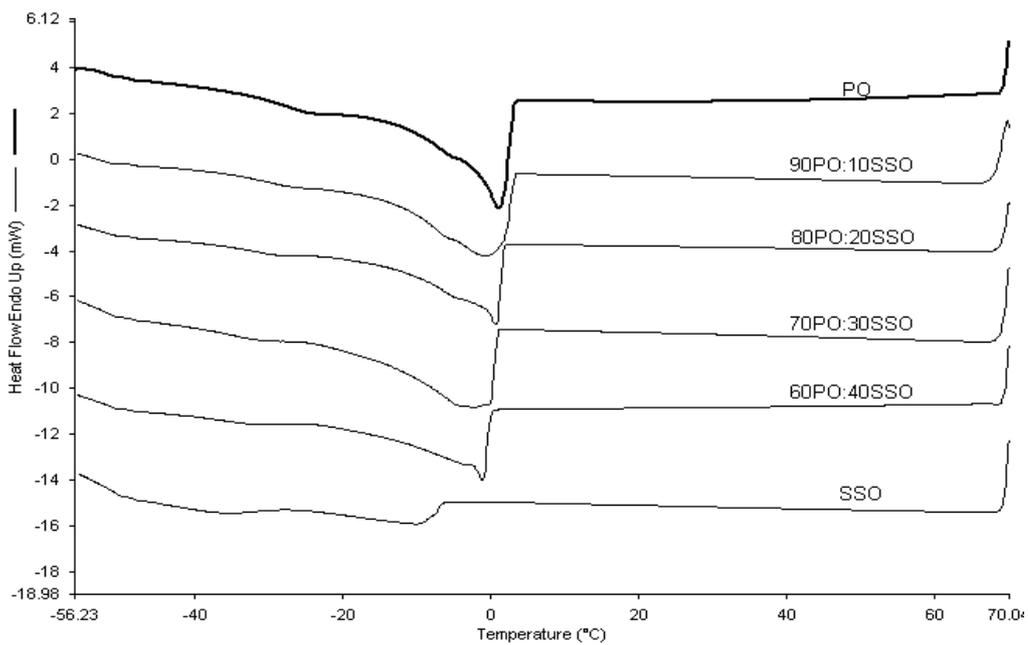


Figure 2b. DSC cooling profile of PO and SSO blends

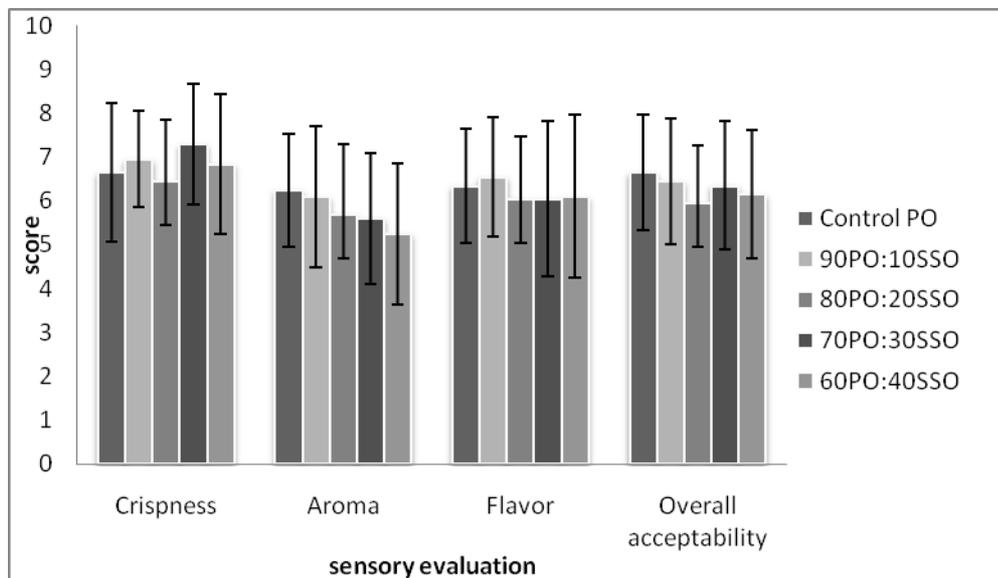


Figure 3a. sensory attributes of PO and SSO blends

(E) 90PO: 10SSO, (F) 80PO: 20SSO, (G) 70PO: 30SSO,
 (H) 60PO: 40SSO, (control) PO

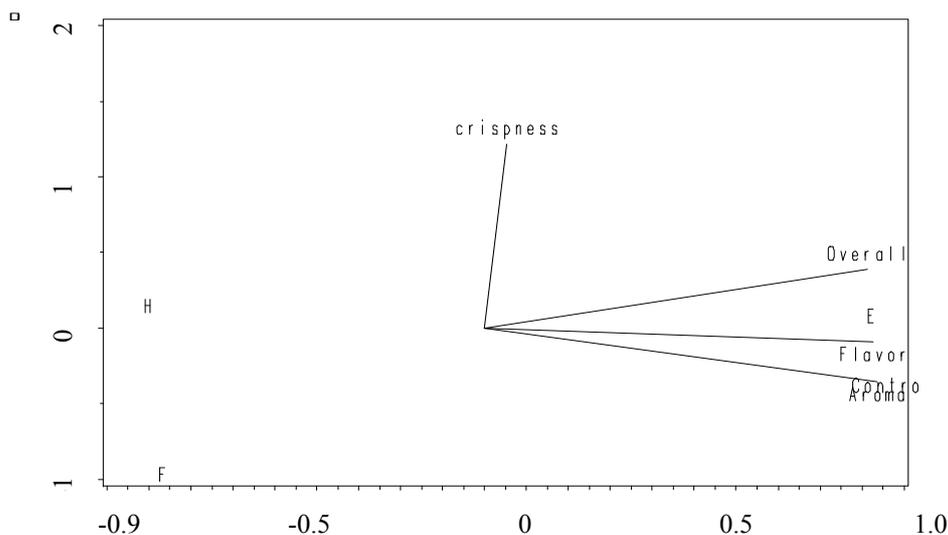


Figure 3b. Biplot of hedonic data; the mean rating by the banana chips sample for 4 attributes. The attribute lines and the 5 banana chips samples with their codes, that is (E) 90PO: 10SSO, (F) 80PO: 20SSO, (G) 70PO: 30SSO, (H) 60PO: 40SSO, (control) PO