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Blending of Milkfat with Refined Palm Oil and its Fractions: Impact on Physicochemical Properties and Fatty Acid Profile

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ABSTRACT: Milkfat has the highest price among all the edible oils and fats and plays a significant role in the economics, nutrition and physicochemical properties of milk and milk products. It can be admixed or replaced with less expensive oils and fats of vegetable or animal origins notably palm oils. Blending of edible fat with vegetable oils is a common practice in many countries to improve the physical and nutritional quality. Milkfat blends with palm oil and its fractions by 1, 2, 5, 10, 20 and 50% (w/w) level were prepared and subjected to various physicochemical analysis. The results showed that total saturated fatty acids were decreased, while oleic and linoleic acids as unsaturated fatty acids were increased in relation to added palm oil. The addition of palm oils caused slight increase in slip melting point, refractive index and red value indicated by Lovibond. Therefore Solid Fat Content (SFC) of oil blends with stearin fractions was higher than both palm oil and milkfat but blends with olein fraction had lower level, while the SFC of oil blends with palm oil was close to pure milkfat.

Keywords: *Fatty Acid Profile, Milkfat, Palm Oil, Palm Olein, Palm Stearin, Physicochemical Properties*.

Introduction

A popular adulteration in edible oils and fats is the replacement of more expensive oils and fats with less expensive ones (Jee, 2002). Such replacement is considered quite profitable for producers (Singer *et al*., 2008). Dairy products have a great and certain position in our diet (Lipp, 1995). Adulteration of milkfat has always been a serious problem due to economic advantages. Because of the high price of milkfat, there is a great temptation to adulterate it with oils with similar fatty acid profiles. It is the task of food monitoring laboratories to uncover such fraud (Precht, 1991). Some procedures in order to reduce production cost replace less expensive vegetable fats as substitutes for milk fat in dairy products (Sutton, 1989; Grummer, 1991; Forcato *et al*., 2004). Today, adulteration is more sophisticated. The situation is more complex when the milkfat is adulterated by addition of plant oil like palm

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oil which is less expensive and readily available. To detect milkfat blending, it is possible to use both major and minor components as detection tool. The most effective ways to detect the presence of foreign fats in milk are by determining the fatty acid composition, the triacylglycerol profile and different fractions of other minor lipid constituents, mainly from the unsaponifiable fraction. Milkfat is one of the highest economic sources of dietary fat. It imparts organoleptic properties such as creamy mouthfeel, buttery aroma, palatability and desirable texture to the food. Nutritionally, milkfat has the highest cholesterol and hypercholesterolemic fatty acids percentage such as myristic and palmetic acids (Rousseau *et al*., 1996). Modification of physical, chemical and nutritional properties of milk fat can be achieved by numerous techniques. Blending and chemical interesterification of fats have been used to modify physiochemical and nutritional properties of natural fats (Rodrigues and Gioielli, 2003). Blending milkfat with vegetable oils can lead to spreads that harmonize nutrition and offer desirable organoleptic attributes as well as lowered overall costs of production (Rousseau *et al*., 1996). Warner and Knowlton (1997) reported that fatty acid profile of milk fat and natural antioxidants can be improved by blending with vegetable oils. Blending milk fat with vegetable oils affected solid fat content. Shen *et al*. (2001) found that the Solid Fat Contents (SFC) of blends (milk fat, hydrogenated coconut and cottonseed oils) were close to the weighted averages of the oil components at temperatures below 15°C. However, from 15 to 25°C, blends of milk fat with hydrogenated coconut oils exhibited SFC lower than those of the weighted averages of the oil components by up to 10% less solid fat. Palm oil is a natural product and has been consumed for many decades. It is now used worldwide in manufacturing of wide varieties of food products, because of its numerous advantageous properties, such as its high thermal and oxidative stability and its plasticity at room temperature (Nor Aini *et al*., 2002; Mamat *et al*., 2005; Wan Rosnani *et al*., 2006). Palm oil and its products are ideally suited to be used in many food product formulations including margarine, soft cheeses, processed cheese, ice cream and milk powder. The use of palm oil can be maximized by employing modification processes such as fractionation, blending, interesterification and hydrogenation (Abdul Azis *et al*., 2011). In addition, palm oil contains a high proportion of palmitic acid (~44%) as well as considerable quantities of oleic (~39%) and linoleic acids (~10%) which give it a higher unsaturated fatty acid content than milkfat. This paper discusses methods for the detection of milk fat purity with an emphasis on physicochemical properties and fatty acid profile because palm oil has particular component which is absent in milkfat. Several methods have been used to check the purity of milkfat. Therefore, this paper discusses methods for the detection using statistical analysis of milkfat blending with an emphasis on chromatographic methods based on fatty acid by GC. Based on this preliminary investigation, the usefulness of this approach could be tested for other oils in the future. These data can be potentially useful in new formulation in about related industries.

This method reveals methods based on parameters like fatty acid composition and the physicochemical constants to detect the differences in pure milkfat with blended samples. Therefore, the aim of this study was to investigate the impact of blending milk fat with refined palm oil on some physicochemical properties and fatty acid profile of blends.

Materials and Methods

- *Materials*

The experimental material consisted of

refined, bleached, deodorized (RBD) palm oil (PO 100%)، palm olein oil (POO 100%) and palm stearin oil (PSO 100%) acquired from Behshahr Industrial Company and Milkfat (MF 100%) was obtained from Vizheh Company. All chemicals and solvents used were of analytical grade unless otherwise specified. The PO، POO and PSO were kept in darkness at 4ºC and melted at 60ºC prior to use. Milkfat was extracted from cream by heating in water bath at temperature of 40ºC for 15 min with the aim to obtain the separation of the fat and water phase. The samples were centrifuged for 15 min at 40ºC and 1400 rpm and the milkfat was collected for other analysis.

- *Preparations of milkfat samples blends with palm oils*

Milkfat and palm, palm olein and palm stearin oil samples were melted at 50ºC until a clear liquid phase was obtained and then were weighted to obtain mixtures at different concentrations of palm oil, palm olein and palm stearin: 0, 1, 2, 5, 10, 20, 50 and 100% (w/w). The blend marked as: PO1, PO2, PO5, PO10, PO20, PO50, POO1, POO2, POO5, POO10, POO20, POO50, PSO1, PSO2, PSO5, PSO10, PSO20 and PSO50.

- *Methods*

The physicochemical properties such as peroxide value, acidity, moisture content, refractive index, slip melting point, iodine value, solid fat content and color were carried out according to AOCS official methods; Cd 8-53, Ca 5a-40, Ca 2e-84, Cc 7-25, Cc 3-25, Cd 1c-85, Cd 16-81, Cc 13e-92 respectively (AOCS, 1997).

The fatty acid compositions of the samples were determined by gas chromatography (GC). The fatty acids were identified by the application of Agilent 6890 Series Gas chromatograph equipment Hp88 and Flame Ionisation Detector according to AOCS method.

- *Statistical analysis*

The experiments were carried out in triplicate order and experiments concerned with the determination of fatty acid by GC were carried out in duplicate and the results were expressed as mean ± standard deviation (SD). The data were analyzed with statistical analysis using the Statistical Package for Social Science program (SPSS 22, USA). Data were calculated and analyzed by a paired sample t-test. Duncan's multiple range tests was used to balance the differences between sample means. Level of significance was defined at $p < 0.05$. Other chemical tests were calculated using the Microsoft excel software (2015).

Results and Discussion

- *Physicochemical analysis*

The physicochemical properties of milkfat, palm oil, palm olein, and palm stearin is presented in Table 1.

Table 1 presents the significant physicochemical values and characteristics of milkfat, palm oil and its fractions. The application of palm oil due to its properties make it an excellent choice for adulteration. Understanding the properties of different palm oils enables full exploitation of usage and application in food products. This study has indicated that palm oils except palm stearin have almost higher refractive index than milkfat sample. The slip melting in palm oil was found to be 33-35ºC quite near to milkfat (32-33ºC). The low melting fraction or olein fraction had melting point of 22ºC whereas the higher melting fraction or stearin had melting point of 53ºC. Palm oil had higher red value as measured by lovibond due to their high levels of carotenoids namely β-carotene. The results have shown that Liquid fraction (olein) had the highest iodine value while the more solid fraction (stearin) had the lowest iodine value but quite nearer to milkfat. The differences in other physical characteristics such as peroxide value, acidity, and moisture content are detailed in

Table 1 and depend on various factors such as methods of packaging or storage of different temperature and extraction procedures. The solid fat content of oil is a measure (in percent) of the amount of solid fat present in the oil at any one temperature. It is measured by means of wide-line nuclear magnetic resonance (NMR) spectrometry after a standard tempering procedure for the sample (Shahidi, 2005).

Tables 2, 3 and 4 show the changes in the physicochemical properties of milkfat blending with 1, 2, 5, 10, 20 and 50 % (w/w) palm oil, palm olein, and palm stearin respectively.

The results of some physicochemical properties of milkfat blends with palm are outlined in Tables 2, 3 and 4.

In terms of refractive index, there are generally no major differences between all blend samples except the by 50% blend.

The slip melting points are present at almost equal levels. The results showed remarkable changes in this property which occurred 50% blending.

Table 1. Major physicochemical properties of milkfat, palm oil, palm olein and palm stearin

Sample/ property	Milkfat (MF)	Palm oil (po)	Palm olein (poo)	Palm stearin (pso)
Peroxide value (meq o2/kg oil)	0± 0.00	0± 0.00	0± 0.00	0± 0.00
Acidity (%)	0.2± 0.00	0.08± 0.00	0.13± 0.00	0.11± 0.01
Moisture Content (%)	0.01± 0.02	0± 0.00	0± 0.00	0.01± 0.01
Refractive index (at 40ºC)	1.4520± 0.00	1.4562± 0.00	1.4564± 0.00	1.4494± 0.00
Slip melting point (ºC)	32.5± 0. 5	34± 1.00	21.83± 0.28	53± 0.00
Color	R:2.9± 0.00	R:4.7± 0.00	R:4.16± 0.05	R:4.2± 0.00
(by Lovibond)	Y:70± 0.00	Y:50± 0.00	Y:50± 0.00	Y:50± 0.00
Iodine value (g/100 g oil)	28.23±2.75	53.05±0.5	55.80±0.46	36.41±0.77
Solid fat content by NMR				
10ºC	48.92± 0.16	48.84± 0.12	38.29± 3.47	69.88± 0.06
20ºC	22.9± 0.12	22.79± 0.03	7.76± 0.75	55.43± 0.23
30ºC	6.72± 0.12	7.98± 0.08	0.17± 0.00	34.65± 0.06
35ºC	1.45± 0.13	4.99± 0.14	0.01± 0.00	27.58± 0.2

* Each value in the Table represents the means± SD of eight analyses from triplicate.
* Colorimetry by lovibond has red value showed by R and yellow value showed by Y.
* Means within each column are significantly ($p < 0.05$) different.

Table 2. Changes in some major physicochemical properties of milkfat blends with 1, 2, 5, 10, 20 and 50% (w/w) palm oil

Sample/ property	PO1	PO2	PO5	PO10	PO20	PO50
Refractive index (at 45ºC)	1.4521± 0.00	1.4521± 0.00	1.4523± 0.00	1.4524± 0.00	1.4529± 0.00	1.4541± 0.00
Slip melting point (ºC)	32.16± 0.11	32.33± 0.05	32.33± 0.05	32.36± 0.11	32.5± 0.00	33.86± 0.11
Color (by Lovibond)	R:2.9± 0.00	R:2.9± 0.00	R:3.1± 0.00	R:3.3± 0.00	R:3.5± 0.00	R:4.1± 0.00
Solid fat content by NMR	Y:70± 0.00	Y:70± 0.00	Y:70± 0.00	Y:70± 0.00	Y:70± 0.00	Y:70± 0.00
10ºC	48.28± 0.9	48.18± 0.87	47.31± 0.61	45.7± 0.1	42.51± 0.61	35.41± 0.4
20ºC	22.70± 0.28	22.48± 0.24	22.12± 0.14	21.82± 0.1	21.35± 0.21	17.69± 0.36
30ºC	6.58± 0.17	6.64± 0.2	6.67± 0.05	6.71± 0.14	6.75± 0.11	6.76± 0.14
35ºC	1.62± 0.1	1.63± 0.13	1.65± 0.17	1.91± 0.13	2.31± 0.1	2.70± 0.2

* Each value in the Table represents the means± SD of four analyses from triplicate.
* Abbreviation: means milkfat has 1,2,5,10,20 and 50 % palm oil.
* Means within each column are significantly ($p < 0.05$) different.

Table 3. Changes in some major physicochemical properties of milkfat blends with 1, 2, 5, 10, 20 and 50 % (w/w) palm olein

Sample/property	POO1	POO2	POO5	POO10	POO20	POO50
Refractive index (at 45ºC)	1.4521± 0.00	1.4521± 0.00	1.4522± 0.00	1.4525± 0.00	1.4529± 0.00	1.4542± 0.00
Slip melting point (ºC)	32± 0.00	31.10± 0.17	30.03± 0.05	28.93± 0.05	26.86± 0.11	26.23± 0.05
Color (byLovibond)	R:2.9± 0.00	R:3± 0.00	R:3.1± 0.00	R:3.2± 0.00	R:3.3± 0.00	R:3.8± 0.00
Solid fat content by NMR	Y:70± 0.00	Y:70± 0.00	Y:70± 0.00	Y:70± 0.00	Y:70± 0.00	Y:70± 0.00
10ºC	48.44± 0.23	48.28± 0.77	45.8± 1	45.09± 2.5	40.74± 0.54	29.96± 0.4
20ºC	22.63± 0.5	21.53± 0.5	21.35± 1.64	20.23± 0.63	18.52± 0.38	12.8± 0.24
30ºC	6.63± 0.22	6.53± 0.48	6.2± 0.1	5.61± 0.16	4.73± 0.18	2.69± 0.18
35ºC	1.43± 0.16	1.2± 0.16	1.17± 0.43	1.01± 0.08	0.37± 0.13	0.2± 0.09

* Each value in the Table represents the means± SD of four analyses from triplicate.
* Abbreviation: means milkfat has 1,2,5,10,20 and 50 % palm olein.
* Means within each column are significantly ($p< 0.05$) different.

Table 4. Changes in some major physicochemical properties of milkfat blends with 1, 2, 5, 10, 20 and 50 % (w/w) palm stearin

Sample/Property	PSO1	PSO2	PSO5	PSO10	PSO20	PSO50
Refractive index (at 45ºC)	1.4521± 0.00	1.4521± 0.00	1.4522± 0.00	1.4523± 0.00	1.4526± 0.00	1.4535± 0.00
Slip melting point (ºC)	31.43± 0.11	31.93± 0.11	32.00± 0.00	32.06± 0.11	34.03± 0.05	42.10± 0.17
Color (by Lovibond)	R:2.9± 0.00	R:2.9± 0.00	R:2.9± 0.00	R:2.9± 0.00	R:3.2± 0.00	R:3.8± 0.00
Solid fat content by NMR	Y:70± 0.00	Y:70± 0.00	Y:70± 0.00	Y:70± 0.00	Y:70± 0.00	Y:70± 0.00
10ºC	48.28± 0.05	48.24± 0.01	47.99± 0.61	47.73± 0.38	47.36± 0.33	43.95± 1.13
20ºC	21.79± 0.22	22.14± 0.46	22.98± 0.45	25.14± 0.05	27.48± 0.25	32.7± 0.43
30ºC	7.05± 0.24	7.31± 0.11	7.98± 0.1	9.77± 0.38	12.29± 0.32	19.60± 0.13
35ºC	1.49± 0.14	1.95± 0.18	2.62± 0.07	4.17± 0.28	6.36± 0.18	13.34± 0.22

* Each value in the Table represents the means± SD of four analyses from triplicate.
* Abbreviation: means milkfat has 1,2,5,10,20 and 50 % palm stearin.
* Means within each column are significantly ($p< 0.05$) different.

The highest change in red value of the color that was carried out by lovibond was shown by the replacement of 50% (w/w) milkfat with 50% (w/w) palm oil, olein and stearin; whereas the replacement of 1 to 10 % exhibited the least changes in color.

The results show that major differences are for levels of 20% and much higher in 50% blending respectively.

The variation of solid fat content carried out by NMR between samples with palm olein revealed that as the temperature increased, from 10ºC to 35ºC the solid fat content decreased.

The change in solid fat content of blended samples with stearin fraction varied and was different from palm oil and olein fractions due to eutectic creation as shown in Table 2.

Besides these properties other major content such as fatty acids, sterols and tocols should be experienced.

- *Fatty acid composition*

One of the first instrumental methods described was the analysis of fatty acid composition using gas chromatography. It is a relatively simple method, although it has certain limitations connected to changes in acid composition, depending on the season of the year and on animal feeding (Heussen *et al*., 2007).

Milkfat has special fatty acid composition which vary by changes in factors such as breed of cow, diet and stage of lactation. Fatty

acid composition can be used to detect vegetable oils and fats with different fatty acid composition in dairy products. However, differences in fatty acid of VOFs and milkfat should be very distinct to be applicable to use as a detection tool (Fox *et al*., 1988; Ntakatsane *et al*., 2013; Ulbert, 1994).

In some cases, it is difficult to use fatty acid composition to detect VOFs such as palm oil in dairy products, because there is similarity in their fatty acid composition and also variation in fatty acid composition of palm oil and milkfat can make the detection of adulteration difficult (Edem, 2002).

The fatty acid composition of milkfat, palm oil and its fractions are shown in Table 5.

The GC chromatograms indicated that the major difference between palm oil and other oils and fats is its higher proportion of palmitic acid in the constituent fatty acids. Palm olein and palm stearin share the same major fatty acids, namely palmitic acid, oleic acid and linoleic acid. However, palm olein has relatively more oleic acids and linoleic and less palmitic acids than does palm stearin.

The fatty acid composition of the oils samples indicated that these oils are highly suitable for milkfat substitution.

The results indicated that the predominant fatty acids in palm oil are palmitic, oleic, linoleic, and stearic acids in respective decreasing order.

Milkfat because of its properties (nutritional value, economics and physical and chemical properties) is one of the most common targets for adulteration.

The fatty acid composition of milkfat may be influenced by several factors, notably diet. As shown in a study carried out milkfat has very low amount of linolenic and linoleic acids. According to the regulation and standards, milkfat should contain 1.0-2.4% linoleic and 0.25-1.1% of linolenic acids. Vegetable fats

Table 5. Fatty acid composition (%) of Milkfat, palm oil and its fractions using GC analysis

Fatty acid composition (%)		Milkfat	Palm oil	Palm olein	Palm stearin
Saturated fatty acids	C4:0 Butyric acid	1.84± 0.57	ND	ND	ND
	C6:0 Caproic acid	1.37± 0.28	ND	ND	ND
	C8:0 Caprilic acid	0.85± 0.21	ND	ND	ND
	C10:0 Capric acid	2.14± 0.19	ND	ND	ND
	C12:0 Lauric acid	2.7± 0.14	0.21± 0.02	0.22± 0.03	0.12± 0.03
	C14:0 Myristic acid	9.49± 0.41	1± 0.00	0.96± 0.08	1.14± 0.06
	C16:0 Palmitic acid	37.86± 0.1	41.9± 0.42	39.57± 0.38	57.81± 0.83
	C18:0 Stearic acid	6.99± 0.15	4.34± 0.07	4.4± 0.42	5.03± 0.38
Monounsaturated fatty acids	C14:1 Tetradecanoic acid	1.12± 0.03	ND	ND	0.1± 0.00
	C16:1 Palmitoleic acid	2.13± 0.1	0.18± 0.02	0.14± 0.06	0.1± 0.00
	Ct18:1 Trans isomers of oleic acid	3± 0.56	0.08± 0.02	0.29± 0.28	0.1± 0.00
	C18:1 Oleic acid	21.73± 2.07	40.61± 0.12	42.6± 0.42	28± 1.13
Polyunsaturated fatty acids	Ct18:2 Trans isomers of linoleic acid	0.53± 0.2	0.25± 0.07	0.35± 0.07	0.2± 0.00
	C18:2 Linoleic acid	3.61± 0.4	9.95± 0.36	10.34± 0.08	6.48± 0.4
	C18:3 Linolenic acid	0.45± 0.07	0.21± 0.02	0.4± 0.28	0.36± 0.33

* Each value in the table represents the means ± SD from duplicate.

contain a high percentage of unsaturated fatty acids (Brat *et al*., 2000; Rodrigues *et al*.,2007; Glew *et al*., 1999; Ledoux *et al*., 2005). One of the most characteristic fatty acids of milkfat is butyric acid (C4:0). The low content of linolenic acid and high proportion of palmitic acid (37.86%) in milkfat might also be taken into consideration.

Milkfat is mainly composed of saturated fatty acids, which are considered to have lower nutritional value than unsaturated fatty acids in milkfat (Sutton, 1989; Grummer, 1991).

As presented in Table 3, the ratio of saturated to unsaturated fatty acid in milkfat was is 1.94 while palm oil is 0.92 these findings are in agreement with values stated in the literature.

A part from the predominant fatty acids in both substrates milkfat showed the presence of short chain fatty acids and tertadecanoic acid, that are absent in palm oils. On the basis of mentioned properties, it is possible to detect the presence of palm origin in dairy product as an adulterant.

As shown in Table 5 milkfat is moderately rich in the monounsaturated and saturated fatty acid particularly palmitic acid (16:0). The composition of the minor fractions defines the genuineness of individual oils and fats along with their respective fatty acid compositions.

In summary changes in fatty acid composition (%) of milkfat samples blended with palm oil and its fractions are summarized in Tables 5, 6, 7, and 8 respectively. In order to simulate blending, milkfat was mixed with palm oil and its fractions in ratios of 1%, 2%, 5%, 10%, 20% and 50%, and GC analysis results of the mixtures were obtained.

When the blending was palm oil, all FA contents except those of lauric acid, myristic acid, and stearic acid decreased; the palmitic acid, oleic acid and linoleic acid contents increased proportionately to the blending level.

The short chain fatty acids (C4:0, C6:0, C8:0 and C10:0) contents were 1.87, 1.37, 0.85 and 2.14% respectively in 100% MF; however, mixtures with 1%, 2%, 5%, 10%, 20% and 50% palm oil contained lower amounts proportional to the blending levels respectively, and tertradecanoic acid content was 1.12 % in pure MF; however this fatty acid was not found in palm oil.

Blending of either palm oil or its fraction with milk fat will have a similar result with respect to the blending ratio.

It should be noted that lauric,palmitic acid in respect of palm oil and short chain fatty acid in case of milk fat can play a key role in the ratio of the blend or mixture.

Kim and co-workers also suggested that milkfat adulteration can be detected through the oleic aci and linoleic acids contents because the commercial MF was richer in short- to medium- chain-length saturated fatty acids than vegetable oils or other fats, significantly ($p > 0.05$). Therefore, it was proposed that myristic acid (C14:0), palmitic acid (C16:0), and stearic acid (C18:0) might be used in detecting MF adulteration (Kim *et al.*, 2015).

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Table 6. Fatty acid composition (%) of milkfat blends using GC analysis

Fatty acid composition (%)		PO1	PO2	PO5	PO10	PO20	PO50
Saturated fatty acids	C4:0 Butyric acid	1.54± 0.05	1.54± 0.02	1.46± 0.04	1.44± 0.15	1.22± 0.17	0.77± 0.03
	C6:0 Caproic acid	1.20± 0.00	1.19± 0.01	1.18± 0.02	1.16± 0.05	1.01± 0.12	0.6± 0.00
	C8:0 Caprylic acid	0.86± 0.02	0.85± 0.02	0.81± 0.02	0.79± 0.00	0.72± 0.08	0.41± 0.01
	C10:0 Capric acid	2.09± 0.01	2.01± 0.1	1.96± 0.15	1.89± 0.08	1.72± 0.11	1.02± 0.11
	C12:0 Lauric acid	2.71± 0.03	2.59± 0.12	2.5± 0.14	2.39± 0.15	2.15± 0.14	1.35± 0.07
	C14:0 Myristic acid	9.49± 0.13	8.96± 0.2	8.89± 0.57	8.40± 0.53	7.53± 0.38	4.86± 0.34
	C16:0 Palmitic acid	37.14± 0.00	37.35± 0.0	37.38± 0.00	38.05±0.01	38.2± 0.00	39.55± 0.07
	C18:0 Stearic acid	6.86± 0.00	6.8± 0.00	6.7± 0.00	6.55± 0.07	6.24± 0.03	5.52± 0.00
Monounsaturated fatty acids	C14:1 Tetradecenoic acid	1.12±0.00	1.05± 0.07	1.02± 0.02	0.98± 0.02	0.9± 0.00	0.53± 0.04
	C16:1 Palmitoleic acid	1.97± 0.00	1.95± 0.01	1.87± 0.00	1.8± 0.00	1.61± 0.02	1.02± 0.03
	Ct18:1 Trans isomers of oleic acid	2.91± 0.12	2.65± 0.06	2.57± 0.04	2.4± 0.00	2.15± 0.2	1.26± 0.08
	C18:1 Oleic acid	20.58± 1.43	21.75± 0.22	22.27± 0.18	22.89± 0.43	24.65± 0.77	31.30± 0.00
Polyunsaturated fatty acids	Ct18:2 Trans isomers of linoleic acid	0.5± 0.00	0.5± 0.00	0.51± 0.02	0.51± 0.15	0.7± 0.00	0.4± 0.00
	C18:2 Linoleic acid	3.6± 0.28	3.7± 0.28	4.13± 0.1	4.19± 0.14	4.98± 0.17	6.98± 0.02
	C18:3 Linolenic acid	0.5± 0.00	0.5± 0.00	0.5± 0.00	0.6± 0.00	0.5± 0.00	0.4± 0.00

* Each value in the Table represents the means ± SD from duplicate.

Table 7. Fatty acid composition (%) of milkfat blends with palm olein using GC analysis

Fatty acid composition(%)		POO1	POO2	POO5	POO10	POO20	POO50
Saturated fatty acids	C4:0 Butyric acid	1.63± 0.07	1.61± 0.1	1.54± 0.06	1.37± 0.1	0.95± 0.21	0.77± 0.1
	C6:0 Caproic acid	1.35± 0.00	1.31± 0.00	1.25± 0.00	1.24± 0.00	0.94± 0.01	0.63± 0.04
	C8:0 Caprylic acid	0.95± 0.00	0.92± 0.00	0.87± 0.00	0.85± 0.00	0.71± 0.02	0.44± 0.05
	C10:0 Capric acid	2.19± 0.00	2.16± 0.00	2.08± 0.00	1.87± 0.1	1.63± 0.04	0.98± 0.11
	C12:0 Lauric acid	2.87± 0.00	2.63± 0.04	2.6± 0.00	2.38± 0.11	2.08± 0.25	1.38± 0.12
	C14:0 Myristic acid	9.64± 0.2	9.44± 0.08	9.09± 0.13	8.55± 0.22	7.62± 0.32	5± 0.28
	C16:0 Palmitic acid	37.54± 0.21	37.61± 0.26	37.73± 0.1	38.06± 0.05	38.49± 0.01	39.01± 0.41
	C18:0 Stearic acid	7.2± 0.14	7.13± 0.24	6.98± 0.16	6.7± 0.00	6.59± 0.15	5.59± 0.14
Mono unsaturated fatty acids	C14:1 Tetradecenoic acid	1.1± 0.00	1.1± 0.00	1.08± 0.02	1± 0.00	0.89± 0.00	0.58± 0.02
	C16:1 Palmitoleic acid	2.14± 0.22	2.1± 0.28	2.08± 0.3	2± 0.28	1.73± 0.24	1.12± 0.11
	Ct18:1 Trans isomers of oleic acid	3.25± 0.35	3.2± 0.28	2.95± 0.07	2.55± 0.07	2.37± 0.03	1.4± 0.00
	C18:1 Oleic acid	21.95± 1.76	22.55± 1.48	22.8± 1.27	24.25± 0.35	26.85± 1.1	33.3± 0.7
Poly unsaturated fatty acids	Ct18:2 Trans isomers of linoleic acid	0.6± 0.14	0.6± 0.14	0.6± 0.14	0.4± 0.00	0.45± 0.07	0.35± 0.07
	C18:2 Linoleic acid	3.6± 0.00	3.75± 0.2	3.88± 0.16	4.35± 0.07	5.24± 0.05	7.2± 0.00
	C18:3 Linolenic acid	0.4± 0.00	0.4± 0.00	0.4± 0.00	0.39± 0.01	0.36± 0.05	0.35± 0.07

* Each value in the Table represents the means ± SD from duplicate.

Table 8. Fatty acid composition (%) of milkfat blends with palm stearin using GC analysis

Fatty acid composition (%)		PSO1	PSO2	PSO5	PSO10	PSO20	PSO50
Saturated fatty acids	C4:0 Butyric acid	1.83± 0.00	1.68± 0.00	1.54± 0.06	1.48± 0.02	1± 0.00	0.4±0.00
	C6:0 Caproic acid	1.42± 0.07	1.33± 0.5	1.28± 0.02	1.16± 0.02	0.89± 0.00	0.41± 0.02
	C8:0 Caprylic acid	1± 0.2	0.87± 0.03	0.86± 0.02	0.8± 0.00	0.71± 0.00	0.34± 0.00
	C10:0 Capric acid	2.18± 0.06	2.14± 0.00	2.09± 0.00	1.85± 0.07	1.55± 0.07	0.9± 0.00
	C12:0 Lauric acid	2.75± 0.07	2.68± 0.02	2.6± 0.00	2.4± 0.00	2.13± 0.5	1.25± 0.07
	C14:0 Myristic acid	9.48± 0.01	9.37± 0.00	9.33± 0.02	8.64± 0.06	7.6± 0.2	5.1± 0.14
	C16:0 Palmitic acid	37.81± 0.07	38.11± 0.00	38.66± 0.01	39.83± 0.23	41.44± 0.00	46.55± 0.07
	C18:0 Stearic acid	7.05± 0.07	6.95± 0.05	6.8± 0.00	6.64± 0.00	6.62± 0.03	6.08± 0.02
Monounsaturated fatty acids	C14:1 Tetradecenoic acid	1.11± 0.01	1.11± 0.01	1.08± 0.02	1.03± 0.02	0.93± 0.02	0.58± 0.00
	C16:1 Palmitoleic acid	1.97± 0.04	1.9± 0.00	1.86± 0.01	1.76± 0.02	1.6± 0.00	1± 0.00
	Ct18:1 Trans isomers of oleic acid	3.35± 0.35	3.35± 0.35	2.9± 0.14	2.7± 0.14	2.3± 0.00	1.4± 0.00
	C18:1 Oleic acid	21.5± 0.28	21.55± 0.21	21.8± 0.14	22.55± 0.07	23.7± 0.00	26.6± 0.00
Polyunsaturated fatty acids	Ct18:2 Trans isomers of linoleic acid	0.5± 0.00	0.6± 0.00	0.6± 0.00	0.62± 0.03	0.6± 0.00	0.3± 0.00
	C18:2 Linoleic acid	3.60± 0.00	3.83± 0.05	3.98± 0.00	4.08± 0.02	4.53± 0.05	6.1± 0.00
	C18:3 Linolenic acid	0.4± 0.00	0.4± 0.00	0.4± 0.00	0.4± 0.00	0.4± 0.00	0.37± 0.03

* Each value in the Table represents the means ± SD from duplicate.

Conclusion

In this study, development of analytical method for detecting milkfat blends with palm oil and its fractions were studied. Chromatographic and physicochemical analyses were capable of providing details of fatty acid composition and quality parameters of blended milkfat. The presence and level of blending can be determined by comparison of milkfat and mentioned oil compositions. The results showed that blending of MF with PO origin can decrease the levels of saturated fatty acids except palmitic acid and also blending decrease the levels of monounsaturated fatty acid except oleic acid, however the concentrations of linoleic acid increase in all blended samples. This work indicated that by increasing the concentrations of palm oil in blending, some properties like slip melting point, refractive index and red value in livibond are increased in all blended samples. This result is more useful for analysis of milkfat content, and it is believed that it can serve as a database for new formulation for dairy industries.

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