Egypt. J. Food. Sci. **Vol. 49,** No. 1, pp. 35-50 (2021)

Egyptian Journal of Food Science
http://ejfs.journals.ekb.eg/

Physico- Chemical Characteristics of Ice Cream Made with Camel Milk Fat Fractions

Marwa M. Desouky
Dairy Unit, Breeding Department, Animal Production Division, Desert Research Center, Matariya, 11753, Cairo, Egypt.

The purpose of this paper is to investigate some quality attributes of camel ice cream (10% fat) prepared by substituting cream with butter oil (BO), solid milk fat fraction (SMF), liquid milk fat fraction (LMF) and SMF: LMF (1:1 v/v) in the mixes. The BO was fractionated by multi-step dry crystallization at 40 and 30ºC to obtain SMF and LMF, respectively. Fatty acids composition and some physical characteristics of the resultant fractions were investigated. All mixes and the resultant ice cream samples were evaluated for their physicochemical, rheological properties and the sensory quality attributes. Results show that the type of milk fat fraction or fat form did not affect pH values, titratable acidity, and surface tension of ice cream mixes while the viscosity was affected ($P \leq 0.05$). The overrun of the ice cream was affected adversely by the viscosity of the mix. Furthermore, the whipping ability decreased gradually with the increasing slip melting point of the fraction used. The use of the SMF in ice cream mix led to decrease adsorption of protein, fat destabilization and characterized by the slowest meltdown of ice cream samples than other milk fat sources. The highest and lowest hardness values were found in ice cream mixes that were made with SMF and LMF, in the same order. In conclusion; ice cream samples could be successfully made by using milk fat fractions in place of cream. However, substitution with the SMF followed by SMF: LMF (1:1 v/v) is recommended in arid and semi-arid zones; improved both whipping abilities, overrun and flavor scores which declined by using LMF in the ice cream mix.

Keywords: Ice cream, camel milk fat fractions, physio-chemical properties, sensory properties.

Introduction

Generally; milk fat has a unique crystallization, melting properties and pleasing flavor which is highly desirable in many food products like ice cream. But milk fat has several attributes that limit its uses. Among these are the negative health aspects represented in the high content of saturated fatty acids, cholesterol, low content poly-unsaturated fatty acids (Rios et al., 2014), and poor spread ability due to its high solid fat content at refrigeration temperature (Micin´skia et al., 2012). A mixture of triacylglycerol with different molecular weights and a wide melting range has been identified with milk fat (Büyükbeşe et al., 2014). This heterogeneity used in many formulations by divide out these different melting components into fractions. Fractionation of milk fat into liquid and solid fractions improves the functional properties of milk fat and expand, its uses in food and dairy processing (Gandhi et al., 2013).

Camel milk is a vital source of nutrients in arid, semi-arid zones and usually consumed either in the fresh or fermented form (Singh et al., 2017). Camel milk fat is characterized by a high content of long-chain unsaturated fatty acids (C14-C18) that decrease risk factors related to cardiovascular diseases. Further, conjugated linoleic acid plays an important role in the preventing of diabetes (Khalil et al., 2011;

*Corresponding author: E-mail: desouky_marwa@yahoo.com
Received: 2/1/2021 ; accepted: 28/1/2021
DOI: 10.21608/EJFS.2021.56225.1089

Mohamed and Mustafa 2016). While, it has a lower content of short-chain fatty acids (C4-C12) compared to cows and goats' milk (Awad et al., 2008; Sunita et al., 2014).

Different types of fractionation processes have been developed, which include melt (German & Dillard, 1998), solvent (Hartel & Kaylegian, 2001), detergent (Rajah, 1996), supercritical fluid extraction (Rizvi & Shankar, 1995) and short path distillation (Campos et al., 2003). Multi-step dry fractionation is the most common process; by this technique; separation of triacylglycerol takes place based on their melting points, offers benefits such as the reasonable cost of scale-up and processing along with the relatively simple equipment required and is more suitable for industrial application due to no risk of solvent residues (Lopez & Ollivon, 2009; Awad et al., 2008; Abd El-Hamid et al., 2019). Multi-step dry fractionation technique was contributing to the concentrate of short-chain and unsaturated fatty acids in liquid milk fat fraction and gradually decreased in middle and high melting fraction (Fatouh et al., 2005; Awad et al., 2008; Abd El-Hamid et al., 2019).

On another view, ice cream has a very complex structure, with a multi-phased system composed of fat globules, air bubbles, and ice crystals that can influence the textural and physical quality attributes of the product (Marshall et al., 2003; Akbari et al., 2019; Hatipoğlu1 & Türkoğlu, 2020). Also, milk fat plays a major function to develop the structure of ice cream, and accountable for the mouthfeel, creaminess, and overall sensation lubricity of ice cream (Adapa et al., 2000; Crilly et al., 2008; Mostafavi et al., 2016; Javidi & Razavi 2018).

The fat content in ice cream is offered primarily by the milk fat, either whole cream, natural butter, anhydrous butter or oil butter (Méndez-Velasco and Goff, 2012). On other hand; ice cream quality depends on numerous factors such as the type and percent of fat and solids non-fat used in the mixture (Syed et al., 2018). Also, the physical properties of the mixture and manufacture methods can influence the texture, physical and sensory properties of the resultant ice cream (Akbari et al., 2016). The important milk fat is its role in building up the texture; impact the flavor, essential in improving meltdown behavior and overall sensations of lubricity of ice cream (Mahdian & Karazhian, 2013).

Although many studies have been conducted on manufacture, developed and evaluated the texture and properties of ice cream using various types of milk, different sources of fat, variety of dairy and non-dairy ingredients (Bahramparvar and Tehrani, 2011; Morais et al., 2014; Karaman et al., 2014; Syed et al., 2018), there is little information on the ice cream made from camel milk using a mixture of cream and solids not fat (Abu-Lehia et al., 1989; Flores & Goff 1999; Salem et al., 2017).

There are inadequate researches existed on using milk fat fractions (Abd El-Rahman et al.,1998; Goff et al., 1988; Abd El-Aziz et al., 2006; Gandhi et al., 2013) while none concerning the use of camel milk fat fractions in ice cream mixture. At refrigeration temperatures, there is always a combine of liquid and crystalline fat within the globules. Consequently, providing suitable solid to liquid ratio fat content at freezing temperatures is important to the configurate of ice cream structure, as crystalline fat is important for partial coalescence (Deosarkar et al., 2016).

Therefore; this study aimed to evaluate the effect of substitution of cream by camel milk fat fractions (obtained by the multi-step dry fractionation technique) in ice cream mixes. The physicochemical, rheological properties and sensory quality attributes of mixes and the resultant ice cream were assayed.

Materials and Methods

Materials

Camel milk was collected from the herd belongs to Desert Research Center at North Western Coastal area, Matrouh, Governorate, Egypt. Bulk milk samples contained 12.53 ±0.14 % total solids, 3.84 ±0.12% fat, 3.56 ±0.10% total protein, 4.31 ±0.02% carbohydrates (by the difference), 0.82±0.001% ash and it had pH value of 6.7 ±0.03. Camel cream (52.60 % total solids and 48% fat) and skim milk (8.85 total solids and 0.4 fat) were mechanically separated from the fresh milk. Cream was traditionally converted to butter oil (BO). Cows' skim milk powder (97% total solids, the product of Dairy America TM), Carboxy methyl cellulose (CMC) as a stabilizer and lecithin as an emulsifier were obtained from BDH Chemical Ltd Poole; England. Commercial grade granulated cane-sugar and vanillin were obtained from the local market at Cairo, Egypt.

Preparation of milk fat fractions

Camel butter oil (BO) was fractionated into solid and liquid fractions by multi-step dry fractionation technique as described by Vanaken et al. (1999). About 1.5 L was placed in a glass double-walled tempering beaker and held at 70°C for 10 min using a circulating water bath (Fisher Model 1013S, Fisher Scientific Inc., Pittsburgh, PA, USA) to destroy all crystal nuclei. While cooling, the sample was continuously stirred with a mixer (McMaster-Carr, Atlanta, GA, USA) consisting of a polypropylene shaft (0.8 cm diameter × 35.1 cm length) with a U shape propeller (6.7 cm diameter). The mixer was attached to laboratory stirrer (Cole-parmer, Chicago, IL, USA) maintained at constant 10 rpm through a variable autotransformer (Staco Energy, Dayton, OH, USA). After 9 hr of total cooling at 30 °C and holding time. The resultant solid milk fat fraction (SMF 30 °C) was separated from the liquid milk fat fraction (LMF 30°C) by centrifugation at 5000 g for 5 min (O'Shea et al., 2000). A similar process was used for fractionation of solid milk fat fraction (SMF 30 °C) at 40 °C resulting in solid milk fat fraction (SMF 40°C) and milk fat fraction (LMF 40 °C). All fractions were stored under freezing till used.

Ice cream preparing procedure

The manufacture of camel ice cream mixture was achieved based on the results of the preliminary study evaluated as an important indicator of potential consumer preferences. It was done by a panel of staff members of the Animal Production Division, Desert Research Center. The best ratios between liquid to solid fat fraction was (1:1 V/V). All ice cream base mixes were prepared according to methods described by Schmidt (2004). Batches of ice cream mixes were prepared to contain 10% fat from different sources (cream, butter oil, liquid melting fraction (LMF) at 30 °C, solid melting fraction (SMF) at 40 °C, LMF: SMF (1:1 v/v). The formula was adjusted to contain 12% milk SNF (fresh skim camels' milk and cow skim milk powder), 15% sucrose, 0.2% CMC, 0.1 % lecithin and 0.1 % vanillin .

Fresh skim milk and melted butter or their fractions were heated to 65 °C/ 5 min in sanitized stainless steel milk cans that were placed in a water bath. During this heating the dry ingredients (skim milk powder, sucrose, stabilizer and emulsifier) for each ice cream mix were weighed mixed and, were added to the liquid ingredients at 45±0.5 °C. All mixes were homogenized at 3000/1500 lb/in2 (stage1/stage2), heated at 81.5ºC and then aged overnight at 4.0±1 °C. Just before freezing in a batch freezer (Taylor, Model, 103), vanillin was added to each mix. The mixes were collected in sanitized stainless steel milk cans and aged quiescently for 24 h at 5 °C. Overrun was checked for all treatments using the weight-volume method (Adapa et al., 2000). The resultant ice cream samples were hardened at –30 °C for 24 h before analysis. Three replicates were made from each treatment

Methods

1-Analysis of camel butter oil and various fractions

Fatty acids methyl esters of camel butter oil and various fractions were prepared according to International Standard (ISO, 2002). Fatty acids methyl esters peaks were identified using Gas Liquid Chromatography (Hewlett Packard Model HP 6890 San Fernando, CA, USA) equipped with a flame-ionization detector and on-column injector. The injector and detector temperatures were 250 and 270 °C, respectively. The temperature programming was as follows; column temperature 90-220 °C; rate at 2 oC/ min, injector temperature 220 °C, and detector temp.240 °C. Gas flow rates were 30, 3 and 300 ml/min for nitrogen, hydrogen, and air, respectively.

The slip melting point, pH values, and specific gravity were determined according to AOCS (2012). Solid fat content (SFC) was measured with a pulsed nuclear magnetic resonance (pNMR) spectrometer (NMS/120; Model Minispec PC/20 BRUKER, USA) operating at 20 MHz. SFC was determined according to the method of the AOCS (2000).

2- Chemical and physico-chemical analysis of ice cream mixes

Total solids, fat contents and pH values of ice cream mix samples were measured according to AOAC (2012). Titratable acidity was determined by titration with NaOH 0.1 N to phenolphthalein endpoint calculated as lactic acid percent according to Arbuckle (1986). Flow time of the mixes were measured as the time seconds required to discharging a 50 mL pipette at 5 °C under atmospheric pressure according to Arbukle (1986). The surface tension of the formulated emulsion was measured according to Arbuckle (1986). A tube of uniform bore is used and the number of drops of the sample falling per time

is compared with that of water. The apparent viscosity (expressed as centipoise, CP.s) was measured at room temperature according to Awad & Metwally (2000) using a Brookfield digital viscometer (Middleboro, MA 02346, USA). All samples were subjected to shear rates ranging from 3 to 100 S-0 for an upward curve with a spindle No.S-0 size 0.15 with a sample volume of 30 ml per run. Apparent viscosity was calculated at shear rate of 48.6 s−1. The freezing point (-°C) of ice cream mixes were also determined according to method of Marshall and Arbuckle (1996). The specific gravity of the ice cream mix and the final frozen product were measured at 20 °C according to Arbukle (1986).

Whipping abilities of the ice milk mix was determined using mixer at speed setting 10 with 3-cm blades (Heidolph N. 50111, Type RZRI, Germany) according to Baer et al. (1999). The mix (150 mL) was placed in a 1-Lstainless steal bowl, calibrated with known volume of water, and placed inside a 2.5 L bowl. An ice and salt mixture was placed between the bowls to cool the mix as it was whipped. Change in volume was rotated at 5, 10, 15 and 20 min.

The adsorbed protein on the surface of fat globules was determined by measuring the protein content (AOAC, 2012; Kjeldahl method: 930.33) of the aqueous phase of ice cream formulas before and after centrifugation (Sigma Laborzentri Fugen, 2 K15, Germany) at 10,350 xg for 30 min at 20 ºC (Casiraghi et al., 2002) and freezing at -30 ºC for 45 min. The adsorbed protein was calculated from the difference between the initial and final proteins of the aqueous phase and expressed as protein load

Protein load (%) = (total protein-serum protein/total protein) *100

3- Physico-chemical analysis of resultant ice cream

The overrun was calculated as mentioned by Muse and Hartel (2004) using the following equation: Overrun = (weight of mix– weight of ice cream)/ weight of ice cream X 100. Melting rate of the resultant ice cream samples was determined as mentioned by Segall and Goff (2002). All ice cream treatments were allowed to melt at room temperature (23±1 °C) and the melted portion was weighed every 10 min. The percent mass loss/min. in the linear region (slope) was used to compare the meltdown rate of different samples.

Fat destabilization index was determined according to Goff & Jordan (1989) by dilution of both mix and melted ice cream samples (1:500 with water) and measurement of turbidity (absorbance) in spectrophotometer at 540 nm.

The hardness of frozen ice cream was measured by adapted the method suggested by Bourne and Comstock (1986) using fruit pressure tester (Penetrometer, mod FT 327). Samples were tempered to -19 °C in chest-type freezer for 24 h before testing. The pounds (Ib/in2) of force required for a cylindrical probe (diameter = 0.8 cm and length = 2.65 cm) to penetrate the sample are a function of the hardness.

evaluation of different ice cream treatments were scored by a panel of 15 staff member of the Animal Production Division, Desert Research Center, Cairo, Egypt, according to Magdoub et al. (1989), for flavor (50 points), body and texture (30 points), appearance (10 points) and melting quality (10 points).

Statistical analysis

Statistical analysis were carried out using the General Linear Models procedure of the SPSS® 16.0 Syntax Reference Guide (SPSS®, 2012) The results were expressed as least squares means with standard errors of the mean. Statistically different groups were determined by the LSD (least significant difference) test ($p \leq 0.05$).

Results and Discussion

Fatty acid composition of camel butter oil and its various fractions

Table 1 depicts the fatty acid composition of the various camel butter oil fractions. Data indicated that, significant differences ($P \leq 0.05$) were found within the fatty acid composition among various fractions. The saturated fatty acids (SFA) were the most abundant among fractions and butter oil (BO). With increasing the fractionation temperature, the long-chain saturated fatty acids (palmitic and stearic) gradually increased, the solid melting fraction (SMF) had the highest contents. Inversely, the unsaturated fatty acids (USFA) decreased ($p \leq 0.05$). Also, the short-chain fatty acids and USFA (oleic and linoleic) migrate to the liquid fractions (LMF) that characterized by the highest values. These findings are supported by Fatouh et al. (2005) Awad et al. (2008) and Büyükbeşe et al. (2017) Among fractions, the ratio of USFA/SFA was highest in LMF followed by LMF: SMF (1:1) and lastly SMF, while camel BO had all-time low (0.471mg/100 mg fat).

TABLE 1. Fatty acids composition (%) of camel butter oil and its fractions.

Fatty acid %	Milk fat forms*			
	BO	LMF	SMF	LMF: SMF (1:1)
Butyric	-	-	-	-
Caproic	$0.41^{B}\pm0.02$	$0.55^{A}\pm0.02$	$0.18^{D}\pm0.01$	$0.34^{C}\pm0.03$
Caprylic	$0.53^{B}\pm0.03$	$0.77^{A}\pm0.04$	$0.26^{C}\pm0.02$	$0.48^{B}\pm0.03$
Capric	$1.52^{A}\pm0.07$	$1.47A^{B}\pm0.06$	$1.54^{A}\pm0.08$	$1.31^{B}\pm0.07$
Lauric	$2.64^{AB}\pm0.09$	$2.54^{B}\pm0.08$	$2.72^{A}\pm0.09$	$1.99^{C}\pm.0.08$
Myristic	$14.49^{A}\pm0.18$	$12.38^{C}\pm0.16$	$13.34^{B}\pm0.17$	$10.98^{D}\pm0.15$
Palmitic	$30.68^{B}\pm0.23$	$26.69^{D}\pm0.21$	$31.02^{A}\pm0.25$	$28.55^{C}\pm0.22$
Palmitoleic	$8.57^{C}\pm0.10$	$10.76^{A}\pm0.14$	$9.12^{B}\pm0.12$	$9.78^{B}\pm0.13$
Stearic	$15.41^{B}\pm0.17$	$14.89^{B}\pm0.16$	$19.25^{A}\pm0.20$	$18.97^{A}\pm0.17$
Oleic	$19.45^{C}\pm0.18$	$23.85^{A}\pm0.20$	$17.86^{D}\pm0.18$	$22.20^{B}\pm0.19$
Linoleic	$2.75^{B}\pm0.08$	$3.47^{A}\pm0.09$	$2.44^{B}\pm0.06$	$2.87^{B}\pm0.08$
α - Linolenic	$1.22^{AB}\pm0.05$	$1.35^{A}\pm0.06$	$0.89^{B}\pm0.04$	$1.24A^{B}\pm0.07$
Arachedonic	$2.31^{A}\pm0.07$	$1.25^{B}\pm0.05$	$1.35^{B}\pm0.06$	$1.27^{B}\pm0.06$
TSC	$0.94^{AB}\pm0.05$	$1.32^{A}\pm0.06$	$0.44^{C}\pm0.04$	$0.82^{B}\pm0.05$
T LC	$99.04^{AB}\pm0.38$	$98.65^{B}\pm0.35$	$99.53^{A}\pm0.40$	$99.16^{A}\pm0.37$
USFA	$31.99^{C}\pm0.24$	$39.43^{A}\pm0.28$	$30.31^{D}\pm0.23$	$36.09^{B}\pm0.25$
SFA	$67.99^{B}\pm0.30$	$60.54^{D}\pm0.29$	$69.66^{A}\pm0.34$	$63.89^{C}\pm0.29$
USFA / SFA	$0.471^{C}\pm0.01$	$0.651^{A}\pm0.02$	$0.435^{C}\pm0.01$	$0.565^{B}\pm0.02$

* BO: Butter oil; LMF: liquid melting fraction (30°C); SMF: solid melting fraction (40°C); TSC: total short chain; TLC: total long chain; USFA: unsaturated fatty acids; SFA: saturated fatty acids.
A, B, C,…: The means with the different capital (A, B,…) superscript letters within the same raw indicate significant ($P \leq 0.05$) differences between butter oil and Milk fat fractions.

Physio-chemical characteristics of camel butter oil and its fractions

Table 2 represents the slip melting point (SMP) of camels' BO and its various fractions. It was observed from the data that, the highest SMP was observed for SMF (45.9 °C) followed by BO (41.7 °C) and LMF: SMF (1:1) while the lowest melting point was observed for LMF (38.8 °C). This might be due to the highest percentages of long-chain fatty acids which are concentrated at SMF (Table, 1).

On the other hand, SMP of LMF was the lowest owing to the decrease in both C 16:0 and C18:0 accompanied by an increase in short-chain fatty acids and long-chain unsaturated fatty acids (C18:1), which have lower melting points (Table 1). Changes in SMP are mainly due to changes that occurred in proportions of palmitic, stearic and oleic acids, which have different melting points (Awad et al., 2008; Fatouh et al. (2005). It is noteworthy that, the substantial differences in the melting properties among fractions are due to that the fractionation process used is based on the different melting points of the triacylglycerol in the mixture and only indirectly on the melting points of individual fatty acids. So, the differences in the slip melting points of various fractions will affect the melting properties of final ice cream.

The melting point of triacylglycerol is a function of the chain length of its three fatty acids residues, their type of unsaturation and their distribution on the glycerol backbone. Our results are in the same trend reported by Awad et al. (2008) and Fatouh et al. (2005); Bindal & Wadhwa (1993); Abbas et al. (2019).

It is noticed from the data given in Table 2 that, specific gravity (Sp.gr) decreased with increasing the slip melting point of the fractions, reaching the lowest value of SMF (0.8979), which has the highest SMP (45.9 °C) that may ascribe to the decrease in its unsaturated fatty acids content (Table 1). Meanwhile LMF had highest Sp.gr value (0.9055). This result could be due to its lowest content of SFA. Also, Sp.gr of inherent BO was close to that found by Hamzawi et al. (1998) and Awad et al. (2008). Differences between fractions may be ascribed to the chain length of fatty acids in the fraction and the content of saturated and unsaturated fatty acids content (Fatouh et al., 2005; Awad et al., 2008).

TABLE 2. Some physical characteristics of camel butter oil and its fractions.

Characteristics	BO	Milk fat fractions*		
		LMF	SMF	LMF: SMF (1:1)
Slip melting point (°C)	41.7^{A}٠,٣٢±	38.80^{C}٠,٢٩±	45.90^{A}٠,٣٥±	40.50^{B}٠,٣٠±
Specific gravity	0.9055^{A}٠,٠٥±	0.9024^{C}٠,٠٤±	0.8878^{D}٠,٠٣±	0.9046^{B}٠,٠٤±
pH	6.62^{B}٠,١٧±	6.63^{A}٠,١٨±	6.62^{B}٠,١٧±	6.63^{A}٠,١٨±

*See foot note Table 1

A, B, C,…: The means with the different capital (A, B,…) superscript letters within the same raw indicate significant ($P \leq 0.05$) differences between butter oil and Milk fat fractions or Temperature, a, b,c,…: The means with the different capital (a, b,…) superscript letters within the same coloumn indicate significant ($P \leq 0.05$) differences between temperatures

The melting point of triacylglycerol is a function of the chain length of its three fatty acids residues, their type of unsaturation and their distribution on the glycerol backbone. Our results are in the same trend reported by Awad et al. (2008) and Fatouh et al. (2005); Bindal & Wadhwa (1993); Abbas et al. (2019).

It is noticed from the data given in Table 2 that, specific gravity (Sp.gr) decreased with increasing the slip melting point of the fractions, reaching the lowest value of SMF (0.8979), which has the highest SMP (45.9 °C) that may ascribe to the decrease in its unsaturated fatty acids content (Table 1). Meanwhile LMF had highest Sp.gr value (0.9055). This result could be due to its lowest content of SFA. Also, Sp.gr of inherent BO was close to that found by Hamzawi et al. (1998) and Awad et al. (2008). Differences between fractions may be ascribed to the chain length of fatty acids in the fraction and the content of saturated and unsaturated fatty acids content (Fatouh et al., 2005; Awad et al., 2008).

The pH values of camels' BO and its various fractions are depicted in Table 2 also. As the fractionation temperature increased, the pH values increased being the lowest value with LMF and it is expected to undergo a faster rate of hydrolysis in LMF than SMF. This is due to the higher ratio of unsaturated fatty acids, which has a great influence on the susceptibility towards hydrolysis to increase the free fatty acids (data not shown) and decrease the pH value. Vis versa SMF had a low amount of unsaturated fatty acids (Table 1), that may be led to decrease the rate of hydrolysis. Same trend reported by Lakshiminarayana & Murthy (1986) and Sagdic et al., (2004). Also, SMF had lowest content of SCFA (Table,1) which make it highly resistant to hydrolysis among all the obtained fractions, as well as the original BO, indicated that it has long keeping quality and stability towards oxidation and hydrolysis (Desouky, 2014). The physical state of the fat greatly influences the rate of hydrolysis, because lipase action is inhibited when fat is in solid state. Therefore, the great resistance exhibited by SMF towards lipolysis may be attributed to its significantly higher content of SFA comparing to LMF. It is well known that, lipase hydrolyzed SCFA triglycerides faster than LCFA triglycerides Fatouh et al. (2005) and Awad et al. (2008).

Solid fat content (g/100 g)

The solid fat content (SFC) is one of the major factors affecting the quality of the product, expecting its performance during storage and transport (Liang et al., 2008). Significant differences ($p \leq 0.05$) in SFC of camel butter oil, fractions were found at all measured temperatures as presented in Table 3. The differences in SFC among fractions are attributed to the modification occurred in the triacylglycerol/fatty acid profile (Table 1) which it affected in their melting points and enthalpies. Same findings are confirmed with Abd El-Rahman et al. (1997) and Awad et al. (2008). Camels' BO and its various fractions (except SMF) melted at 43 °C and attributed the high SMP to the high percentage of solid fat over the entire melting range relative to SMF (data presented in Table 2). These results are in the same trend reported by Bindal & Wadhwa (1993) and Fatouh et al., 2005. As expected, the SFC decreased with the decrease of the fractionation temperature and it decreased with increasing measured temperatures, the SFC increased within the subsequent order: LMF, LMF: SMF (1:1) and SMF. Also, SMF and LMF showed the highest and the lowest SFC, respectively at all measured temperature due to the proportion of SFA and USFA content Table (1) of each fraction. It was obvious that LMF revealed a sharp melting behavior over a melting range from 0 °C to 25 °C.

TABLE 3. Solid fat content (g/100 g) of camel butter oil and its fractions at different temperature

Temperature (°C)	BO	Milk fat fraction form*		
		LMF	SMF	LMF: SMF (1:1)
0	69.85^{Ba}±0.36	60.11^{Da}±0.33	77.50^{Aa}±0.38	65.20^{Ca}±0.32
10	58.19^{Bb}±0.28	52.70^{Db}±0.26	65.55^{Ab}±0.31	57.55^{Cb}±0.26
15	51.80^{Bc}±0.24	40.22^{Dc}±0.16	57.67^{Ac}±0.25	46.22^{Cc}±0.18
20	39.65^{Bd}±0.16	25.40^{Dd}±0.12	49.28^{Ad}±0.19	32.44^{Cd}±0.15
25	26.77^{Be} ±0.13	15.28^{De}±0.10	38.97^{Ae}±0.16	20.09^{Ce}±0.17
30	18.80^{Bf}±0.11	9.45^{Df}±0.07	24.19^{Af}±0.11	13.11^{Cf}±0.09
35	9.03^{Bg}±±0.08	2.86^{Dg}±0.04	17.11^{Ag}±0.16	6.70^{Cg}±0.05
40	2.73^{Bh}±0.04	0.88^{Dh}±0.02	8.80^{Ah}±0.07	1.22^{Ch}±0.01
45	0.99^{Bi}±0.01	-	2.45^{Ai}±0.03	0.50^{Bi}±0.01
50	0.55^{Bi}±0.01	-	1.03^{Ag}±0.02	-

*See foot note Table 2

At 0 °C, the SFC of LMF was the lowest (60.11 g/100 g) with a continual decrease with increasing the measured temperature until the fractions melted entirely (35 ºC). SMF constantly possessed the highest SFC among all the resultant fractions at any given temperature which might due to the higher level of long chain saturated fatty acids (Table 1) and a higher melting point thus led to marked changes in the physical properties comparing with BO and all other fractions that indicating their potential to have a waxy mouth-feel as will presented and discussing in Table 6. Similar results obtained by Dimick et al. (1996) and Hayati et al. (2002).

Physio-chemical properties of ice cream mixes

Table 4 represents the effect of various camels' milk fat forms used in the manufacture of ice cream mixes on the physicochemical properties of the resultant product. No significant differences ($P \leq 0.05$) were observed in the means of total solids contents, pH values and acidity amongst the various mixes as affected with fat source used as shown in Table 4. These values of all treatments are within the normal range reported by Marshall et al. (2003) and Abd El-Aziz et al. (2006).

The specific gravity and weight per gallon (kg) of the ice cream mixes made with liquid melting fraction (LMF) slightly increased compared with the cream sample or other treatments (Table 4). This increase in the specific gravity depends on the formula components as well as mix ability to hold the air pulps and overrun percent within the resultant ice cream (Marshall et al., 2003). Also, the specific gravity of ice cream mixes decreased with increasing slip melting point of the fraction used, which may ascribe to the decrease in the unsaturated fatty acids content with increasing the fractionation temperature. Same observation was confirmed by Fatouh et al. (2005) and Awad et al. (2008).

TABLE 4. Physio-chemical properties of camel ice cream mixes as affected by milk fat forms.

Milk fat forms *	Items									
	Total Solids %	pH	Acidity %	Specific gravity	Weight per gallon (kg)	Freezing point (-˚C)	Flow time (s)	Total protein load (%)	Apparent viscosity (cp) at 48.6 sec^{-1}	Surface tension (dyne)
Cream	36.99^{AB}±0.15	6.43^{A}±0.05	0.24^{B}±0.01	1.1321^{AB}±0.03	4.286^{BC}±0.04	-	79.24^{B}±0.41	69.11^{A}±0.36	1066.82^{B}±8.11	52.22^{AB}±0.28
BO	36.57^{B}±0.14	6.42^{AB}±0.06	0.25^{AB}±0.02	1.1290^{B}±0.02	4.274^{C}±.0.04	-	76.30^{C}±0.36	63.22^{D}±0.35	977.25^{C}±6.24	51.97^{BC}±0.26
LMF	36.50^{B}±0.14	6.40^{B}±0.04	0.27^{A}±0.02	1.1344^{A}±0.03	4.295^{A}±0.05	-	70.12^{E}±0.35	66.58^{B}±0.35	899.44^{E}±5.83	51.45^{C}±0.24
SMF	37.04^{A}±0.16	6.44^{A}±0.05	0.23^{B}±0.01	1.1278^{B}±0.02	4.270^{C}±0.05	-	82.88^{A}±0.42	62.16^{E}±0.32	1122.80^{A}±9.35	52.48^{A}±0.26
LMF: SMF1:1	36.55^{B}±0.14	6.41^{B}±0.05	0.26^{A}±0.02	1.1332^{A}±0.03	4.290A^{B}±0.04	-	73.44^{D}±0.36	64.50^{C}±0.33	938.92^{D}±6.81	51.73C±0.25

*See foot note Table 1

A, B,C,…: The means with the different capital (A, B,…) superscript letters within the same raw indicate significant ($P \leq 0.05$) differences between milk fat / sources

The freezing points of ice cream mixes significantly ($P \leq 0.05$) affected by fat source used in the formula (Table 4). Where, the mixes showed higher freezing points with SMF ice cream mixes. Meanwhile, the low freezing points within the treatments manufacture with LMF may be due to the presence of high ratio of unsaturation fatty acids in this fraction (Table, 1) compared with the control treatment. The obtained results are in line with Marshall et al. (2003).

Values of flow time (s) and surface tension (dyne) significantly affected ($P \leq 0.05$) by the fat source used in the ice cream mixes. Flow time and surface tension of ice cream mixes decreased with decreasing the melting point of the fat source used in the formula being the lowest with LMF (Table 4). This could be attributed to its lower content of solid fat (saturated fatty acids) and higher content of unsaturated fatty acids comparing to SMF flow time (82.88 s) that was similar to found by Abd El-Aziz et al. (2006). Gonzalez et al., (2003) found that the higher content of unsaturated fatty acids (Oleic and Linoleic) than the control milk fat resulted in decreasing the viscosity of the resultant ice cream mix.

Among treatments, solid (SMF 40 ºC) and liquid (LMF 30 ºC) fat fraction used in the ice mixes indicated the highest and lowest viscosity values in the same order (Table 4) and ice cream became less viscous by increasing the liquid fat in the mixes than those formulated with solid fraction at certain rate. The higher saturated fat content of the SMF may have contributed to the higher dynamic viscosity in ice cream containing this fraction which may have been due to the presence of a greater amount of solidified fat in SMF and a difference in fatty acid composition between milk fat fractions used. The solid fat fraction contributed more palmitic and stearic acid than the liquid fraction (Table, 1). The higher levels of saturated fatty acids make the structure of the ice cream more compact as compared to that make with the liquid fraction. Our findings were in agreement with Scott et al. (2003). Also, the viscosity of the mix made with LMF was lower than that made with cream or BO, possibly because of LMF, which contained a higher amount of liquid fat, and, in turn, caused the fat globules to agglutinate during aging (Abd El-Rahman et al., 1997). The mix made with cream characterized by higher viscosity values 1066.82 cp than that made with AMF (977.25 cp), perhaps because of the phospholipids in cream, which act as an emulsifier caused fat crystals to stick together and thereby increased the viscosity of emulsions and increase the viscosity of the mix. These findings agree with those of Keenan et al. (1995); Abd El-Rahman et al. (1997).

Table 4 shows significant ($P \leq 0.05$) differences within the total protein load (%) of ice cream treatments prepared with various fat sources. The lower the melting point of the fraction used, the higher the adsorbed protein on the fat globules. Among treatments the ice cream mixes made with SMF and LMF exhibited the lowest and highest values of adsorbed proteins, respectively. It may be because of the adsorption of proteins to the oil droplet surface is based on the presence of hydrophobic segments of the protein molecule which penetrate to the outer triacylglycerol layers of the oil droplet. The affinity of hydrophobic protein segments to lipids in the liquid state is much stronger than to crystallized lipids which cannot dissolve protein (Windhab & Wildomoser, 2002).

On another hand; whipping ability of ice cream mixes made with different fat fractions is illustrated in Fig.1. A comparison between volumes of ice cream mixes at different times of whipping reveals significant differences ($P \leq 0.05$) amongst the mixes. A substantial increase in the initial volume of all ice cream mixes was observed after whipping for 5 min being the highest volume with LMF ice cream mixes. As whipping continued, the increase in volume diminished, indicating decrease whipping ability and the final volumes after whipping for 20 min did not substantially increased (data not shown). The results obtained could be readily explained by the virtue of the differences ($P \leq 0.05$) in the viscosity of the mixes (Table, 3). As the mixes viscosity increases the resistance to melting and smoothness of texture increases but the rate of whipping decreases. Also, whipping rate is also dependent upon the efficiency of the whipping mechanism and mix processing. Proper homogenization and aging of the mix improve its whipping ability (Marshall et al., 2003). In addition, absorbed protein and whipping ability of ice cream mixes decreased gradually with increasing slip melting point of fraction used (Fatouh et al., 2006). Conversely, the amount of solidified fat was higher in mix made with very high melting fraction (Abd El-Rahman et al., 1997).

Properties of resultant ice cream

The properties of ice cream treatments are illustrated in Table 5. Specific gravity and weight per gallon of ice cream were affected ($P \leq 0.05$) by the fat source used in the manufacture. Both values of specific gravity and weight per gallon decreased with adding the SMF to the ice cream mix compared to the LMF.

It could be due to the melting point of the fraction used, which may responsible for the increase in the saturated fatty acids content with increasing the fractionation temperature. Similar observation was confirmed by Fatouh et al. (2005) and Rezk et al. (2008). Also, the specific gravity of resultant ice cream depends on the form of ingredients used and the ability of mix to retain air bubbles and therefore the overrun percent in the resultant ice cream (Marshall et al., 2003).

Overrun percent was significantly ($P \leq 0.05$) affected by the addition of different fat sources in the mixes (Table 5) and increased by adding LMF as a substitution of cream in the mixture while, it decreased ($P \leq 0.05$) in treatment with SMF. On the other hand, the treatments made with cream characterized by the highest overrun values. Changes in overrun percentages among treatments could be related to the different viscosity values.

A certain level of viscosity in the ice cream mix is needed for proper whipping and retention of air cells. Beyond that level with higher or lower viscosity values, the mix will be poor in whipping and maintenance of air cells, so the overrun will be reduced (Pinto & Dharaiya, 2014; Desouky, 2020). SMF and BO ice cream mixes had a higher amount of saturated fat leads to a very high viscosity level that the air cells cannot be easy to incorporate into the mix during the freezing process. Therefore, lowering the saturated fat in the treatments made by LMF and LMF; SMF (1:1) may help to lower the viscosity to a suitable point and increase the overrun value. Similar results obtained by Abou Zeid et al., (2015); Tekin et al., (2017). Table 5 exhibits that, the time required for freezing ice cream mixes was increased in LMT treatment and this is due to the decrease in freezing point of the mix as shown in Table 4. In contrast, the time required for freezing ice cream mixes was decreased with increasing the ratio of saturated fatty acids as in SMF (Table 1). The decrease in freezing time could be due to the increase in freezing point of the mixes. The obtained results are in line with Marshall et al. (2003); Abdel-Haleem & Awad (2015).

The hardness of ice cream was influenced ($P \leq 0.05$) by the addition of different fat sources in the ice cream mixes as shown in Table 5. The Hardness values of ice creams was in the range of 21.28 to 29.52 (lb/in2) and tended to decrease with increasing the unsaturation fatty acids content of the fraction used. Same findings reported by Abd El-Rahman et al. (1997) and Gonzalez et al. (2003). In addition, differences between treatments may occur because of heat shock, which causes an incomplete thawing and refreezing of the product that, in turn, promotes the growth of ice crystals. During heat shock, the milk proteins and other solids in the mixture may be permanently altered and lose some of their previous water-binding capacity. When this situation occurs, the free water that is produced cannot be totally reabsorbed but remains available for ice crystal growth. This increase in the size of ice crystals results in pronounced coarseness and iciness in ice cream (Abd El-Rahman et al., 1997 and Marshall et al., 2003). The ice cream made with SMF was harder than that made with LMF that had a smoother body and texture. It could be due to the differences in the fatty acids distributions especially SFA (Table 1). Same findings found by Fatouh et al. (2006).

The melting rates of ice cream samples as affected by the addition of different fat forms in the ice cream formulas are depicts in Fig.2 and Table 5. The data reveal a substantial impact of fractions thermal properties on the melting characteristics of the ice cream. As the melting point of the fraction used decreased (LMF) the melting resistance of the ice cream decreased. The differences between the melting rates of the ice creams were significant ($P \leq 0.05$). Ice cream made with SMF exhibited the lowest melting rate (90.5%) while the ice cream made with LMF had the highest one (96.59 %) as presented in Table 5. Also, ice cream made with SMF required more time for the first drop to fall and had a lower melting rate as compared to ice cream made with cream or BO. The trend of the data confirmed other reported studies Abu-Lehia et al. (1989); Im et al. (1994), and Abd El-Rahman et al. (1997).

TABLE 5. Physio-chemical properties of camel ice cream as affected by milk fat forms.

Properties	Milk fat forms*				
	Cream	BO	LMF 30°C	SMF 40°C	LMF:SMF(1:1)
Specific gravity	$0.7814^{B}\pm0.03$	$0.7142^{BC}\pm0.02$	$0.8210^{A}\pm0.3$	$0.6762^{C}\pm0.02$	$0.8042^{A}\pm0.03$
Over run (%)	$69.27^{A}\pm0.36$	$60.72^{D}\pm0.33$	$67.50^{B}\pm0.35$ 35	$58.88^{E}\pm0.32$	$65.20^{C}\pm0.35$
Freezing time (min)	$16.50^{C}\pm0.12$	$15.30^{D}\pm0.11$	19.00A±0.13	$14.00^{E}\pm0.11$	$18.00^{B}\pm0.15$
Weight per gallon (kg)	2.958B$^{C}\pm0.03$	$2.704^{C}\pm0.02$	$3.108^{A}\pm0.03$	$2.559^{C}\pm0.02$	$3.045^{AB}\pm0.03$
Hardness (lb/in2)	$27.69^{B}\pm0.13$	$24.19^{C}\pm0.12$	$21.28^{E}\pm0.11$	$29.52^{A}\pm0.13$	$23.13^{D}\pm0.11$
	Total melting resistance (Loss% after)				
15 min	$2.96^{Cf}\pm0.02$	$3.50^{Cf}\pm0.03$	$5.55^{Af}\pm0.04$	$0.55^{Df}\pm0.01$	$4.60^{Bf}\pm0.03$
min 30	$8.70^{De}\pm0.06$	$9.20^{Ce}\pm0.08$	$13.40^{Ae}\pm0.10$	$4.90^{Ee}\pm0.03$	$11.30^{Be}\pm0.09$
min 45	$22.00^{Dd}\pm0.10$	$27.30^{Cd}\pm0.11$	$35.40^{Ad}\pm0.14$	$16.77^{Ed}\pm0.10$	$32.00^{Bd}\pm0.13$
min 60	$51.00^{Dc}\pm0.30$	$57.60^{Cc}\pm0.31$	$68.30^{Ac}\pm.035$	$47.20^{Ec}\pm0.22$	$63.70^{Bc}\pm0.31$
min 75	$79.60^{Db}\pm0.36$	$84.80^{Cb}\pm0.41$	$90.90^{Ab}\pm0.43$	$73.40^{Eb}\pm0.35$	$88.80^{Bb}\pm0.42$
min 90	$91.70^{Ca}\pm0.44$	$92.28^{Ca}\pm0.44$	$96.59^{Aa}\pm0.45$	$90.50^{Da}\pm0.42$	$93.66^{Ba}\pm0.43$
Fat destabilization index	$1.88^{D}\pm0.01$	$2.55^{C}\pm0.02$	$5.67^{B}\pm0.02$	$0.75^{E}\pm0.01$	$4.20^{A}\pm0.02$

*See foot note Table 1

A, B,C,…: The means with the different capital (A, B,…) superscript letters within the same raw indicate significant ($P \leq 0.05$) differences between differences between Ice cream/ milk fat sources.

a, b,c,…: The means with the different capital (a, b,…) superscript letters within the same column indicate significant ($P \leq 0.05$) differences between total melting resistance.

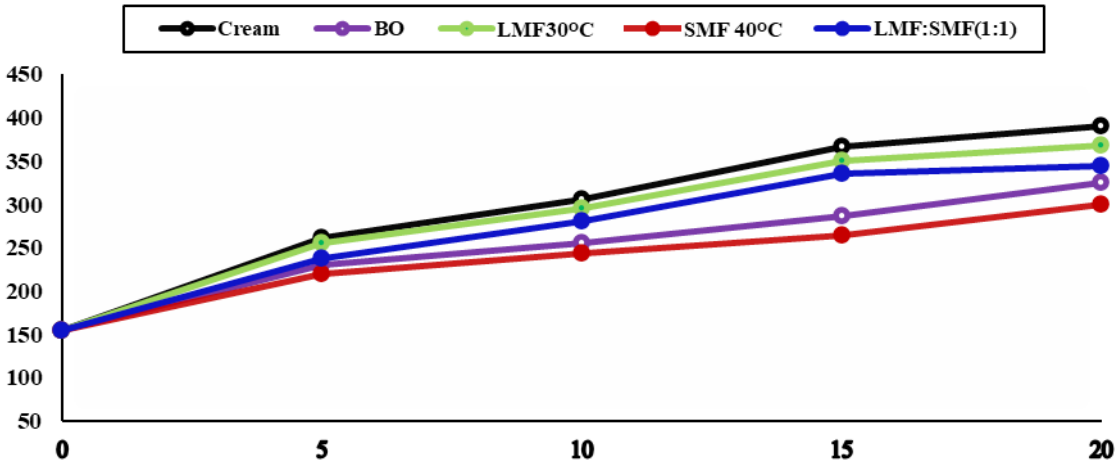

Fig. 1. Whipping ability (ml) of camel ice cream mixes as affected by various milk fat forms.

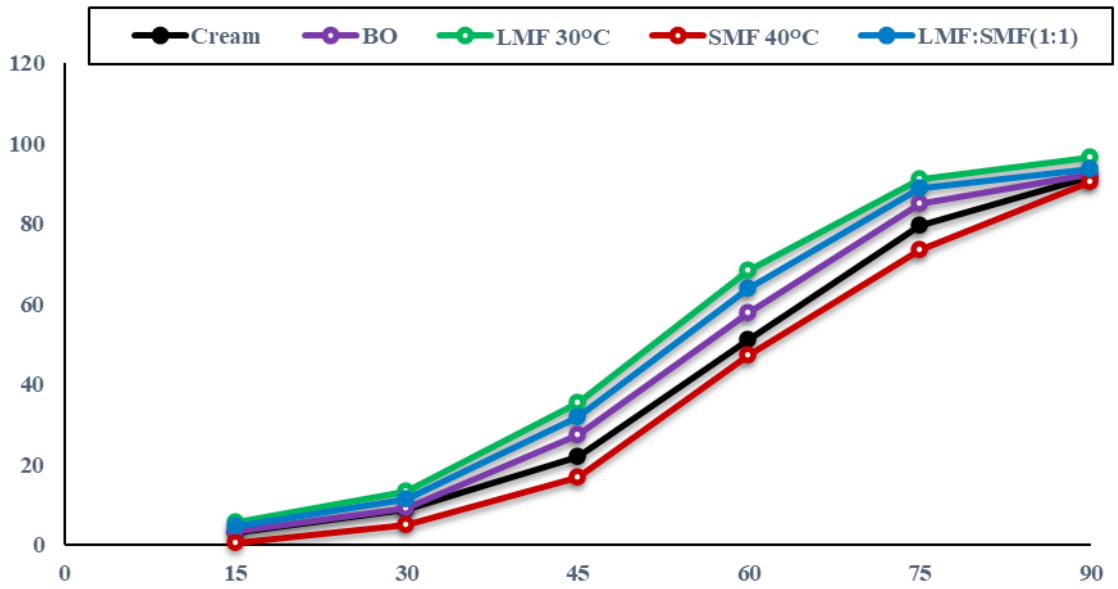

Fig. 2. Melting rates (ml) of camel milk ice cream as affected by various milk fat forms.
BO: Butter oil; LMF: liquid melting fraction (30 °C); SMF: solid melting fraction (40 °C).

Fat destabilization of ice cream was also estimated. The differences in fat destabilization index among ice cream treatments were significant ($P \leq 0.05$) as shown in Table 5. The ice cream made with LMF was characterized with the highest fat destabilization value (5.67%) which was referred to the high liquid fat content (Table, 1) while, SMF treatment gave the lowest (0.75 %) which may be due to that increased the solid fat content in the milk fat globule reduces shear sensitivity by increasing the rigidity of the globule and thus results in less fat destabilization. Conversely, decreased solid fat content increase the susceptibility of the fat globule to broken by the shear forces throughout freezing. Similar results obtained by Adleman & hartel (2002). Also, differing saturated to unsaturated ratios can affect the amount and strength of fat destabilization. The high melting milk fat fractions or solid fraction increase the stability of fat contents. Same finding was reported by (Koxhalt et al., 2001.

Sensory properties of ice cream samples

Results for sensory properties of ice cream as illustrated in Table 6 indicated that the fat source used in the ice cream mixes significantly ($p \leq 0.05$) affects its sensory attributes (appearance, flavor, body, and texture).

The ice-cream treatment made with BO was characterized by smoothness, creaminess, and slightly pale color. Also, the flavor score was highest when cream was the source of fat. The flavor score for ice cream made by SMF was significantly higher than those made by AMF, LMF and LMF: SMF (1:1). This decrease in acceptability was more pronounced in ice cream made with LMF, which had higher unsaturated fatty acids contents as shown in Table, 1. Besides, slight differences were observed for the texture scores of ice creams made with cream or SMF. Also, differences in texture scores between BO or LMF was not significant. These findings were in line with that reported by Abd El-Rahman et al. (1997) and Abd El-Aziz et al. (2006). The substitution of cream with LMF significantly decreased body and texture quality. Among treatments, the mean overall acceptability scores for ice cream made with cream were higher than those for the other treatments. The ice cream made with cream had a smoother body and texture among ice cream treatments. It could be due to its high content of protein load which improve its whipping ability (as shown in Fig.1). Also, the increase in the protein load may be responsible for the increase in the thickness of the protein layer covering the oil droplet, which increases the fat stability (Desouky, 2020).

TABLE 6. Sensory properties of camel ice cream as affected by milk fat forms.

Milk fat / forms*	Sensory properties parameters				
	Appearance (10 points)	Melting quality (10 points)	Body and texture (30 points)	Flavor (50 points)	Total scores (100 points))
Cream	$9.57^{A}\pm0.08$	$9.25^{AB}\pm0.07$	$28.93^{A}\pm0.12$	$48.55^{A}\pm0.26$	$96.30^{A}\pm0.44$
BO	$8.22^{C}\pm0.06$	$8.25^{C}\pm0.06$	$25.88^{BC}\pm0.11$	$46.00^{C}\pm0.24$	$88.35^{D}\pm0.37$
LMF 30°C	$8.00^{C}\pm0.05$	$7.50^{D}\pm0.05$	$25.42^{C}\pm0.11$	$45.50^{D}\pm0.23$	$86.42^{E}\pm0.35$
SMF 40°C	$9.00^{AB}\pm0.08$	$8.80^{BC}\pm0.06$	$28.50^{A}\pm0.13$	$47.65^{B}\pm0.25$	$93.95^{B}\pm0.38$
LMF:SMF (1:1)	$8.55B^{C}\pm0.05$	$8.50^{BC}\pm0.05$	$26.90^{B}\pm0.12$	$46.70^{BC}\pm0.24$	$90.65^{C}\pm0.41$

*See foot note Table 1

A, B,C,…: The means with the different capital (A, B,…) superscript letters within the same raw indicate significant ($P\leq0.05$) differences between differences between Milk fat / sources.

The overall acceptability of ice cream made with SMF was higher than that of ice cream made with AMF, possibly reflecting the flavor acceptability of ice cream samples. The substitution of cream with SMF enhanced the melting properties of the ice cream, in contrast significantly lower the melting quality of the resultant ice cream was occurred when LMF used. The results showed that SMF can be used as a substitute for cream in the ice cream mixes Furthermore, the ice cream became more harden when the SMF was used rather than cream and this is maybe due to the excess in saturated fatty acids (As shown in Table 1) where, the ice cream became less meltable, maintained flavor, improved body and texture more acceptable to panelists, and with slight differences in the color. Also, its high viscosity means hardly moves within the mouth and it may feel sticky on the appetite because of its resistance to movement. However, low viscosity with LMF is easy to move within the mouth, and it may be perceived as watery immediately after the cream has liquefied. Same results stated by Wang et al. (2013).

Conclusion

Generally, it could be concluded that ice cream samples were successfully prepared from different camel milk fat fractions with acceptable sensory quality attributes. The substitution of cream with SMF enhanced the melting properties resulted in firm ice cream, in contrast the melting quality decreased ($P \leq 0.05$) when LMF used. The LMF produces higher fat destabilization than the high melting fraction which is a desirable feature for ice cream structure. Among treatments, substitution with camel butter oil and its fractions was highly recommended in ice cream processing especially for use in arid and semi-arid zones.

References

Abbas; Hayam M., Laila B. Abd El-Hamid, Asker; A. A., Jihan M. Kassem and Salama, M.I. (2019) Bioactive Lipids and Phospholipids Classes of Buffalo and Goat Milk Affected by Seasonal Variations. *American J. Food Sci. & Nutr.,* 1, 2212-7866.

Abd El-Aziz, M., Faten L. Seleet and Hamad, Y.A. (2006). Effect of using liquid milk fat fractions on ice milk properties. *Egyptian J. Dairy Sci.,* 27, 10-18.

Abd El-Hamid, L.B, Abbas, Hayam, M., Asker, A. A. Kassem, J.M., Salama, M.I. (2019) Bioactive-Lipids Distribution in Buffalo Fatty Products. Int. *J. Nutritional Sci. & Food Technol.* 5, 34-42.

Abd El-Rahman, A. M., Shalabi, S. I, Hollender R. and Kilara A. (1997) Effect of milk fat fractions on the sensory evaluation of frozen desserts. *J. Dairy Sci.,* 80, 1936-1940. https://doi.org/10.3168/jds.S0022-0302(97)76134-4

Abd El-Rahman, A.M., Shalabi, S.I., and Kilara, A. (1998) Chemical and physical properties of anhydrous milk fat, low and very high melting milk fat fractions obtained by a commercial fractionation process. *Milschwissenscht,* 53, 77-81.

Abdel-Haleem, A. M. H. and Awad, R. A. (2015) Some quality attributes of low fat ice cream substituted with hulless barley flour and barley ß-glucan. J. Sci. Technology, 52, 6425–6434. https://doi.org/10.1007/s13197-015-1755-x

Abou Zeid, N.A., Zedan, A.N., El-Sisi, A.S. and Ali,A.O.M. (2015) Effect of replacing skim milk

powder (SMP) with chickpea flour on ice milk quality. *Minufiya J. Agriculture,* 40, 1–14. https://doi.org/10.1007/s13197-015-1755-x

Abu-Lehia, I. H., AL-Mohizea, H. S. and El-Behry, M. (1989) Studies on the production of ice cream from camel products. *The Australian J. Dairy Technology,* 44, 31-34.

Adapa, S., Dingeldein, H., Schmidt, K. A. and Herald, T.J. (2000) Rheological properties of ice cream mixes and frozen ice creams containing fat and replacers. *J. Dairy Sci.,* 83, 2224-2229. https://doi.org/10.3168/jds.S0022-0302(00)75106-X

Adleman, R. and Hartel, R.W. (2002) Lipid crystallizationand its effect on the physical structure of ice cream. In: *Crystallization Process in Fats and Lipid Systems*. Grati, N. and Sato, K. (Eds), Marcel Dekker, Inc., NY, USA, pp.329-355.

Akbari, M., Eskandari, M. H., Niakosari, M. and Bedeltavana, A. (2016) The effect of inulin on the physicochemical properties and sensory attributes of low-fat. *International Dairy J.,* 57, 52-55. https://doi.org/10.1016/j.idairyj.2016.02.040

Akbari, M., Eskandari, M.H., Davoudi, Z. (2019). Application and functions of fat replacers in low-fat ice cream: a review, T*rends in Food Science & Technology,* 86, 34-40. https://doi.org/10.1016/j.tifs.2019.02.036.

AOAC (2012) Official Methods of Analysis. Association of Official Analytical Chemists, 19th ed.; Gaithersburg, MD, USA.

AOCS (2000) Official Methods of Analysis of the Association of Official Analytical Chemists' (AOAC) International. 17th ed., Horwitz, H. (ED); (AOAC) International; Gaithersburg, MD, USA.

Arbuckle, W. S. (1986) Ice Cream. 4 th ed. AVI Pub. Co., Inc, Westport, Connecticat, USA, pp. 325–326.

Awad, R.A., Hamzawi, L.F., Marwa M. Desouky and Soryal, K.A. (2008) Oxidative stability and some functional properties of goat and camel milk fat fractions. Annals of Agricultural Science, Cairo, 53, 231-243.

Awad, R.A.and Metwally A.I. (2000) Evaluation of total milk proteinate as a milk solids source in ice cream manufacture. Annals of Agriculture Science Ain Shams University, Cairo, 45, 603–618.

Baer, R.J., Krishnaswamy, N. and Kasperson, K, M. (1999) Effect of emulsifiers and food gum on nonfat ice cream. *J. Dairy Sci.,* 82, 1416-1424. https://doi.org/10.3168/jds.S0022-0302(99)75368-3

Bahramparvar, M, Mazaheri Tehrani M. (2011) Application and functions of stabilizers in ice cream. *Food Reviews International,* 27, 389-407. https://doi.org/ 10.1080/87559129.2011.563399

Bindal, M.P. and Wadhwa, B.K. (1993) Compositional differences between goat milk fat and that of cows and buffaloes. *Small Ruminant Res.,* 12, 79-88. https://doi.org/10.1016/0921-4488(93)90040-O

Bourne, M.C. and Comstock, S.H. (1986). Effect of temperature on firmness of thermally processed fruits and vegetables. *J. Food Sci.,* 51,531–533. https://doi.org/10.1111/j.1365-2621.1986.tb11179.x

Büyükbeşe, D., Rousseau, D. and Kaya, A. (2017) Composition and shear crystallization of milkfat fractions extracted with supercritical carbon dioxide. *International J. Food Properties,* 20, S3015–S3026. https://doi.org/10.1080/10942912.2017.1396476

Büyükbeşe, D., Emre, E.E. and Kaya, A. (2014) Supercritical Carbon Dioxide Fractionation of Anhydrous Milk Fat. *J. American Oil Chemists' Society,* 91, 169–177. https://doi.org/10.1007/s11746-013-2359-0

Campos, R.J., Litwinenko, J. W. and Marangoni, A.G. (2003). Fractionation of milk fat by short- path distillation. *J. Dairy Sci.,* 86,735-745. https://doi.org/10.3168/jds.S0022-0302(03)73654-6

Casiraghi, F.M., Rossi, M. and Bravo, L.(2002) Influence of fat content and mix aging on some chemical and physical characteristics of retail-manufactured ice cream. *Milchwissenschaft,* 57, 149-152.

Crilly, J. F., Andrew, B. R., Andrew, R. C. and Deryck, C. J. (2008) Designing Multiscale Structures for Desired Properties of Ice Cream. *Industrial & Engineering Chemistry Research,* 47, 6362–6367. https://doi.org/10.1021/ie701773z

Deosarkar, S.S., Khedkar, C.D., Kalyankar,S. D. and Sarode, A.R. (2016) Ice Cream: Uses and Method of Manufacture. In*: Caballero, B., Finglas, P. and Toldrá, F. (Eds.). The Encyclopedia of Food and Health,* 3, 391-397.

Desouky, M. M. (2014) Oxidative storage stability of traditional butter oil produced from spontaneous

fermentation of goats' milk. *Egyptian J. Dairy Sci.,* 42, 71-80.

Desouky, M. M. (2020) Improving the texture properties of camels' milk rayeb. *Egyptian J. Food Sci.,* 48, 89–99. https://doi.org/10.21608/ejfs.2020.25124.1043

Dimick, P.S., Reddy, Y.S. and Ziegler, G.R. (1996) Chemical and thermal characteristics of milk-fat fractions isolated by a melt crystallization. *J. American Oil Chemists' Society,* 73, 1674-1652.

Fatouh, A. E., Mahran, G. A., Singh, R. K. and Metwally, A. I. (2006) Effect of incorporating buffalo butter oil fractions on the physical properties of ice cream. *Egyptian J. Food Sci.,* 34, 91-101.

Fatouh, A.E., Singh, R.K., Koehler, P.E., Mahran, G.A. and Metwally, A. E. (2005). Physical, chemical and stability properties of buffalo butter oil fractions obtained by multi-step dry fractionation. *J. Food Chemistry,* 89,243-252. https://doi.org/10.1016/j.foodchem.2004.02.031

Flores, A.A. and Goff, H.D. (1999). Ice Crystal Size Distributions in Dynamically Frozen Model Solutions and Ice Cream as Affected by Stabilizers. *J. Dairy Sci.,* 82, 1399-1407. https://doi.org/10.3168/jds.S0022-0302(99)75366-X

Gandhi, K., Sarkar, P., Aghav, A., Hazra, T. and Lal, D. (2013) Modified Milk Fat and Its Applications in Food Products. Research and Reviews: *J. Dairy Sci. &Technology,* 2, 16-24.

German, J. B. and Dillard, C. J. (1998) Fractionated milk fat: composition, structure and functional properties. *Food Technology,* 52, 33-38.

Goff, H. D., Sherbon, J. W. and Jordan, W. K. (1988) The influence of milk fat crystallization on emulsion stability during ice cream manufacture. *J. Dairy Sci.,* 70, 71-81.

Goff, J.D. and Jordan, W.K. (1989) Action of emulsifier in promoting fat destabilization during the manufacture of ice cream. *J. Dairy Sci., 72,* 18-27. https://doi.org/10.3168/jds.S0022-0302(89)79075-5

Gonzalez, S., Duncan, S.E., O'keefe, S.F. Summer, S.S. and Herbein, J.H. (2003). Oxidation and textural characteristics of butter and ice cream with modified fatty acid profiles. **J. Dairy Sci.,** 86, 70-77. https://doi.org/10.3168/jds.S0022-0302(03)73585-1

Hamzawi, L. F., Mahran, G. A., Askar, A. A. and Akasha, A.E. (1998). Effect of stage of lactation on some physical and chemical properties of camel milk fat. *Proc., the 3rd Saudi Symposium on Food &Nutrition, Riyadh,* Saudi Arabia, 205-215. https://doi.org/10.15192/PSCP.SA.2016.16.2.4953

Hartel, R.W. and Kaylegian, K. E. (2001) Advances in milk fat fractionation: technology and applications. In: *crystallization processes in fats and lipids systems.* Garti, N. and K. Sato (Eds.). Marcel Dekker, Inc., New York, USA, PP. 381-427.

Hatipoğlu1, A. and Türkoğlu, H. (2020). A research on the quality features of ice cream produced using some fat substitutes. *J. Food Sci. & Engineering,* 10, 1-10. https://doi.org/ 10.17265/2159-5828/2020.01.001

Hayati, I. N., Aminah, A., Mamot, S., Aini, I. N., & Lida, H. M. (2002) Physical characteristics of modified milkfat in high-melting fat preparation. *International J. Food Sci. & Nutrition,* 53, 43–54. https://doi.org/10.1080/09637480120057000

Im, J.S., Marshall, R.T. and Heymann, H. (1994) Frozen desert attributes change with increased amounts of fatty acids. *J. Food Sci.,* 59, 1222-1226. https://doi.org/10.1111/j.1365-2621.1994.tb14682.x

ISO (2002) Milk fat preparation of fatty acids methyl esters. International Standard ISO 15884-IDF 182.

Javidi, F. and Razavi, S. M. A. (2018). Rheological, physical and sensory characteristics of light ice cream as affected by selected fat replacers. *J. Food Measurement & Characterization,* 12, 1872–1884. https://doi.org/10.1007/s11694-018-9801-9.

Karaman, S., Ömer, S.T., Ferhat, Y., Mustafa, Ç, Ahmed, K. and Mahmut, D. (2014) Physicochemical, bioactive, and sensory properties of persimmon-based ice cream: Technique for order preference by similarity to ideal solution to determine optimum concentration. *J. Dairy Sci.,* 97, 97–110. https://doi.org/10.3168/jds.2013-7111

Keenan, T. W. and Dylewski, D. P. (1995) Intercellular origin of milk lipid globules and the nature and structure of the milk lipid globule membrane. Page 89 in Advanced Dairy Chemistry. 2nd ed. Vol. 2. Lipids. P. F. Fox, ed. Chapman and Hall, NY.

Khalil, I.E., Muhammad, H.A., Hana, A.A., Inteaz, A. and Taha, R. (2011) Comparison and characterization of fat and protein composition for camel milk from eight Jordanian locations. *Food*

Chemisty, 127, 282–289. https://doi.org/10.1016/j.foodchem.2010.12.112

Koxhalt, M.M.R., Eisenmann, B. and Hinrichs, J. (2001). Effect of the fat globule sizes on the meltdown of ice cream. *J. Dairy Sci.,* 84, 31–37. https://doi.org/10.3168/jds.S0022-0302(01)74448-7

Lakshiminarayana, M. and Murthy, M. K. (1986) Cow and buffalo milk fat fractions. Part Ш: Hydrolytic and autoxidative properties of milk fat fractions. *Indian J. Dairy Sci.,* 39, 251-255.

Liang, B., Shi, Y. and Hartel, R.W. (2008) Correlation of rheological and microstructural properties in a model lipid system. *J. American Oil Chemist. Socity,* 85, 397–404. https://doi.org/10.1007/s11746-008-1213-2

Lopez, C. and Ollivon, M. (2009) Triglycerides obtained by dry fractionation of milk fat 2. Thermal properties and polymorphic evolutions on heating. *Chemistry & Physics of Lipids,* 159, 1-12. https://doi.org/10.1016/j.chemphyslip.2009.02.009

Magdoub, M. N. I., Hammad, Y. A. and Yassen, M. M. (1989) Effect of vegetable oils on plain ice cream properties. *Egyptian J. Food Sci.,* 19, 9-15.

Mahdian, E. and Karazhian, R. (2013) Effects of Fat Replacers and Stabilizers on Rheological, Physicochemical and Sensory Properties of Reduced-fat Ice Cream. *J. Agricultural Sci. & Technology,* 15, 1163-1174.

Marshall, R.T. and Arbuckle, W.S. (1996) Ice cream 5th ed. Indian diet Prof Int Soy protein food conf., Chapman and Hall, Int, Thomson Pub.USA, pp70

Marshall, R.T., Goff, H.D. and Hartel, R.W. (Eds.) (2003) *Ice cream;* kluwer Academic/ plenum Publisher, NY, USA.

Méndez-Velasco, C. and Goff, H. D. (2012) Fat structures as affected by unsaturated or saturated monoglyceride and their effect on ice cream structure, texture and stability. *International Dairy J.,* 24, 33-39. https://doi.org/: 10.1016/j.idairyj.2011.11.009

Micin´skia, J., Grzegorz, Z., Ireneusz, M. ,Kowalski, J. S. , Bogusław, P. and ski , J. R. (2012) The effects of bovine milk fat on human health. *Polish Annals of Medicine,* 19, 170–175. https://doi.org/10.1016/j.poamed.2012.07.004

Mohamed, E. and Mustafa, A. (2016) Fatty acids content in milk of dromedary camel (Camelus dromedarius) from farming and pastoral systems in Sudan. *International J. Sci. & Research,* 5, 570-573.

Morais, E. C., Cruz, A. G. and Bolini, H. M. A. (2014) Development of chocolate dairy dessert with addition of prebiotics and replacement of sucrose with different high-intensity sweeteners. *J. Dairy Sci.,* 97, 2600–2609. https://doi.org/10.3168/jds.2013-7603

Mostafavi, F. S., Tehrani, M. M. and Mohebbi, M. (2016) Rheological and sensory properties of fat reduced vanilla ice creams containing milk protein concentrate (MPC). *J. Food Measurement & Characterization,* 11, 567–575.

Muse, M.R. and Hartel, R.W. (2004). Ice cream structural elements that affect melting rate and hardness. *American Dairy Sci. Association,* 87, 1–10. https://doi.org/10.3168/jds.S0022-0302(04)73135-5

O'Shea, M.; Devery, R., Lawless, F., Keogh, K. and Stanton, C. (2000) Enrichment of the conjugated linoleic acid content of bovine milk fat by dry fractionation. *International Dairy J.,* 10, 289-294. https://doi.org/10.1016/S0958-6946(00)00049-2

Pinto, S. and Dharaiya, C.N. (2014) Development of a low fat sugar free frozen Dessert. *International J.Agriculture Science,* 4, 90–101.

Rajah, K.K. (1996). Fractionation of Fat Separation Processes in the Food and Biotechnology Industries: principles and Applications. pp. 207-210. Grandison A.S. and M. J. Lewis (Eds). Lancaster, PA, USA.

Rios, R.V., Ferreira, M. Eibel, D., Pessanha1, F., DeAlmeida1, P. Viana1, C.L., da silva lannes, S. C. (2014) Application of fats in some food products. *Food Sci. Technology, Campinas,* 34, 3-15. https://doi.org/10.1590/S0101-20612014000100001

Rizvi, S.S.H. and Bhaskar, A.R. (1995) Supercritical fluid processing of milk fat:Fractionation, scale-up and economics. *Food Technology,* 49, 90-100.

Sagdic, O., Donmez, M. and Demirci, M. (2004). Comparison of characteristics and fatty acid profiles of traditional Turkish yayik butters produced from goats', ewes' or cows' milk. *Food Control.* Elsevier Science LTD, Oxford, UK. 15,485-490. https://doi.org/10.1016/j.foodcont.2003.07.003

Salem, S.A. , Fardous, M. Meead, G. and El-Rashody, H. (2017) Effect of Camel Milk Fortified with

Dates in Ice Cream Manufacture on Viscosity, Overrun, and Rheological Properties during Storage Period. *Food & Nutrition Sci.,* 8, 551-564. https://doi.org/ 10.4236/fns.2017.85038

Schmidt, K.A. (2004) Dairy: Ice cream. Food processing – Principles and applications; Blackwell publishing: Ames, IA, pp. 287-296. https://doi.org/10.1002/9780470290118.ch15

Scott, L. L., Duncant, S. E., Sumnert, S. S. and Watermant, K. M. (2003) Physical properties of cream reformulated with fractionated milk fat and milk-derived components. *J. Dairy Sci.,* 86, 3395-3404. https://doi.org/10.3168/jds.S0022-0302(03)73943-5

Segall, K. I. and Goff, H, D. (2002). A modified ice cream processing routine that promotes fat destabilization in the absence of added emulsifier. *International Dairy J.,* 12,1013-1018. https://doi.org/10.1016/S0958-6946(02)00117-6

SPSS (2102). Statistical Package for Social Science. SPSS Inc. (SPSS v.18), 233 South Wacker Drive, 11th Floor, Chicago, IL, USA.

Sunita, S., Rajput, Y.S. and Sharma, R. (2014) Comparative fat digestibility of goat, camel, cow and buffalo milk. *International Dairy J.,* 35,153–156. https://doi.org/10.1016/j.idairyj.2013.11.009

Syed, Q.A., Anwar, S., Shukat, R., Zahoor, T. (2018) Effects of different ingredients on texture of ice cream. *J. Nutritional Health & Food Engineering,* 8, 422-435. https://doi.org/10.15406/jnhfe.2018.08.00305

Tekin, E., Serpil, S. and Gulum, S. (2017) Physicochemical, rheological, and sensory properties of low-fat ice cream designed by double emulsions. *European J. Lipid Sci. & Technology,* 119, 1-9. https://doi.org/10.1002/ejlt.201600505

Vanaken, G.A., Ten, E., Grotenhuis, A. J., Langevelde, V. and Schenk, H. (1999) Composition and crystallization of milk fat fractions. *J. American oil chemists' Society,* 76, 1323-1331. https://doi.org/10.1007/s11746-999-0146-8

Wang, C., He, X., Huang, Q., Fu, X. and Liu, S. (2013) Physicochemical properties and application of micronized cornstarch in low fat cream. *J. Food Engineering,* 116, 881–888. https://doi.org/10.1016/j.jfoodeng.2013.01.025

Windhab, E.J. and Wildomoser, H. (2002). Extrusion: A novel technology for the manufacture of ice cream. In: New processing technologies for the future. *Proceeding of emerging technologies conference,* IDF world dairy summit 2001. IDF Bulletin No, 374, 43-49.

الخصائص الفيزوكميائية للمثلجات القشدية المصنعة باستخدام شقوق دهن لبن الابل

مروه محمد دسوقي عبد الجليل

مركز بحوث الصحراء- القاهره- مصر

تهدف هذه الدراسة إلى دراسه امكانيه تصنيع الايس كريم (01٪ دهن) من لبن الابل باستبدال القشده في مزيج الآيس كريم بدهون اللبن اللامائية (FMA) وشقوق الدهن الصلبة (FMS) ، السائله (FML) وخليط من الشقوق الصلبة والسائلة بنسبة 1:1 ، تم تجزئة دهون اللبن اللامائية عن طريق التبلور الجاف متعدد الخطوات للحصول على الشقوق المختلفه (FMS ، FML). تم دراسه تركيب الأحماض الدهنية وبعض الخصائص الفيزيائية للشقوق الناتجة .كذلك تم تقييم الخصائص-الفيزيائية والكيميائية والريولوجية وخصائص الجودة الحسية للخلطات وللآيس كريم الناتج. أظهرت النتائج ما يلي: أن استخدام شقوق الدهن لم يؤثر على قيم الأس الهيدروجيني ، الحموضة ، التوتر السطحي لخلطات الآيس كريم بينما تأثرت اللزوجة بدرجة معنوية ($P \geq 50.0$) كما تأثر قوام الآيس كريم عكسياً باللزوجه. ايضا تتناقص الريع تدريجياً مع زيادة نقطة الانصهارلشق الدهن المستخدم في خلطه الايس كريم. أدى استخدام الشقوق الصلبة في مزيج الآيس كريم إلى خفض الـnoitazilibasted taF ومعدل الانصهار مقارنه بالشقوق الاخري. أظهرت النتائج ايضا ان أعلى وأدنى قيم صلابة في خلطات الآيس كريم كانت التي تم تصنيعها باستخدام FMS و FML بنفس الترتيب.مما سبق يتضح امكانيه تصنيع الآيس كريم بصفات جودة حسية عالية مع زيادة نسبة الريع باستخدام شقوق دهن لبن الابل كمصدر للدهن. لذلك ، يوصى بالاستبدال بـ FMS متبوعًا بـ FML :FMS (v /v) في المناطق القاحلة وشبه القاحلة التي لايتوافر بها القشدة الطازجة .