Modification of fatty acid profile of cow milk by calcium salts of fatty acids and its use in ice cream

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Abstract This study was conducted to determine the effect of calcium salts of fatty acids (CSFA) on fatty acid profile of milk of “Sahiwal” cows and suitability of milk with modified fatty acids in the formulation of ice cream. Fatty acid profile of cow milk was modified by feeding CSFA to eighteen randomly stratified “Sahiwal” cows of first and early lactation divided into three groups. CSFA were offered at two different levels i.e. T_1 (150 g per cow per day) T_2 (300 g per cow per day) both treatments were compared with a control (T_0) without any addition of calcium salts of fatty acids. Iso caloric and iso nitrogenous feeds were given to both experimental groups and control. Concentrations of short chain fatty acids in T_0 , T_1 and T_2 were $9.85 \pm 0.48a$, $8.8 \pm 0.24b$ and $7.1 \pm 0.37c$ %, respectively and the concentrations of C18:1 and C18:2 increased ($P < 0.05$) from $27.6 \pm 1.32b$ % to $31.7 \pm 1.68a$ % and $2.15 \pm 0.09b$ % to $2.79 \pm 0.05a$ %, respectively, at T_2 level. Incorporation of milk fat of T_1 and T_2 (modified fatty acids profile) in ice cream did not have any adverse effect on pH, acidity and compositional attributes of ice cream. Viscosity of T_1 was $67.94 \pm 3.77a$ as compared to (T_0) control $68.75 \pm 2.46a$ (CP). Firmness of experimental samples and control were almost similar ($P > 0.05$) overall acceptability score of T_2 was $7.1 \pm 0.28b$ out of 9 (total score) which was more than 78 ± 2.92 %. It was concluded that CSFA may be successfully incorporated up to T_2 level (300 g per cow per day) into the feed of “Sahiwal” cows to produce milk with higher content of unsaturated fatty acids and it may be used in the formulation of ice cream with acceptable sensory characteristics and increased health benefits.

Keywords Calcium salts of fatty acids · Ice cream · Fatty acids · Melting time

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Introduction

Milk fat is one of the most important functional ingredient in ice cream and responsible for desirable physico-chemical and sensory characteristics (Adhikari and Aurora 1994). Milk fat is characterized by higher content of saturated fatty acids (65–68 %) which have many health risks (McSweeney and Fox 2003). Myristic and lauric acids are atherogenic, and increase the risk of cardio vascular disease by increasing blood cholesterol and low density lipo proteins while oleic, linoleic and linolenic are beneficial for health and increase the beneficial HDL cholesterol (Mathur et al. 1999). Milk is a risk factor for coronary heart disease because of higher content of saturated fatty acids (Tavani et al. 2002). Cardio vascular disease is the biggest global cause of death for mankind, with an estimated 17 million deaths per year, which are predicted to reach 25 millions by the year 2020. It is the number one cause of deaths in the U.S., U.K., Australia and Europe (BHF 2005). The World Health Report estimated that 85 % of the deaths in low and middle-income countries are due to cardiovascular disease (EHN 2005). One in every three persons over the age of 45-years suffers from hypertension (Nishtar 2002). Milk fat composition may be altered by means of feeding and it is possible to significantly increase the content of unsaturated fatty acids and bioactive compounds through manipulation in feeding regime (Ashes et al. 1992). These strategies include enrichment of the feed stuffs with vegetable oils or oil seeds for example canola, soybeans, sunflower, linseeds, calcium salts of fatty acids etc. (AbuGhazaleh and Holmes 2009). Microbial activity in the rumen causes bio hydrogenation of unsaturated fatty acids. Calcium salts of fatty acids (CSFA) may be used as viable protection of unsaturated fatty acid from rumen bio hydrogenation and transesterification (Moate et al. 2004). Present study was designed to find out the effect of CSFA on fatty acid profile of “Sahiwal” cows and suitability of milk with modified fatty acids in the

formulation of ice cream on the basis of some physico-chemical and sensory attributes.

Materials and methods

Raw materials Calcium salts of fatty acids (CSFA) were procured from Millac, Karachi, feed ingredients were obtained from grain market of District Okara, skim milk powder, glycerol mono stearate, sunset yellow color, vanilla flavor and cane sugar were procured from market of Lahore.

Animals feeding Eighteen *Sahiwal* cows of first and early lactation were randomly divided into three groups at Livestock Production Research Institute Bahadur Nagar, Okara and were randomly assigned to two different treatments in a completely randomized design. Each group was comprised of 6 cows managemental practices, drinking water facility, number of stalls, barn conditions etc. were same for each group. CSFA were fed at two different levels i.e. T₁ (150 g per cow per day) T₂ (300 g per cow per day) both treatments were compared with a control (T₀) without any addition of CSFA. Iso caloric and iso nitrogenous feed was given to each group (Table 1). Milk samples were collected after 14-days of adjustment period, milk of morning and evening were proportionately mixed for fatty acid profile analysis and ice cream manufacturing.

Manufacturing of ice cream Ice cream was manufactured by following the formulation of Potter and Hotchkiss (1998). Milk was passed through the cream separator (APV) to separate the milk into fat (35 %fat) and skim milk. This experiment was involved in the manufacturing of three different types of ice creams i.e. T₁, from milk of cows fed with CSFA at the rate of 150 g per cow per day, T₂, from milk of cows fed with CSFA at the rate of 300 g per cow per day, T₀, from milk of cows fed on normal concentrate i.e. without

calcium salts of fatty acids. Formulation of all types of ice cream was comprised of 10 % fat, 11 % milk solids not fat, 15 % sugar and 0.5 % stabilizer and emulsifier. Vanilla flavor and color was added at the rate of 1 mL/l mix in all the treatments and control. Each treatment was replicated three times.

Analysis Fatty acids profile was determined as fatty acid methyl esters, 300-μL melted and well mixed sample was taken into 11-mL screw capped test tube, dissolved in 3-mL isooctane and 2-mL 1.5 N sodium methoxide was added vortexed at higher speed for exactly 3-min, allowed to separate for 5 min and the supernatant was injected into Gas Chromatograph model Shmidzu, Japan 17-A, fitted with a methyl lignoserate-coated (film thickness 0.25 l m), SP-2330 (SUP ELCO Inc. Supelco Park Bellefonte, PA 16823–0048, USA) polar capillary column (30 m×0.32 mm) using flame ionization detector as per of Sukhija and Palmquist (1988). Fat, protein and total solids were determined by using the respective protocols as prescribed in AOAC (2000) (method# 984.15, 991.20, and 990.19). Ash content was determined by following the method of Morris (1999) pH and acidity of milk were determined by following the methods of Ghatak and Bandyopadhyay (2007). The viscosity readings were taken after ageing the mix at 4 °C for 24 h. The overrun was determined as per method of Potter and Hotchkiss (1998).

Sensory evaluation The ice cream samples were frozen to –18 °C for 2 h before serving. All the samples were coded with a 3 digit random numbers and servings were fully randomized. Ice cream was evaluated for color, taste, firmness and overall acceptability. The sensory evaluation of triplicate samples was carried out by a panel of five trained judges using 9-point Hedonic scale (1-the worst; 9-the best) as stated by Larmond (1987).

Statistical analysis The statistical analysis of the data (triplicate replicate of each treatment) was conducted by analysis

Table 1 Composition of feed administered for *Sahiwal* Cows

Ingredients	T ₀ (Control)	T ₁	T ₂
Cotton Seed Cake%	45	44	48
Calcium Salts of Fatty Acids %	–	150 g per day	300 g per day
Maize Gluten 60 %	10	8	7
Maize Grains Broken %	10	22	13
Wheat Bran%	15	15	20
Rice Polishing%	7	12	–
Molasses%	11	7	–
Mineral Mixture%	2	2	2
Total %	100	100	100
Crude Protein %	17.7	17.09	17.49
Metabolizable Energy	2.71	2.76	2.78

T₁: 150-g CSFA/Cow/Day

T₂: 300-g CSFA/Cow/Day

T₀: Control

of variance technique as prescribed by Steel et al. (1997) by using completely randomized design and significant difference among the treatments was made by using *T*-Test.

Results and discussion

The results of Table 2 showed that feeding CSFA significantly ($P<0.05$) decreased the concentrations of short chain fatty acids at T_1 and T_2 level (150 and 300 g CSFA per cow per day). Concentrations of short chain fatty acids (C4 to C10) decreased from $9.8\pm0.48a$ % to $8.7\pm0.24b$ % and $7.1\pm0.37c$ % in T_1 and T_2 , respectively. Decrease in short chain fatty acids at T_1 and T_2 was 10.9 ± 0.21 % and 28.0 ± 0.35 %, respectively. The probable reason for lower concentrations of short chain fatty acids in the experimental samples was due to the presence of higher concentrations of long chain fatty acids (oleic acid 44 % and linoleic acid 9.5 %) in CSFA which significantly contributed in this phenomenon. The concentration of atherogenic acids; lauric and myristic was decreased by 48.14 ± 0.35 and 8.6 ± 0.15 %, respectively at T_2 level. Feeding CSFA decreased ($P>0.05$) the concentration of cholesterol from 34.15 ± 0.11 to 10.89 ± 0.05 mg/100 mL which was 68.11 % less than the control. Fahey et al. (2002) studied the effect of feeding CSFA on cholesterol content of milk and reported that about 60 % was decreased when cow's ratio in was augmented with CSFA. Similar findings were described by Abu-Ghazaleh et al. (2001) and Whitlock et al. (2002). CSFA are commercially manufactured from the deodorizer distillate obtained during refining of vegetable oils (palm oil, soybeans, sunflower oil, canola etc.) and has higher

concentrations of long chain fatty acids (Fereidoon 2005). Elliott et al. (1996) investigated the role of calcium salts of palm fatty acids in the modification of fatty acid composition of milk of Friesian cows and reported that augmentation of feed with CSFA at 300 g/cow/day significantly ($P<0.05$) lowered the concentrations of short chain fatty acids and momentarily increased ($P<0.05$) the content of long chain fatty acids of milk. Palmquist et al. (1993) studied the effect of rumen by pass fat on milk fat composition and recorded an increase in the concentration of long chain fatty acids. Feeding calcium salts of fatty acid increased ($P<0.05$) the content of long chain fatty acids at both T_1 and T_2 level (150 and 300 g CSFA per cow per day). The concentrations of C18:1 and C18:2 greatly increased ($P<0.05$) from $27.69\pm0.05b$ % to $31.67\pm1.68a$ % to and $2.15\pm0.09b$ % to $2.79\pm0.05a$ %, respectively at T_2 level (CSFA-300 g per cow per day). Fahey et al. (2002) while studying the effect of CSFA on milk fatty acid profile of Holstein-Friesian cows reported that augmentation of CSFA momentarily increased ($P<0.05$) the concentrations of long chain fatty acids in the milk. Similar results were reported by (Griinari et al. 1999; Abu-Ghazaleh et al. 2001 and Whitlock et al. 2002). Ashes et al. (1992) investigated the effect of formaldehyde treated canola seeds on fatty acid composition of milk and found that concentrations of C16:0, C14:0 and C12:0 was momentarily ($P<0.05$) lower than control and the content of mono-unsaturated fatty acids in milk was increased by 54 %. The momentous increase in monounsaturated fatty acid was attributed to the higher concentrations of oleic acid in canola seed (54–58 %). Tymchuk et al. (1998) incorporated heated canola seeds into the feed of cows and observed that palmitic acid was decreased by 15 % and oleic acid was increased by 14 % in milk.

Table 2 Effect of Different Levels of calcium salts of fatty acids on selected fatty acids of milk of "Sahiwal" cows

	Fatty Acid Cows (n)	To 6	T_1 6	T_2 6
C4:0	(Butyric Acid)	$3.5\pm0.38a$	$3.2\pm0.45b$	$2.6\pm0.17c$
C6:0	(Caproic Acid)	$2.3\pm0.14a$	$2.1\pm0.23b$	$1.1\pm0.09c$
C8:0	(Caprylic Acid)	$1.2\pm0.11a$	$1.1\pm0.18b$	$0.9\pm0.24c$
C10:0	(Capric Acid)	$2.6\pm0.23a$	$2.3\pm0.31b$	$1.9\pm0.32c$
Short Chain Fatty Acids (%)		$9.6\pm0.24a$	$8.7\pm0.48b$	$7.1\pm0.37c$
C12:0	(Lauric Acid)	$2.7\pm0.28a$	$1.9\pm0.12b$	$1.4\pm0.19c$
C14:0	(Myristic Acid)	$9.3\pm0.99a$	$9.1\pm0.83b$	$8.5\pm1.25c$
C16:0	(Palmitic Acid)	$25.9\pm2.34c$	$27.1\pm1.95b$	$30.7\pm3.46a$
Medium Chain Fatty Acids (%)		$37.9\pm1.34b$	$38.1\pm0.68b$	$40.6\pm0.39a$
C18:0	(Stearic Acid)	$14.3\pm1.26a$	$12.7\pm1.68b$	$11.8\pm1.96c$
C18:1	(Oleic Acid)	$27.6\pm2.88c$	$30.5\pm3.49b$	$31.7\pm2.64a$
C18:2	(Linoleic Acid)	$2.1\pm0.45c$	$2.3\pm0.08b$	$2.7\pm0.15a$
C18:3	(Linolenic Acid)	$0.7\pm0.07a$	$0.5\pm0.11b$	$0.2\pm0.09c$
Long Chain Unsaturated Fatty Acids (%)		$30.4\pm0.23c$	$33.3\pm0.11b$	$34.5\pm0.36a$

Means of triplicate experiments; Means sharing same letter in a row are statistically non significant at 0.05 level of significance by Tukey's *T*-Test

Non Significant ($P>0.05$)

Significant ($P<0.05$)

Refer to Table 1 for To, T_1 and T_2

From the results of Table 3 it is evident that milk with modified fatty acids profile did not have any significant effect on compositional attributes, pH and acidity of ice cream. pH and acidity of control and T₂ (300 g CSFA per cow per day) was 6.65, 6.73 and 0.17, 0.18 %, respectively. The non significant variation ($P>0.05$) in the compositional attributes of the ice cream was probably due to the care taken in formulation, identical manufacturing process and identical formulation. Nadeem et al. (2010) investigated the effect of high oleic rape seed oil on quality of ice cream and reported non significant variation in composition, pH and acidity among all the experimental samples and control. Abdou et al. (1996) studied the influence of palm kernel oil on physico-chemical characteristics of ice cream and did not observe significant variation ($P>0.05$) in composition of ice cream. Abdullah et al. (2003) reported that pH of ice cream samples, prepared by replacing skim milk powder with soya milk was in the range of 6.7 to 6.71. pH and acidity are good parameters for the quality assessment of dairy products, indirectly represents the microbiological quality of dairy foods. Lower pH values indicate higher bacterial load,

poor customer acceptability and keeping quality. Fat contributes in flavor and body of ice cream, also concentrated source of energy and one of the main energy providers in ice cream. US standards describe that ice cream should contain at least 10 % fat (Guinard et al. 1996), thus the results of this study are in line with US regulations. Protein in ice cream is directly associated for the holding of air molecules during the whipping process and also confer useful contribution in body and texture of ice cream. Ice cream should contain at least 3.28 % protein for reasonable texture and acceptable sensory characteristics (Keller et al. 1987). The protein content of all the samples and control are more than the said limit of 3.28 %.

Viscosity of ice cream is related with aeration process, higher the viscosity of mix, better would be the entrapment of air (Potter and Hotchkiss 1998). Control sample exhibited the highest values of viscosity (68.75 ± 2.46 a CP) which progressively decreased from T₁ to T₂ (67.94 ± 3.77 a to 62.39 ± 1.52 b CP). Viscosity of control and T₁ were at par with each other ($P>0.05$). Control has higher concentrations of saturated fatty acids while T₁ and T₂ have higher concentrations of unsaturated fatty acids. Viscosity greatly depends upon the ratio of solid to liquid fat (Kaylegian and Lindsay 1995). Saturated fatty acids have higher melting point than unsaturated fatty acids, higher proportions of long chain fatty acids means fats would have lower melting point (Fereidoon 2005). Modified milk fat (containing higher concentrations of unsaturated fatty acids) have lower solid fat index which is of great importance for the physical properties of ice cream mix (Gonzalez et al. 2003). Viscosity also depends upon the ingredients and processing conditions, type of fat globules and interaction with stabilizer and major ingredients especially sugar. Im and Marshall (1998) in an attempt to incorporate unsaturated fatty acids in ice cream replaced milk fat with canola and soybean oils and reported lower values of viscosity in experimental samples than the control and attributed it to lower contents of saturated fatty acids and higher contents of unsaturated fatty acids in ice cream mix. Nadeem et al. (2010) recorded lower viscosity when milk fat was partially replaced with high oleic rape seed oil in low fat ice cream.

As can be seen from the results of Table 3 that addition of modified milk fat (obtained from cows fed on CSFA; 150 and 300 g CSFA per day per cow respectively) in ice cream decreased overrun at both T₁ and T₂ levels. Overrun of T₂ (75.2 ± 1.91 b %) was significantly ($P<0.05$) less than control (80.65 ± 3.36 a %) while overrun of T₁ (79.4 ± 2.87 a) was not different from the control. The decline in overrun of the experimental samples could be attributed to the higher concentrations of long chain unsaturated fatty acids and lower proportions of saturated fatty acids. Nadeem et al. (2010) incorporated oleic acids in ice cream through high oleic rape seed oil and observed a significant decline in overrun of the

Table 3 Effect of modified fatty acids on quality characteristics of ice cream

Parameters	Treatments		
	T ₀	T ₁	T ₂
Chemical Composition			
Fat%	9.7±0.25a	9.8±0.38a	9.9±0.17a
Protein%	3.9±0.27a	4.0±0.52a	4.1±0.31a
Ash%	0.7±0.15a	0.7±0.22a	0.7±0.19a
Total Solids%	36.5±0.10a	36.4±0.10a	36.2±0.10a
pH	6.6±0.25a	6.7±0.37a	6.7±0.42a
Acidity%	0.17±0.08a	0.16±0.03a	0.18±0.04a
Physical Characteristics			
Viscosity (Centi Poise)	68.7±2.46a	67.9±3.77a	62.3±1.52b
Overrun%	80.6±3.36a	79.4±2.87a	75.2±1.91b
Melting Time	16.5±0.72a	16.2±1.26a	15.3±0.35b
Sensory Characteristics			
Color	7.8±0.65a	7.5±0.80a	7.6±0.45a
Taste	7.6±0.52a	7.1±0.18b	6.4±0.11b
Firmness	7.8±0.25a	7.5±0.29a	7.4±0.34a
Overall acceptability	7.6±0.24a	7.4±0.08a	7.1±0.28b

Means of triplicate experiments; Means sharing same letter in a row are statistically non significant at 0.05 level of significance by Tuckey's *T*-Test Non Significant ($P>0.05$)

Significant ($P<0.05$)

Refer to Table 1 for T₀, T₁ and T₂

Melting Time: minutes

ice cream. Tong (1984) studied the suitability of sunflower oil in ice cream and recorded lower values of overrun as compared to control. Rodriguez et al. (1991) while studying the impact of corn oil on quality of ice cream observed lower values of overrun with increasing increments. The overrun of ice cream should be 70 to 100 % Potter and Hotchkiss (1998). The overrun of T_2 was more than the lower prescribed limits. Abdullah et al. reported overrun of ice cream prepared from skim milk and soya milk blends in the range of 80–82 %. Siddique et al. (1988) used guar gum as stabilizer in the formulation of ice cream and observed that values of overrun ranged from 74–85 % at different concentrations of the stabilizer. Thus the results of current study are in close association with the findings of other researchers.

Melting time of ice cream is directly associated with melting point and solid fat content of the fats. The slip melting point of control, T_1 and T_2 as measured in capillary tubes was 34.8, 33.5 and 31.5 °C, respectively. The lower melting points of the experimental samples were due to the presence of higher content of unsaturated fatty acids (Table 2). Melting time of both the treatments were less than control at 22–25 °C (Table 3). Melting time of T_1 and control was at par with each other ($P>0.05$). Melting time of control was 16.5 min as compared to T_2 (15.35 min). Higher melting time of control could be attributed to the relatively higher melting point of milk fat. Gonzalez et al. (2003) studied the effect of using milk with modified fatty acids through ruminal diet manipulation on physico-chemical quality of ice cream and reported that melting time of ice cream made from milk with higher concentrations of linolenic acid was lower as compared to control the time recorded for first ice cream drip to occur in high linoleic acid cream was 14.75 min as compared to control 16.60 min. Melting time of the ice cream is directly dependent upon the melting point of fats, fats having higher melting points will take more time to melt, the fats with lower melting point will melt quickly (Flack 1988). Nadeem et al. (2010) made functional ice cream from milk fat and rape seed oil blends and observed that the samples of ice cream augmented with rape seed oil melted more quickly than control. The short chain fatty acids have low melting point as compared to long chain saturated fatty acids (McSweeney and Fox 2003). Melting point of modified milk fat of both the experimental samples was progressively decreased as the concentration of long chain unsaturated fatty acids was increased through feeding of CSFA. Most of the contribution in the decline of melting point of the modified versions of fats was due to higher concentration of oleic acid which has melting point (4.5 °C) as it was the most dominant fatty acid in the modified fats. Another reason for the decline of melting point of the modified fats was due to the relatively lower concentrations of stearic acid which has high melting point (63 °C). The melting point of modified fats could not increase even though the concentration of

short chain fatty acids was decreased because of the above mentioned possibilities. Change of fatty acid composition from more saturated to more unsaturated fatty acids have a definite and pronounced effect on the melting time, viscosity and overrun of ice cream at T_2 level. Fats having lower melting characteristics are considered more healthful than those who have higher melting points (Ghatak and Bandyopadhyay 2007).

It is obvious from the results of sensory evaluation that addition of milk fat with modified fatty acid profile obtained through feeding CSFA in ice cream did not have any significant negative effect on color score. Color score of control and T_2 was 7.8 ± 0.65 and 7.6 ± 0.45 . Gonzalez et al. (2003) incorporated milk fat in ice cream with modified fatty acids achieved by feeding diet high in oleic and linoleic acid and reported non significant difference in all the samples and control with respect to this parameter. It was concluded that rumen protected feed rich in unsaturated fatty acids can be successfully used as viable technology to transfer healthy fatty acids of milk to fat rich dairy products. Taste score of T_1 and T_2 was significantly influenced from control. The highest taste score was obtained by control followed by T_1 and T_2 . Milk fat is unique among the edible fats for having appreciable amount of short chain fatty acids like butyric, capric, caprylic, caproic acids which are responsible for characteristics flavor of milk and milk products Marshall et al. (2003). T_1 and T_2 have significantly lower concentrations of short chain fatty acids (Table 1) and higher concentrations of long chain fatty acids which resulted in lower sensory scores of these treatments. Some of the panelists criticized T_2 for not having typical taste of milk fat. Fatty acid profile of milk can affect the flavor of dairy products Hillbrick and Augustin (2000) especially the unsaturated fatty acids are susceptible to autoxidation can develop oxidized, oily, metallic and stale flavor in dairy products. Chen et al. (2004) studied the quality of ice cream made from milk with modified fatty acid profile through feeding and reported that sensory score of ice cream made from milk with higher proportions of unsaturated fatty acids was significantly less ($P<0.05$) than control. Modified fats develop rancid flavor more quickly than control. Firmness of the ice cream was determined by scoop test at -18 °C and all the samples along with control were at par with each other ($P>0.05$) with respect to this parameter. Gonzalez et al. (2003) investigated the influence of milk with modified fatty acids on firmness of ice cream and observed non significant variation in firmness when high oleic and linoleic acids milk fat was incorporated into ice cream. Gonzalez et al. (2003) while studying the impact of textural properties of ice cream made from milk with modified fatty acids profile reported that firmness of all the experimental samples were almost same between temperature of -13 to -17 °C. The incorporation of milk with modified fatty acids at T_2 level significantly decreased the overall acceptability score. Rodriguez et al. (1991) studied

the use of vegetable oils in ice manufacturing and found that overall acceptability of the all the treatments was less than control. Nadeem et al. (2010) during the partial replacement of milk fat with rape seed oil recorded lower values of sensory scores for experimental samples than control.

Conclusion

From the results of Tables 2 and 3 it is obvious that inclusion of calcium salts of fatty acids at both levels (T_1 and T_2) significantly decreased the concentration of short chain fatty acids and momentarily increased the content of long chain fatty acids in milk. Milk with modified fatty acid profile did not have any adverse effect on compositional attributes, pH and acidity of ice cream. Viscosity, overrun and melting time of T_1 was not significantly influenced from control. The overall acceptability score of T_2 was 7.1 out of 9 (total score) which was more than 78 % hence, milk with modified fatty acid profile may be successfully used in the formulation of ice cream, with increased health benefits and acceptable sensory characteristics.

References

- Abdou SM, Montasser EA, Younis HA (1996) Evaluation of some dairy blends for dietetic ice cream. *Egypt J Dairy Sci* 24:103–114
- Abdullah M, Rehman S, Zubari H, Saeed HM, Kousar S, Shahid M (2003) Effect of skim in soymilk blend on the quality of ice cream. *Pak J Nutr* 2(5):305–311
- AbuGhazaleh AA, Holmes L (2009) Altering dairy cow's milk fatty acid composition through grazing and oil supplementation. *Milchwissenschaft* 64(3):241–244
- AbuGhazaleh AA, Schingoethe DJ, Hippen AR (2001) Conjugated linoleic acid and other beneficial FA in milk from cows fed soybean meal, fish meal, or both. *J Dairy Sci* 84:1845–1850
- Adhikari K, Aurora KA (1994) Development of mellorine type frozen desserts: effect of stabilizers and emulsifiers. *Indian J Anim Sci* 64:526–533
- AOAC (2000) Official methods of analysis, 17th edn. American Association of Analytical Chemists. Inc, Washington, D.C
- Ashes JR, Welch PSV, Gulan SK, Scott W, Bro GH (1992) Manipulation of the fatty acid composition of milk by feeding protected canola seeds. *J Dairy Sci* 75:1090–1096
- BHF 2005. British Heart Foundation (2005). The Burden of Cardiovascular Disease, <http://www.bhf.org/> 24-11-2005.
- Chen S, Bobe G, Zimmerman S, Hammond EG (2004) Physical and sensory properties of dairy products from cows with various milk fatty acids compositions. Deptt. of Food Sci., Iowa State University
- EHN (2005). European Heart Network. Chronic diseases-cardiovascular diseases, statistics. <http://www.ehn.org/> 13-06-2005.
- Elliott JP, Drackley JK, Weigel DJ (1996) Digestibility and effects of hydrogenated palm fatty acid distillate in lactating dairy cows. *J Dairy Sci* 79:1031–1039
- Fahey J, Mee JF, Murphy JJ, Callaghan DO (2002) Effects of calcium salts of fatty acids and calcium salts of methionine analogue on plasma, prostaglandin, F2 α metabolite and milk fatty acid profile of late lactation Holstein-Friesian Cow. *J Therio* 58:1471–1482
- Fereidoon S (2005) *Baileys Industrial Edible Oil and Fat Products*, 6th edn. John Wiley and sons pub. Co, NY
- Flack E (1988) Factors which influence the melting properties of ice cream. *Ice cream Frozen Confectionary* 39:232–237
- Ghatak PK, Bandyopadhyay AK (2007) *Practical Dairy Chemistry*. Kalyani Publishers, New Delhi, pp 140–149
- Gonzalez S, Duncan SE, Keefe SFO, Sumner SS, Herbein JH (2003) Oxidation and textural characteristics of butter and ice cream with modified fatty acid profiles. *J Dairy Sci* 86(1):70–77
- Griinari J, Nurmela MK, Dwyer DA, Barbano DM, Bauman DE (1999) Variation of milk fat concentration of conjugated linoleic acid and milk fat percentage is associated with a change in ruminal biohydrogenation. *J Anim Sci* 77:117–118
- Guinard JXC, Morse Z, Morie L, Panyam D, Kilara A (1996) Effect of sugar and fat on acceptability of vanilla ice cream. *J Dairy Sci* 79:1922–1927
- Hillbrink G, Augustin MA (2000) Milk fat characteristics and functionality: opportunities for improvement. *Aust J Dairy Technol* 57:45–51
- Im JS, Marshall R (1998) Effects of homogenization pressure on the physical, chemical and sensory properties of formulated frozen. *Food Sci Biotechnol* 7:90–94
- Kaylegian KE, Lindsay RC (1995) *Handbook of Milk fat fractionation technology and applications*, campaign. AOCS Press, IL
- Keller JJ, Steinmann MA, Wentzel BS (1987) The quality of South African ice cream. *S Afr Tydskrif Suiwelkunde* 19:145–147, *Food Sci. Tech. Abstr.*, 20: P102
- Larmond E (1987) *Laboratory Methods for Sensory Evaluation of Foods*. Research Branch, Department of Agriculture, Canada
- Marshall RT, Goff RD, Hartel RW (2003) *Ice cream*, 6th edn. Kluwer Acad/Plenum Pub, New York
- Mathur MP, Datta RD, Dinkar P (1999) *Text book of dairy chemistry*. Indian Council of Agricultural Research, New Delhi
- McSweeney PL, Fox HPF (2003) *Advanced dairy chemistry*, vol 1, 3rd edn, Proteins. Kluwer Academic Plenum Pub, NY
- Moate PJ, Chalupa W, Jenkins TC, Boston RC (2004) A model to describe ruminal metabolism and intestinal absorption of long chain fatty acids. *Anim Feed Sci Technol* 112:79–105
- Morris BJ (1999) The chemical analysis of foods and food products. 3rd edn. CBS Publishers and Distributors pp. 261–266
- Nadeem M, Abdullah M, Ellahi MY (2010) Effect of incorporating rape seed oil on quality of ice cream. *Mediterr J Nutr Metab* 3:121–126
- Nishtar S (2002) Prevention of coronary artery diseases in South Asia. *Lancet* 360:1015–1018
- Palmquist DL, Beaulieu AD, Barbano DM (1993) Feed and animal factors influencing milk fat composition. *J Dairy Sci* 76:1753–1771
- Potter NW, Hotchkis J (1998) *Food Science*. AVI Publishing Co. Inc, New York
- Rodriguez T, Otero M, Camejo J, Banguela S (1991) Utilization of vegetable fat in ice cream. *Alimentaria* 228:45–47
- Siddique MI, Mukhtar M, Rehman S, Awan JA (1988) Use of guar gum as a stabilizer in ice cream. *Sci Technol Dev* 7:10–14
- Steel RGD, Torrie JH, Dickey DA (1997) *Principles and Procedures of Statistics. A biometrical approach*, 3rd edn. Mc-Graw Hill Book Co, New York
- Sukhija PS, Palmquist DL (1988) Rapid method for determination of total fatty-acid content and composition of feedstuffs and feces. *J Agric Food Chem* 36:1202–1206

- Tavani A, Gallus A, Negri E, Vecchia CL (2002) Milk, dairy products, and coronary heart disease. *J Epidemiol Commun Health* 56:471–472
- Tong JH (1984) Use of sunflower oil in ice cream. *J Dairy Sci* 67:779–783
- Tymchuk SM, Khorasani GR, Kennelly JJ (1998) Effect of feeding formaldehyde and heat-treated oil seed on milk yield and milk composition. *Can J Animal Sci* 78: 693–700
- Whitlock DA, Schingoethe DJ, Hippen AR, Kalscheur KF, Baer KJ, Ramaswamy N, Kasperon KM (2002) Fish oil and extruded soybeans fed in combination increase conjugated linoleic acids in milk of dairy cows more than when fed separately. *J Dairy Sci* 85:234–243