Pak. j. sci. ind. res. Ser. B: biol. sci. 2015 **58** (1) 40-46

Effects on Physicochemical Characteristics of Yoghurt and Ice Cream with Fatty Acid Modification and Cholesterol Removal

Muhammad Nadeem[a]*, Rahman Ullah[a], Muhammad Imran[b] and Atta Muhammad Arif[a]
[a]Department of Dairy Technology, University of Veterinary and Animal Sciences, Lahore, Pakistan
[b]Department of Food Science, Nutrition & Home Economics, Institute of Home and Food Sciences, Faculty of Science and Technology, Govt. College University, Faisalabad, Pakistan

(received June 3, 2014; revised January 20, 2015; accepted January 30, 2015)

Abstract. This study investigated the effect of fatty acid modification and cholesterol removal on physicochemical characteristics of yoghurt and ice cream. Fatty acid profile of milk fat was modified by feeding calcium salts of soybean oil fatty acids to cows and cholesterol was removed by β-cyclodextrin. β-cyclodextrin removed 76% and 60% cholesterol from yoghurt and ice cream. Modification of fatty acid composition did not have a significant effect on α-tocopherol content; while β-cyclodextrin treated milk had substantially lower α-tocopherol content. The concentration of α-tocopherol in control and β-cyclodextrin treated yoghurt was 45.62, 32.73 μg/g and 210.34, 185.56 μg/g for ice cream, respectively. Fatty acid modification and cholesterol removal significantly decreased the overrun in ice cream ($P<0.05$), with no effect on sensory characteristics of yoghurt and ice cream. These results evidenced that milk with higher content of unsaturated fatty acids and low cholesterol can be used in the formulation of yoghurt and ice cream with improved health benefits and suitable sensory features.

Keywords: β-cyclodextrin, yoghurt, ice cream, fatty acid, α-tocopherol

Introduction

Among all the known sources of dietary fats and oils, milk fat is regarded as the greatest source of potentially harmful atherogenic fatty acid. Milk fat is characterised with 3-5% unsaturated fatty acids, this usually does not have favourable impact (Mihailova, 2006). The concentration of atherogenic fatty acids can be significantly decreased; similarly, the concentration of beneficial unsaturated fatty acids can be considerably enhanced in milk and milk products (Sacks and Katan, 2002). The increased prevalence of hypertension and cardiovascular diseases has led the American people to side-step the milk and dairy products (Hansel *et al.,* 2007). The American Heart Association guidelines (AHA, 2004) also direct the consumers to decrease the intake of atherogenic fatty acids. The correlation between cardiovascular disease and saturated fatty acids was discovered in 1970s, the medium chain fatty acids of milk fat (myrisitic, lauric and palmitic acid) has been correlated with hypercholesterolemia, which is regarded as a potential risk for cardiovascular disease (Honda *et al*., 2007; Jensen, 2002). In such a situation, milk and dairy products becomes the first choice of criticism by the medical professionals. Milk and dairy products with modified fatty acid composition have a lower atherogenic index (Poppitt *et al*., 2002). The popularity of dairy products can be resumed through the development of functional dairy products with lower atherogenic index and dietary cholesterol.

Studies evidenced that, the concentration of unsaturated fatty acids in milk can be efficiently increased through the manipulation of bovine feed with no effect on cholesterol (AbuGhazelah and Holmes, 2009). The research work has revealed that reduction of cholesterol from milk and milk products was most proficiently achieved by β-cyclodextrin (Alonso *et al*., 2009; Kwak *et al*., 2002). Yoghurt is one of the main sources of useful lactic acid bacteria, essential fatty acids, amino acids, minerals and several bio-active compounds. The customer's perception about ice cream is shifting and evading tendency has been reflected (Marshall *et al*., 2003). Several studies have been performed on the reduction of saturated fatty acids and cholesterol from milk and dairy products, however, the combined effects of fatty acid modification and cholesterol removal on physicochemical characteristics of yoghurt and ice cream has not been reported previously.

This study was aimed to investigate the effects of fatty acid modification and cholesterol removal on physical and chemical characteristics of yoghurt and ice cream prepared by milk.

*Author for correspondence; E-mail: sheikhnadeem@live.com

Materials and Methods

Materials. Milk with modified fatty acid composition was obtained from an other study regarding the enhancement of unsaturated fatty acids in milk by feeding calcium salts of soybean oil to cows at 1% and 2% concentrations (Nadeem *et al*., 2013). The fatty acid composition of milk used in this study has been presented in Table 1. The chemicals were HPLC grade and purchased from Sigma, Aldrich, USA. Cream (40% fat) was treated with 2% and 4% β-cyclodextrin (Kwak *et al*., 2002). Decholesterolised cream was used for the manufacturing of ice cream along with skim milk powder and other ingredients, for yoghurt manufacturing whole milk (fat 4.1%) was treated with 0.5% and 1% β-cyclodextrin at 10 ºC for 30 min, followed by removal of β-cholesterol through centrifugation (Alonso *et al*., 2009).

Table 1. Effect of CSO on fatty acid profile of milk

Fatty acid	Control	1% CSO	2% CSO
$C_{4:0}$	1.84±0.09[c]	2.15±0.03[b]	2.34±0.15[a]
$C_{6:0}$	2.09±0.07[a]	1.97±0.11[a]	1.72±0.09[b]
$C_{8:0}$	2.25±0.12[a]	2.14±0.02[a]	1.82±0.28[b]
$C_{10:0}$	2.45±0.10[a]	2.39±0.05[a]	2.17±0.11[b]
$C_{12:0}$	2.71±0.04[a]	2.64±0.03[a]	2.39±0.08[b]
$C_{14:0}$	10.87±022[a]	9.93±0.15[b]	8.15±0.18[c]
$C_{16:0}$	30.55±0.34[a]	25.24±0.57[b]	21.35±0.79[c]
$C_{18:0}$	9.74±0.45[c]	10.97±0.44[b]	11.85±0.65[a]
$C_{18:1}$	24.49±0.67[c]	27.37±0.35[b]	32.22±0.62[a]
$C_{18:2}$	2.14±0.06[c]	2.46±0.11[b]	2.94±0.12[a]
$C_{18:3}$	0.31±0.02[a]	0.28±0.01[a]	0.26±0.03[a]
VA	0.55±0.01[c]	1.14±0.05[b]	1.47±0.06[a]
C9,t11-CLA	0.42±0.04[c]	0.92±0.05[b]	1.28±0.09[a]
AI	2.74±0.11[a]	2.10±0.12[b]	1.47±0.05[c]

Means of triplicate experiments; means sharing the different letter in a row are statistically non-significant (P<0.05); CSO = calcium salts of soybean oil; Reference: Nadeem *et al.* (2013).

Treatments. Treatments of yoghurt were; (a) yoghurt from milk of cows fed on normal diet, (b) yoghurt from milk of cows fed on 1% calcium salts of soybean oil fatty acids, (c) yoghurt from milk of cows fed on 2% calcium salts of soybean oil fatty acids, (d) yoghurt from milk not treated with β-cyclodextrin, (e) yoghurt from milk treated with 0.5% β-cyclodextrin and (f) yoghurt from milk treated with 1% β-cyclodextrin. Treatments of ice cream were; (a) ice cream from milk of cows fed on normal diet, (b) ice cream from milk of cows fed on 1% calcium salts of soybean oil fatty acids, (c) ice cream from milk of cows fed on 2% calcium salts of soybean oil fatty acids, (d) ice cream from the cream which was not treated with β-cyclodextrin, (e) ice cream from the cream treated with 2% β-cyclodextrin and (f) ice cream from the cream treated with 4% β-cyclodextrin.

Manufacturing of yoghurt and ice cream. Whole milk without any standardisation was used for the manufacturing of yoghurt using *Strepotococcus thermophiles* and *Lactobacillus bulgaricus* starter culture (Abdullah *et al*., 2012). Ice cream was prepared according to the formulation prescribed by Potter and Hotchkiss (1998). Formulation of ice cream comprised of 13% sugar, 11% MSNF, 10% milk fat, 0.25% stabiliser and 0.25% emulsifier. Yoghurts and ice creams were filled in polypropylene cups and stored at 4 and -18 °C for further study.

Analysis. The pH and syneresis were determined by following methods of Cueva and Aryana (2008). Cholesterol in yoghurt and ice cream was determined as per method of Rudel and Morris (1973). Thiobarbituric acid (TBA) value was measured in accordance with the method described by Hekmat and McHamon (1997). Viscosity of ice cream mix was measured at 4 ºC by using the Brookfield DV-E viscometer (Ozer *et al*., 1999). Free fatty acids and peroxide value were determined by the standard method (AOCS, 1995). Overrun in ice cream was determined by following the method of Potter and Hotckiss (1998), melting time was measured as suggested by Gonzalez *et al.* (2003). Fat from yoghurt and ice cream was separated according to the standard method (AOAC, 1997). The concentration of α-tocopherol was determined on HPLC. The extracted fat (0.2 g) was mixed with 2 mL hexane in 11 mL screw capped test tube, vortexed at 2200 rpm for 30 sec, 25 µL were injected into HPLC (Miford, MA; 715 Ultra WISP injector; 25 cm × 4.6 mm diameter 5 µm Supelcosil LC-Si (Supelco, Bellefonte, PA). The mobile phase consisted of 0.5% ethyl acetate and 0.5% acetic acid in hexane with a flow rate of 1.5 mL/min. The concentration of α-tocopherol was expressed as µg/g (Jang and Xu, 2009). Sensory evaluation of yoghurt and ice cream was performed by a trained panel of 10-judges on a 9 point scale (1-extremely poor and 9-excellent). Judges were selected on the basis of their experience and availability. Unsalted crackers and distilled water was provided in the individual sensory evaluation booths to rinse the palate (Larmond, 1987). All the treatments of yoghurt and ice cream were performed in triplicate and every sample was analysed three times. The data were expressed as

Table 2. Effect of modified fatty acid profile and cholesterol removal on chemical characteristics of yoghurt

Treatments	pH	Cholesterol mg/100 g	Syneresis	PV (meq/kg)	TBA	FFA (%)	α-tocopherol (μg/g)
Control	4.65±0.15^{a}	29.67±0.52^{a}	51.73±1.42^{a}	0.20±0.03a	4.21±0.06^{a}	0.11±0.02^{a}	45.62±0.61^{a}
1%CSO	4.61±0.21^{a}	28.77±0.41^{a}	50.65±1.84^{a}	0.22±0.05a	4.22±0.11^{a}	0.10±0.01^{a}	44.85±1.18^{a}
2%CSO	4.69±0.25^{a}	28.49±0.39^{a}	50.42±2.49^{a}	0.18±0.02a	4.25±0.15^{a}	0.11±0.02^{a}	43.95±0.76^{a}
BCD Untreated	4.67±0.14^{a}	30.51±0.35^{a}	52.25±1.73^{a}	0.26±0.04a	4.28±0.05^{a}	0.10±0.01^{a}	42.55±1.46^{a}
2%BCD	4.61±0.16^{a}	12.20±0.65^{b}	52.67±1.19^{a}	0.25±0.03a	4.19±0.09^{a}	0.10±0.01^{a}	38.15±0.66^{b}
4%BCD	4.63±0.06^{a}	7.09±0.18^{c}	52.78±2.35^{a}	0.25±0.02a	4.17±0.10^{a}	0.10±0.01^{a}	32.73±0.94^{c}

With a column means denoted by a different letter are statistically different (P<0.05); PV = peroxide value; TBA = thiobarbituric acid value; FFA = free fatty acids; CSO = calcium salts of soybean oil fatty acids; BCD = β-cyclodextrin.

Mean ± SD, analysed by using SAS 9.1 (SAS Institute Inc., Cary, NC). Treatments were subjected to Duncan's Multiple Range Test for the screening of significant difference (P < 0.05).

Results and Discussion

Physicochemical characteristics of yoghurt. The pH of the yoghurts was not influenced (P > 0.05) as a function of fatty acid composition and cholesterol content of the milk (Table 2). Major changes were noted in concentration of dietary cholesterol, cholesterol ranged from 7.09 to 29.67 mg/100 g, among the treatments. In β-cyclodextrin treated yoghurts, the concentration of cholesterol was 58.9% and 76.1% lesser than control. The significant reduction in dietary cholesterol has a healthy perspective; cholesterol is strongly correlated with total and LDL cholesterol. The reduction of cholesterol from milk as a function of β- cyclodextrin has been extensively reported in literature (Alonso *et al*., 2009; Lee *et al*., 2007; Kwak *et al*., 2002). However, little information is available regarding the conversion of low cholesterol milk into yoghurt. The breakage of protein strands and structural rearrangement results in the expulsion of whey from the yoghurt (Serra *et al*., 2009). Whey separation in yoghurt is regarded as one of the crucial aspects of yoghurt texture (Lee and Lucey, 2010). The extent of syneresis in all the treatments was not different from control (P>0.05). Syneresis mainly depends upon the textural changes triggered by the pH, the non-variation in syneresis might be correlated to the non-variation in pH of yoghurts. Syneresis of yoghurt supplemented with transesterified palm olein was not different from the standard yoghurt (Abdullah *et al*., 2012). Fatty acid modification and cholesterol removal did not reveal any effect on peroxide value, TBA value and free fatty acids of fresh yoghurts. The determination of α-tocopherol was observed in this study to investigate the effect of fatty acid modification and cholesterol removal on the concentration of α-tocopherol. Fatty acid modification did not have any effect on α-tocopherol content, however, treatment of milk with 2% and 4% β-cyclodextrin considerably decreased the concentration of α-tocopherol in the treated stuffs (P<0.05). The present study reported a decline in the α-tocopherol content with β-cyclodextrin in a concentration dependent manner. Removal of some bioactive compounds; vitamins, fatty acids etc., with β-cyclodexrin, from milk and milk products have been verified by Ha *et al*. (2009). However, little information is available in literature regarding the entrapment of α-tocopherol in β-cyclodextrin. Fatty acid modification of milk fat increased, its susceptibility towards autoxidation (Gonzalez *et al*., 2003). Non-variation in free fatty acid and peroxide value of freshly extracted milk fat has been reported by Nadeem *et al*. (2013). Free fatty acids, peroxide and TBA values are strongly correlated to the quality and shelf stability of the fats, elevated levels usually signify poor keeping quality (Fereidoon, 2005).

Physicochemical characteristics of ice cream. Noticeable changes were observed in the overrun of ice creams in response to fatty acid modification and cholesterol removal (Table 3). Overrun of ice cream from the milk of cows fed on 2% calcium salts of soybean oil was significantly less than control. Overrun of ice creams prepared from cholesterol reduced milk differed considerably from each other and control. Overrun decreased from 82.6% to 74.7% and 69.4% in ice creams prepared from 2% and 4% β-cyclodextrin treated milks. The overrun is an important criterion for the quality and economy viewpoints. The lowest overrun observed in this study was about 70%. Table 4 represents the results of melting time of ice creams formulated from milk fat with changed fatty acid composition and reduced cholesterol. Fatty acid composition and cholesterol reduction had a pronounced effect on melting time of

Table 3. Effect of modified fatty acid profile and cholesterol removal on chemical characteristics of ice cream

Treatments	pH	Overrun (%)	MT (min)	Viscosity (CP)	TBA	FFA (%)	Cholesterol (mg/100 g)	α-tocopherol (μg/g)
Control	6.75±0.15[a]	85.8±2.56[a]	15.8±0.29[a]	264±10.29[a]	4.15±0.08[a]	0.11±0.01[a]	72.5±1.51[a]	210.34±5.64[a]
1%CSO	6.69±0.23[a]	83.5±1.95[a]	14.9±0.56[a]	255±08.54[a]	4.19±0.09[a]	0.11±0.01[a]	71.6±2.43[a]	205.64±11.27[a]
2%CSO	6.65±0.14[a]	75.9±1.64[b]	12.5±0.35[b]	229±12.84[b]	4.22±0.12[a]	0.11±0.02[a]	70.8±2.94[a]	198.47±05.43[a]
BCD untreated	6.79±0.16[a]	82.6±2.34[a]	15.5±0.64[a]	259±15.64[a]	4.18±0.19[a]	0.11±0.01[a]	71.4±1.88[a]	215.73±15.69[a]
2%BCD	6.64±0.19[a]	74.7±1.32[b]	11.9±0.74[b]	247±19.37[a]	4.19±0.16[a]	0.12±0.02[a]	28.61±1.61[b]	192.35±04.27[b]
4%BCD	6.67±0.08[a]	69.4±1.78[c]	11.5±0.48[b]	242±17.48[a]	4.22±0.21[a]	0.12±0.01[a]	12.73±1.55[c]	185.56±7.51[b]

With a column means denoted by different letter are different; MT = melting time; TBA = thiobarbituric acid value; FFA = free fatty acids; CSO = calcium salts of soybean oil fatty acids; BCD = β-cyclodextrin.

Table 4. Changes in TBA value of yoghurt and ice cream during storage of 4-weeks

Treatments	0-Week	1-Week	2-Weeks	3-Weeks	4-Weeks	Increase
Yoghurt						
Control	4.21±0.10[c]	4.23±0.08[c]	4.25±0.13[c]	4.29±0.22[c]	4.37±0.08[c]	0.16
1%CSO	4.22±0.05[c]	4.26±0.12[c]	4.30±0.04[c]	4.48±0.16[b]	4.55±0.07[b]	0.33
2%CSO	4.25±0.09[c]	4.28±0.15[c]	4.32±0.05[c]	4.59±0.14[b]	4.82±0.23[a]	0.57
BCD untreated	4.24±0.03[c]	4.26±0.17[c]	4.27±0.12[c]	4.30±0.27[c]	4.32±0.19[c]	0.08
2% BCD	4.19±0.13[c]	4.21±0.19[c]	4.24±0.15[c]	4.29±0.31[c]	4.33±0.14[c]	0.14
4% BCD	4.17±0.14[c]	4.23±0.18[c]	4.28±0.07[c]	4.30±0.12[c]	4.32±0.11[c]	0.15
Ice Cream						
Control	4.15±0.08	4.17±0.11[a]	4.19±0.02[a]	4.22±0.09	4.25±0.08[c]	0.10
1%CSO	4.19±0.06[c]	4.22±0.09[c]	4.25±0.05[c]	4.28±0.07[c]	4.47±0.06[b]	0.28
2%CSO	4.22±0.05[c]	4.25±0.21[c]	4.28±0.07[c]	4.32±0.04[c]	4.75±0.16[a]	0.53
BCD untreated	4.18±0.03[c]	4.19±0.06[c]	4.22±0.06[c]	4.25±0.03[c]	4.28±0.12[c]	0.10
2% BCD	4.19±0.02[c]	4.21±0.07[c]	4.24±0.17[c]	4.26±0.01[c]	4.29±0.14[c]	0.10
4% BCD	4.22±0.05[c]	4.23±0.06[c]	4.25±0.25[c]	4.27±0.15[c]	4.31±0.17[c]	0.11

Within the rows and columns of a product means denoted by different letter are different; CSO = calcium salts of soybean oil fatty acids; BCD = β-cyclodextrin.

ice cream. Melting time of ice creams prepared from 2% and 4% β-cyclodextrin treated milks was considerably lower than controls. Melting point and solid fat content of fats is determined by the fatty acid composition, more is the saturated fatty acids, more will be melting point (Richmond, 2007). Melting point of cholesterol is about 149.5 ºC and its removal could have a significant effect on the melting characteristics of the rest of the stuff. The overrun of ice cream prepared from milk fat with modified fatty acid composition was less than the original milk fat (Gonzalez *et al*., 2003). Fatty acid modification and cholesterol removal did not reveal any significant effect on free fatty acids and TBA value in fresh ice creams. Generation of free fatty acids is the outcome of hydrolysis of triglycerides, the degree of unsaturation does not have any correlation with their generation. The α-tocopherol content of ice creams was not affected by the fatty acid modification. Removal of cholesterol from cream through β-cyclodextrin had a major influence ($P<0.05$) on the concentration of tocopherol. The α-tocopherol decreased from 215.73 to 185.56 μg/g, when cream was treated with 4% β-cyclodextrin. Some of the tocopherols could have been adsorbed in the central hollow cavity of β-cyclodextrin along with cholesterol, which could be the reason for their decline in treated ice cream. The loss of some milk nutrients in the β-cylodextrin-cholesterol complexation phenomenon has been reported by Ha *et al*. (2009). However, the loss of α-tocopherols in the decholestrolisation process has not been fully studied.

Changes in TBA value during storage. Thiobarbituric acid (TBA) value of all the treated and untreated yoghurts and ice creams increased to a varying extent during the storage period (Table 4). The rise in TBA value was dependent upon the storage period and kind of treatments,

Table 5. Sensory characteristics of yoghurt and ice cream

Treatments	Yoghurt				Ice cream			
	Colour	Smell	Taste	OA	Colour	Smell	Taste	OA
Control	8.5±0.25[a]	8.4±0.15[a]	8.2±0.19[a]	7.8±0.10[a]	8.2±0.19[a]	8.4±0.19[a]	8.5±0.15[a]	8.3±0.45[a]
1%CSO	8.4±0.35[a]	8.3±0.22[a]	8.1±0.14[a]	7.7±0.56[a]	8.1±0.10[a]	8.3±0.14[a]	8.4±0.13[a]	8.0±0.14[a]
2%CSO	8.2±0.16[a]	7.6±0.29[b]	7.7±0.12[b]	7.2±0.62[b]	8.1±0.35[a]	7.6±0.15[b]	7.5±0.38[b]	7.2±0.25[b]
BCD untreated	8.3±0.17[a]	8.3±0.35[a]	8.1±0.26[a]	7.8±0.34[a]	8.1±0.44[a]	8.2±0.13[a]	8.1±0.34[a]	8.2±0.32[a]
2% BCD	8.2±0.12[a]	8.2±0.42[a]	8.0±0.31[a]	7.6±0.29[a]	8.1±0.52[a]	8.2±0.24[a]	8.1±0.27[a]	8.1±0.25a
4% BCD	8.1±0.34[a]	8.0±0.19[a]	8.0±0.46[a]	7.5±0.14[a]	8.0±0.27[a]	8.1±0.29[a]	8.0±0.17[a]	8.0±0.21a

Within a column means denoted by different letter are statistically different (P<0.05); OA = overall acceptability; CSO = calcium salts of soybean oil fatty acids; BCD = beta cyclodextrin.

fatty acid composition had a great effect on TBA value, whereas, cholesterol removal seemed to be neutral. After 4-weeks of storage, TBA value of yoghurts and ice creams derived from the milks with altered fatty acid composition was significantly higher than the untreated yoghurts and ice creams. TBA value and the concentration of $C_{18:1}$ was strongly correlated; relatively higher oxidation in these samples might be due to the oxidative breakdown of linoleic acid into oxidation products. The oxidisability of linoleic acid is 12 times greater than oleic acid (Reynhout, 1991). The concentration of unsaturated fatty acids decreased in ice cream, formulated from milk fat-flax seed oil blends, during storage period of 42-days (Lim *et al*., 2010). Ice cream from modified milk fat suffered more oxidation as compared to unmodified milk fat (Gonzalez *et al*., 2003).

Sensory evaluation. The results of sensory evaluation of yoghurt and ice cream prepared from milk with lower contents of saturated fatty acids and cholesterol are given in Table 5. The fatty acid modification had a pronounced effect on smell, taste and overall acceptability of yoghurts and ice creams prepared from milk of cows fed on 2% calcium salts of fatty acids. The significant variation in sensory characteristics could be connected to the decline of short-chain fatty acids. The main contribution in aroma and flavour of dairy products is due to short-chain fatty acids. The decline in the concentration of short-chain fatty acids had a strong influence on the sensory characteristics of ice cream (Lim *et al*., 2010). The sensory characteristics of low cholesterol yoghurt and ice cream were not different from the controls. Sensory characteristics of β-cyclodextrin treated bulk pasteurised milk were not different from the untreated milk (Alonso *et al*., 2009). The effect of β-cyclodexrin on the removal of short-chain fatty acids of milk was non-significant (Ha *et al*., 2009).

Conclusion

Beta cyclodextrin removed 76% and 60% cholesterol from yoghurt and ice cream. Fatty acid modification did not have any effect on α-tocopherol content; however, treatment of milk with β-cyclodextrin considerably decreased the concentration of α-tocopherol in the treated stuffs, with no effect on sensory attributes of yoghurt and ice cream. These results suggest that milk with lower contents of saturated fatty acids and cholesterol can be successfully converted into yoghurt and ice cream with increased health benefits and acceptable sensory characteristics.

Acknowledgement

The first author is highly obliged to Higher Education Commission of Pakistan for the kind financial assistance to complete this research work as a part of Ph.D programme.

References

Abdullah, M., Nadeem, M., Pasha, T.N., Hussain, I., Inayat, S., Ilyas, M., Rashid, A. 2012. Preparation and evaluation of yoghurt like fermented dairy product containing transesterified palm olein. *Mediterranean Journal of Nutrition and Metabolism*, **5:** 39-44.

AbuGhazaleh, A.A., Holmes, L. 2009. Altering dairy cow's milk fatty acid composition through grazing and oil supplementation. *Milchwissenschaft*, **64:** 241-244.

Alonso, L., Guesta, P., Fontecha, J., Juarez, M., Gilliland, S.E. 2009. Use of β-cyclodextrin to decrease the level of cholesterol in milk fat. *Journal of Dairy Science,* **92:** 863-869.

AHA, 2004. *Heart Attack and Related Diseases,* American

Heart Association, Washington, DC., Found at:http://www.americanheart.org/.

AOAC, 1997. *Official Methods of Analysis*, vol. **11**, pp. 147, 16th edition, Association of Official Analytical Chemists, Inc., AOAC Internet Gaithersburg, MD., USA.

AOCS, 1989. *Official Methods and Recommended Practices,* 4th edition, American Oil Chemists' Society, Inc., Champaign, IL, USA.

Cueva, O., Aryana, K.J. 2008. Quality attributes of a heart healthy yogurt. *Swiss Society of Food Science and Technology LWT*, **41:** 537-544.

Fereidoon, S. (ed.) 2005. Bailey's Industrial Oil and Fat Products, In: *Edible Oil and Fat Products: Speciality Oils and Oil Products,* vol. **3**, pp. 121-137, 6th edition, John Wiley and Sons, NY, USA.

Gonzalez, S., Duncan, S.S.E., Keefe, S.F.O., Sumner, S.S., Herbein, J.H. 2003. Oxidation and textural characte-ristics of butter and ice cream with modified fatty acid profiles. *Journal of Dairy Science,* **86:** 70-77.

Ha, J.H., Ahn, J., Min, S.G., Kwak, H.S. 2009. Properties of cholesterol-reduced ice cream made with cross-linked β-cyclodextrin. *International Journal of Dairy Technology,* **62:** 452-457.

Hansel, B., Nicolle, C., Lalanne, F., Tondu, F., Lassel, T., Donazzolo, Y., Ferrières, J., Krempf, M., Schlienger, J.L., Verges, B., Chapman, M.J., Brucket, E. 2007. Effect of low-fat, fermented milk enriched with plant sterols on serum lipid profile and oxidative stress in moderate hypercholesterolemia. *The American Journal of Clinical Nutrition,* **86:** 790-796.

Hekmat, S., McMahon, D.J. 1997. Manufacture and quality of iron-fortified yogurt. *Journal of Dairy Science*, **80:** 3114- 3122.

Honda, S., Tanaka, K., Hamada, K., Kitagawa, H., Kishida, H. 2007. Lipid Absorption inhibitor for Preventing Cardiovascular Disorders, e.g. Hyperlipi-demia or Hypertriglyceridemia, Contains (gamma)-cyclodextrin as Active Ingredient. Patent number (s): JP2007284366-A.

Jang, S., Xu, Z. 2009. Lipophilic and hydrophilic antioxidants and their antioxidant activities in purple rice bran. *Journal of Agricultural and Food Chemistry,* **57:** 858-862.

Jensen, R.G. 2002. Invited review: The composition of bovine milk lipids: January 1995 to December 2000. *Journal of Dairy Science*, **85:** 295-350.

Kwak, H.S., Jung, C.S., Shim, S.Y., Ahn, J. 2002. Removal of cholesterol from cheddar cheese by β-cyclodextrin. *Journal of Agricultural and Food Chemistry,* **50:** 7293-7298.

Larmond, E. 1987. *Laboratory Methods for Sensory Evaluation of Foods,* pp. 76-85, Research Branch, Canada, Department of Agriculture, Ottawa Publications, Canada.

Lee, W.J., Lucey, J.A. 2010. Formation and physical properties of yogurt. *Asian Australian Journal of Animal Science*, **23:** 1127-1136.

Lee, S.J., Hwang, J.H., Lee, S., Ahn, J., Kwak, H.S. 2007. Property changes and cholesterol- lowering effects in evening primrose oil-enriched and cholesterol-reduced yogurt. *International Journal of Dairy Technology*, **60:** 22-30.

Lim, C.W., Norziah, M.H., Lu, H.F.S. 2010. Effect of flaxseed oil towards physicochemical and sensory characteristic of reduced fat ice creams and its stability in ice creams upon storage. *International Food Research Journal*, **17:** 393-40.

Marshall, R.T., Goff, R.D., Hartel, R.W. 2003. *Ice cream*, pp. 36-42, 6th edition, Kluwer Academic / Plenum Publication, New York, USA.

Mihailova, G. 2006. Cis- and trans- fatty acids in milk from mountain pastured sheep. *Food Stuff Industry*, **4:** 13-17.

Nadeem, M., Hussain, I., Abdullah, M. 2013. Effect of feeding calcium salts of soybean oil fatty acids on physical and chemical characteristics of milk in cows. *Indian Journal of Animal Sciences*, **83:** 811-814.

Ozer, B.H., Stenning, R.A., Grandison, A.S., Robinson, R.K. 1999. Rheology and microstructure of labneh (concentrated yogurt). *Journal of Dairy Science*, **82:** 682-689.

Poppitt, S.D., Keogh, G.F., Mulvey, T.B., McArdle, B.H., MacGibbon, A.K., Cooper, G.J. 2002. Lipid-lowering effects of modified butter fat: a controlled intervention trial in healthy man. *European Journal of Clinical Nutrition*, **56:** 64-71.

Potter, N.W., Hotchkis, J.H. 1998. *Food Science,* pp. 233-245, 3rd edition, Springes Publishing Co. Inc. New York, USA.

Reynhout, G. 1991. The effect of temperature on induction time of stabilized oil. *Journal of the*

American Oil Chemists Society, **68:** 983-984.
Richmond, H.D. 2007. *Dairy Chemistry*: *A Practical Handbook for Dairy Chemists and Others Having Control of Dairies,* 504 pp., Cook Press, USA.
Rudel, L.L., Morris, M.D. 1973. Determination of cholesterol using *o*-phthalaldehyde. *Journal of Lipid Research*, **14:** 364-366.
Sacks, F.M., Katan, M. 2002. Randomized clinical trials on the effects of dietary fat and carbohydrate on plasma lipoproteins and cardiovascular disease. *The American Journal of Medicine*, **113:** 13-24.
Serra, M., Trujillo, A.J., Guamis, B., Ferragut, V. 2009. Evaluation of physical properties during storage of set and stirred yogurts made from ultra-high pressure homogenization-treated milk. *Food Hydrocolloids*, **23:** 82-91.