DOI : 10.5958/2277-8934.2022.00006.6 *Vol 29 No 1, p 41-48*

IMPROVING HEALTH BENEFITS, NUTRITIONAL VALUE AND QUALITY ATTRIBUTES OF LOW FAT ICE MILK MADE FROM CAMEL'S MILK AND DEFATTED CHIA SEEDS FLOUR

N. Yousif[1,4], S. Althobaiti[1,4], H. Kesba[2], H. ELzilal[1,4], S. Sabra[1,4], S.F. Mahmoud[3] and S. Sayed[1,4]

[1]Department of Science and Technology, University College-Ranyah, [3]Department of Biotechnology, College of Science, [4]High Altitude Research Center, Taif University, B.O. Box 11099, Taif 21944, Saudi Arabia

[2]Zoology and Agricultural Nematology Department, Faculty of Agriculture, Cairo University, Giza 12613, Egypt

ABSTRACT

Defatted chia seeds flour (DCSF) was prepared and its chemical composition and some functional properties were assessed. Nine chocolate ice milk batches were prepared to study the effect of replacing milk fat with DCSF. Control ice milk contained 4% fat, while the other 8 batches were prepared by replacing 25, 50, 75 and 100% of milk fat with DCSF either at the rate of 50 and 100% of substituted fat. Replacement of milk fat with the same amount of DCSF increased specific gravity, weight per gallon and viscosity, while decreased the freezing point of ice milk mixes. On the other hand substitution of milk fat with DCSF increased melting resistance, total protein, ash content and titratable acidity of ice milk treatments. This increase was more obvious by replacing with fat with the same amount of DCSF than those of ice milk treatments made by replacing milk fat with DCSF at the rate of 50% of substituted fat. Total solids, total protein and ash content and acidity of ice milk treatments did not change significantly during storage period. Replacing milk fat up to 50% with the same amount of DCSF increased the overrun and total scores of organoleptic properties, while increasing the rate of replacement above 50% reduced the overrun and scores of organoleptic properties. Ice milk treatment T_{22} that made with replacing 50% of milk fat with the same amount of DCSF gained the highest total score of organoleptic properties and was most acceptable ice milk treatment. Treatment T_{31} that made with replacing 75% of milk fat with 37.5% of DCSF exhibited higher total score than control ice milk. Therefore, it is possible to milk a good quality low fat ice milk by decreasing 50% of milk fat with 50% of DCSF and / or reducing 75% of milk fat with 37.5% of DCSF.

Key words: Camel's milk, chia seeds, fat replacers, ice milk

Camel's milk is important component in human diet in arid and semiarid zones. There is a growing interest to use camel's milk in the manufacture of many dairy products, because of its crucial health benefits.

Chia (*Salvia hispanica* L.) is an annual herbaceous plant, which has incredible nutritional and functional properties and health benefits it has been cultivated recently in many regions in the world such as Australia, Colombia, Argentina, South-East Asia, Africa, North America and Europe (Ali *et al,* 2012; Romankiewicz *et al,* 2017; Grancieri *et al,* 2017 and Rana 2019). Chia seeds contain higher concentration of protein, dietary fibre, n-3 fatty acids, phenolic compounds, some minerals and vitamins, therefore, it has crucial functional and technological properties such as higher water and oil holding capacity, so it could be used as stabiliser or emulsifier and fat replacer. Chia seeds exhibit tremendous dietary, health and medicinal benefits (Ali *et al,* 2012; Darwish *et al,* 2018; Kulezynski *et al,* 2019; Kwon *et al,* 2019 and Rana 2019). Many studies have been devoted to incorporate chia seed and its products in many food products such as yoghurt, frozen yoghurt, bread, frankfurters, beverage, biscuit, cake, pasta, chips, gravies, soups, salad, cereals, salad dressing, chocolate cakes and biodegradable edible films (Ali *et al,* 2012; Darwish *et al,* 2018; Ikumi *et al,* 2019; Kulegynski *et al,* 2019; Kavon *et al,* 2019 and Rnaa 2019).

There has been substantial interest to develop some dairy products of reduced fat contents to avoid the health problems associated with high fat intake (Williams, 1985; Krauss *et al*, 2000; Niki and Traber, 2012 and Wakai *et al,* 2014).

The objectives of this study were therefore, to assess the chemical composition and some functional

SEND REPRINT REQUEST TO S. SAYED email: samy_mahmoud@hotmail.com

properties of defatted chia seed flour, evaluate the possibility of making a good quality low fat ice milk using camel's milk with defatted chia seed flour, study the effect of replacing milk fat with defatted chia seed flour on quality of ice milk and to monitor the changes of ice milk quality during storage period.

Materials and Methods

Camel milk was obtained from camel farm at Taif Governorate, Saudi Arabia. Cream was obtained by separating camel's milk in the pilot plant. Non-fat dry milk was obtained from Hoogwegt International BV, Arnhenn, the Netherlands. Stabiliser was gratefully provided by Meer Corporation, North Bergen, NJ, USA. Sucrose, cocoa and corn oil were purchased from the local market.

Preparation of defatted chia seed flour (DCSF)

Chia seeds (*Salvia hispanica* L.) were collected from a farm at Ranyah, Taif, Saudi Arabia and were ground using electric grinder and passed through a 60 mesh sieve. Defatted chia seed flour was obtained (Mansour and Khalil, 2000).

Manufacture of ice cream

Control chocolate ice milk mix was prepared according to Khader *et al* (1992) with the following composition: 4% milk fat, 13% milk solid not fat, 155 sugar, 0.5% stabiliser and 3.0% cocoa. Another 8 ice milk mixes were prepared with the previous composition except that 25, 50, 75 and 100% of milk fat were replaced with defatted chia seeds flour at the rate of 50 and 100% of the substituted fat. All chocolate ice milk mixes were heated at 69°C for 30 min, cooled and then aged over night at 4°C. Ice milk mixes were frozen in ice cream batch freezer (Cattabriga, Bolongia, Italy). The resultant frozen ice milk was packaged in plastic cups and stored in deep freezer at -18°C for 24 hrs. for hardening. All frozen ice milk batches were stored at -20 + 2°C for 10 weeks. All experiments were conducted in 3 replicates.

Physical and chemical analysis

Defatted chia seeds flour was analysed for moisture, total protein, crude fibre, fat and ash according to AOAC (2010), while total phenolic compounds were determined according to Skerget *et al* (2005). Water and oil holding capacities of defatted chia seeds flour were determined as described by Rana (2019). The specific gravity of all ice milk mixes and ice milk samples were determined according to Omar (2014). Weight per gallon of ice milk mixes and ice milk were calculated according to Arbuckle (1986). Freezing point and viscosity of ice milk mixes were determined as described by FAO (1977) and (Morrison and Macjary, 2001), respectively. Melting resistance of ice milk was determined according to Omar (2014). Overrun of ice milk treatments were determined (Arbuckle, 1986). Titratable acidity and fat content of ice milk were determined according to (Ling, 1963). Total solids, ash and total protein were determined (AOAC, 2010).

Sensory evaluation

All ice milk batches were evaluated at zero time and every 2 weeks of storage period using score sheets described by Kebary and Hussein (1997).

Statistical analysis

Completely randomised block design and 2 × 3 factorial design were used to analyse all data. Newman-Keuls Test was used to make the multiple comparisons (Steel and Torrie, 1980) using Costat Program. Significant differences were determined at $p < 0.05$.

Results and Discussion

Physicochemical properties of defatted chia seeds flour

The gross chemical composition of defatted chia seeds flour (DCSF) is presented in table 1. Defatted chia seeds flour contained 38.32% protein, 45.09% crude fibre, 0.76% fat and 8.42% ash content. These values are higher than those reported by Rana (2019). These differences in chemical composition might be due to cultivation region, environmental conditions (climate, availability of nutrient, soil condition, etc.) and genetic factors (Ali *et al,* 2012 and Ikumi *et al,* 2019). Defatted chia seeds flour contained higher concentration of total phenolic compounds (Table 1), therefore, it possess higher antioxidant activity.

Table 1. Mean of physico-chemical analysis of defatted chia seeds flour (DCSF).

Parameter	Mean value
Moisture (%)	7.41 + 0.41
Protein (%)	38.32 + 2.31
Fibre (%)	45.09 + 1.98
Fat (%)	0.76 + 0.02
Ash (%)	8.42 + 0.68
TPC (mg GAE)	0.91 + 0.11
WHC (g/g)	14.19 + 0.39
OHC (g/g)	20.32 + 0.64

WHC: Water holding capacity; OHC: Oil holding capacity; TPC: Total phenolic compounds.

These results are in agreement with those reported by Alfredo *et al* (2009) and Rana (2019).

Defatted chia seeds flour exhibited higher water and oil holding capacities 14.19 and 20.32, respectively. These results were similar to those reported previously (Coorey *et al,* 2012; Olivos-Lugo *et al,* 2010; Rana, 2019). These results might be attributed to the higher fibre and protein content of defatted chia seeds flour as reported by Darwish *et al* (2018) and Alfredo *et al* (2009). The higher water and oil holding capacities of defatted chia seeds flour might enables it to be used as stabiliser emulsifier and fat replacer in the manufacture of many food products (Alfredo *et al,* 2009; Darwish *et al,* 2018; Grancieri *et al,* 2019; Ikumi *et al,* 2019; Rana, 2019).

Ice milk mixes properties

Both specific gravity and weight per gallon of ice milk mixes table 2 followed almost similar trends (El-Kholy, 2018 and Osman *et al,* 2020). Replacement of camel's milk fat with defatted chia seeds flour (DCSF) caused a significant increase of specific gravity and weight per gallon. The increase was more obvious when defatted chia seeds flour was added with the same rate of substituted fat and at the higher rate of replacement (Table 2). This increase was proportional to the rate of substitution. Ice milk mix T_{42} that was made by replacing 100% of milk fat with the same amount of defatted chia seed flour had the highest specific gravity and weight per gallon, while control ice mix exhibited the lowest specific gravity and weight per gallon. These results might be due to the higher specific gravity of defatted chia seeds flour (DCSF) than that of milk fat, which subsequently increased the specific gravity of ice milk mixes. Similar trends were reported by other researchers (Hamed *et al,* 2014; Kamaly *et al,* 2017).

Table 2. Effect of replacing camel's milk fat with defatted chia seeds flour (DCSF) on some properties of low fat ice milk mixes.

Ice mix treatments*	Specific gravity	Weight / gallon (kg)	Freezing point (°C)	Viscosity (cp)
C	1.1129^{F}	4.2134^{F}	-2.19^{A}	238.1^{F}
T_{11}	1.1134^{E}	4.2153^{E}	-2.24^{B}	240.2^{E}
T_{12}	1.1141^{D}	4.2180^{D}	-2.29^{C}	245.6^{D}
T_{21}	1.1143^{D}	4.2187^{D}	-2.33^{D}	246.3^{D}
T_{22}	1.1149^{C}	4.2210^{C}	-2.40^{E}	251.2^{C}
T_{31}	1.1148^{C}	4.2206^{C}	-2.43^{E}	248.6^{C}
T_{32}	1.1156^{B}	4.2237^{B}	-2.50^{F}	256.3^{B}
T_{41}	1.1153^{B}	4.2225^{B}	-2.56^{F}	252.9^{C}
T_{42}	1.1166^{A}	4.2274^{A}	-2.66^{G}	264.2^{A}

Means followed with different letters within each column are not significantly different according to Duncan test (P = 0.05).
*C: the control mix.
T_{11} and T_{12}: Ice mix treatments containing 3% fat with adding 0.5 and 1.0% DCSF.
T_{21} and T_{22}: Ice mix treatments containing 2% fat with adding 1.0 and 2.0% DCSF.
T_{31} and T_{32}: Ice mix treatments containing 1% fat with adding 1.5 and 3.0% DCSF.
T_{41} and T_{42}: Ice mix treatments without fat adding 2.0 and 4.0% DCSF.

Freezing point of low fat ice mixes decreased significantly ($p < 0.05$) by increasing the rate of replacing milk fat, with defatted chia seeds flour (DCSF). Ice milk mix T_{42} that was made by replacing 100% of milk fat with DCSF exhibited the lowest freezing point, while control ice milk mix had the highest freezing point (Table 2). These results could be attributed to the dissolve of some DCSF constituents and / or differences of mixes acidity that help to dissolve some mix constituents which consequently cause the decrease in freezing point of ice milk mix, Kebary (1996) and Khalil and Blassey (2019) reported that when fat was replaced with dissolved substances in ice cream the freezing point decreased. Osman *et al* (2020) also stated that freezing point of ice cream mix was decreased by replacing of milk fat with ingredient containing higher concentration from fibre and mineral, which is similar to defatted chia seeds flour where it contains higher concentration from fibre and minerals (Table 1).

Replacement milk fat with DCSF caused a pronounced increase in the viscosity. There was a positive correlation between the rate of replacing milk fat milk with DCSF and the viscosity of ice milk mixes (Table 2). Replacing milk fat with the same amount from DCSF was more efficient to increase the viscosity of ice milk mixes (Table 2). These results might be due to the higher water holding capacity of DCSF and consequently its higher ability to retain water, which increase the viscosity (Borneo *et al,* 2010; Darwish *et al,* 2018; El-Kholy, 2018; Ervina and Abdilla, 2018; Jain and Rai, 2018; Grancieri *et al,* 2019; Ikumi *et al,* 2019 and Osman *et al,* 2020). Similar results were reported by (Hamed *et al,* 2014 and Kamaly *et al,* 2017) who used inulin as a fat replacer.

Properties of ice milk

Specific gravity and weight per gallon of ice milk treatments followed similar trends in reported by El-Kholy (2018) and (Khalil and Blassey, 2019). Replacement of milk fat with defatted chia seeds flour (DCSF) caused a marked increase of both specific gravity and weight per gallon of ice milk treatments (Table 3). This increase was proportional to the rate of replacement. The differences among ice milk treatments in both specific gravity and weight per gallon could be attributed to 2 factors, first factor is using DCSF which has higher specific gravity than milk fat and the second factor is the overrun which has negative correlation with specific gravity and weight per gallon (Hamed *et al,* 2014; El-Kholy, 2018; Osman *et al,* 2020). Ice milk treatment T_{42} which made by replacing 100% of milk fat with the same amount of DCSF and had the lowest overrun exhibited the highest specific gravity and weight per gallon, while ice milk treatment C, which made without replacing milk fat exhibited the lowest specific gravity and weight per gallon (Table 3). These results are in agreement with those of others researchers (Hamed *et al,* 2014; Kamaly *et al,* 2017; El-Kholy, 2018; Osman *et al,* 2020) who substituted milk fat with different fat replacers.

Table 3. Effect of replacing camel's milk fat with defatted chia seeds flour (DCSF) on some properties of low fat ice milk.

Ice milk treatments*	Specific gravity	Weight / gallon (kg)	Overrun	Melting resistance		
				First 60 min	Next 30 min	Last 30 min
C	0.6738^{D}	2.5510^{D}	63.45^{C}	30.60^{A}	43.3^{A}	26.1^{F}
T_{11}	0.6785^{D}	2.5688^{D}	65.09^{C}	29.2^{A}	43.6^{A}	27.2^{F}
T_{12}	0.6816^{C}	2.5805^{C}	66.38^{B}	28.3^{B}	41.9^{B}	29.8^{E}
T_{21}	0.6829^{C}	2.5854^{C}	66.09^{B}	28.1^{B}	41.5^{B}	30.4^{E}
T_{22}	0.6883^{C}	2.6059^{C}	68.16^{A}	26.9^{C}	39.7^{C}	33.4^{D}
T_{31}	0.6953^{B}	2.6324^{B}	63.09^{C}	27.5^{C}	39.6^{C}	32.9^{D}
T_{32}	0.6992^{B}	2.6472^{B}	59.13^{E}	25.6^{D}	37.2^{D}	37.2^{B}
T_{41}	0.6936^{B}	2.6259^{B}	61.57^{D}	27.0^{C}	38.9^{C}	34.1^{C}
T_{42}	0.7138^{A}	2.7024^{A}	55.18^{F}	23.1^{E}	36.1^{E}	40.8^{A}

Means followed with different letters within each column are not significantly different according to Duncan test (P = 0.05).

Overrun of ice milk increased significantly by increasing the rate of replacing milk fat with the same amount of DCSF up to 50% which might be due to improving the whipability of ice milk by adding DCSF (Grancieri *et al,* 2019 and Ikumi *et al,* 2019). El-Kholy (2018) reported that the increase of overrun might be due to the interaction between dietary fibre and milk proteins and formation of complex matrix that increase the entrapment of air in ice milk. Increasing the rate of replacing milk fat with the same amount of DCSF above 50% caused a significant ($p < 0.05$) reduction of overrun of ice milk treatments (Table 3). This decrease of overrun might be due to the increase of viscosity that subsequently suppress the ability of ice milk to retain the air in ice milk (Chang and Hartel, 2002; Sofjan and Hartel, 2004). Ice milk treatment (T_{21}, T_{22}, T_{32} and T_{43}) those made by replacing milk fat with the same amount from DCSF were significantly different from corresponding ice milk treatments (T_{11}, T_{21}, T_{31} and T_{41}) those made by adding DCSF at the rate of 50% of substituted fat (Table 3). Similar trends were reported by Hamed *et al* (2014) and Kamaly *et al* (2017).

Replacement of milk fat with DCSF caused an obvious reduction of the rate of melting, which means increasing the melting resistance of ice milk at 60 min and the next 30 min (Table 3). This increase of melting resistance was proportional to the rate of replacing milk fat with DCSF. Ice milk treatment T_{42} that made with replacing 100% of milk fat with the same amount of DCSF exhibited the highest melting resistance while control ice milk exhibited the least melting resistance (Table 3). These results might be due to the higher fibre content of DCSF that increase the viscosity and the higher water holding capacity (Alfredo *et al,* 2009; Darwish *et al,* 2018; Ikumi *et al,* 2019; Rana, 2019), which binds higher amount of water and left lowest amount of free water that can be melted faster than the bound water, therefore increase the melting resistance. These results are in agreement with those of other researchers (Ervina and Abdillah, 2018; Jain and Rai, 2018; El-Kholy, 2018; Aljewicz *et al,* 2020; Kebary *et al,* 2020; Osman *et al,* 2020). Ice milk treatments (T_{12}, T_{22}, T_{32} and T_{42}) made by replacing milk fat with the same amount of DCSF exhibited higher melting resistance than those of corresponding ice milk treatments (T_{11}, T_{21}, T_{31} and T_{41}) which were made by adding DCSF at the rate of 50% of substituted fat (Table 3). These results might be due to the differences in fibre content and water holding capacity. On the other hand, melting resistance of ice milk treatments after the last 30 min followed contradictory trend of those at the first 60 min. These results were in accordance with those reported by Hamed *et al* (2014), Kamaly *et al* (2017) and Kebary *et al* (2020).

Ice milk treatments were significantly ($p < 0.05$) different from each other in titratable acidity, which means replacement of milk fat with DCSF increased significantly ($p < 0.05$) the titratable acidity of the resultant ice milk treatments (Tables 4 and 6). There was positive correlation between the rate of replacement and the titratable acidity of ice milk treatments.

Ice milk treatment T_{42} that made with replacing 100% of milk fat with the same amount of DCSF had the highest acidity, while control ice milk had the lowest titratable acidity (Tables 4 and 6). Ice milk treatments (T_{12}, T_{22}, T_{32} and T_{42}) those made by replacing milk fat with the same amount from DCSF exhibited higher acidity than corresponding ice milk treatments (T_{11}, T_{21}, T_{31} and T_{41}) those made by replacing milk fat with only 50% of DCSF (Tables 4 and 6). These results could be attributed to the higher protein content of DCSF which increases the buffering capacity and consequently increases the titratable acidity of the resulting ice milk treatments. On the other hand, titratable acidity of all ice milk treatments did not change significantly ($p > 0.05$) during storage period (Tables 4 and 6). These results are in agreement with those reported by Hamed *et al* (2014) and Kebary *et al* (2020).

Ice milk treatments C, T_{12}, T_{22}, T_{32}, and T_{42} were not significantly ($p > 0.05$) different from each other in total solids content, which means replacing of milk fat with the same amount of DCSF did not have significant effect on total solids content of the resultant ice milk treatments (Tables 4 and 6). Similar results were reported by Hamed *et al* (2014) and Kamaly *et al* (2017), who used inulin as a fat replacer. On the other hand, replacement of milk fat with DCSF at the rate of 50% of substituted fat caused a significant reduction of total solids of the resultant ice milk treatments and this decrease of total solids was proportional to the rate of replacement (Tables 4, 6). Total solids content of all ice milk treatments did not change significantly ($p > 0.05$) throughout the frozen storage period (Tables 4, 6). Similar results were reported by Hamed *et al* (2014) and Kebary *et al* (2020).

Fat content of ice milk treatments decreased by increasing the rate of replacing milk fat with DCSF (Tables 4, 6). There was negative correlation between the rate of replacement and the fat content of ice milk treatments. Control ice milk treatment contained the highest fat content, while those treated (T_{41} and T_{42}) and made by replacing 100% of milk fat with DCSF contained the lowest fat content. These results were in agreement with those reported by Hamed *et al* (2014) and Kamaly *et al* (2017).

Replacement of milk fat with DCSF either at the rate of 100% or 50% of substituted fat did not have significant ($p > 0.05$) effect on the fat content of ice milk treatments. Therefore ice milk treatments (T_{12}, T_{22}, T_{32} and T_{42}) did not change significantly ($p > 0.05$) from corresponding ice milk treatments (T_{11}, T_{21}, T_{31} and T_{41}), respectively. Fat content of all ice milk treatments did not change significantly ($p > 0.05$) as storage period proceeded (Tables 4 and 6) (Hamed *et al,* 2014; Kamaly *et al,* 2017; Kebary *et al,* 2020).

Total protein and ash contents of ice milk treatments followed almost similar trends (Tables 4 and 6). Both total protein and ash content of ice milk treatments increased significantly ($p < 0.05$) with replacing milk fat with DCSF added either at the rate of 100% or 50% of substituted fat (Tables 4, 6). This increase was proportional to the rate of replacement (Tables 4 and 6). The increase of protein and ash content of ice milk treatments (T_{12}, T_{22}, T_{32} and T_{42}) those made by replacing milk fat with the same amount of DCSF was more pronounced than those of ice milk treatments (T_{11}, T_{21}, T_{31} and T_{42}) made by replacing milk fat with DCSF @ 50% of substituted fat (Tables 4 and 6). Ice milk treatment (T_{42}) that was made by replacing 100% of milk fat with 100% of DCSF contained the highest total protein and ash contents, while control ice milk treatment contained the lowest total protein and ash contents (Tables 4 and 6). These results might be due to the higher total protein and ash content of DCSF (Alfredo *et al,* 2009;

Table 4. Effect of replacing camel's milk fat with defatted chia seeds flour (DCSF) on the gross composition of low fat camel ice milk during the frozen storage for 10 weeks.

Ice milk Treatments*	Total solids (%)		Fat (%)		Proteins (%)		Ash (%)		Titratable acidity (%)	
	Fresh	10 weeks	Fresh	10 weeks	Fresh	10 weeks	Fresh	10 weeks	Fresh	10 weeks
C	34.25	34.76	3.9	4.0	4.92	4.81	1.08	1.10	0.225	0.230
T_{11}	33.76	34.05	2.9	2.9	5.06	5.09	1.12	1.18	0.231	0.234
T_{12}	34.33	34.51	2.9	2.9	5.19	5.22	1.16	1.19	0.238	0.243
T_{21}	33.28	33.43	2.0	2.0	5.18	5.20	1.16	1.21	0.239	0.242
T_{22}	34.21	34.56	2.0	2.0	5.43	5.50	1.22	1.25	0.248	0.251
T_{31}	22.17	32.41	1.0	1.0	5.36	5.41	1.21	1.26	0.246	0.249
T_{32}	34.31	34.58	1.0	1.1	5.71	5.78	1.28	1.30	0.253	0.256
T_{41}	32.31	32.46	0.1	0.1	5.41	5.46	1.23	1.29	0.249	0.254
T_{42}	34.43	34.66	0.1	0.1	6.09	6.16	1.39	1.42	0.258	0.262

Grancieri *et al,* 2019; Ikumi *et al,* 2019; Rana, 2019). On the other hand, total protein and ash contents of all ice milk treatments did not change significantly (p > 0.05) as storage period progressed (Tables 4 and 6). These results are in agreement with reported by other researchers (Hamed *et al,* 2014; Kamaly *et al,* 2017; Kebary *et al,* 2020).

Scores of organoleptic properties (flavour, body and texture, melting quality and colour) of ice milk treatments stored for 10 weeks are presented in Table 5. There were slight differences among ice milk treatments in body and texture and melting quality, while there were no significant (p > 0.05) differences in the colour of ice milk treatments. Replacement of milk fat up to 50% with the same amount of DCSF increased the scores of flavour and the total scores and improved the acceptability of ice milk treatments, while increasing the rate of replacement above 50% reduced the scores of flavour and the total scores of organoleptic properties (Tables 5 and 6). Ice milk treatment (T_{22}) that was made by replacing 50% of milk fat with the same amount of DCSF gained the highest total scores of organoleptic properties and was the most acceptable ice milk treatments (Tables 5 and 6). Also ice milk treatment (T_{31}) that was made with replacing 75% of milk fat with DCSF at the rate of 50% of substituted fat gained total scores of organoleptic properties higher than control ice milk, but lower than treatment (T_{22}) (Tables 5 and 6). These results might be due to the higher fibre content of DCSF that provided a uniform smooth body and texture (Soukoulis *et al,* 2009). On the other hand, the total scores of organoleptic properties of all ice milk treatments did not change significantly during storage period up to 8 weeks, then declined up to the end of storage period (Hamed *et al,* 2014; Kebary *et al,* 2020).

Defatted chia seeds flour (DCSF) contained higher concentration of total protein, fibre ash and

Table 5. Effect of replacing camel's milk fat with defatted chia seeds flour (DCSF) on the scores of organoleptic properties of low fat ice milk during the frozen storage for 10 weeks.

Ice milk treatments*	Flavour (45)						Body and texture (35)						Melting quality (10)						Colour (10)						Total score (100)					
	Storage period (weeks)																													
	0	2	4	6	8	10	0	2	4	6	8	10	0	2	4	6	8	10	0	2	4	6	8	10	0	2	4	6	8	10
C	40	40	40	38	38	36	32	32	31	30	30	30	9	9	8	8	7	7	9	9	8	8	8	7	90	90	87	84	83	80
T_{11}	42	42	40	38	38	35	32	32	31	30	30	30	9	9	8	8	8	7	9	9	8	8	8	7	92	92	88	84	84	79
T_{12}	42	42	40	39	37	36	32	32	30	30	29	29	9	9	9	8	8	7	9	8	8	8	8	7	92	91	87	85	82	79
T_{21}	41	41	40	38	36	34	33	32	31	30	28	26	9	9	9	8	8	8	9	8	8	8	7	7	92	91	88	84	81	75
T_{22}	43	42	40	38	35	35	33	33	30	30	30	30	9	9	9	8	8	8	9	8	8	8	7	7	94	91	86	84	80	80
T_{31}	41	40	40	39	36	34	31	33	32	30	30	28	9	9	9	8	8	8	9	9	9	8	8	7	92	90	87	85	82	77
T_{32}	39	38	38	36	34	32	31	30	30	29	30	28	9	9	8	8	8	7	8	8	8	8	7	7	87	85	84	81	79	74
T_{41}	40	40	40	38	36	34	32	31	30	28	28	28	9	9	8	8	8	8	8	8	8	8	8	7	89	88	86	82	82	77
T_{42}	36	36	36	34	31	30	30	28	28	28	27	26	8	8	8	8	7	7	8	8	7	7	7	7	82	80	79	77	72	70

Table 6. Statistical analysis of low fat ice milk properties.

Camel ice milk properties	Means square	Effect of treatments									Means square	Effect of storage (weeks)					
		C	T_{11}	T_{12}	T_{21}	T_{22}	T_{31}	T_{32}	T_{41}	T_{42}		0	2	4	6	8	10
Total solids	5.367*	A	B	A	C	A	D	A	E	A	2.610	A					A
Fat	0.381*	A	B	B	C	C	D	D	E	E	0.870	A					A
Ash	0.071*	F	F	E	E	C	D	B	C	A	0.076	A					A
Proteins	0.547*	G	F	E	E	C	D	B	C	A	0.765	A					A
Titratable acidity	0.077*	E	D	C	C	B	B	AB	B	A	0.861	A					A
Organoleptic properties:																	
Flavour	21.186*	C	B	B	B	A	B	D	C	E	3.214*	A	A	A	A	AB	B
Body and texture	11.125*	A	A	A	A	A	A	A	A	A	0.192*	A	A	A	A	AB	B
Melting quality	1.831	A	A	A	A	A	A	A	B	B	0.056*	A	A	A	A	AB	B
Colour	1.936*	A	A	A	A	A	A	B	B	B	0.139*	A	A	A	A	AB	B
Total score	76.13*	C	B	B	B	A	B	D	D	E	0.831	A	A	A	A	AB	B

Means followed with different letters within each column are not significantly different according to Duncan test (*P* = 0.05).

exhibited higher water and oil holding capacities. Replacement of milk fat with DCSF especially, at the rate of 100% of substituted fat increased the specific gravity, weight per gallon and viscosity, while decreased the freezing point of ice milk mixes. Substitution of milk fat with DCSF caused a significant increase of melting resistance, total protein, ash and acidity of ice milk. Replacement of milk fat up to 50% with the same amount of DCSF increased the overrun and the total scores of organoleptic properties of ice milk, while increasing the rate of replacement above 50% decreased the total scores and the overrun. Therefore, it could be recommended that it is possible to reduce the fat content of ice milk that was prepared by using camel's milk up to 50% with adding the same amount of DCSF, without detrimental effects on the resultant ice milk and / or reducing milk fat up to 75% with adding only 37.5% from DCSF.

Acknowledgements

The authors would like to thank High Altitude Research Centre, Taif University, Saudi Arabia, for the financial support for this research through a research grant No: 1-442-46.

References

Alfredo VD, Gabriel RR, Luis CG and David BA. Physicochemical properties of fibrous fraction from chia (*Salvia hispanica* L.). LWT-Food Science and Technology. (2009); 42:168-173.

Ali NM, Yeap SK, Ho WY, Beh BK, Tan SW and Tan SG. The promising future of chia, *Salvia hispanica* L. Journal of Biomedicine and Biotechnology. (2012); pp 1-9.

Aljewicz M, Florezuk A and Dabrowska A. Influence of β-Glucan structures and content of low-fat ice cream during storage. Polish Journal of Food and Nutrition Sciences. (2020); 70:233-240.

AOAC. Official Methods of Analysis of Association of Official Analytical Chemists. 18th edition, Washington, DC. (2010); 6:10.

Arbuckle WS. "Ice cream". 4th ed., The AVI Publishing Co. INC. Westport, Connecticut, USA. (1986).

Borneo R, Aguirre A and Leon AE. Chia (*Salvia hispanica* L.) gel can be used as egg or oil replacer in cake formulation. Journal of the American Dietetic Association. (2010); 110:946-949.

Chang Y and Hartel RW. Development of air cells in a batch ice cream freezer. Journal of Food Engineering. (2002); 55:71-78.

Coorey R, Grant A and Jayasena V. Effect of chia flour incorporation on the nutritive quality and consumer acceptance of chips. Journal of Food Research. (2012); 1:85-95.

Darwish AMG, Khalifa RE and El Sohaimy SA. Functional properites of chia seed mucilage supplemented in low fat yoghurt. Alexandria Science Exchange Journal. (2018); 39:450-459.

El-Kholy WM. Preparation and properties of probiotic low fat frozen yoghurt supplemented with powdered Doum (*Hyphaene thebaica*) fruit. Egyptian Journal of Dairy Science. (2018); 46:67-78.

Ervina IS and Abdillah I. The potential of avocado paste (*Persea Americana*) as fat substitute in non dairy ice cream. Earth and Environmental Sciences. (2018); 102:1-12.

FAO. Regional Dairy Development and Training Center for the Near East. Laboratory Manual, Spring. (1977).

Grancieri M, Martino HSD and Mejia EG. Chia seed (*Salvia hispanica* L.) as a source of proteins and bioactive peptides with health benefits: a review. Comprehensive Reviews in Food Science and Food Safety. (2019); 18:480-499.

Hamed AI, Kebary KMK, Badawi RM, Salem OM and Omar NS. Manufacture of low fat prebiotic ice milk. Menoufia Journal of Agriculture Research. (2014); 39:1317-1329.

Ikumi P, Mburu M and Njoroge D. Chia (*Salvia hispanica* L.) A potential crop for food and nutrition security in Africa. Journal of Food Research. (2019); 8:104-118.

Jain VK and Rai DC. Physicochemical properties of reduced fat low caloric and protein rich ice cream. Journal of Pharmacognosy and Phytochemistry. (2018); 7:2631-2636.

Kamaly KM, Kebary KMK, El-Sonbaty AH and Badawi KR. Quality of low fat probiotic frozen yoghurt. Menoufia Journal of Food and Dairy Sciences. (2017); 2:23-35.

Kebary KMK. Viability of *Bifidobacterium bifidum* and its effect on quality of frozen zabady. Food Research International. (1996); 29:431-437.

Kebary KMK and Hussein SA. Quality of ice cream as influenced by substituting non-fat dry milk whey-bean proteins co-precipitates. Egyptian Journal of Dairy Science. (1997); 25:311-325.

Kebary KMK, El-Sonbaty AH, Kamaly MK and Badawi KRM. Evaluation of quality attributes of low fat sucrose symbiotic frozen yoghurt. Egyptian Journal of Dairy Science. (2018); 46:119-134.

Kebary KMK, Hussein SA, Badawi RM and Eldhshan FE. Quality of ice cream supplemented with mango's peals powder. Menoufia Journal of Food and Dairy Sciences. (2020); 5:1-13.

Khader AE, Farag SI, Moussa AH and El-Bataway AM. The use of whey protein concentrate in ice cream mixes. Menoufia Journal of Agriculture Research. (1992); 17:637-647.

Khalil RAM and Blassey KI. Preparation and properties of low fat ice cream supplemented with baked sweet potato puree. Egyptian Journal of Dairy Science. (2019); 47:61-70.

Krauss RM, Eckel RH and Howard B. American Heart Association's (AHA): AHA Dietary Guidelines-Revision 2000: A Statement for Health Care Professionals from the Nutrition Committee of the AHA. Journal of Nutrition. (2000); pp 131-132.

Kulczynski B, Kobus-Cisowska J, Taczanowski M, Kmiecik D and Gramza-Michalowska A. The chemical composition and nutritional value of chia seed-current state of knowledge. Nutrient. (2019); 11:1-16.

Kwon HC, Bae H, Seo HG and Han SG. Short communication: Chia seed extract enhances physiochemical and antioxidant properties of yoghurt. Journal of Dairy Science. (2019); 120:4870-4876.

Ling ER. A Text Book of Dairy Chemistry, Vol. 2 Practical 3rd ed. Chapman and Hall, Ltd., London. (1963).

Mansour EH and Khalil AH. Evaluation of antioxidant acidity of some plant extracts and their application to ground beef patties. Food Chemistry. (2000); 95:1-7.

Morrison KR and Macjary EM. Viscosity of lactose and whey protein solutions. International Journal of Food Properties. (2001); 4:441-454.

Niki E and Traber MG. A history of vitamin E. Annals of Nutrition and Metabolism. (2012); 61:207.

Olivos-Lugo BL, Valdivia-López MÁ and Tecante A. Thermal and physicochemical properties and nutritional value of protein fraction of Mexican chia seed (*Salvia hispanica* L.). Food Science and Technology International. (2010); 16:89-96.

Omar NSS. Studies on ice milk, Ph.D. Thesis. Faculty of Agriculture, Menoufia University, Egypt. (2014).

Osman M, Abbas F, Blasses K and Galal N. Functional low-fat frozen yoghurt with persimmon (*Diospyros kabi* L.). Pulp. Egyptian Journal of Dairy Science. (2020); 48:101-116.

Rana M. Characterisation of chia seed flour and wellbeing endorsing possessions. International Journal of Food Science, Nutrition and Dietetics. (2019); 8:419-426.

Romankiewicz D, Hassoon WH, Cacak-Pietrzak G, Sobczyk M, Wirkowska-Wojdyla M, Ceglinska A and Dziki D. The effect of chia seeds (*Salvia hispanica* L.) addition on quality and nutritional value of wheat bread. Journal of Food Quality. (2017); pp 1-7.

Skerget M, Kotnik P, Hadolin M, Aizner-Hras A, Simonic M and Knez L. Phenols, pro-anthocyanidins, flavones and flavonols in some plant materials and their antioxidant activities. Food Chemistry. (2005); 89:191-198.

Sofjan RP and Hartel RW. Effects of overrun on structural and physical characteristics of ice cream. International Dairy Journal. (2004); 14:255-262.

Soukoulis C, Lebesi D and Tzia C. Enrichment of ice milk with dietary fibre: Effects on rheological properties, ice crystallisation and glass transition phenomena. Food Chemistry. (2009); 115:665.

Steel RGD and Torrie JH. Principles and Procedures of Statistics. A Biometrical Approach. 2nd ed. McGraw-Hill Book Co., New York. (1980).

Wakai K, Naito M, Date CH, Iso H and Tamakoshi A. Dietary intakes of fat and total mortality among Japanese populations with a low fat intake: the Japan collaborative cohort (JACC) study. Nutrition and Metabolism. (2014); Doi: 10.1186/1743-7075-11-12.

Williams SR. Nutrition and Diet Therapy. Times Mirror / Mosluy, College Publishing, St. Louis, Toronto and Stanta Clara. (1985).