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LOW-FAT ICE MILK MANUFACTURED WITH FRUITS OF NABQ (*ZIZIPHUS SPINA-CHRISTI* L.)

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ABSTRACT

Ice milk is one of the most popular frozen desserts in Egypt and nowadays consumers are interest of healthier and functional food. Therefore, the aim of this study was to produce a low- fat ice milk by replacing cream with nabq fruits pulp (NFP) at 25, 50, 75 and 100% to obtain a product with functional characteristics. The chemical composition, total phenolic compounds, antioxidant activity, mucilage content, physicochemical characteristics and sensory acceptance of the ice milk were analyzed, beside, sensory acceptance. Ice milk containing NFP had a higher concentration of phenolic compounds and posteriorly had higher antioxidant activity compared to the control samples at zero time and after 40 days for all concentration of NFP. %Overrun increased significantly in T3 compared to other treatments, whereas freezing time decreased by the increasing of replacement percentage of NFP. Also, the high level of NFP (100% replacement) led to increase viscosity as this fruit contain mucilage and fibers. Our findings purported that the best percentage of replacement was 50% for panelist's acceptance. Nabq fruit pulp potentially recorded as a natural source of antioxidants and mucilage to fortify and develop new products.

1.Introduction

At recent days, dairy factories are turning to increase production of dairy products lower in their fat content and richer in nutraceutical and functional properties. Consumers are interested in eating these products that are being acceptable in taste, flavor, appearance and cheap. Among of these products, many kinds of new regular and low fat ice cream or known as ice milk available in the markets now. Substitution of traditional ingredients in ice cream with healthful and functional food ingredients without altering taste, mouth feel, or other sensory properties was the target of various studies (Salama, et al., 2017). In Egypt and according to the Egyptian Standard 1185-3/2005, the fat content of ice milk must not less than 3% (Soad et al., 2014). Fat plays an important role in the stabilization of the ice cream structure, as partially merged fat is mainly responsible for stabilizing the air bubbles and the foam structure (Koxholt, et al., 2001).On the other hand, substitution of milk fat with fat replacers, may change both the texture and flavour profile of ice cream (Prindiville et al., 2000). Fat replacers consist of mixtures of lipid originated fat substitutes, protein- or carbohydrate originated fat mimetic, or their combinations (Huyghebaert et al., 1996). *Zizyphus spina-christi* is a deciduous shrub which belongs to *Rhamnaceae* Family. Fruits are commonly used in folk medicine for the curing of various diseases (Abdel-Zaher et al., 2008).They are wide-spread in the Mediterranean region, Africa, China, India, Australia and tropical America (Jaeschke et al., 2006). The genus Zizyphus is famous for their high biologically active material contents such as polyphenols, exhibiting antimicrobial, antioxidant, antitumor properties. Also these fruits act as a hypoglycemic, hypotensive, anti-inflammatory, and liver protective agent and an immune system stimulant.(Said et al., 2006) and (Abdel-Zaheret al., 2005). The main important compounds characterized in this plant are flavonoids, alkaloids, triterpenoids, saponins, lipids, proteins, free sugars and mucilage (Adzu et al., 2003). Mucilage is a plant hydrocolloid, which is a polymer of a monosaccharide or mixed monosaccharide. In fact, polysaccharide mucilage is highly hydrophilic substances with high molecular weight molecules. The polysaccharides are soluble and dispersible in water due to their ability to interact with water and swell. The swelling properties are characterized by the entrapment of a large amount of water between the polymer chains and branches. Thus, mucilage can be used as one of the food additives, to modify the food quality in terms of food stability, texture and appearance properties by acting as emulsifiers, thickeners, viscosity and gelling agents or texture modifiers. So, it could be used as stabilizer in ice-cream, sauce and salad dressing (Nussinovitch, 1997 and Deogade et al., 2012). Modern life style habits cause many people to develop abnormally high levels of oxidative stress which caused mainly by free radicals(Bores et al., 1990). For the protection against free radicals, organisms are endowed with endogenous (antioxidant enzymes) and exogenous defense systems. These systems unable to protect our tissues when the generations of free radicals are significantly increased(Pakin et al., 2001). Phenols are very important plant constituents because of their scavenging ability on free radicals due to their hydroxyl groups, therefore, the phenolic content of plants may contribute directly to their antioxidant action (Kaneto et al., 1999 and Himesh et al., 2011). The aim of this study is to investigate the benefits of nabq which is characterized by its high nutritional value and it can be used as a fat replacer in healthy and functional ice milk to replace fat partially or completely and to examine the effects of fat replacement by the addition of nabq fruit on the ice milk quality, especially, there is a lack of information regarding analysis as well as utilization of nabq fruits in food products.

2. Materials and methods

2.1. Materials

Fresh skimmed cow's milk (8.76% Total Solids, 0.1% Fat, 3.44% Protein, 0.59% Ash, 4.63% Lactose and pH value was 6.67) was obtained from the Faculty of Agriculture, Cairo University, Giza, Egypt. Skimmed milk powder (SMP) (96.2% TS, 0.8% Fat, 33.40% Protein, 7.90% Ash, 54.10% Lactose and pH value was 6.60)(Ecoval N.V., Paris, France), Cream (64% TS, 60% Fat, 1.90 % Protein, 0.60% Ash, 1.50% Lactose and pH value was 6.62) was obtained by separating of fresh buffalo's milk using cream separator (made in Egypt) and vanilla were obtained from the local market. Commercial grade sugar cane (sucrose) was purchased from sugar and Integrated Industries Company, Giza, Egypt. High viscosity carboxy methyl cellulose (CMC) produced by TIC gums, MD, USA was used as a stabilizer. 2,2-diphenyl-1-picrylhydrazyl (DPPH) was obtained from Sigma-Aldrich, (Germany).Fresh full ripened Nabq fruits (*Ziziphus spina-christi*var Hozain) were purchased from the Faculty of Agriculture, Asuit University, Egypt, in March, 2020.

2.2. Methods

2.2.1. Preparation of Nabq fruit pulp (NFP).

The fruits were washed; the pulp was separated, heated with steam until reaching 85°C for 3 min to inhibit enzymatic browning reaction and then mixed using a mixer (electric mixer, Moulinex, France). The mixture was stored in a plastic bag in a freezer at -18°C, until used.

2.2.2. Manufacture of Ice Milk

According to the Egyptian standards of ice cream (Egyptian Standard (EOS, 2005), the basic ice milk mix contained 0.25%cmc, 4% fat and 12.58% milk solids non–fat (MSNF) and 14% sucrose in the mixture. Napq fruit pulp (NFP) was added to the basic ice milk mixture to replace cream content as follows: T1: control (3% cream without replacement), T2: 25% of cream was replaced with NFP, T3: 50% of cream was replaced with NFP, T4: 75% of cream was replaced with NFP and T5: 100% of cream was totally replaced with NFP. The other ingredients content was kept at a stable level as presented in Table (1), except CMC, as nabq fruits pulp includes mucilage, which acts as CMC. Mixture was heated to 85 ± 1°C for about 30 seconds, then rapidly cooled to 5 ± 1°C and aged at the same temperature for 24 hrs. After ageing, 0.01 % vanilla powder was directly added to the mixes before frozen in horizontal batch freezer (Taylor Co., USA). The frozen ice milk was drawn in plastic cups (*Ca.* 120 mL) and hardened at – 26° C for 24 h before analyses. The frozen ice milk was then stored in freezer for 40 days to determine the antioxidant activity before and after storage. All treatments were of three replicates.

Table 1. Formulation of one kg low-fat ice milk containing different ratios nabq fruits pulp (NFP).

Ingredients	T1*	T2	T3	T4	T5
Cream (60% fat) (g)	65.500	49.125	32.750	16.375	0.000
Fresh skimmed cow's milk (8.76% SNF) (g)	656.500	656.500	656.500	656.500	656.500
Skim milk powder (g)	125.500	125.500	125.500	125.500	125.500
Sucrose (g)	150.000	150.000	150.000	150.000	150.000
CMC (g)	2.500	-	-	-	-
Nabq fruits (g)	-	18.875	35.250	51.625	68.000
Total (g)	1000	1000	1000	1000	1000

Vanilla was added at 0.1 g/kg,

*T1 : control (3% cream without replacement), T2: 25% of cream was replaced with NFP, T3: 50% of cream was replaced with NFP, T4: 75% of cream was replaced with NFP and T5: 100% of cream was totally replaced with NFP

2.2.3.Physico- Chemical properties

Moisture, total solids, crude protein, crude fat, crude fiber and total ash contents were determined according to AOAC (2007).Total available carbohydrates were calculated by differences as described by Ceirwyn (1995). The pH values were measured using a digital Laboratory by pH meter (HI93 1400, Hanna instruments) with glass electrode that was standardized with buffers of pH 4.0 and 7.0 before pH measurements by the method described in AOAC (2005). Titrable acidity was determined by the method of AOAC (2005). Percentage of total soluble solids (TSS) were determined by the method of AOAC (2005) using Abbe Refractometer (Leica Mark

II 10481) at 25° C. Minerals content (Fe, Zn, P, Mg , K and Ca) were determined as described by Hankinson (1975) using Atomic absorption Spectrophotometer No.3300 (PerkinElmer, Us instrument Division Norwalk, CT, USA). Mucilage content% (g/100g on fresh weight) was determined by the method described by Thanatcha and Pranee (2011).

2.2.4.Determination of total phenolic content

Total phenolic content was determined colorimetrically by the Folin Ciocalteu method according to the method described by (Zheng and Wang, 2001)with some modifications as described by (Martinet al., 2012), sample extracts were dissolved in methanol to yield a concentration (w/v) of 10 mg/mL. Then, 50 μL aliquots were mixed with 1.25 mL of Folin–Ciocalteu reagent (diluted 1:10 fold) and 1 mL of 7.5% sodium carbonate solution. After 30 min, absorbance was measured by Janway model 6705 Spectrophotometer (England) at a λ=765 nm, at room temperature. The results were expressed as mg gallic acid equivalents (GAE) per 100 g nabq fruit pulp on fresh weight.

2.2.5.Determination of antioxidant activity

The 2.2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity was performed as described by (Oms-Oliue al., 2009) 250 µg /mL of methanolic solution of extract was prepared. An aliquot (10μL) of methanolic extract was mixed with 90 μL of distilled water and 3.9 ml methanolic DPPH solution (0.025 g/L), then incubated for 30 min in darkness. The absorbance was measured at 515nm against methanol as blank, using a Jenway model 6705 Spectrophotometer (England). Negative control was prepared with 10 μL methanol, 90 μL distilled water and 3.9 mL DPPH solution. The antioxidant activity was calculated using the following equation.

$$\%\text{ inhibition DPPH} = \frac{(\text{ABS control} - \text{ABS sample})}{\text{ABS control}} \times 100 \quad (1)$$

where:
-AA is the antioxidant activity.
- Abs DPPH is the absorbance of DPPH free radical solution in methanol;
-Abs sample is the absorbance of DPPH free radical solution mixed with sample.

2.2.6. Physical properties of low- fat ice milk containing different ratios of napq fruits pulp (NFP).

The pH values were measured and Titrable acidity was determined as described above. The specific gravity of ice milk mixes and the resultant ice milk was determined as described by Arbuckle (1986).The freezing point (-°C) of ice milk mixes was also determined according to method of Marshall and Arbuckle (1996). The overrun values of ice milk were calculated mentioned by Marshall et al., (2003). Melting resistance of the resultant ice milk as samples was determined as mentioned by Segall and Goff (2002). Determination of viscosity was determined using a coaxial rotational viscometer (Rheotest II, Medingen, Germany) at shear rates ranging from 3.0 to 1312 s^{-1}. The measuring device (S1) was used as a sample volume of 30 ml per run. All samples were adjusted to 20 ± 1° C before loading in the viscometer device. Apparent viscosity was calculated at shear rate of 48.6 s^{-1}, (RPM= 20, spindle= 21). The hardness of resultant ice milk was measured by adapted the method suggested by Bourne and Comstock (1986) using fruit pressure tester (Penetrometer, Model FT 327). Samples were tempered to -19 °C in chest-type freezer for 24 h before testing. The pounds (Ib/in^2) of force required for a cylindrical probe (diameter = 0.8 cm and length = 2.65 cm) to penetrate the sample are a function of the hardness. Whipping abilities of the ice milk mix was determined using mixer at speed setting 10 with 3-cm blades (Heidolph N. 50111, Type RZRI, Germany) according to Baer et al. (1999). The mix (150 mL) was placed in a 1-Lstainless steal bowl, calibrated with known volume of water, and placed inside a 2.5 L bowl. An ice and salt mixture was placed between the bowls to cool the mix as it was whipped. Change in volume was rotated at 5, 10, 15 and 20 min.

2.2.7.Sensory evaluation

Samples of ice milk after 24 h of hardening at -26° C were judged by ten members of Food Technology Research Institute, Agricultural Research Center. The samples were scored for flavour (out of 45 point), body and texture (out of 35 point), melting properties (out of 10 point) and colour (out of 10 point) as suggested by Arbuckle (1986).

2.2.8.Statistical analysis

All data were expressed as mean values ± SD (standard deviation). Statistical analysis system (SAS) software program (SAS Institute 2004) was performed using one-way analysis of variance (ANOVA) followed by using T tests (LSD) at $P \leq 0.05$ being considered statistically significant difference.

3. Results and discussions

3.1.Physico chemical properties of Nabq fruit pulp

The proximate chemical composition of nabq fruit pulp was calculated on fresh wt. basis as shown in Table 2. Results show that the percentages of moisture, fat, protein, ash, fibers and carbohydrate were 84.00, 0.08, 0.56, 0.29, 0.65 and 14.40% respectively. Our results were in agreement with Pareek, (2013) and Kavitha, (2013). Meanwhile results in Table 3, indicated that pH , total titrable acidity and total soluble solids of nabq fruit pulp were 4.33±0.58, 0.562±0.09 and 14.17% ±0.29,respectively.These results are near to those of Kavitha (2013) and (Gündüz and Saraçoğlu, 2014).

Table 2. Chemical composition of nabq fruits pulp on fresh weight basis

Criteria	Nabq fruits pulp
Moisture (%)	84±0.16
Fat (%)	0.08±0.03
Crude Protein (%)	0.56±0.14
Total Ash (%)	0.29±0.07
Crude fibers (%)	0.65±0.11
Total available carbohydrates (%)	14.4±0.27
pH	4.60±0.15
Total titrable acidity (as citric acid)	0.562±0.09
Mucilage (%)	0.8±0.19
TSS (%)	14.0±0.12
Antioxidant activity (%)	68.43±0.52
Total phenol (mg GAE/100g)	173.7±2.5
Fe (mg/100g)	0.52
Zn (mg/100g)	0.48
P (mg/100g)	23.6
Mg(mg/100g)	12.4
K (mg/100g)	246
Ca (mg/100g)	25.4

* Values are means of three replicates ±SD

Mucilage is a plant hydrocolloid which is a polymer of a monosaccharide or mixed monosaccharide (Deogade et al., 2012).Mucilage content in fresh nabq fruits pulp was 0.8gm/100 g (5 gm /100gm. dw),this result was in agreement with that of Thanatcha and Pranee (2011) who reported that % mucilage in the ripe stage of nabq was 5.34 on dry weight basis. In fact, polysaccharide mucilage is highly hydrophilic substances with high molecular weight molecules. The polysaccharides are soluble and dispersible in water due to their ability to interact with water and swell. The swelling properties are characterized by the entrapment of large amount of water between the polymer chains and branches. Thus, mucilage can be used as one of the food additives, to modify the food quality in terms of food stability, texture and appearance properties by acting as emulsifiers, thickeners, gelling agents or texture modifiers (Noorlaila et al., 2015).On the other hand, it could be noticed that total phenolic content constituted 173.7±2.5 mg gallic acid equivalent/100g. Our finding is in agree with Krishna and Parashar (2013) who reported that total phenolic content ranged from 48.69 to 196.34 mg GAE/100 g (F.W basis) .On the other hand, our findings were greater than those of Kaur et al., (2015) who reported that total phenolic compounds were 105.36 mg GAE /100 g fresh weight . These differences in phenolic contents may be attributed to the influence of many external factors such as soil composition, geographical location, climatic conditions and light intensity as reported by Meng et al. (2012).

Antioxidant activity of NFP was determined by DPPH assay as shown in Table 2. It recorded 68.43±0.52 and our result is in agree with Al-Jassabi and Abdullah (2013) who reported that antioxidant activity ranged from 31.76% - 90.23% . The antioxidant nature of Zizyphus is defined mainly by the presence of a β-ring chatechol group (dihydroxylated β--ring) capable of readily donating hydrogen electron to stabilize a radical species (Waggas, A. and R. Al-Hasani, 2010).

Nabq is a nutritive fruit; it is a rich source of minerals and elements. Table 2, showed that the fruit contains Fe (0.52 mg/100g), Zn (0.48 mg/100 g), P (23.6 mg/100 g), K (246 mg/100 g) and Ca (25.4 mg/100 g). Our results in agreement to those presented by USDA (2018). It could be noticed the high content of in potassium. It is noteworthy that it helps nerves to function and muscles to contract, besides, the heartbeats stay regular. It also helps move nutrients into cells and waste products out of cells. On the other hand, high potassium content in the diet could help to offset sodium's harmful effects on blood pressure (Anon., 2021).

3.2.Chemical composition of ice milk containing different ratios of napq fruits pulp (NFP)

The chemical composition of ice milk mixture presented in Table 3, indicated that the reduction of cream caused the reduction of lipids. Data in Table 3 ascertained that there are no significant differences among treatments in TS% and crude protein. On the other hand , significance ($p \geq 0.05$) appears in fat content among treatments as the replacement of cream with different % nabq fruits pulp, the lowest value appeared in T5 (100% nabq fruit pulp), it was 0.10% compared to control (4.10%), where the decrement of fat content reached to 97.6%. The results are supported by the findings of Murtaza et al., (2004),who found that ice cream without fruits (control) had the highest fat contents however ice cream with fig in treatments showed gradually lower levels according to the fat replacement. Table 3, also shows the significant ($p \geq 0.05$) decrement in crude fibers for the control (T1), it was the lowest value (0.202%), but the highest value was in T5, it might be due to high fibers content in of nabq fruits pulp (NFP) that raised the fibers content for other treatments. Also, there was significant increment in total carbohydrates with the increasing of NFP concentration. The lowest ash contents were observed in control ice milk followed by T2, while it increased significantly (p≥0.05) in other treatments (Table 3).

Table 3. Chemical composition (%) of low-fat ice milk mixes containing different ratios of napq fruits pulp (NFP) (on fresh wet basis).

Property (%)	T1*	T2	T3	T4	T5
Total solids	32.600 ^{a} ±0.12	32.620 ^{a} ± 0.15	32.650 ^{a} ± 0.05	32.670 ^{a} ± 0.16	32.690 ^{a} ± 0.10
Crude protein	5.460 ^{a} ± 0.10	5. 440 ^{a} ± 0.18	5.240 ^{a} ± 0.15	5.360 ^{a} ± 0.05	5.330 ^{a} ±0.19
Crude Fat	4.100 ^{a} ± 0.03	3.111 ^{b} ± 0.04	2.100 ^{c} ± 0.10	1.110 ^{d} ±0.09	0.100 ^{e} ± 0.07
Crude fibers	0.202 ^{e} ±0.005	0.212 ^{d} ±0.002	0.221 ^{c} ±0.0.004	0.233 ^{b} ±0.001	0.240 ^{a} ±0.002
Total ash	0.970 ^{b} ±0.22	0.990 ^{b} ± 0.21	1.080 ^{a} ± 0.12	1.100 ^{a} ± 0.11	1.110 ^{a} ±0.01
Total available carbohydrates**	21.870 ^{e} ± 0.005	22.870 ^{d} ± 0.015	24.010 ^{c} ± 0.015	24.870 ^{b} ± 0.0.017	25.910 ^{a} ± 0.01

*T1 : control (3% cream without replacement), T2: 25% of cream was replaced with NFP, T3: 50% of cream was replaced with NFP, T4: 75% of cream was replaced with NFP and T5: 100% of cream was totally replaced with NFP.
**Total available Carbohydrates content was determined by difference.
Values are means ± standard deviations of triplicate determinations.
Means in the same row with different superscript (a,b,c…..) are significantly different (p≥0.05).

3.3.Physicochemical properties of ice milk mixes containing different ratios of napq fruits pulp (NFP)

Total acidity in T5 (100% replacement of cream by nabq fruits) recorded the highest value and decreased gradually for the other treatments under investigation. Moreover, the results of pH values were in inversely proportional with the results of total acidity. As the pH increased, total acidity decreased for all the tested samples. They were statistically significantly (p≥0.05) difference. Data in Table 4, showed that the control (ice milk containing 3% cream) showed the highest freezing point, whereas the addition of nabq fruits affected significantly on freezing point. The mixes showed lower freezing point gradually with the increasing replacement of cream by nabq fruits. Our findings were in agreement with Khalil and Blassy (2015) who reported that full fat ice cream exhibited the highest freezing point. Freezing point reduction affects on the initial and gradual growth of the formed ice crystals and also their native thermodynamic instability (Hartle, 2001). Also Ohmes et al. (1998) and El-Kholy (2005) reported that, when fat is removed from ice cream and is replaced with non-fat milk solids or other dissolved substances the freezing point is lowered. Data in Table 4 also showed that replacing fat by NFP, increased significantly (p≥0.05) the specific gravity of mixes, in a positive way with the rate of substitution. Regarding apparent viscosity of ice milk mix as presented in (Table 4), it could be observed that it increased accordance with replacing fat by nabq fruit. There was a direct proportional between viscosity and the ratio of replacement (Table 4). A certain level of viscosity in ice milk mixes is needed for proper whipping and retention of air cells. Our results were in accordance with El-Kholy and Abbas (2015) who reported that apparent viscosity increased in appositive way with the replacement of fat by pumpkin. This may be due to TSS and fibers contents which were responsible for gel forming viscous, as well as particle size and high water holding capacity of fibers (Vani and Zayas, 1995 and Hassan, 2005).

Table 4. Physicochemical properties of low-fat ice milk mixes with different ratios of nabq fruits pulp (on fresh wet basis).

Properties	T1*	T2	T3	T4	T5
Total acidity (%)	0.40 ^{e} ±0.03	0.44 ^{d} ±0.01	0.46 ^{c} ±0.02	0.48 ^{b} ±0.01	0.50 ^{a} ±0.01
pH value	6.43 ^{a} ±0.04	6.21 ^{b} ±0.04	6.08 ^{c} ±0.04	5.99 ^{d} ±0.03	5. 92 ^{e} ±0.03
Freezing point (−°C)	-2.31 ^{a} ±0.02	-2.44 ^{b} ±0.03	-2.56 ^{c} ±0.03	-2.60 ^{d} ±0.04	-2.64 ^{e} ±0.03
Specific gravity	1.0852^{c} ±0.0076	1.1014^{b} ±0.0017	1.1039 ^{b} ±0.0005	1.1048 ^{a} ±0.0005	1.1050 ^{a} ±0.0.0005
Apparent viscosity (mPas)	159.0±0.62 ^{e}	194.0±0.99 ^{d}	227.0 ^{c} ±0.41	270.0 ^{b} ±0.87	322.0 ^{a} ±0.91

* T1 : control (3% cream without replacement), T2: 25% of cream was replaced with NFP, T3: 50% of cream was replaced with NFP, T4: 75% of cream was replaced with NFP and T5: 100% of cream was totally replaced with NFP
Values are means ± standard deviations of triplicate determinations.
Means in the same row with different superscript (a,b,c…..) are significantly different (p≥0.05)

3.4.Effect of storage time and treatments of low-fat ice milk mixed with different ratios of nabq fruits on total phenols and antioxidant activity Both total phenols and antioxidant activity significantly increased among the nabq fruits ice milk treatments in direct proportion with increasing the concentration of nabq fruits, this finding may be due its content of phenols. Whereas, they decreased with the increasing storage time among treatments (T3, T4 and T5). This may be due to freezing that affect phenols. Thus, it may be concluded that the decrement in total phenol in ice cream treatments (Table 5) is closely related to the decline in their antioxidant capacity. Our results were in accordance with Vital et al. (2018), who reported that there was degradation of the phenolic compounds appeared in the ice creams supplemented with grape juice residue during storage.

Table 5. Total phenols and antioxidant activity of low-fat ice milk mixed with different ratios of nabq fruits pulp (NFP) during storage.

Treatments	Total phenols (mg/100g)		Antioxidant activity (%) by DPPH	
	Zero time	**40 days**	**Zero time**	**40 days**
***T1**	9.40 ^{eA} ±0.27	9.17 ^{eA} ±0.31	1.96 ^{eA} ±0.80	1.50 ^{dA} ±0.70
T2	15.11 ^{dA} ±1.39	13.47 ^{dA} ±0.84	8.35 ^{dA} ±0.40	7.78 ^{cA} ±0.45
T3	20.43 ^{cA} ±0.68	19.11 ^{cB} ±0.37	15.27 ^{cA} ±1.38	9.76 ^{cB} ±0.25
T4	24.56 ^{bA} ±1.14	22.06 ^{bB} ±1.15	22.38 ^{bA} ±0.30	15.13 ^{bB} ±0.07
T5	27.13 ^{aA} ±0.56	24.53 ^{aB} ±0.63	30.66 ^{aA} ±0.57	24.57 ^{aB} ±3.01

*T1:control (3% cream without replacement), T2: 25% of cream was replaced with NFP, T3: 50% of cream was replaced with NFP, T4: 75% of cream was replaced with NFP and T5: 100% of cream was totally replaced with NFP
**A& B: The means with the different capital (A& B) superscript letters within the same raw indicate significant (LSD at 5%) differences between the two periods of storage.
*** a, b,c...,: The means with the different small (a, b,…) superscript letters within the same column indicate significant (LSD at 5%) differences among treatments.The data are means of 3 replicates ± SD.

3.5.Mineral content of low fat ice milk mixed with different ratios of nabq fruits pulp (NFP).

Milk and milk products are considered poor sources of Fe, so addition of nabq fruit to ice milk will be useful. Results in Table 6, showed that the iron content of substituted cream with nabq fruit varied between 0.09 – 0.33 (mg/100g), compared to 0.05 (mg/100g) in control treatment. Also the addition of nabq fruits to ice milk was accompanied by high level of potassium content because of the high level of it in nabq fruits. On the other hand, adding of nabq fruits increased the level of calcium, because nabq fruits contains high amount of calcium (25 mg/100g on fresh weight basis).Each of Zn and P increased in ice milk in direct proportional to the addition of nabq fruits.

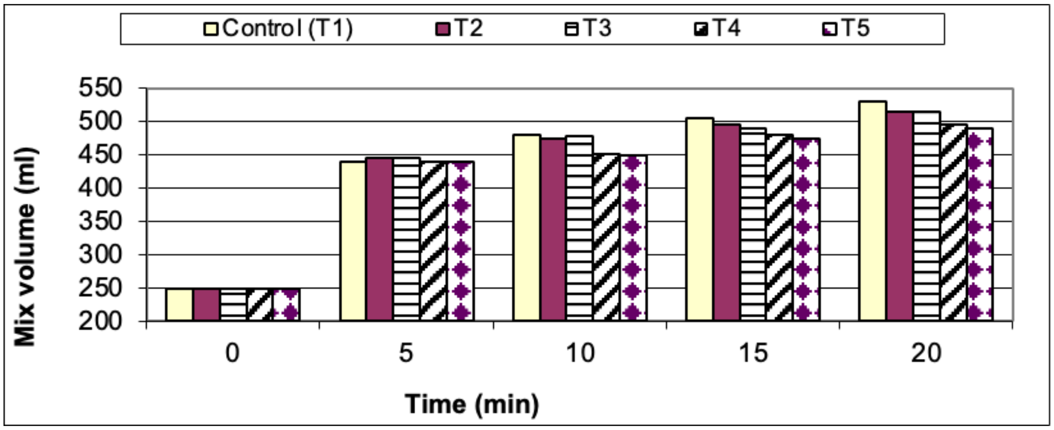
Table 6. Mineral content (mg/100g) of low-fat ice milk mixes with different ratios of napq fruits pulp (NFP).

Minerals content (mg/100g)	T1*	T2	T3	T4	T5
Fe	0.05	0.09	0.18	0.27	0.33
Zn	33.95	34.99	34.15	34.19	34.25
Mg	33.6	35.9	37.6	40.6	42.9
K	200	222	254	276	311
Ca	142.12	150.51	156.21	162.81	166.71
P	95.12	99.52	105.71	109.14	113.10

* T1: control (3% cream without replacement), T2: 25% of cream was replaced with NFP, T3: 50% of cream was replaced with NFP, T4: 75% of cream was replaced with NFP and T5: 100% of cream was totally replaced with NFP

3.6.Whipping ability

Figure 1, shows the whipping ability (increase the volume with the time) of ice milk mixes containing nabq fruit. The values were in directly proportional increased with the time for each treatment. The results revealed that the control (without nabq fruit) recorded the highest whipping ability after 20 minutes followed by T2 and T3 (milk mixes containing 25% and 50% nabq fruits of cream respectively) whereas T5(milk mixes containing 100% nabq fruits of cream) recorded the lowest whipping ability after 20 min. These results could be attributed to the high ratio of nabq fruit in T5 that had higher viscosity, which prevent air incorporation. High viscous systems do not favour foaming capacity but do favour foam stability (Stanley et al., 1996). As nabq fruit contains mucilage, it is concluded that at the same shear rate, the shear stress and viscosity of mucilage solution at high concentration were higher than that of lower concentration (Thanatcha and Pranee, 2011).Camacho et al. (2001) suggested that hydrocolloids cause kinetic hindrance to the cream foaming which could be referred to not only the increase in the liquid-phase viscosity but also to stabilizer-protein interactions that could partially inhibit the foaming properties of milk proteins.



T1 : control (3% cream without replacement), T2: 25% of cream was replaced with NFP, T3: 50% of cream was replaced with NFP T4: 75% of cream was replaced with NFP and T5: 100% of cream was totally replaced with NFP

Figure 1. Whipping ability of low-fat ice milk mixes with different ratios of fruits of Nabq.

3.7.Properties of the resultant low-fat ice milk mixes with different ratios of fruits of Nabq.

Table 7, shows the significant differences of specific gravity values among treatments. The highest value was in T5 (100% replacement of cream by nabq fruits) comparing with T1 (control without nabq fruits). The increments were observed by the increasing ratio of nabq fruit in ice milk mixes. Also, significances appeared in values of overrun % for all treatments. These results may be due to the increase in viscosity and / or reduction in freezing point (Khalafalla et al., 1975 and Kebary, 1996).From Table 7 we noticed that the highest value of overrun was in T3 compared to T1(control) followed by T2.On the contrast T4 and T5 had adverse effects on the overrun of resultant ice milk. Improvement in overrun in T3 followed by T2 may be attribute to mucilage in nabq fruit. Marshall *et al*. (2003) reported, as the viscosity increases, the resistance to melting and the smoothness of texture increases but the rate of whipping decreases.

Table 7. Effect of using different percentages of nabq fruits pulp (NFP) on the physical properties of the resultant low-fat ice milk

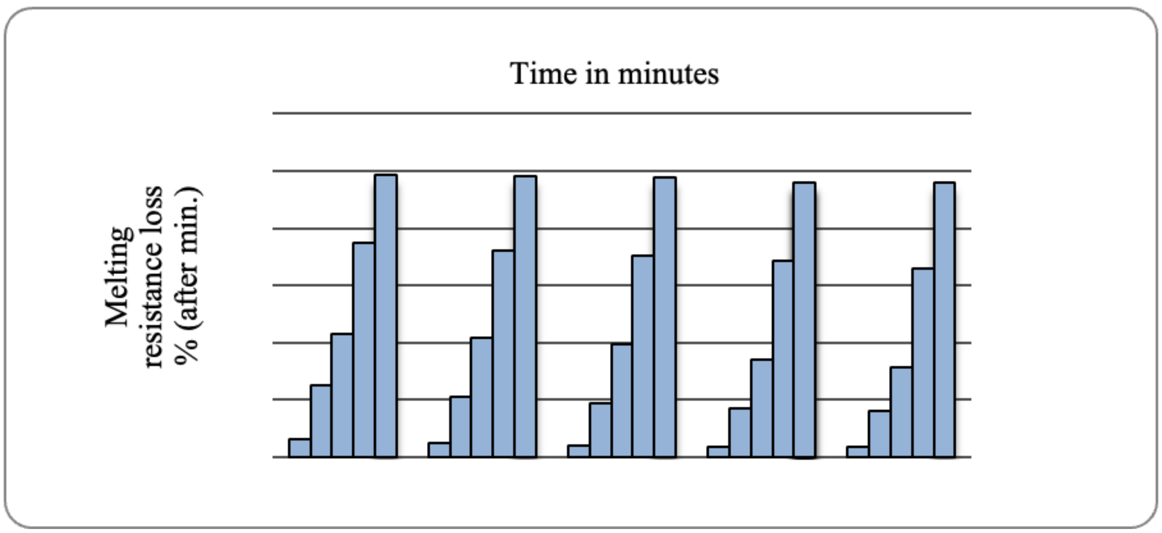
Properties	T1	T2	T3	T4	T5
Specific gravity	0.660^{b} ±0.003	0.655^{b}±0.003	0.649^{c} ±0.004	0.657^{b} ±0.002	0.670^{a} ±0.003
Overrun (%)	63.51^{d} ±1.57	73.8^{ab} ±1.65	75.12^{a} ±1.12	72.42^{bc} ±1.12	69.90^{c} ± 1.45
Freezing time (min.)	17.25^{a} ± 0.75	16.00^{b} ±0.50	15.60^{c} ±0.75	15.5^{c} ± 0.75	15.10^{c} ±0.75
Hardness	9.28^{a} ±0.09	9.22^{a} ±0.10	9.15^{a} ± 0.11	9.10^{a} ± 0.15	9.00^{a} ± 0.13

* T1 : control (3% cream without replacement), T2: 25% of cream was replaced with NFP, T3: 50% of cream was replaced with NFP, T4: 75% of cream was replaced with NFP and T5: 100% of cream was totally replaced with NFP
Values are means ± standard deviations of triplicate determinations.
Means in the same row with different superscript (a,b,c…..) are significantly different (p≥0.05).

Our results were in accordance with Abd El-Aziz et al., (2015) who concluded that the volume increase (overrun) requires a certain level of viscosity and that depends on the type and proportions of ingredients in the ice cream mixture. Our finding is in agreement with Akesowan, (2008) who reported that hydrocolloids enhance emulsion stability binding free water. Also Marshall and Arbuckle (1996) argued that air cells in ice cream are stabilized by surface active components such as proteins, phospholipids and stabilizers. From Table 7, it could be observed that the time required for freezing ice milk samples decreased with the increment of nabq fruits concentration. In addition, hardness of ice milk is not affected by addition of nabq fruit in ice milk, it could be noticed in Table 7 that there were nonsignificant differences among treatments.

3.8.Melting resistance

As shown in Figure 2, The control of ice milk scored the highest level of melting resistance but it decreases in sequence way with the increment of nabq fruits ratio. Melting resistance of ice milk was expressed as the loss in weight percent of the initial weight of the tested formula during 90 min. The increase of melting resistance of nabq ice milk attributed to nabq fruit ratio addition especially in T2 and T3, whereas there was a higher melting in T4 and T5 than other treatments. These were in accordance with Sofjan and Hartel (2004), who stated that ice cream which has a low overrun value will melt faster. On the contrary, ice cream which has high overrun will have a better resistance to melting properties.



T1 : control (3% cream without replacement), T2: 25% of cream was replaced with NFP, T3: 50% of cream was replaced with NFP, T4: 75% of cream was replaced with NFP and T5: 100% of cream was totally replaced with NFP

Figure 2. Melting resistance (loss % after min.) of low-fat napq fruits ice milk

3.9.Sensory evaluation

From Table 8, it could be noticed significances (p ≥0.05) differences in all tested samples concerning flavour parameter, T3 (50% nabq fruit of cream) scored the highest level , whereas there were no significant differences in treatments T1, T2 and T3(control, 25 and 50% nabq fruit of cream) and decreased significantly in T4 and T5 (75 and 100 % nabq fruit of cream, respectively).The same sequence was observed in melting properties, this means that the replacement of cream up to 50% with nabq fruits maintain sensory properties of ice milk.

On the other hand, colour was more acceptable in T5 than that of control because its colour was light cafe and this colour was due to the slight enzymatic browning in nabq during processing. So, T5 was preferable by panelists and this appeared through total score that there were no significant differences among the first three treatments (T1, T2 and T3).

Table 8. Sensory properties of low-fat nabq fruits ice milk samples

Parameter	T1	T2	T3	T4	T5
Flavour(45)	42.00 ^{d} ±1.41	43.60 ^{c} ± 1.17	44.40 ^{a} ±0.84	44.10 ^{b} ± 1.44	43.90 ^{e} ±0.87
Body &texture (35)	33.00 ^{a} ±1.33	33.00 ^{a} ± 1.49	33.00 ^{a} ±1.41	29.60 ^{b} ± 2.17	29.00 ^{b} ±1.39
Melting properties(10)	9.10 ^{a} ±1.05	9.00 ^{a} ± 1.56	9.50 ^{a} ± 0.82	8.40 ^{b} ± 1.49	8.00 ^{b} ± 1.49
Colour(10)	8.70 ^{c} ± 1.05	9.00 ^{b} ± 1.56	9.60 ^{a} ± 0.82	9.00 ^{b} ± 1.49	8.60 ^{d} ± 1.49
Total score (100)	92.80 ^{a} ±3.36	94.60 ^{a} ± 3.13	96.50 ^{a} ± 2.01	91.10 ^{b} ± 3.03	89.50 ^{c} ±3.57

T1 : control (3% cream without replacement), T2: 25% of cream was replaced with NFP, T3: 50% of cream was replaced with NFP, T4: 75% of cream was replaced with NFP and T5: 100% of cream was totally replaced with NFP

Values are means ± standard deviations of triplicate determinations.

Means in the same row with different superscript (a,b,c…..) are significantly different ($p \geq 0.05$).

4.Conclusions

Low-fat ice milk with nabq fruits has high nutritional value and has good physical and organoleptic properties especially at 50% replacement of fat in the mix. The final products can be considered as a functional and healthy ice milk.

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