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THE USE OF COLOSTRUM TO IMPROVE THE FUNCTIONAL AND CHEMICAL PROPERTIES OF ICE CREAM

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ABSTRACT

Ice cream is made using different proportions of colostrum. The physical chemical activity, rheology, antioxidant scavenging and organoleptic properties of colostrum-fortified ice cream were studied.

From the results obtained, it was found that there was an increase in the content of protein, carbohydrates and antioxidants by adding colostrum during the manufacture of ice cream and the T_3 score was higher (30% colostrum) than control. The chemical composition of the produced ice cream indicates excess fat, ash, TS and mineral contents; there was also an increase in the viscosity and antioxidant activity by increasing the added colostrum. On the other hand, all types of ice cream showed a decrease in mating rate. Tissue properties (TPA) are improved by increasing the amount of added colostrum.

Conclusively, *there was improvement in nutritional and sensory properties by adding colostrum.*

Key words: Ice cream, colostrum, physic-chemical, antioxidant activity and sensory quality.

INTRODUCTION

Ice cream is a sweetened frozen food mostly eaten as a snack or dessert. It is usually made up of dairy products, such as milk and milk cream and also often combined with fruits or other ingredients for flavor and as well as color. It is typically sweetened with sugar or sugar alternatives. Flavorings and colorings are added in combination to stabilizers and emulsifiers. For ice cream preparation, the prepared ice cream mixture is agitated to incorporate void or air spaces and cooled down rapidly below the freezing point of water to prepare ice cream of desired characteristics (Kailasapathy and Sultana, 2003).

As a result, produced ice cream would have smooth, semi-solid foam which is solid at low temperature. It becomes softer again as the temperature increases. Nutritional and physico-chemical properties are important deciding factor when consumers purchase any dairy products. Earlier ice cream was considered a food for enjoyment, rather than a basic food. Driven by increasing incomes and health consciousness among the consumers, value addition to dairy products has witnessed a significant increase over the past few years. Fortify ice cream with nutrients or other bioactive substances such as colostrum, led to improve quality and physical-chemical properties of ice cream (Anal and Singh, 2007).

Ice cream can be considered as an aerated suspension of crystallized fat and water in a highly concentrated sugar solution containing hydrocolloids, casein micelles, and proteins Eisner *et al.* (2005). The texture of the ice cream depends on many factors such as the state of aggregation of the fat globules, the amount of air, the size of the air cells, the viscosity of the aqueous phase, and the size and state of aggregation of ice crystals (Aime *et al.*, 2001).The energy value of the products from which it is made. Ice cream also contains high levels of milk fat, 10-16% and is a source of high quality protein and energy. Ice cream plays an important role of actual food which, besides its digestive and metabolic qualities, has nutritive qualities, but can also influence the mind because of its organoleptic characteristics and its importance as thermoregulatory food in the fight against heat (Del Giovine and Piccioli, 2003). Several studies of pediatrics recognize that ice cream plays a fundamental role in children's diets, who consume great amounts of it. But the presence of additives, particularly of dyes, can introduce a risk factor. Therefore, the use of natural additives to ice cream has an important concept (Del Giovine and Piccioli, 2003).

Colostrum is considered as a vital food for the newborn of all mammals in the first day after birth. Colostrum contains various nutrients including protein, fat, carbohydrate, water, fat-soluble vitamins and minerals as well as many biologically active substances such as immunoglobulins, antimicrobial factors, growth factors and others (Gauthier *et al.,* 2006). The most important bioactive components in colostrum improved growth and developments of the newborn while antimicrobial factor provide passive immunity and protect against infections during the first weeks of life. The antimicrobial activity of colostrum is due mostly to immunoglobulins, although colostrum also contains other antimicrobial factors, lactoferrin, lysozyme and lactoperoxidase (Gauthier *et al.,* 2006).

In general, colostrum contains less lactose and more fat, protein, peptides, non-protein nitrogen, ash, vitamins and minerals, hormones, growth factors, cytokines and nucleotides than mature milk; except in the case of lactose, the levels of these compounds decrease rapidly during the first 3 days of lactation (Uruakpa *et al.,* 2002). Colostrum is characterised by its very high concentration of immunoglobulin which is of particular importance to the neonate, whose gut, immediately following parturition, allows the passage of large immunoglobulins, thereby conferring passive immunity (Stelwagen *et al.*, 2009). It is essential that the newborn calf receives an adequate supply of colostrum as the concentration of immune-globulins and permeability of the gut decrease rapidly over the first 24 h following parturition (Moore *et al.*, 2005). In addition, colostrum intake influences metabolism, endocrine systems and the nutritional and stimulates the development and function of the gastrointestinal tract but, typically, milk collected during the colostrum period is considered unmarketable and often is excluded from bulk milk collection Marnila and Korohnen (2002). The high protein content of colostrum leads to multiple problems in industrial processes, *e.g.* poor heat stability, which interferes with pasteurization (McMartin *et al.*, 2006). Also, the high content of antimicrobial components in colostrum may affect the fermentation process. Despite this, colostrum has attracted considerable interest as a functional food ingredient (Korohnen, 1998).

Consumption of dairy products is associated with beneficial health effects beyond their nutritional values. The healthy perception, dairy products have been served as vehicles for functional food ingredients over the last 25 years. Due to the bioactive components in the colostrum such as immunoglobulins, antimicrobial such as lactoferrin, lysozyme and lactoperoxidase growth factors and others.

Therefore, the objective of the present study was to investigate the effect of addition of colostrum to increase antioxidant properties of ice cream and to determine the potential use of colostrum as a healthy ingredient in ice cream. Also, to evaluate the effects of adding colostrum on the functional and organoleptic properties of ice cream.

MATERIALS AND METHODS

MATERIALS

Fresh buffalo milk (6% fat) and buffalo colostrum used in this study was obtained from the dairy farm at the Animal Production Research Station, Mahatta Moses, Kafr El-Sheikh, Agricultural Research Center, Ministry of Agriculture, Egypt.

Treatments:

The contents of components used in ice cream mix formulations (percentage by weight) are shown in (Table1)

Table (1): The content of components used in ice cream mix formulations (percentage by weight)*.

Sample	Ingredient						
	buffalos milk (kg)	**buffalos colostrum (kg)**	**Butter (85%fat) (gm)**	**Skim milk powder (gm)**	**Sugar (10%) (gm)**	**Stabilizer (0.5%) (gm)**	**Vanillin (0.1%) (gm)**
Control	4	-	305	105	750	25	5
T1	3.600	0.400	295	85	750	25	5
T2	3.200	0.800	280	63	750	25	5
T3	2.800	1.200	266	42	750	25	5
T4	2.400	1.600	253	21	750	25	5

*5 kg mixture.

METHODS:

Manufacture of Ice cream:

The ice cream mixture was prepared using different formulations of full cream buffalo milk (6% fat) with four levels of buffalo colostrum. Ice cream was prepared according to (Marshall and Arbuckle, 1996). The basic ice cream mixture has been standardized to contain 10% fat, 10% non-fat solid milk (MSNF), 15% sugar (66% sucrose + 33% glucose), and 0.5% gelatin as a stabilizer. The required quantities of sugar, stabilizer, skimmed milk powder (97% DM), butter (85% fat), and whole buffalo milk (6% fat) were calculated.

The mixture was divided into five equal parts, 0.1% vanilla was added to the part, while the other parts (T_1, T_2, T_3, T_4) were enriched with colostrum at a concentration of 10, 20, 30 and 40%, respectively. This concentration was added to ice cream mixes according to the levels used. The mixture was heated at 85 °C for 5 minutes, then cooled to 5 °C and kept at the same temperature (5 °C) overnight for aging. After aging the ice cream maker (Taylormate TM Model 152, Taylor Company, Blackhawk Blvd, USA) was whipped. Ice cream was collected at an exit temperature of -5.5 °C and placed in 100 mL plastic cups, covered and stored at -18 °C until analysis. All ice cream treatments were prepared in three replications.

Chemical and physical properties:

The ice cream samples were analyzed triplicates. Total solids, protein, fat, titratable acidity, ash, pH value and carbohydrate contents were determined according to the (AOAC, 2007). The antioxidant activity DPPH Assay (2, 2-Dipheny1-1-picrylhydrazyl) was determined by the method described by (Blois, 1958). Mineral content Ca, Na, K, Mg, Fe and Zn were determined according to the method of James (1995). Ice cream mixes were analyzed for specific gravity, weight per gallon of ice cream mix in kilograms and freezing point (Arbuckle 1986). Viscosity measurements of the molten ice cream were taken at 10 ^{o}C with a Brokfield viscometer (Model DV-1+, Brookfield Engineering Laboratories, Inc., Middleboro, USA). The viscometer was operated at 30 rpm (spindle number 4). Each result in triplicate was recorded in cP at 30s rotation (Akbulut and Coklar, 2008).

The overrun was measured as described by (Marshall and Arbuckle 1996). Meltdown rates of the ice cream samples were measured in a controlled temperature chamber (23±2 °C). The ice cream samples were stored at -25 °C before carrying out the melting test. For melt-down rate 75g of ice cream were placed on a stainless steel screen (mesh size 2.5 mm) under which a measuring cylinder was put for the melted ice cream collection. The timing of the melt-down rate began when the first drop of the melt after 19-23 s touched the bottom of the cylinder. The weight of the material passing through the screen was recorded every 15 min for 75 min (Bollinger *et al.,* 2000).

Sensory analysis:

The sensory attributes of fresh ice cream from different treatments were assessed by 10 panelists of Department of dairy science Animal Production Research Institute, Agricultural Research Center, Ministry of Agriculture. The samples stored at -18^{o}C were tempered at room temperature for 10 min prior to sensory testing. Scoring was carried out according to Gafour *et al.* (2007) for flavour (50 points), body and texture (30 points), melting properties (10 points) and colour (10 points).

Statistical analysis:

All measurements were done in triplicates, and analysis of variance with one factorial (treatments) were conducted by the procedure of General Linear Model (GLM) according to (Snedcor and Cochran, 1967) using Costat under windows software version 6.311 and least significant difference (LSD) test were employed to determine significant difference at P <0.01.

RESULTS AND DISCUSSION

Table (2) illustrate the physical chemical properties of fresh buffaloes milk and buffaloes colostrum used for preparation of ice cream including fat, protein, total solids, ash, lactose, acidity, pH, specific gravity, DPPH inhibition, lgG, lgM, lactoferrin, vitamin A, vitamin E, and mineral contents. According to the obtained data it could be conclude that all the components of buffalo's colostrum were higher than that of buffalo's milk

Table (2): Physico- chemical composition of buffalo's milk and buffalo's colostrum used in preparation of ice cream*.

Components	Buffaloes milk	Buffaloes colostrum
Total solids %	16.80	24.00
Fat %	6.00	8.80
Protein %	4.35	10.20
Lactose %	5.50	3.80
Ash %	0.75	1.20
Acidity %	0.16	0.25
pH	6.63	6.32
Specific gravity	1.034	1.062
DPPH inhibition** %	7.89	12.30
IgG*** mg/ml	11.44	25.00
IgM**** mg/ ml	2.10	1.80
Lactoferrin mg/ml	0.20	1.20
Vitamin A IU/100ml	102.00	188.30
Vitamin E IU/100ml	190.40	396.55
Ca mg/100ml	129.00	284.80
Na mg/100ml	133.00	105.80
K mg/100ml	42.00	102.20
Mg mg/100ml	9.70	29.20
Zn mg/100ml	2.80	0.20
Fe mg/100ml	0.30	0.78

*C. F. Saleh *et al*., (2019).

**DPPH inhibition: 2, 2-Diphenyl-1-picrylhydrazyl (DPPH) inhibition (%)

***IgG: Immunoglogulin G (IgG)

****IgM: immunoglobulins termed IgM

except the value of lactose which recorded 5.50% for buffalo's milk. These results are in accordance with (Vincu *et al.* 2005) who reported that colostrum is very rich in minerals, proteins and immunoglobulin but has less lactose compared to the whole milk.

Results presented in Table (3) shows the chemical composition of ice cream that was prepared with buffalo's colostrum. Addition of 10, 20, 30 and 40% buffalos colostrum significantly increased the total solids (TS), fat, protein, ash and carbohydrate contents of ice cream compared with the control. Total solids (TS) content was significantly affected by adding buffalo's colostrum. The recorded value in ice cream (36.29%) was significantly higher ($P < 0.01$) in treatment T4 compared to the control, T_1, T_2 and T_3 (34.20, 35.56, 35.90 and 36.12% respectively). Fat content in ice cream was found to be slightly or not affected by adding buffalo's

Table (3): Effect of using different ratios of buffalo's colostrum on the chemical properties of the resultant ice cream (average of three replicates).

Property	Treatments*				
	Control	**T_1**	**T_2**	**T_3**	**T_4**
TS %	34.20^{d}	35.56^{c}	35.90^{b}	36.12^{ab}	36.29^{a}
Fat %	10.00^{d}	10.20^{c}	10.26^{c}	10.40^{b}	10.56^{a}
Protein %	4.90^{c}	4.95^{c}	5.10^{b}	5.18^{b}	5.37^{a}
Acidity %	0.22^{e}	0.24^{d}	0.28^{c}	0.31^{b}	0.36^{a}
pH	6.49^{a}	6.41^{b}	6.38^{c}	6.34^{d}	6.32^{d}
Ash %	0.88^{d}	0.90^{c}	1.07^{b}	1.08^{b}	1.09^{a}
Carbohydrate%	4.92^{d}	5.59^{d}	5.63^{c}	5.75^{b}	5.98^{a}
Antioxidant activity DPPH (%)	12.24^{e}	14.50^{d}	15.35^{c}	18.20^{b}	19.55^{a}

a, b, c….Means with the same column with different superscript are significantly different ($P<0.01$).

*See legend to Table (1) for details

colostrum, as shown in Table (3). The highest value was recorded in the ice cream made from treatment T_4 (10.56%), followed by those from T_3 (10.40%), T2 (10.26%), T_1 (10.20%) and control (10%) respectively. This attributes to the higher percentage of milk proteins especially whey proteins in colostrum (Table 2).

Concerning protein content, the recorded average values of ice cream were the lowest ($P < 0.01$) in the control compared with treatments T_1, T_2, T_3 and T_4. However, the protein content gradually increased in all treatments with an increase in the added percentage of buffalo's colostrum. The measured average values were 4.90, 4.95, 5.10, 5.18 and 5.37 % for control, T_1, T_2, T_3 and T_4 respectively.

Table (3) showed that the acidity, pH values, ash, carbohydrates and total antioxidant activity of ice cream without colostrum compared to ice cream with colostrum samples had slightly higher acidity than control. Also, due to the presence of bioactive ingredients in colostrum and its effective use (Tripathi and Vashishtha, 2006). The pH values of all the produced ice cream took an opposite trend to that of the acidity. The obtained results also revealed the increase of ash contents of ice cream contained colostrum than the control samples. The increase was also proportional to the increase of colostrum added. This could be due to that colostrum had high total solids as compared to normal milk (Poonia and Dabur, 2015).

The results in Table (3) showed the effectiveness of buffalo colostrum used in making ice cream in its carbohydrates and antioxidant content. The results obtained indicated that the control ice cream had the lowest carbohydrate content. But the results obtained showed that ice cream made with different proportions of buffalo colostrum had the highest antioxidant activity. The samples recorded 12.24, 14.50, 15.35, 18.20 and 19.55% inhibition of DPPH for control, T_1, T_2, T_3 and T_4 respectively. In general, fortification of ice cream with colostrum increased antioxidant activity and this increase in parallel with the proportion of added colostrum**.**

The physical properties of ice cream are presented Table (4). The physical properties of ice cream are presented Table (3). Results showed that all ice cream samples had higher values for specific gravity than the control one. This may be due to the high solids not fat contents as compared to control one. Adding buffalo's colostrum increases significantly (P <0.01) specific gravity values and these increases were proportional to the added colostrum ratio. The specific gravity of buffalo's colostrum was found to be 1.062 which explains the increase in the specific gravity on its addition to ice cream. Additionally, control tends to have a higher rate of bypass% than treatments with colostrum. This may be due to the high contribution of fat to the stability of air phase of ice cream during freezing and whipping (Goff *et al.,* 1999). The control showed a significant increase (P <0.01) in the ice cream overrun for the treatments, which could be attributed to the increase in the viscosity of the mixture that did not contain colostrum (Table 4). The increases in overrun are parallel to the increase for viscosity values.

The low freezing point is an important parameter in ice cream production because it affects the initial average size and thermodynamic instability of the ice crystals formed resulting in their growth (Hartel, 2001). The freezing point (Table 4) of the control ice cream was -2.40^{o}C which is close to that found by (Cogne *et al.*, 2003). Statistical analysis showed significant difference i freezing point T_1, T_2, T_3 and T_4 which can be attributed to the differences in total solids and fat contents.

Table (4) shows that the ice cream with colostrum added that took longer time to melt than the ice cream without colostrum. They indicate that milk fat improved the melting resistance of ice cream. The contribution of fat to the structural characteristics properties of ice cream and reduced heat conductivity can explain the former effects (Soukoulis *et al.*, 2010). Addition of colostrum slightly improved the melting resistance of the ice cream samples.

Table (4): Effect of using different ratios of buffalo's colostrum on the physical properties of the resultant ice cream (average of three replicates).

Property	Treatments*				
	Control	**T_1**	**T_2**	**T_3**	**T_4**
Specific gravity	1.0352^{d}	1.0385^{c}	1.0426^{b}	1.0485^{b}	1.0549^{a}
Overrun %	30.00^{ab}	26.00^{bc}	21.65^{d}	20.33^{d}	19.00^{d}
Viscosity (cp)	2.49^{a}	2.29^{d}	2.24^{d}	2.32^{c}	2.40^{b}
freezing point (^{O}C)	-2.40^{a}	-2.49^{a}	-2.58^{b}	-2.60^{c}	-2.64^{c}
Meltdown rates (%) after 15 min at 25°C	75.53^{d}	75.96^{d}	76.42^{c}	77.10^{b}	78.32^{a}

a, b, c…. Means with the same column with different superscript are significantly different (P<0.01).

*See legend to Table (1) for details

Table (5) showed that the mineral contents (mg/100gm) of ice cream with buffalo's colostrum. The results of mineral analysis revealed that the Ca, Mg, Na, Fe, K and Zn contents of ice cream with buffalo's colostrum had higher values compared to control ice cream samples and this was proportional to the amount of colostrum added. This also, due to the higher contents of colostrum for minerals. These results are in agreement with (Saleh *et al.,* 2019), who found that the use of colostrum in the manufacture of stirred yoghurt increases the mineral content.

Table (5): Effect of using different ratios of buffalo's colostrum on the minerals contents (mg/100gm) of the resultant ice cream (average of three replicates).

Property	Treatments*				
	Control	**T_1**	**T_2**	**T_3**	**T_4**
Ca	125.90^{e}	160.10^{d}	185.50^{c}	225.00^{b}	286.20^{a}
Mg	10.50^{e}	11.50^{d}	13.20^{c}	15.75^{b}	17.98^{a}
Na	35.50^{e}	40.30^{d}	42.65^{c}	45.90^{b}	49.25^{a}
Fe	0.33^{d}	0.45^{c}	0.69^{b}	0.70^{b}	0.95^{a}
K	71.92^{e}	75.90^{d}	80.00^{c}	81.20^{b}	98.59^{a}
Z	2.25^{e}	3.80^{d}	4.20^{c}	5.80^{b}	7.93^{a}

a, b, c….Means with the same column with different superscript are significantly different (P<0.01).

*See legend to Table (1) for details

Table (6) shows the scores for sensory properties of the ice cream produced by adding different proportions of buffalo's colostrum. The

Table (6): Effect of using different ratios of buffalo's colostrum on the sensory evaluation of the resultant ice cream (average of three replicates).

Property	Control	*T_1	T_2	T_3	T_4
Flavour (50points)	48.50	48.00	48.00	48.50	47.00
Body &Texture (50 points)	28.00	28.00	28.00	28.50	27.00
Melting properties (10 points)	9.50	9.00	9.50	10.00	9.00
Colour (10 points)	10.00	9.00	9.50	9.50	9.00
Total cceptability	96.00^{a}	94.00^{b}	95.00^{ab}	96.50^{a}	92.00^{c}

a, b, c…. Means with the same column with different superscript are significantly different (P<0.01).

*See legend to Table (1) for details

creamy ice cream resulting from the control and coefficients T_1, T_2 and T_3 was distinguished by the creamy taste and obtained the highest degrees of sensory evaluation of the flavor, while T_4 got a lower score. Milk fat has been recognized as a critical parameter for the formation and support of the structural properties of ice cream (Turgut and Cakmacki 2009). The results showed that adding buffalo's colostrum to the ice cream mixture up to 30% led to a significant improvement in the body & texture, melting properties and colour of the resulting ice cream samples and gained acceptance scores such as control. Generally, T_3 and T_2 have a similar degree of control, but T_1 and T_4 had a lower degree of control.

Conclusively, addition of colostrum to enrich antioxidant properties of ice cream was investigated. Functional and organoleptic properties of enriched ice cream with colostrum were also evaluated. It could be concluded that, colostrum was effective regarding antioxidant activity.

Therefore, it could be used as good source of antioxidants for making ice cream with good nutritional and functional properties. Also, the obtained results suggest that, ice cream can be successfully mad using colostrum for improving the nutritional and sensorial qualities and physic-chemical characteristics of ice cream. Also, the produced ice cream with colostrum had had antioxidant activity better than the control ice cream throughout storage at $-18C^0$. Colostrum can be used in the manufacture ice cream up to 30 or 40%.

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استخدام اللبأ في تحسين الخواص الوظيفية و الكيميائية للأيس كريم

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قسم بحوث كيمياء الالبان و*قسم بحوث تكنولوجيا الالبان - معهد بحوث الانتاج الحيوانى- مركز البحوث الزراعية- وزارة الزراعة - مصر.

تم صناعة الايس كريم الوظيفى و المدعم بنسب مختلفة من اللبأ الجاموسى ودراسة الخصائص الوظيفية و الفيزيائية و الكيميائية و الحسية للأيس كريم الناتج.

أظهرت النتائج المتحصل عليها أن أضافة تركيزات مختلفة من اللبأ الجاموسى 10،20،30،40 % أدى الى زيادة فى نسب الجوامد الكلية والبروتين والدهن والرماد والمعادن عن الكنترول. وكذلك زيادة المواد المضادة للاكسدة. وقد أشارت النتائج للخواص الحسية أن الأيس كريم المدعم باللبأ حسن من الخواص الحسية و كانت المعاملة 20،30% من اللبأ أعلى درجة قبول مقارنة بالكنترول ومن كل المعاملة الأولى والرابعة. وزيادة محتوى الايس كريم الناتج من العناصر المعدنية.

التوصية: توصى الدراسة باضافة اللبأ الجاموسى (السرسوب) الى المخلوط المعد لصناعة الأيس كريم بنسب 20 أو 30% وذلك لزيادة المواد المضادة للاكسدة وتحسين الخواص الكيميائية و الخواص الحسية للأيس كريم و كذالك زيادة محتواه من العناصر المعدنية.