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Quality characteristics of ice milk prepared with combined stabilizers and emulsifiers blends

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Abstract

This study examined the effect of stabilizers namely konjac flour and k-carrageenan levels as well as mono& diglycerides (60%) as emulsifier either singly or in combinations on some physical and sensory properties of ice milk. Stabilizer blends had slight effect on pH – value and increased the viscosity as compared with control. Slight changes were observed in pH – value of ice milk mixes upon aging. Viscosity of ice milk mix containing konjac flour alone was higher than that of its correspondence containing K-carrageenan alone. The use of konjac flour and k-carrageenan combinations in ice milk mix formulation resulted in improvement of their overrun at the level of 0.29%: 0.01 % followed by that 0.27:0.03% as compared with their single form. However, the overrun was still lower than that of the control. Ice milk samples containing konjac flour alone or konjac flour 0.28% and 0.02% k-carrageenan exhibited the highest organoleptic scores. Addition of mono and diglycerides 60% decreased the pH – value and viscosity in all treatments and improved the overrun of ice milk as compared with emulsifier - free treatments except for samples containing k-carrageenan in the single form. Use of 0.1% mono and diglycerides as emulsifier produced ice milk with desirable quality and improved the organoleptic attributes of the resultant product.

Introduction

Ice cream is a delicious, wholesome, nutritious frozen dairy product. It has higher nutritive, biological and caloric value. Consumer acceptance of ice cream depends largely on its structure, textural quality, resistance to melting and flavor. Ice milk is a term used in the USA to refer to a standardized frozen dessert class with a fat content between 2 and 8% (Tharp and Young, 2013). In Egypt and according to the Egyptian Standard 1185-3/2005, the fat content of ice milk must not less than 3%. Anhydrous milk fat can be partially or totally replaced by plant oils.

Stabilizers are one such ingredient, which, in spite of the low level in the formulation, impart specific and important functions to the finished product. The basic role of a stabilizer is to reduce the amount of free water in the ice cream mix by binding it as “water of hydration”, or by immobilizing it within a gel structure. Also it is the ability to absorb and hold large amounts of bound water, which produces good body, smooth texture, slow melt down and heat shock in the resultant product (Keeney, 1982; Goff, 1997).

In ice cream manufacturing, it is always difficult to get all the properties of ice cream using a single stabilizer. Today Dairy/Food Technologists have found a new technique of blending these stabilizers in different proportions to get excellent properties (Naresh and Merchant, 2006). Gelatin is a translucent, colorless, brittle (when dry), flavorless solid substance, derived from collagen obtained from various animal by-products. It is commonly used as a gelling agent in food. The use of gelatin as a stabilizer produces thin mixes that require a long aging period. Gelatin disperses easily and does not cause wheying off or foaming (Kilara and Chandan, 2008).

Carrageenans are a family of linear sulfated polysaccharides that are extracted from edible seaweeds. They are widely used in the food industry for their gelling, thickening and stabilizing properties. Their main application in dairy and meat products, due to their strong binding to food proteins. There are three main varieties of carrageenan, which differ in their degree of sulfation (kappa, iota and lambda). Carrageenan is used in many stabilizer blends at levels of 0.01 – 0.02% to prevent phase separation (wheying off) through interaction with milk protein (Kilara and Chandan, 2008).

Konjac flour, a neutral polysaccharide from the tuber of *Amorphophallus konjac* C. Koch. and *A. oncophallus*, is composed of D-glucose and D-mannose joined by β-glycosidic linkage (Imeson, 2010). Konjac flour is generally recognized as safe (GRAS) which has special properties as thickening, gelling, texturizing and water binding. It lowers cholesterol without any adverse effects and can be

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three times as effective as other polymers (Vuksan *et al*., 2000). Also it is synergistic with stanols and sterols for low-density lipoprotein (LDL) reduction (Yashida *et al*., 2006).

Emulsifiers added to ice cream have several important functions such as reduced whipping time, controlled fat destabilization, enhanced smoothness of texture, increased resistance to melting and shrinkage, and improved dryness (Arbuckle, 1986, Marshall and Arbuckle, 1996). Usually, blends of stabilizer and emulsifier designed to function best in full fat, low fat, or nonfat ice creams are used. The purpose of this study was to improve the quality attributes of ice milk using different blends of Konjac flour, k-carrageenan and emulsifiers.

Materials and Methods

Materials

Both of skimmed milk powder (SMP - 99% MSNF) and coconut oil (100% fat) were obtained from Bell Foods, Egypt. Sucrose and vanilla powder were purchased from the local market. K- carrageenan was gained from Cp kelco, EU while konjac flour was obtained from Hangzhou Ruuiang Chemical Corporation, China. Gelatin was obtained from El Nasr Gelatin Co., Egypt. Mono and diglycerides (60%) as emulsifier was obtained from Kerry, Malaise.

Manufacture of ice milk

Two sets of ice milk were manufactured. The first one (T1 –T5) was designed to show the effect of single and combined stabilizers (konjac flour and K-carrageenan) while the second one (T6 –T10) show the effect of stabilizer / emulsifier blends on ice milk properties. Both sets samples were compared with control sample which contained gelatin as stabilizer. Table 1 illustrates the ice milk formulations. For each set of ice milk, preweighted dried ingredients were well mixed. The amount of calculated water was added to the dry blend and good mixed in a high speed mixer for 1 min. All ice milk mixes were heated at 85^{o}C for 15 min., cooled to 5°C and aged for about 24 h. Natural vanilla was added to the aged mixes before freezing. Ice milk mixes were frozen in batch freezer (1kg each) for 30 min. then the resultant frozen ice milks were packed in plastic cups and stored at -22°C. All experiments were carried out in triplicates and the mean values were tabulated.

Determination of pH - value

The pH - value of the mixes was measured using a digital pH meter (Metrohm-691, Swiss).

Determination of mixes viscosity

Mixes viscosity (in centipoise cP) was determined before and after aging at 25 and 5°C using a Brookfield viscometer model DV-E using spindle No. 4 at 100 rpm.

Determination of overrun

Overrun of ice milk samples was calculated using a standard 100 ml cup according to Arbuckle (1986) utilizing the following equation:

$$\% \text{ Overrun} = [(\text{Net wt of cup of mix - net wt of cup of ice milk})/ \text{Net wt of cup of ice milk}] \times 100$$

Determination of melting resistance

Melting resistance of ice milk samples was evaluated according to Olson *et al*. (2003) as follows: 100 gm of ice milk were placed on mesh which fitted on a funnel stand on a beaker. The weight of the melted ice milk after 15, 30, 45, 60 and 75 min. at 25±2°C was determined and expressed as percent of the weight of the initial ice milk.

Sensory evaluation

After one day of storage at -22°C, ice milk samples were evaluated by 10 staff members of Dairy Department, Faculty of Agric., Cairo University and Quality Control Department of Misr Food Additives (MIFAD) Company according to Bodyfelt *et al*. (1988).

Statistical analysis

The obtained results were statistically analyzed according to Snedecor and Cochran (1994) using the statistical program (MSTAT-C 1989).

Results and Discussion

Effect of combined stabilizers

Regarding the pH - value of the ice milk mixes before and after aging, it ranged from 6.38 to 6.65 with minor changes in some treatments. pH – value of all treatments was increased upon aging (Table 2). This trend is in accordance with Akesowan (2008) and Rezaei (2011). Viscosity is an important characteristic in that a specific viscosity amount is required for achieving desirable whipping ability and retaining of air bubbles (Tarkashvand, 2005). Stabilizers have a high water-holding capacity and can influence the rheological properties of ice cream mix. Concerning the viscosity of the ice milk mix before and after aging, it was found to increase upon addition of konjac flour and k-carrageenan either in single or combined form as compared with that of

Table 1. Different formulations of ice milk

Ingredients %	Control	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}
Gelatin	0.5	---	---	---	---	---	---	---	---	---	---
K-carrageenan	---	0.1		0.01	0.02	0.03	0.1	---	0.01	0.02	0.03
Konjac flour	---	---	0.3	0.29	0.28	0.27	---	0.3	0.29	0.28	0.27
Mono and diglyceride 60 %	---	---	---	---	---	---	0.1	0.1	0.1	0.1	0.1
Skim milk powder	12	12	12	12	12	12	12	12	12	12	12
Coconut oil	3	3	3	3	3	3	3	3	3	3	3
Sugar	16	16	16	16	16	16	16	16	16	16	16
Vanillin powder	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Water	68.4	68.8	68.6	68.6	68.6	68.6	68.8	68.6	68.6	68.6	68.6

Table 2. Some physical properties of ice milk mix and ice milk as affected by type of stabilizers

Treatments*	pH		Viscosity (cP)		Overrun %	Meltability % Time (min.)				
	Before aging	After aging	Before aging	After aging		15	30	45	60	75
Control	6.38	6.51	22	344	77.29	0.00	3.36	29.15	51.65	74.06
T_1	6.41	6.58	404	610	46.99	1.00	19.50	56.00	76.00	95.00
T_2	6.44	6.65	604	1164	66.70	2.20	29.30	58.80	78.80	97.80
T_3	6.47	6.62	524	974	71.77	0.90	30.00	61.30	81.30	99.60
T_4	6.5	6.58	622	1102	62.55	1.50	30.10	61.0	81.00	99.60
T_5	6.49	6.59	778	1128	69.10	1.50	26.50	56.50	76.50	95.50

* See Table (1)
LSD at 0.05 for overrun %: 1.8938
LSD at 0.05 value for melting resistance:
Treatments: 0.576
Time: 0.5265
Interactions: 1.2898

0.5 gelatin treatment (control). Data in Table 2 also indicated that the use of konjac flour or k-carrageenan and its combinations led to increase the viscosity of the ice milk mix before and after aging with some fluctuation in T3. It is worthy to note that the viscosity of all ice milk mixes tended to increase upon aging. These findings emphasize the role of konjac flour in improving the physicochemical properties of its ice milk mixes.

Overrun expressed the amount of air incorporated in the ice cream and influence the product quality. The results presented in Table 2 indicated that usage of konjac flour or k-carrageenan as stabilizers either singly or combined in ice milk processing instead of 0.5% gelatin (control) significantly reduced the overrun of the resultant products. This finding is in agreement with the results reported by Akesowan (2008) who found that using 0.3% konjac flour alone in ice cream making significantly decreased the overrun of the resultant ice cream as compared with that of ice cream containing konjac flour and k-carrageenan as combined stabilizers at the rate of 0.27: 0.03% and 0.24: 0.06 % as well as that of ice cream containing 0.3% supergelIC® as a control.

The obtained results (Table 2) exhibited that the use of konjac flour and k-carrageenan combinations as combined stabilizers in the ice milk mix formulation resulted in improvement of their overrun specially when 0.29%: 0.01% (T3) of the above-mentioned stabilizers respectively was expremented followed by that of T5 (0.27:0.03%) and lastly T4 (0.28:0.02). However, the overrun was still lower than that of the control.

Meltability of the ice milk expressed as percentage of melted ice milk during 75 minutes at intervals of 15 minutes is recorded in Table 2. The recorded data indicated that meltability % was lowest in ice milk containing 0.5% gelatin (control). Upon using konjac flour and k-carrageenan in a single form the meltability of the resulted ice milk was significantly increased than that of the control treatment. The meltability of ice milks of all treatments after 15 min. ranged from zero to 2.20%. This means that ice milks can be consumed without melting. After 30 min. and onwards meltability of ice milks of all treatments continued to increase reaching about 74.06-99.6% after 75 min. especially in ice milks containing konjac flour or a combination of konjac and k-carrageenan.

Table 3. Sensory properties of ice milk as affected by type of stabilizers

Treatments*	Flavor (45)	Body and Texture (30)	Melting resistance (20)	Color (5)	Total (100)
Control	30.00	19.00	19.00	5.00	73 .00
T_1	31.00	20.00	18.00	5.00	74 .00
T_2	40.00	26.00	16.00	5.00	87 .00
T_3	35.00	23.00	15.00	5.00	78.00
T_4	36.33	24.00	15.00	5.00	80.33
T_5	33.00	22.00	14.00	5.00	74 .00
LSD at 0.05	3.1099	1.7259	1.4947	NS	4.8124

* See Table (1)

Sensory evaluation

Mean scores of organoleptic properties of ice milk as affected by type of stabilizers are presented in Table 3. It is clear that both types of stabilizer and its combinations had no effect on the color of the resultant ice milk. Significant differences were observed between the flavor of all treatments and control except T1 as there was no significance difference. The highest flavor scores was recorded for T2 (Konjac flour alone) followed by T4 (Konjac flour: k-carrageenan 0.28:0.02), while control samples had the lowest scores. As for body and texture of ice milk, samples containing konjac flour alone or combined stabilizers are significantly differed from control and k-carrageenan samples. Concerning the melting resistance, although samples containing konjac flour alone or combined with k-carrageenan had the best body and texture, it had low melting resistance as compared with control and ice milk containing k-carrageenan alone.

The sensory evaluation of the ice milk produced using single or different stabilizers blends, indicated that among the stabilizers used konjac flour at a level of 0.3% gave an ice milk which gained the highest organoleptic scores (85 degrees of 100) with creamy texture and good flavor and melting resistance during first 15 min.. The use of combined stabilizers consisted of 0.28% konjac flour and 0.02% k-carrageenan (T4) resulted in an ice milk that gained 80 degrees and stand second. The use of 0.1% k-carrageenan alone (T1), 0.5% gelatin (control) and combined stabilizer consisted of 0.27% konjac flour and 0.03 % k-carrageenan (T5) gave ice milks which gained the lowest organoleptic scores (Table 3).

Effect of stabilizers / emulsifiers blends

Data in Table 4 delineated the physicochemical properties of the ice milk mixes containing the above mentioned single and combined stabilizers plus 0.1% mono/ diglycerides (60%) as emulsifier (T6-T10). The results recorded in Table 4 indicated that the pH of the ice milk mixes containing stabilizers/emulsifier blends was slightly lower either before or after aging of these mixes than that of their correspondence containing stabilizers alone (Table 2). It ranged from 6.38 to 6.58. This finding disagreed with the results of Baer *et al.* (1997) who reported that the type of emulsifiers and level had no influence on mix pH. Furthermore, the pH values of the ice milk mixes containing stabilizers/emulsifier blends were markedly increased after aging in all treatments.

Table 4 also shows the viscosity of the ice milk mixes before and after aging. It is clear that upon addition of emulsifier, the mix viscosity of all treatments was decreased as compared with that of their emulsifier-free correspondence (Table 2). These results disagree the data obtained by Butt *et al.* (1999) who found that glycerol mono stearate when added to ice cream mixes containing combined stabilizers resulted in increase in viscosity of the mixes as compared with that of the control treatment (emulsifier-free) containing Palsgaard only as a stabilizer.

As for the overrun, the obtained results indicated that it was highest in case of using 0.29:0.01% of konjac flour: k-carrageenan combined with 0.1% of mono and diglyceride (T8) followed by that of T10, control, T7, T9 and T6, respectively with significant differences between all treatments. It is worthy to note that the overrun of the resultant ice milk containing emulsifier was higher in all treatments except for that of ice milk containing k-carrageenan as a single stabilizer (Table 4). This is in line with the results reported by Murtaza *et al.* (2004) who found that overrun, standup time, meltdown, moisture, total solids, pH and acidity were affected significantly by different stabilizers/emulsifier blends as well as storage period.

Regarding the meltability of ice milks containing stabilizers plus emulsifier, it was noticed that it decreased in all treatments as compared to emulsifier free samples (Table 2). It was also found that addition of emulsifier reduced meltability of the resultant ice milks at 15 and 30 min. intervals for treatments T6-T8. This indicated that added emulsifier improved the meltability resistance for the ice milk of these treatments. These results are in accordance with Bhandari (2001) who stated that most of ice cream manufactures use blends of stabilizers and emulsifiers to achieve the desired characteristics. Beyond the 15 min. interval a similar trend for meltability of that emulsifier-free ice milk was exhibited.

Table 4. Some physical properties of ice milk mix and ice milk as affected by type of stabilizers / emulsifiers blends

Treatments*	pH		Viscosity(cP)		Overrun %	Meltability % Time (min.)				
	Before aging	After aging	Before aging	After aging		15	30	45	60	75
Control	6.38	6.51	22	344	77.29	0.00	3.36	29.15	51.65	74.06
T_6	6.41	6.54	292	504	46.47	0.36	11.82	42.30	63.81	81.95
T_7	6.41	6.56	536	1014	74.70	1.34	26.83	57.91	78.07	91.89
T_8	6.43	6.58	454	721	85.67	1.32	28.45	55.08	75.48	90.75
T_9	6.44	6.56	470	772	70.50	2.47	28.95	55.85	76.13	91.10
T_{10}	6.44	6.57	658	1130	77.66	2.07	25.45	52.71	76.02	90.95

*See Table (1)
LSD at 0.05 for overrun %: 2.6207
LSD at 0.05 value for melting resistance:
Treatments: 0.7230
Time: 0.66
Interactions: 1.6168

Table 5. Sensory properties of ice milk as affected by stabilizers / emulsifiers blends

Treatments*	Flavor (45)	Body and Texture (30)	Melting resistance (20)	Color (5)	Total (100)
Control	30.00	19.00	19.00	5.00	73.00
T_6	32.60	23.60	14.07	5.00	75.27
T_7	31.00	19.00	14.40	5.00	69.40
T_8	34.00	24.80	15.00	5.00	78.80
T_9	38.00	25.40	14.50	5.00	82.90
T_{10}	30.37	16.80	11.00	5.00	63.17
LSD at 0.05	1.7496	0.9005	0.5393	NS	2.1303

* See Table (1)

Sensory evaluation

Concerning the sensory properties of ice milk as affected by the stabilizers / emulsifiers blends, data in Table 5 show that it were affected by the variations of konjac flour and k-carrageenan in the presence of 0.1% mono and diglycerides (60%). The color of the ice milk treatments did not affected as a result of using emulsifier. Flavor scores were the highest in case of T9 samples which contained 0.28% konjac flour: 0.02% k-carrageenan with significant differences between treatments. The same trend was observed for the body and texture. As for the melting resistance, as previously observed from Table 3, the emulsifier did not improved the melting resistance. The overall organoleptic scores were highest in T9 where konjac flour: k-carrageenan ratio was 0.28%:0.02% being 82.9 followed by T8, T6, control, T7 and lastly T10.

Conclusion

In conclusion, the results of the present study have shown that addition of various combined stabilizers containing konjac flour and k-carrageenan resulted in higher mix viscosity and lower overrun, however it improved its organoleptic attributes. Moreover, use of 0.1% mono and diglycerides as emulsifier produced ice milk with desirable quality and improved the overrun and organoleptic attributes of the resultant product.

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