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Rheological, physiochemical and sensory properties of no fat to high fat ice creams samples prepared using stabilizer/emulsifier blends created with liquid and powder polysorbate-80

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Abstract

Stabilizer/Emulsifier blends were created using liquid polysorbate-80 (Sample A) and powder poysorbate-80 (Sample B) separately along with other stabilizers and emulsifiers. Ice-cream samples were prepared at pilot scale using blend A and B at the dosage of 0.5% with varying fat content of butter and studied their rheological, physiochemical and sensory properties. Ice-creams prepared with Blend-B having higher viscosity than one done with Blend-A i.e. liquid polysorbate. The moisture content is inversely proportional to solid levels in all ice cream samples prepared. The titratable acidity value of ice cream mix was between 0.20 and 0.21%. Hardness of B samples was higher in high-fat ice-creams. Maximum overrun of 156±45% was obtained from B samples prepared at 0.7% fat level. Ice-creams prepared with high fat content had high melting range of 6.5±5 ml in 14% fat whereas it was low 0.0 ml in 10 mins in ice-cream with low fat. B samples made with low fat levels (0.7% and 2%) had lower melting rate than A samples but it was reverse in ice-cream samples made with high fat content (6-14%) in both A and B samples. Fat destabilization of B samples was higher than that of A samples. In both low and high fat ice-creams, powder PS-80 had outperformed in terms of all quality parameters with higher overall acceptance as compared to ice cream samples made with liquid PS-80.

Introduction

Ice cream may be defined as a frozen dairy product made by apt blending and processing of cream and other milk products together with sugar, flavor and color, with the incorporation of air, with or without stabilizer during the freezing process (Sukumar, 1980). There are many criteria in formulation and processing factors that influence the texture and overall acceptance of ice cream.

Despite the low level presence, stabilizers/emulsifiers play dominant role in ice cream preparation. The primary purposes for using stabilizers in ice cream are to maintain uniform nature and stabilize the protein and fat. It helps to prevent the formation of ice crystals especially in fluctuation of temperature during storage condition. It gives creaminess and texture as well as reduce or slowing the meltdown rate (Goff *et al*., 1996; Marshall *et al.*, 2003). carob gum, guar gum and carboxy methyl cellulose (CMC) are the most used hydrocolloids in stabilizers blend, they help to increase the viscosity since they have good hydrating properties and carrageenan acts as stabilizer in ice cream product (Klesmenta *et al.,* 2014). Kappa carrageenan can also reacts with casein used to prevent wheying off, sometimes combination of kappa and iota carrageenan blend can be used and it depends upon types of ice cream to be manufactured (Naresh *et al*., 2006). Emulsifiers help to get smoother texture improve whipping and maintain the drawing temperature. Mono and di glycerides and polyoxyethylene derivatives such as polysorbate series are the important emulsifiers. They have ability to disperse the fat globules and play role in whipping and melting properties. It can also stabilize the fat result into desired smooth texture (Kloser *et al.*, 1959).

Polysorbate-80 commonly exists in liquid form and it is one of the main emulsifiers used in ice-cream preparation, it has been proven to maintain the shape as well as slow down the melting rate of ice cream (Muse *et al.,* 2004). However, making blend by liquid polysorbate 80 has always been challenging, thus, it has to be mixed in two stages as to ensure no lump is present in final blend and these drawback associated with liquid polysorbate prompted us to conduct a trial on difference in liquid and powder polysorbate and their function and quality of final

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ice-creams products.

The objective of the present study is to understand the function of liquid and powder polysorbate 80 in stabilizer-emulsifier blend on the rheological, physiochemical and sensory properties of ice cream prepared using with different fat contents.

Materials and Methods

Stabilizers and emulsifiers

The skimmed milk powder and butter were procured from Hatsun agro products, India and sucrose was procured from Nice chemicals Pvt. Ltd, India. Food grade Guar gum (E412) (Sarda Gums & Chemicals, India), sodium carboxymethyl cellulose (E466) (Wealthy chemicals industry, Suzhou, China), polysorbate-80 liquid (E433) (Nice chemicals Pvt. Ltd, India), polysorbate-80 powder (Bimal pharma, Mumbai) and glycerol monostearate (E471) (Kerry, Novotech, India) were sourced locally in India. Kappa (Batch No 134/2016) and iota (Batch No 012/2016) semi-refined carrageenans (E407a) were used from stock of Aquagri Processing Private Limited, Manamadurai, India.

Preparation of stabilizer and emulsifier blend

Liquid polysorbate- 80 was initially mixed with kappa and iota carrageenan, then this mix was dried overnight, lumps were ground and sieved through 80 mesh and mixed with other stabilizers like guar gum and sodium carboxymethyl cellulose (CMS) to get stabilizer/emulsifier Blend A, whereas powder ps-80 was directly mixed with other stabilizers and emulsifiers to create Blend B. The ratio of stabilizers/ emulsifiers in blend A and B as shown in table 1 were created and used to make ice cream samples.

Apparatus and instruments

Remi motor-RQ 122, Remi elektrotechnik Ltd, India, Water bath-250 W, Sigma Scientific Instrument (P) Ltd, Chennai, India, Blue Star Chest freezer, Model CHF 200 B, India, Sony Cyber shot, GPS-DSC- HX 200 were used in this present study.

Ice cream preparation

The ice cream samples were prepared as described by Muse and Hartel (2004). Water, skim milk powder and partial sugar were mixed together in a vat with agitation and heated to 45°C. Remaining sugar and stabilizer / emulsifier blend were mixed together and added to avoid lump formation. They were slowly added to the mix in vat with agitation at 55°C. Butter was added at 55-60°C to mix as to ensure it is melted and mixed properly. Then mix was filtered and pasteurized at 80°C for 25 seconds and homogenized in two stages at 2000 psi and 500 psi. The mix was then immediately cooled at 4°C and stored for 4hr for aging to allow stabilizer - emulsifier blend to act properly. After aging the mix was homogenized for 15 min and then it was stored at -18°C for 24 hr. Then ice cream samples obtained using blend A and B were analyzed for their rheological, physicochemical and sensory properties. The experiment was repeated for 5 times and average values were subjected for interpretation.

Table 1. Composition of stabilizer/emulsifier blend A and B

Ingredients (%)	Stabilizers / Emulsifiers blend	
	Blend A (Liquid form of polysorbate 80)	Blend B (Powder form of polysorbate 80)
Kappa carrageenan	10	10
Iota carrageenan	5	5
Guar gum	20	20
Sodium CMC	20	20
Glycerol mono stearate	30	30
Sucrose	10	10
Polysorbate 80	5	0.5

Physico-chemical analysis

Moisture and acidity were estimated as per method described by Kirk *et al.* (1991). Viscosity of mixes was determined using Brookfield viscometer (DV-II + Pro) at 15°C with spindle no. 4 at 20 rpm. The determination of viscosity of ice-cream samples based on the method (Thaiudom *et al.*, 2008).

Overrun

Overrun was calculated immediately after the mixes were frozen in an ice cream batch freezer as described by Varnam and Sutherland (1994).

Overrun (%) = (Volume of ice cream)-(Volume of mix)/Volume of mix X100

Meltdown rate

The ice cream samples were weighed (25.0 ± 2.0 g) and placed on a SS mesh attached to a beaker and maintained in a controlled temperature chamber at 25±2°C. The dripped volume was measured for every 10 minutes and the time (min) taken was plotted against the dripped volume (ml) (Lee and White, 1991).

Fat destabilization Index

Fat destabilization was measured by the method of Keeney and Josephson (1958). Mix and ice cream samples were thawed and 3 ml of both samples mixed with 27 ml distilled water at RT, then it was diluted it at 1:10 was placed in a 50-ml volumetric flask and then absorbance were measured in spectrophotometer at 540 nm. Turbidity as an indicator of fat destabilization was calculated by following equation:

Fat destabilization index = (A540 (Diluted mix)-A540 (Diluted melt))/ A540 (Diluted mix) X100

Hardness

Hardness was determined using a Brookfield texture analyzer (CT3 4500) provided with cylindrical probe at room temperature (Roland et al., 1999). Ice cream hardened at -30°C was cut to fill a small rectangular box and kept overnight at −15°C and hardness was measured (Lim *et al.,* 2008).

Heat shock stability and sensory properties

Heat shock test was conducted by placing ice cream samples at room temperature (25±1°C) for 30 mins from hardening room. Then the samples were back to the hardening room and it was conducted for 10 days (Huse *et al*., 1984). Then the samples were evaluated for their sensory parameters such as creaminess, iciness, texture, sweetness and flavor using 9 point hedonic scale by involving 25 trained panelists (Buyck *et al*., 2011).

Statistical analysis

Statistical analysis such as analysis of variance (ANOVA, SYSTAT version 7), correlation and regression were applied to analysis the data.

Results and Discussion

Physico-chemical analysis

Physicochemical properties of ice cream prepared with stabilizer/emulsifier blend of A and B at different dosage and different fat content is presented in table 2. Viscosity of ice cream mix is directly proportional to types and ratio of gums used in blend (Hagiwara and Hartel, 1996). Low fat ice cream samples had high viscosity then one prepared with high fat. Viscosity of ice cream samples prepared with no fat were 6600±1790 cps and 6270±3404 cps in blend A and B respectively and same trend was observed with ice cream samples of 2% fat (4870±1670 and 4880±2030 cps) and 14% fat ice cream samples it was 2090±615 cps and 1790±714 cps in blend A and B respectively. Ice cream samples prepared with blend B (herein after called ice cream samples B) had higher viscosity than one prepared with blend A (herein after called ice cream samples A) in low fat ice cream and it was found reverse in high fat ice cream. Viscosity showed significant positive correlation with fat destabilization (r = 0.998; p = 0.001) in 14% fat ice cream made from blend A and it also showed positive correlation with hardness in 2% fat ice cream made from blend B (r = 0.977; p = 0.001). At 0.7% dosage level both ice cream samples were negatively correlated to moisture content (r = -0.909; p = 0.02) and (r = -0.889; p = 0.02).

Moisture content of ice cream samples ranged between 57.45±0.27 % to 60.87±0.55 % for sample B and 58.17±0.64% to 60.46±0.43% for sample A. Ice-cream samples prepared with 0.7% fat had higher moisture content due to its high level of MSNF with high amount of protein in it than one prepared with high fat 14% in butter. Moisture content showed negative correlation with viscosity in 2% fat ice cream made from blend A (r = -0.991; p = 0.001). In 10% fat ice cream made from blend A has shown as moisture content was positive correlation with hardness of (r = 0.961; p = 0.02).

Titratable acidity values of ice-cream samples were 0.20 to 0.21% in both A and B samples prepared at 14% fat as compared to samples of other fat levels. The titratable acidity in milk is generally dependent on albumin, phosphates, citrates and carbon dioxide and difference in protein content and chemical composition leads to changes in titratable acidity (Atherton and Newlander, 1997). For 14% fat ice cream sample made with B, acidity showed negatively correlation with viscosity (r = -0.821; p = 0.05). It showed negative correlation with moisture in 10% fat ice cream from blend B (r = -0.921; p = 0.01) and positive correlation with moisture in 10% fat ice cream from blend A (r = 0.961; p = 0.02).

Hardness of ice-cream samples B was higher in high-fat ice-creams (4286±378) (g/cm^2) as compared to A samples (4176 ±207) and this observation is in similar with the report of Atherton and Newlander (1977) who had reported that full-fat ice cream was significantly harder than reduced-fat ice creams (Pridiville *et al.*, 1999). Hardness was found positively correlation with viscosity in 0.7% (blend A) and 6% (blend B) as r = 0.951; p = 0.01 and r = 0.994; p = 0.001. For 0.7% fat ice cream blend from A showed hardness negatively correlation with moisture content (r = -0.983; p = 0.001). It has shown negatively correlation with acidity in 2% fat ice cream blend from A (r = -0.842; p = 0.05). In 2% fat ice cream blend from B hardness negatively correlation with fat destabilization (r = -0.927; p = 0.01).

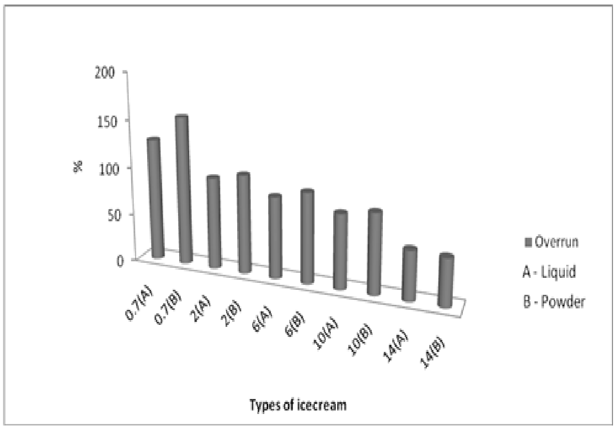

Figure 1. Overrun of ice cream prepared using blend A and B

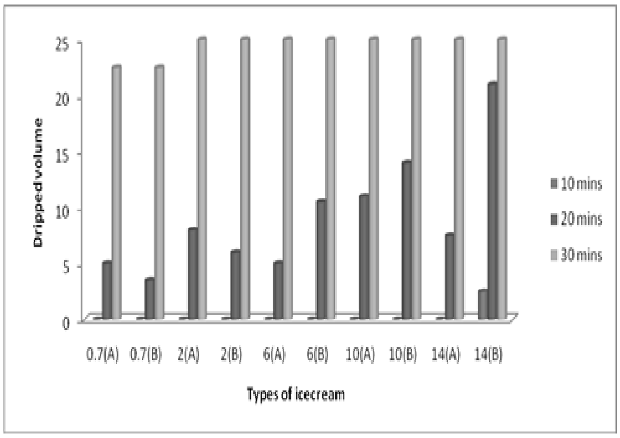

Figure 2. Meltdown rate of ice cream prepared using blend A and B

Overrun

Maximum overrun of 156% was obtained in blend B made with fat level of 0.7%. It is the main parameter which differentiates the nature of polysorbate powder and liquid, in which powder polysorbate 80 showed superior results in ice creams made with different fat levels. It found declined when fat percent increased from 0.7% to 14%. 96% and 94% overrun observed for 2% fat ice cream and 10% fat ice cream respectively, prepared from blend A. 103% and 94% overrun observed in both 2% fat and 10% fat ice cream respectively prepared from blend B. The present investigation is in agreement with literature report that types and ratio of emulsifiers/ stabilizers improve the overrun depends upon range of protein (Mahdian and Karazhian, 2013) (Figure 1). 2% fat ice cream made from blend B showed overrun negative correlation with acidity ($r = -0.887$; $p = 0.02$). Overrun was significantly correlated with acidity in 14% fat ice cream made from blend A and negatively correlation in blend B ($r = 0.846$; $p = 0.05$) and ($r = -0.970$; $p = 0.01$).

Meltdown rate

It was observed that melting rate of ice cream found increased with increasing fat content of the ice cream samples. Koxholt *et al.* (2001) had reported that fat globule size and composition influenced the melting rate and they observed that ice cream samples with high fat level had high melting rate (Koxholt *et al*., 2001). Ice cream prepared with nil fat showed slow melting rate of 5 ml and 3.5 ml for 20 mins in both liquid and powder and respectively and it followed same in low fat of 2% of 8 ml and 6 ml for 20 mins in both liquid and powder blends respectively. Dripped volume was lower in blend B ice cream samples compared to blend A made ice cream samples. It was found in reverse as the samples with fat content of 6%, 10% and 14% where blend A dripped volume was lower than blend B made ice cream samples dripped volume. It found as 5 ml, 11 ml and 7.5 ml dripped volume for ice cream made with blend A in of 6%, 10% and 14%. In other side, 10.5 ml, 14 ml and 21 ml dripped volume for 20 mins found in ice cream made in 6%, 10% and 14%. Despite our study results, low destabilized fat content ice cream having high melting rate (Bolliger et al., 2000) (Figure 2).

Fat destabilization index

Fat destabilization index increases towards high end fat ice creams which made from both blend A and B. But fat destabilization of ice cream made from blend B found to be equal to ice cream made from blend A. It stated as property of emulsifier does not have effect on fat destabilization in pre-post homogenization process. The extent of fat destabilized is not as great as when stabilizer/ emulsifier blend present at the homogenization (Lim *et al*., 2008). Turbidity found as 21.67±1.35% and 22.54±2.49% for 0.7% fat ice cream made from blend A and B respectively, it has increased depend on fat percent of ice cream as 27.36±0.78, 34.27±0.07, 35.02±5.60 and 34.95±6.64 for 2%,6%,10% and 14% fat ice cream made from blend A. Similarly 29.03±2.20, 38.49±1.19, 39.06±1.35 and 40.98±2.07 for 2%, 6%, 10% and 14% fat ice cream made from blend B (table 2). 0.7% fat ice cream made from blend A and B showed fat destabilization positive correlation with acidity ($r = 0.907$; $p = 0.02$) and ($r = 0.972$; $p = 0.01$). Only 0.7% fat ice cream from blend B showed positive correlation of fat destabilization with overrun ($r = 0.852$; $p = 0.05$).

Heat shock stability and sensory properties

Ice cream made with medium and high fat (10% and 14%) from both blend A and B found low scores. 0.7% fat had good overall score as 6.7 and 7.2 for

Table 2. Physicochemical properties of ice cream prepared using blend A and B

Physico-chemical properties	No Fat Ice cream		Low fat Ice cream		Light fat ice cream		Medium fat ice cream		High fat Ice cream	
	0.7%(A)	0.7%(B)	2(A)	2(B)	6(A)	6(B)	10(A)	10(B)	14(A)	14(B)
Viscosity (cps)	6600± 1790	6270± 3404	4870± 1670	4880± 2030	3700± 1918	3820± 1536	2490± 823	2150± 800	2090± 615	1790± 714
Moisture content (%)	60.46± 0.43	60.87± 0.55	58.91± 0.18	59.18± 0.57	58.34± 0.35	59± 0.61	58.40± 0.73	58.52± 0.84	58.17± 0.64	57.45± 0.27
Acidity (%)	0.21± 0.0	0.21± 0.0	0.21± 0.0	0.21± 0.0	0.21± 0.0	0.20± 0.0	0.20± 0.0	0.20± 0.0	0.20± 0.0	0.20± 0.0
Hardness (g/cm^2)	3490± 606	3109± 953	2817± 193	1741± 579	2512± 865	1934± 499	3716± 170	3805± 100	4176± 207	4286± 378
Fat destabilization index (%)	21.67± 1.35	22.54± 2.49	27.39± 0.78	29.03± 2.20	34.27± 0.07	38.49± 1.19	35.02± 5.60	39.06± 1.35	34.95± 6.64	40.85± 2.07

Table 3. Sensory acceptability of ice cream samples prepared using blend A and B

Sensory properties	No Fat Ice cream		Low fat Ice cream		Light fat ice cream		Medium fat Ice cream		High fat Ice cream	
	0.7(A)	0.7(B)	2(A)	2(B)	6(A)	6(B)	10(A)	10(B)	14(A)	14(B)
Iciness	6.9±0.14	7.2±1.2	6.4±0.31	7.2±0.05	5.5±0.54	6.7±0.25	5.0±1.02	5.4±0.32	4.9±0.05	5.2±1.07
Creaminess	6.7±1.0	8.0±0.58	6.6±0.11	6.9±0.09	6.4±0.21	6.7±0.36	5.9±0.25	6.3±0.23	5.8±0.25	6.0±0.91
Texture	6.8±0.22	7.6±0.21	6.5±0.22	7.0±0.90	5.9±0.33	6.7±0.09	5.5±1.35	5.9±0.11	5.3±0.54	5.6±0.16
Sweetness	6.5±0.35	6.5±0.31	6.5±0.54	6.5±0.74	6.5±0.81	6.5±0.03	6.5±0.26	6.5±0.94	6.5±0.31	6.5±0.33
Flavor	6.5±0.50	6.5±0.55	6.5±0.73	6.5±0.2	6.5±0.56	6.5±0.83	6.5±0.33	6.5±0.83	6.5±0.76	6.5±0.54
Overall acceptance	6.7±0.07	7.2±0.28	6.5±0.09	6.8±0.33	6.2±0.10	6.6±0.09	5.9±0.78	6.1±0.33	5.8±0.71	6.0±0.81

blend A and B made ice cream respectively. Iciness scores perceived to be reflects in the creaminess. The viscosity and small droplet of fat globules are the main factor determines creaminess (Richardson *et al*., 1993). Despite, the statement of high fat resulted to creaminess was reverse in our study. 0.7% scores 6.7 and 8 in creaminess of both blend A and B respectively, 2% scores 6.6 and 6.9 in creaminess of both blend A and B respectively. Light fat ice cream from blend A and B scores 6.4 and 6.7. In other side, medium and high fat ice cream having low scores in creaminess. This iciness and creaminess depicted the intensity of overall texture. Flavor (6.5) and sweetness (6.5) scores same to all fat ice cream. Overall texture and acceptance sensory results after heat shock trial, powder polysorbate results surpassed then liquid polysorbate in all fat percentage ice cream.

Conclusion

Powder polysorbate 80 was convenient in making stabilizer/emulsifier blend as compared to its liquid form. Powder PS-80 has outperformed in terms of rheological and physicochemical properties with higher overall acceptance. Therefore, powder PS 80 can be used in commercial ice-cream production.

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