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Optimizing Yoghurt-Ice Cream Mix Blend in Soy Based Frozen Yoghurt

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ABSTRACT

Yoghurt ice cream (YIC) or frozen yoghurt dessert can be regarded as a healthy alternative to plain ice cream. Also use of soy derived products in food formulations can lead to the development of products of improved nutritional and health promoting values. Yoghurt ice cream was prepared using full-fat soy flour to substitute 55% of non fat dry milk content. Product formulation comprised of 12% SNF, 10% fat, 18% sucrose, 0.4% stabilizer-emulsifier and 0.1% vanillin. The effect of incorporating yoghurt at the rate of 5.3%,15.9%, 26.5%, 37.1% and 47.7% of the total ice cream mix on the flow behavior, physico-chemical and sensory properties of Yoghurt Ice Cream was evaluated as compared with control, devoid of any yoghurt. The mixes all showed pseudoplastic flow behavior, with the viscosity increasing from 0.7 to 1.57 pa s when the yoghurt content increased from 0 to 47.7%. Higher contents of yoghurt in the mixes significantly improved the melting rate of the yoghurt ice cream where the minimum melting rate (16%) was obtained for the sample of 47.7% yoghurt content. The highest overrun value of 58% was obtained for the sample containing 15.9% yoghurt. However the specific gravity of the product decreased with increasing yoghurt content with the highest specific gravity of 1.108 being recorded for control. In the light of these findings, it can be concluded that yoghurt ice cream, containing full fat soy flour, can be successfully made by incorporating 25.6% yoghurt in the mix with the end product maintaining its acceptable sensory characteristics.

Keywords: Frozen yoghurt, Full-fat soy flour, Overall acceptance, Physico-chemical characteristics, Yoghurt ice cream.

INTRODUCTION

Yoghurt Ice Cream (YIC) also referred to as frozen yoghurt is a functional frozen dairy dessert that can be produced either by fermentation of ice cream mix with lactic acid bacteria (often mixed cultures of *Streptococcus thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus*) or by blending yoghurt with ice cream mix (Davidson *et al.*2000).

In recent years consumers are becoming more interested in YIC because it combines the physical characteristics of ice cream with the sensory and therapeutic properties of fermented milk products. Frozen yoghurt dessert can be regarded as a healthy alternative to ice cream for people suffering from obesity, cardiovascular disorders and lactose intolerance, due to the product's low fat as well as reduced lactose contents (Inoue *et al*., 1998).

No specific standard for YIC has yet been established for acidity and quantum of yoghurt added to ice cream mix. Such incorporation rate could vary from 5 to 70%, depending on the acidity and consistency of the yoghurt

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utilized (Soukoulis and Tzia 2008). The common practice in the industry is to consider titratable acidity of the finished yoghurt ice cream mix of 0.3% Lactic Acid (LA) for establishing the quantity of yoghurt to be added to the mix (Marshal and Arbuckle 1996). A pH range of 5.76 to 6.72 and a titratable acidity range of 0.2 to 0.43% (expressed as lactic acid) have been reported by Schmidt *et al*. (1997). Ordonez *et al.* (2000) reported that production of lactic acid exceeding 0.4% LA in frozen yoghurt may lead to excessive viscosity of the product. The preferred pH and acidity for frozen yoghurt stored at -35°C for 6 months were reported as 5.5 and 0.4% LA respectively (Inoue *et al*., 1998).

There is scanty literature on frozen yoghurt prepared from yoghurt itself. Martinou-Voulasiki and Zerfiridis (1990) converted 78% of the total milk to yoghurt possessing 1.0% LA. Other such ice cream ingredients as sucrose, butter and emulsifier were dissolved in the remaining milk (22%) and then blended this syrup with yoghurt. Nagar *et al*. (2002) prepared YIC by blending yoghurt (pH 4.4) with ice cream pre-mix (1:1).

Guner *et al*. (2007) incorporated yoghurt with varying acidities (0.7, 0.8, 0.9 and 1% LA) at the rate of 74.3% of ice cream mix. They recommended preparing yoghurt of acidity not exceeding 0.7% LA; acidity levels greater than which led to progressive loss of sensory qualities of the resultant end product.

The use of soy protein products in the manufacture of foodstuffs has been widely investigated since FDA approved health claims as related to soy and health in 1998. Some positive aspects related to soy products' consumption include: lowering the risk of such cancers as breast and prostate cancer, lowering the risk of such diseases as arterial and cardiovascular. Lowering of cholesterol, protective effects against obesity, diabetes, irritation prevention of the digestive tract as well as a lowering of the bone and kidney diseases are among the advantages (Dervisoglu *et al*., 2005). Even though, products containing soya solids have been criticized for some of their beany or woody off flavours, yet some dairy dessert products may potentially serve as carriers of such value-added ingredients as soya solids.

The substitution of Milk Solids Not Fat (MSNF) in ice cream formulations containing such soy products as: soymilk, soy protein concentrate, and soy protein isolate has been reported by a few authors (Rajor and Gupta 1982; Saleem *et al*., 1989; Dervisoglu *et al*., 2005; Herald *et al*., 2008). However, a study of incorporating soya solids in YIC has not yet been reported. Therefore, the objective of this study was to determine the optimal yoghurt:ice cream mix proportion, in a functional dairy dessert containing soy flour as part substitute of conventional MSNF (i.e. NFDM) (MSNF =Milk Solid Non Fat and NFDM= Non Fat Dry Milk).

MATERIALS AND METHODS

Materials

The full-fat soy flour containing 19.6% fat and 96.13% total solids (Toos Soyan Co. Iran), low fat milk powder of 1.32% fat and 96.15% total milk solids (Golshad Co, Iran), cream containing 30% fat (Pegah Milk Industry, Mashhad, Iran), commercial stabilizer-emulsifier blend (Panisol ex, Danisco, Denmark), sugar powder and vanilla were obtained from reputable scientific suppliers.

Freeze-dried DVS (Direct Vat Starter) type yoghurt culture BY-1/63 (consisting of *Streptococcus thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus*) was obtained from Lactina (Denmark), and activated in 11% reconstituted low fat milk powder at a temperature between 43 and 45ºC for 15-20 minutes.

Yoghurt Ice Cream Formulation

Product formulation comprised of 12% SNF, 10% fat, 18% sucrose, 0.4% stabilizer-emulsifier blend as well as 0.1% vanillin; total solids being 40.5%. The batch size totalled 500 grams. Substitution of MSNF by soy flour was made at 55%, a level found optimal in an earlier study (Mahdian *et al,* 2011).

Preparation of Soymilk Blend

To produce soy milk with uniform consistency and reduced particle size, 33 grams of full-fat soy flour was blended with 2.75 grams of food grade sodium citrate. The blend was mixed with 27.1 grams of low fat milk powder in 203.5 ml of hot water at 95ºC. The mixture was stirred for about 15 minutes at 90-95ºC.The prepared mixture was homogenized in a two stage clean and sanitized homogenizer (Armfield Ltd. FT9) at ambient temperature and at pressures of 68.9 and 10.3 MPa respectively. The soy based milk made following this treatment was free from gritty, sandy or powdery mouthfeel when incorporated in YIC (Gandhi *et al.*, 2001).

Preparation of YIC

The mix obtained from the previous stage was pasteurized at 72ºC for 10 minutes and divided into two parts according to the desired yoghurt:mix ratio. One portion was cooled to 42-43ºC and inoculated with 2% of previously prepared yoghurt bulk starter culture followed by incubation at same temperature. At the time of curd formation (pH= 4.5-4.6) yoghurt was removed from incubator and cooled to 10-15ºC. The other part of mix was blended with cream, sugar, stabilizer and pasteurized at 72ºC for 10 minutes, then cooled to 10-15ºC before being mixed with yoghurt and vanilla. Yoghurt was added at levels of 0, 5.3, 15.9, 26.5, 37.1 and 47.7% of final ice cream mix. The resultant mix was then aged at 4ºC for 24 hours (Guner *et al*., 2007).

YIC mixes were frozen in a domestic batch type ice cream maker equipped with a compressor (1liter, Feller IC 100, Germany). Freezing took 20 minutes (at -18°C) before 50 gram portions were put into plastic cups and hardened at -18°C for about 24 hours. YIC production was done in triplicates.

Physico-chemical Analyses

The total solids of soybean flour as well as of low fat dried milk were determined by having the samples dried at 105±1ºC for 5.0 hours (using an air draft forced oven) till constant weight (PAAT-ARIYA Co. SH2006, Iran) as prescribed in AOAC, 1997. The fat contents of both powders were determined through Gerber method (ISIRI number 2450, 2005). Titratable acidities of yoghurt and of YIC were determined through the method of Marshal and Arbuckle, (1996) and expressed as % lactic acid. Flow behavior of YIC mixes was evaluated using rotational viscometer (Bohlin Model Visco88, Bohlin Instruments, UK) equipped with a circulator. Product temperature was controlled at 5±0.5°C by a refrigerated/heating circulator (Julabo, Model F12-MC; Julabo Labortechnik, Seelbach, Germany). Apparent viscosity was expressed in Pa s at a shear rate of 52.1 s^{-1} (Morris 1983).

The specific gravity of yoghurt ice cream mix was determined at 25ºC by use of a pichnometer as per method of Muhsenin (1978).

The overrun of YIC was estimated using the formula of Marshal and Arbuckle (1996).

YIC melting rate was determined according to Sakurai *et al*. (1996) with some modifications. The YIC (30 g in weight, instead of 100 g, because of more melting resistance of soy based YIC samples) at -18ºC was placed on a Buchner funnel at ambient temperature (25°C). The weight of the melted material was recorded after 15 minutes past and expressed as percentage weight melted.

Sensory Evaluation

The sensory evaluation of YIC was carried out by 18 trained panelists of postgraduate students at the Ferdowsi University of Mashhad. YIC samples were removed from frozen storage (-18ºC) after 24 hours of hardening and immediately offered to panelists. Ice cream samples were coded with three digit random numbers with all orders of serving completely randomized and while served in odorless plastic cups. A 9-point hedonic scale was employed to determine the degree of liking of the products (9= Extreme like, 5= Neither like nor dislike, 1= Extreme dislike). The samples were rated for color and appearance, flavour/taste, body/texture, as well as overall acceptability as prescribed by Herald *et al.* (2008).

Statistical Analysis

The data coming from three replications were obtained by applying a one factor completely randomized block design with the outcome of the data being analyzed through MSTAT-C software and by use of Analysis of Variance technique. Significant differences ($P \leq 0.05$) were determined through the Duncan's Multiple Range Test (Steel *et al.*, 1997). Excel software was employed for plotting the curves.

RESULTS AND DISCUSSION

Flow Behaviour of YIC Mixes

YIC mix rheograms at 5°C are presented in Figures 1 (a-b). According to primary tests, the results obtained from all samples were non-newtonian, time independent fluids, as in conformity with some previous reports (Cottrel *et al.*, 1980; Goff and Davidson, 1994; Kaya and Tekin, 2001).

Profiles of shear stress and of viscosity versus shear rate revealed shear thinning behavior of all mixes where viscosity values decreased with increasing shear rate. The reason for such behavior is that in low shear rates, molecules are of irregular arrangements that lead to high viscosity values. With increasing shear rate, these molecules get in more similar directions and consequently intermolecular friction increases while viscosity values decrease (Rha, 1975; Glichsman, 1982).

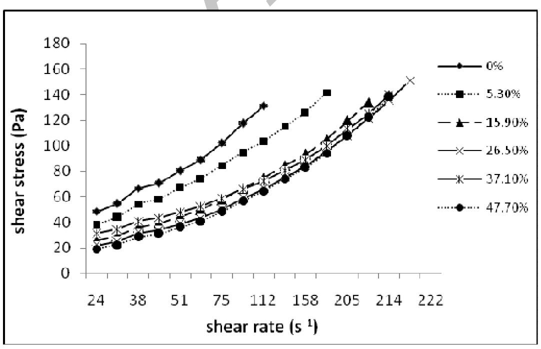
In the current study, shear stress and shear rate values were fitted using power law model:

$$\sigma = k\gamma^n$$

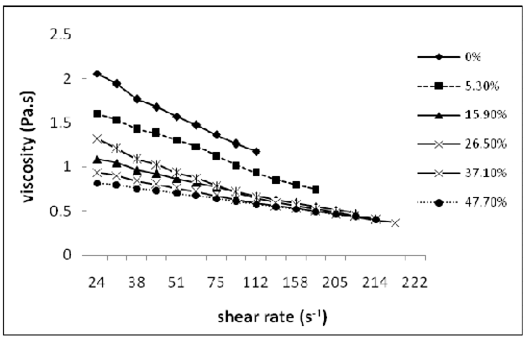
Where, σ is shear stress (Pa), γ stands for shear rate (s^{-1}), k is consistency coefficient (Pa s^n) and n denoting flow behavior index.

Flow behavior indices, consistency coefficients and correlation coefficients (r^2) of the model for each sample are presented in Table1. Values of n for all samples obtained amounted to less than 1 indicating the shear thinning behavior of all the mixes.

As seen from the results indicated in Table 1, there were no significant ($P< 0.05$) differences observed between values of *n* for all the samples. This implies that the level of yoghurt added to YIC mixes did not significantly affect the pseudoplastic behavior ($P< 0.05$). A flow behavior index of 0.7 was reported for ice cream mixes (Goff and Davidson, 1994). Values of *k* for



(a)



(b)

Figure 1. Changes in Shear stress vs. (a) and viscosity vs. (b) shear rate in YIC mixes containing varying yoghurt levels.

Table 1. Flow behavior indices (n), consistency coefficients (k) and correlation coefficients (r^2) of power law model for YIC mixes containing varying yoghurt levels.

Yoghurt levels (%)	*n*	*k*	r^2
0	0.80±0.14a*	1.85±1.69b	0.97b
5.3	0.67±0.02a	2.84±0.35ab	0.99a
15.9	0.73±0.09a	2.27±1.00b	0.99a
26.5	0.65±0.07a	3.60±1.32ab	0.98ab
37.1	0.72±0.06a	3.47±1.25ab	0.99a
47.7	0.70±0.06a	5.08±1.49a	0.99a

Values are average±standard error (n= 3).
*Values in a column which do not share a common letter are statistically different (P= 95%).

the mixes containing 0, 5.3 and 15.9% yoghurt were significantly lower than those for mixes with a higher level of yoghurt (P< 0.05). Consistency coefficient being an important parameter for estimating viscous nature of food products (Sopade and Kassum, 1992) was reported to be in the ranges of 0.0733 to 1.260 Pa s^n and 0.145 to 0.0211 Pa s^n by Muse and Hartel (2004) and by Minhas *et al*. (2002) respectively. The higher consistency coefficients obtained for YIC mixes in this study, in comparison with the previously reported values, may be attributed to the incorporation of soy flour and the effect of soy proteins plus carbohydrates on water absorption and viscosity of the samples.

Similarly, Soukoulis *et al*. (2009) showed that the use of dietary fibres in ice cream mix formulation significantly increased viscosity and shear thinning behavior.

Physico-chemical Properties

The physico-chemical properties of YIC mixes and of the finished YIC are presented in Table 2. Specific Gravity (SG) decreased while viscosity increased with the increasing level of yoghurt in the YIC mixes, the decrease in specific gravity being significant (P< 0.05). The specific gravity of ice cream mix as reported by the authors ranged from 1.05 to 1.12 (Marshal and Arbuckle, 1996). Hossein and Aumara (2006) reported that specific gravity of frozen yoghurt mix varied from 1.05 to 1.16 depending on ingredients and type of starter culture utilized in the product formulation.

There is no significant (P< 0.05) increase observed in viscosity when the level of yoghurt in the mix is up to 26.5 % (Table 2). Guner *et al*. (2007) reported the viscosity of YIC mix in the range of 9.8-11.6 MPa s. The authors further observed that use of yoghurt in place of milk, along with the same level of total solids, resulted in a greater decrease in the viscosity of frozen yoghurt mix as compared with control. Use of protein concentrates WPC (Whey Protein Concentrate) as a substitute for 25, 50, 75 and 100% of SNF (Solid Non Fat), MPC (Milk Protein Concentrate) for replacing 20 and 50% of ice cream protein content and SPC (Soy Protein Concentrate) at levels of 1.5, 3 and 4.5% of total ice cream mix) increased the mix viscosity significantly (Thampson *et al*., 1983; Lee and White, 1991; Alvarez *et al*., 2005; Dervisouglu *et al*., 2005; Herald *et al*., 2008).

It is reported that the viscosity of frozen yoghurt mix increased when utilizing yoghurt of low pH in the resultant mix. This could be attributed to the networking of protein matrix as a result of attaining low pH which culminates in increased mix viscosity (Hossein and Aumara, 2006). Ordonez *et al.* (2000) observed increase in the viscosity of YIC mixes from 0.63 to 4.4 Pa s as the acidity increased from 0.25 to 0.5% LA.

The pH and acidity values of YIC samples are directly affected by the quantity of yoghurt incorporated in the formulation (Table 2); pH decreased while acidity

Table 2. Physicochemical properties of YIC mixes and YIC containing varying yoghurt levels.

Yoghurt levels (%)	YIC mix: Specific gravityat 25ºC	YIC mix: Viscosity (Pa s) at 5ºC	YIC: Overrun (%)	YIC: Melting rate(% melted after 15 minutes at 25ºC)	YIC: pH	YIC: Acidity (% LA)
0	1.108±0.003a*	0.70±0.009c	51.8±0.35ab	77.8±8.42a	6.82±0.10a	0.22±0.015e
5.3	1.096±0.012b	0.93±0.111bc	44.6±12.01abc	83.7±12.00a	6.44±0.04b	0.28±0.006d
15.9	1.071±0.029c	0.76±0.093c	58.0±3.40a	79.2±8.10a	5.92±0.44c	0.37±0.006c
26.5	1.023±0.037f	0.87±0.001c	32.3±7.40cd	61.1±15.50ab	5.51±0.08d	0.44±0.011b
37.1	1.052±0.030d	1.30±0.073ab	42.0±5.59bc	49.9±21.06b	5.28±0.15de	0.49±0.036b
47.7	1.027±0.026e	1.57±0.071ab	23±6.75d	16±7.80c	5.13±0.06e	0.6±0.00a

Values are average ± standard error (n= 3).
*Values in a column which do not share a common letter are statistically different (P= 95%).

increased with increase in the level of yoghurt incorporated in YIC.

Utilization of yoghurt up to 15.9% in frozen yoghurt formulation did not present any negative effect on overrun while the level exceeding this, decreased the overrun significantly (Table 2). Least overrun (23 %) was associated with YIC containing maximum (47.7%) level of yoghurt. Maximum overrun was associated with YIC bearing 15.9% yoghurt. Use of yoghurt to replace milk at 74.3% of total ice cream mix led to decreased overrun as compared to control (Guner *et al*., 2007).

In general, as the viscosity increases, the resistance to melting and the smoothness of texture increases, however, this may be deterrent to whipping. High acidity contributes to excess mix viscosity, leading to decreased overrun (Arbuckle, 1986). Soukoulis *et al*. (2010) reported that YIC overrun decreased from 52.7 to 38.4 when yoghurt level increased from 25 to 50% in the mix.

It is suggested that production of YIC with yoghurt incorporated up to 15.9% is desirable taking overrun into consideration.

Use of incremental addition of yoghurt in YIC mix from 0 to 47.7% significantly improved the melting rate of the resultant product (Table 2). Using yoghurt up to 15.9% of the mix did not exert any influence on the melting rate; levels greater than this led to improved melting resistance. YIC of 47.7% yoghurt exhibited the highest melting resistance.

Fat destabilization is the most important parameter affecting ice cream melting rate (Muse and Hartel, 2004). Herald *et al*. (2008) reported that increasing ice cream mix viscosity resulted in lower melting rate and improved product smoothness.

It could be said that the highest melting resistance of the sample with 47.7% yoghurt content could be attributed to the maximum viscosity for such a mix. On the contrary, Guner *et al*. (2007) reported that yoghurt incorporation does not impair the melting characteristics of ice cream.

Sensory Properties

The flavor of YIC samples was acceptable when yoghurt was utilized in the blend up to 26.5% of the mix; beyond which (37.1 and 47.7% levels) there was a significant decrease observed in the flavor score (Table 3).

The same trend was observed with regard to texture and overall acceptance of YIC samples. The sample containing 47.7% yoghurt was of a significantly lower texture, bearing an overall acceptance score as compared to control.

The color scores of all the YIC samples compared well with each other. The maximum and minimum color scores were given by panelists to samples containing 47.7 and 5.3% yoghurt respectively.

Quantity of sugar and acid value are the two main factors determining the acceptability of the frozen yoghurt. The increase in yogurt content was accompanied by increased bulky and wheying off defects and a decrease of foamy and thinness attributes. The curdy appearance of ice cream melts is particularly associated with protein destabilization and salt imbalance due to increase in acidity, parameters which also explain the syneresis defect (Soukoulis *et al*., 2010).

The sensory panelists found better acceptability of frozen yoghurt having lower acidity (0.23-0.29% LA) than those of higher acidities; such effect being independent of the sugar concentration (Guinard *et al.,* 1994). A pH of 5.5 and an acidity of 0.4% LA for frozen yoghurt was reported to be the most acceptable one (Inoue *et al*., 1998). Guner *et al*. (2007) suggested keeping maximum acidity in frozen yoghurt to 0.47%; beyond which there was loss observed in sensory qualities.

In order to control the viscosity developed as a result of fermentation during yoghurt making, a maximum acidity of 0.3% LA in the resultant yoghurt-ice cream mix blend has been suggested (Ordonez *et al*., 2000).

In the current experiment, acidity of up to 0.44% LA of frozen yoghurt is organoleptically desirable which could be attained by resorting to application of yoghurt at a level of maximum 26.5% of the final product.

CONCLUSIONS

Incorporation of yoghurt at levels of 5.3 - 47.7% of the total mix for soy based Yoghurt ice cream, resulted in increased viscosity and decreased specific gravity of the resultant mix. All YIC mixes were pseudoplastic (non-newtonian, time independent fluids with shear thinning behavior) and the samples did not significantly differ from each other in this respect. The melting resistance of YIC increased with application of yoghurt up to 47.7%, whereas improvement in overrun was observed with an incorporation of 15.9% of yoghurt in the formulation. Frozen yoghurt containing yoghurt quantity beyond 26.5% led to more acidic taste decreasing its

Table 3. Sensory properties* of YIC containing varying yoghurt levels.

Yoghurt levels (%)	Colour	Flavour	Texture	Overall acceptance
0	5.5±1.30ab**	7±1.76a	6.5±1.64ab	6.6±1.83a
5.3	5.3±1.48b	6.8±1.34a	6.8±1.30ab	6.5±1.42a
15.9	5.9±1.70ab	6.1±1.82ab	6.9±1.27ab	6.4±1.34a
26.5	5.5±1.50ab	6.2±1.64ab	6.9±1.41ab	6.2±1.42a
37.1	5.9±1.79ab	5±1.92bc	6.3±1.49ab	5.8±1.67ab
47.7	6±1.68a	5±1.79c	5.9±2.13b	5.2±1.61b

Values are average ± standard error (n = 3).

*Based on 9-point hedonic scoring: 9: Excellent, 1: Very poor.

**Values in a column which do not share a common letter are statistically different (P= 95%).

sensory quality. Good quality Frozen Yoghurt can be successfully obtained using yoghurt incorporated at 26.5% of the total mix; the frozen yoghurt ended up with an acidity of 0.44% LA.

REFERENCES

1. 1. Alvarez, V. B., Wolters, C. L., Vodovotz, Y. and Ji, T. 2005.Physical Properties of Ice Cream Containing Milk Protein Concentrates. *J. Dairy Sci.,* **88:** 862-871.
2. AOAC. 1997. *Official Methods of Analysis*. 16th Edition, 3rd Revision, Association of Official Analytical Chemists, Arlington, VA.
3. Arbuckle, W. S. 1986. *Ice Cream.* 4th Edition, The AVI Pub Co. Inc. Westport, USA, PP. 20-369.
4. Cottrel, J. I. L., Pass, G. and Phillips, G. O. 1980. The Effect of Stabilizers on the Viscosity of an Ice Cream Mix. *J. Sci. Food. Agri.,* **31:** 1066-1070.
5. Davidson, R. H., Duncan, S. E. and Hackney, C. R. 2000. Probiotic Culture Survival and Implications in Fermented Frozen Yogurt Characteristics. *J. Dairy Sci.,* **83:** 666–673.
6. Dervisoglu, M., Yazici, F. and Aydemir, O. 2005. The Effect of Soy Protein Concentrate Addition on the Physical, Chemical, and Sensory Properties of Strawberry Flavoured Ice Cream. *Eur. Food Res. Technol.,* **221:** 466-470.
7. Gandhi, N. R., Hachbarth, H. R. and Chen, M. 2001. Soy Milk Composition and Methods of Preparation. *United States Patent,* **6(B1):** 322-846. www.us-patent-search.com
8. Glicksman, M. 1982. *Brown Seaweed Extracts (Alginates): Food Hydrocolloids*. (Eds.): King, A. H.. CRC Press Inc., Boca Raton, Florida, **III:** 68–75.
9. Goff, H. D. and Davidson, V. J. 1994. Controlling the Viscosity of Ice Cream Mixes at Pasteurization Temperatures. *Modern Dairy,* **73:** 12-14.
10. Guinard, J. X., Little, C., Marty, C. and Palchak, T. R. 1994. Effect of Sugar and Acid on the Acceptability of Frozen Yogurt to a Student Population. *J. Dairy Sci.,* **77:** 1232-1238.
11. Guner, A., Ardic, M., Keles, A. and Dogruer, Y. 2007. Production of Yogurt Ice Cream at Different Acidity. *Int. J. Food Sci. Technol.,* **42:** 948–952.
12. Herald, T. J., Aramouni, F. M. and Abu-Ghoush, M. H. 2008. Comparison Study of Egg Yolks and Egg Alternatives in French Vanilla Ice Cream. *J. Texture Stud.,* **39:** 284-295.
13. Hossein, G. A. M. and Aumara, I. E. 2006. Preparation and Properties of Probiotic Frozen Yoghurt Made with Sweet Potato and Pumpkin. *Arab Univ. J. Agric. Sci*., **14:** 679-695.
14. Inoue, K., Shiota, K. and Ito, T. 1998. Preparation and Properties of Ice Cream Type Frozen Yogurt. *Int. J. Dairy Technol.,* **51(2):** 44-50.
15. ISIRI Number 2450. 2005. Institute of Standards and Industrial Research of Iran. "*Ice-cream: Specification and Test Method*". 1st Revision, Tehran, Iran.
16. Kaya, S. and Tekin, A. R. 2001. The Effect of Salep Content on the Rheological Characteristics of a Typical Ice Cream Mix. *J. Food Engg.,* **47:** 59-62.
17. Lee, F. Y. and White, C. H. 1991. Effect of Ultrafiltration Retentates and Whey Protein Concentrates on Ice Cream Quality during Storage. *J. Dairy Sci.,* **74:** 1170-1180.
18. Mahdian, E., Mazaheri Tehrani, M. and Shahidi, F. Evaluationof the Effect of Soy Flour Substitution on Rheological Properties of Hard Ice Cream. *Iran. J. Food Sci. Technol.*, **8(31):** 107-114.
19. Marshal, R. T. and Arbukle, W. S. 1996. *Formulas and Industry Standards: Ice Cream*. (Ed.): Arbukle, W. S.. 5th Editionn, Chapman and Hall, New York, PP.314-327.
20. Martinou-Voulasiki, I. S. and Zerfiridis, G. K. 1990. Effect of Some Stabilizers on Textural and Sensory Characteristics of Yogurt Ice Cream from Sheep Milk. *J. Food Sci.,* **55:** 703–707.
21. Minhas, K. S., Sidhu, J. S., Mudahar, G. S. and Singh, A. K. 2002. Flow Behaviour Characteristics of Ice Cream Mix Made with Buffalo Milk and Various Stabilizers. *Plant Food. Hum. Nutr.,* **57:** 25-40.
22. Morris, E. R. 1983. Rheology of Hydrocolloids. In: "*Gums and Stabilizers for the Food Industry*", (Ed.): Morris, E. R.. Pergamon Press Oxford, UK, **II:** 73-95.
23. Muhsenin, N. N. 1978. *Physical Properties of Plant and Animal Materials*. Gorden and

Breach Science Publishers, New York, 101 PP.
24. Muse, M. R. and Hartel, R.W. 2004. Ice Cream Structural Elements that Affect Melting Rate and Hardness. *J. Dairy Sci.,* **87:** 1-10.
25. Nagar, G., Clowes, G., Tudorica, C. M., Kuri, V. and Brennan, C. S. 2002. Rheological Quality and Stability of Yog-ice Cream with Added Inulin. *Int. J. Dairy Technol.,* **55:** 89–93.
26. Ordonez, J. A., Jeon, I. J. and Roberts, H. A. 2000. Manufacture of Frozen Yoghurt with Ultrafiltered Milk and Probiotic Lactic Acid Bacteria. *J. Food Process. Pres.,* **24:** 163-176.
27. Rajor, R. B. and Gupta, S. K. 1982. Soft Serve Ice Cream from Soybean and Buttermilk. I. Method of Manufacture. *Indian J. Dairy Sci.,* **35:** 454-459.
28. Rha, C. 1975. Theories and Principles of Viscosity. In: "*Theory Determination and Control of Physical Properties of Food Materials*", (Ed.): Rha, C.. Dordreretch, The Reidel, Netherlands, PP. 123-141.
29. Sakurai, K., Kokubo, S., Hakamata, K., Tomita, M. and Yoshida, S. 1996. Effect of Production Conditions on Ice Cream Melting Rate and Hardness. *Milchwissenchaft***, 51:** 451–454.
30. Saleem, R. M., Shaker, K. A. and Al-Waeely, M. S. 1989. The Use of Soy Milk in Ice Cream Mixes. *Egypt. J. Dairy Sci.,* **17:** 281-288.
31. Schmidt, K. A., Kim, J. and Jeon, I. J. 1997. Composition of Carbohydrates and Concentration of *β*-galactosidase of Commercial Frozen Yogurt. *J. Food Quality,* **20:** 349–358.
32. Sopade, P. A. and Kassum, A. L. 1992. Rheological Characterization of Akamu: A Semi-Fluid Food from Maize Millet and Sorghum. *J. Cereal Sci.,* **15:** 193-202.
33. Soukoulis, C. and Tzia, C. 2008. Impact of the Acidification Process, Hydrocolloids and Protein Fortifiers on the Physical and Sensory Properties of Frozen Yogurt. *Int. J. Dairy Technol.,* **61:** 170-177.
34. Soukoulis, C., Lebesi, D. and Tzia, C. 2009. Enrichment of Ice Cream with Dietary Fibre: Effects on Rheological Properties, Ice Crystallization and Glass Transition Phenomena. *Food Chem.,* **115:** 665–671.
35. Soukoulis C., Lyroni E. and Tzia C. 2010. Sensory Profiling and Hedonic Judgment of Probiotic Ice Cream as a Function of Hydrocolloids, Yogurt and Milk Fat Content. *LWT, Food Sci. Technol.*, **43**: 1351-1358.
36. Thampson, L. U., Reniers, D. J., Baker, L. M. and Siu, M. 1983. Succinylated Whey Protein Concentrates in Ice Cream and Instant Puddings. *J. Dairy Sci.,* **66:** 1630-1637.

بهینه سازی مخلوط ماست و بستنی جهت تولید بستنی ماستی بر پایه سویا

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چکیده

بستنی ماستی یا ماست منجمد می تواند به عنوان یک جایگزین خوب برای بستنی معمولی مطرح باشد. همچنین استفاده از فراورده های سویا در ترکیب محصولات غذایی منجر به بهبود ویژگیهای تغذیه ای و تولید یک محصول سلامتی بخش می شود. در این تحقیق بستنی ماستی با جایگزینی ۵۵٪ از ماده جامد بدون چربی شیر با آرد کامل سویا تولید شد.ترکیب محصول شامل ۱۲ درصد ماده جامد بدون چربی، ۱۰ درصد چربی، ۱۸ درصد شکر، ۰/۴ درصد مخلوط پایدارکننده/امولسیفایر و ۰/۱ درصد وانیل به عنوان طعم دهنده بود. اثر مقدار ماست در سطوح ۵/۳، ۱۵/۹، ۲۶/۵، ۳۷/۱ و ۴۷/۷ درصد از کل

مخلوط بر رفتار جریان و خصوصیات فیزیکوشیمیایی و حسی بستنی ماستی بررسی و با نمونه شاهد فاقد ماست مورد مقایسه قرار گرفت. مخلوط همه نمونه ها رفتار رقیق شونده با برش داشته و با افزایش مقدار ماست از صفر تا ۴۷/۷ درصد، مقدار ویسکوزیته از ۰/۷ تا ۱/۵۷pa.s افزایش یافت. استفاده از مقادیر بالاتر ماست منجر به بهبود سرعت ذوب نمونه ها به طور معناداری گردید به طوری که کمترین سرعت ذوب (۱۶٪) برای نمونه حاوی ۴۷/۷ درصد ماست به دست آمد. همچنین بیشترین ضریب افزایش حجم برابر ۵۸ درصد برای نمونه حاوی ۱۵/۹ درصد ماست به دست آمد. مقادیر وزن مخصوص با افزایش درصد ماست کاهش یافت و بیشترین مقدار وزن مخصوص برابر با ۱/۱۰۸ در مورد نمونه شاهد فاقد ماست به دست آمد.بر اساس نتایج به دست آمده، می توان بستنی ماستی با ویژگیهای حسی مطلوب را با استفاده آرد کامل سویا و کاربرد ۲۶/۵ درصد ماست تولید کرد.