

## Preparation and quality characterization of soy milk based non-dairy ice cream

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### Abstract

*Soy milk made from soybean has prospective to be used as a substitute of milk due to its health benefits. It is a rich source of iso-flavones, omega-3-fatty acid, dietary fiber, vitamin C, carotenoids, protein and oligosaccharides. The current study was designed to examine the effects of galacto-mannan on ice cream by using commercially available (silk) and locally prepared soy milk. Galacto-mannan (guar gum) was used in different concentration (0.3, 0.4, 0.5 and 0.6%) for the preparation of ice cream. Ice cream was analyzed for physico-chemical and sensory characteristics at 0, 30 and 60 days of storage interval. Overrun, meltdown, viscosity, total solids, pH and acidity were affected significantly by ice cream samples as well as storage. While non-significant effects of stabilizer and storage were found on fat, protein, and ash contents of ice cream. On organoleptic evaluation, the highest scores were awarded to the ice cream sample prepared with 0.5% of guar gum. Ice cream manufactured with locally prepared soy milk and guar gum revealed comparable quality with lower cost.*

### History

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## 1. Introduction

The production of non-dairy food products has been pointed out as a novel trend in the production of functional foods (Kano et al., 2002). The market of food products containing functional ingredients such as: prebiotics, probiotics, dietary fiber, soy and derivatives grows approximately 5% per year worldwide and the selling of these products is expected to be over US\$19.6 billion in 2013 (Granato et al., 2010a).

Soy-based products have become gorgeous and attractive source as a potential alternative of cow's milk. Soybeans are an excellent source of high-quality proteins and carbohydrates but are devoid of lactose and cholesterol. It is a plentiful and inexpensive source of nutrition for milk allergy patients, lactose-intolerant individuals and also for the vegetarians (Liu & Lin, 2000). Soy bean protein, due to its undigested pepsin fraction may affect the fecal excretion of bile acids or

steroids and also influence the cholesterol metabolism (Tomat, Costa, & Arranz, 2011).

Soy has an important influence on the host's well-being as it is an important source of many other nutrients including proteins, vitamins, oligosaccharides, dietary fiber and trace minerals. Due to presence of oligosaccharides, soy exhibits its important physiological role and could meet the prebiotic standards.

Soy bean, due to its high quality protein could serve as a complete source of protein for vegetarians (Romanich-Cerpovicz, Abbott, & Dent, 2011). On the basis of composition soybean has 40% protein, 20% oil contents, and 15% saccharides, 15% dietary fiber and 10% others (Kim et al., 2005).

Soy based products are of worth importance because they reduce menopausal symptoms, as well as having potential role in the prevention, reduction and treatment of diseases such as osteoporosis, cancer, kidney disease and atherosclerosis (Garcia et al., 2009). Soy milk contains a non-steroidal phytoestrogen that has verified as a protective effect against age-related bone loss and

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other chronic diseases. It act as a diet rich in iso-flavonoids and associated with a lowered risk of many diseases, such as prostate and breast cancers, cardiovascular diseases and osteoporosis (Clarkson, 2002). Moreover, iso-flavonoids have also proven their anti-cancer, hormone altering, estrogenic and anti-estrogenic properties. Soybean is low in saturated fat so it could be helpful in reducing coronary heart diseases (Romanchik-Cerpovicz, Abbott, & Dent, 2011).

Guar Gum, commonly known as guar flour, a natural water soluble nonionic polysaccharide isolated from the seeds of *Cyamopsis tetragonolobus*. Guar gum lowers the cholesterol and glucose level as well as helpful for the prevention of obesity (Mudgil, Barak, & Khatkar, 2011).

The population is increasing regularly and insufficient supply of protein has involuntarily increased the manifestation of malnutrition in developing countries. Animal protein is also wholly inadequate and relatively expensive in developing countries so to meet the protein demands in these countries, research effort is geared in the direction of finding alternative sources of protein from legume seeds (Romanchik-Cerpovicz, Abbott, & Dent, 2011).

Topical industrial dessert products are chiefly cow milk-based so these contains lactose as well as cholesterol which could cause limitations in product (Granato et al., 2010b). Soy-based foods provide health benefits to consumers due to their anti-cholesterolemic, hypolipidemic, anti-allergenic and anti-atherogenic properties (Lopez-Lazaro, 2002).

Keeping in view the significance of soy milk and carbohydrate based polysaccharides, the current research was planned to add the galacto-manan in various concentrations in the locally prepared and commercial available soy milk for the preparation of soy milk ice cream and to analyze its effects on the physical, chemical and sensory features.

## 2. Materials and methods

Soybeans, guar gum, egg yolks and sugar were purchased from the local market. The chemicals and reagents used for analysis were acquired from Sigma Aldrich (USA), Oxoid (UK) and Merck (Germany).

### 2.1. Preparation of soy milk

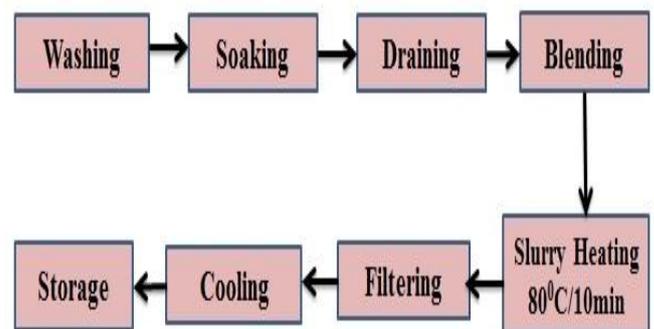
Soybeans (100 g) were washed in de-ionized water. The cleaned beans were soaked in 1L of water for 14 h at 4 °C. The swollen soybeans were drained and blended with 1L of boiling water in a blender at low speed for 5 min. The slurry was heated for 10 min at 80 °C. The hot mixture was filtered through four layers of cheese cloth and the filtrate (-850 g) was collected. The soy milk was cooled at room temperature and then kept at 4 °C (Pathomrungsriyounggul, Lewis, & Grandison, 2010)

### 2.2. Analysis of soy milk

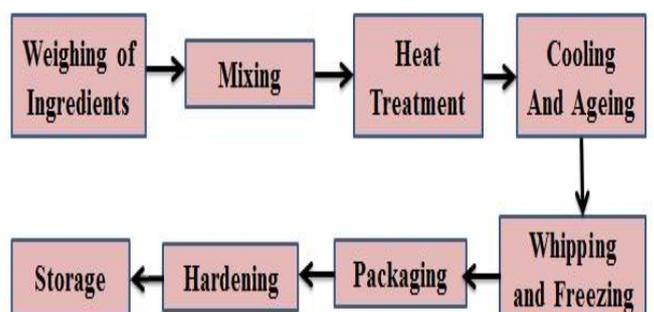
Soy milk was analyzed for its composition (fat, protein, ash, SNF and total solids) as well as physico-chemically (pH and Acidity). The pH was determined by Electrical digital type pH meter (WTW series pH-720). pH, acidity, fat, ash, protein and total solids were determined as described in (AOAC, 2003). The milk solid not fat content was determined as (Kirk & Sawyer, 1991).

### 2.3. Procedure of ice cream

Ingredients needed to concoct soy milk ice cream were mixed prudently after weighing and then pasteurized. Aging was done for 24 hours, after that whipping and freezing process was performed in the manufacturing



**Figure 1.** Flow diagram of Soy milk Preparation



**Figure 2.** Flow diagram of the preparation of soymilk based ice-cream

**Table 1. Treatment Plan**

Treatments	Control	Commercially available Soy Milk	Locally prepared Soy Milk
		Guar gum (%)	Guar gum (%)
T <sub>0</sub>	No GG	-	-
T <sub>1</sub>	-	0.3	-
T <sub>2</sub>	-	0.4	-
T <sub>3</sub>	-	0.5	-
T <sub>4</sub>	-	0.6	-
T <sub>5</sub>	-	-	0.3
T <sub>6</sub>	-	-	0.4
T <sub>7</sub>	-	-	0.5
T <sub>8</sub>	-	-	0.6

machine. Finally freezing was done for its structure hardening (Innocente, Comparin, & Corrandini, 2002).

#### 2.4. Ice cream analysis

Ice cream was analyzed for its composition (fat, protein, ash and total solids) according to the methods as described in (AOAC, 2003). Viscosity of the ice cream samples was measured by using Brookfield viscometer LVDVE-230 (MA, USA) to check the rheological properties of (Kaya and Tekin, 2001). The hardness of ice cream was determined by using texture analyzer TAXT2. The ice cream was added to a 33 mL cylindrical container and kept at  $-17 \pm 2$  °C for 48 hours. The measurements were obtained at room temperature ( $25$  °C  $\pm$  2 °C), using a texture analyzer (TA-XT2i, Stable Microsystems Ltd., UK) equipped with a 5-mm stainless steel cylindrical probe. The penetration speed of the probe was 2.0 mm/s to a distance of 5mm, test speed 3mm/s; post-test speed 10mm/s, data acquisition rate 250pps, trigger type auto 20 g (Santana, Rebiro, & Igut, 2011).

Meltdown test is very important in case of ice cream because it provides us the information about the firmness of ice cream at the time of consumption. The rate of melting of all samples of ice cream were calculated according to the volume of liquid which drained off from 25-30g of ice cream samples and placed on a sieve with 2-mm openings, during 10 minutes at  $25$  °C  $\pm$  2 °C (Santana, Rebiro, & Igut, 2011). Over run was determined by the method which was based on duplicate comparing the weight of a fixed volume of pre ice cream mix and ice cream. The result was expressed in % as

$$\text{Over run \%} = \frac{M-I}{I} \times 100$$

I

Where M = weight of mix and I = weight of ice cream

#### 2.5. Sensory evaluation

Sensory evaluation based on flavor, taste, texture, firmness and overall acceptability was conducted by the panel of twenty trained judges of National Institute of Food Science and Technology by using 9 point hedonic scale (9 = like extremely; 1 = dislike extremely) according to the method as described by (Meilgaard, Car, & Civille, 2006).

#### 2.6. Statistical analysis

Statistical analyses were performed by using Statistix 8.1 software and by using two factor factorial test and Fisher's Least Significant Difference (LSD) multiple comparison- test to determine the level of significance. All determinations for chemical analyses were carried out in triplicates. For all comparisons, the level of significance was set to  $P < 0.05$ .

#### 3. Results and discussion

Comparison was made among two types of soy milk i.e. commercial available soy milk '*Silk*' and locally prepared soy milk. The results are presented in table 3 and are comparable.

Data revealed that fat contents ranged between 2.45-2.77 among different treatments. Fat contents of all the treatments vary non- significantly ( $p > 0.05$ ) from each other throughout the storage interval. The selected stabilizer/emulsifier had no effect on fat content of the ice cream and low fat ice cream can be produced by using galacto-mannans in non-dairy ice cream. Furthermore, it is evident from the literature that galacto-mannans can also be used as fat replacer. Therefore, the available fat in both of the treatments (commercial 3% and locally prepared soymilk 2.5%) was acceptable for the ice cream formation. Low fat under such formulations is preferably being offered to diet conscious persons (Bhandari & Bhandari, 2001).

Total solid contents of soy milk based ice-cream ranged between 32.17-32.67 among different treatments. Results showed that total solid contents of soy ice cream varied significantly ( $P < 0.05$ ) in all the treatments as

**Table 2. Mean value of composition of commercial and local soy milk**

Compositional Parameter	Commercial soymilk	Local soymilk
Fat	3%	2.5%
Protein	3.5%	3.3%
Ash	0.5%	0.7%
SNF	7.2%	10%
Total Solids	10.5%	12.7%
Ph	6.74	6.72
Acidity	0.24%	0.28%

well as during storage while there was a non-significant effect ( $p>0.05$ ) of their interaction and these findings were supported by (Hematyar et al., 2012).

The ash is an inorganic residue obtained after the removal of water and organic matter by heating in the presence of oxidizing agents. It actually measures the total amount of mineral in the food.

Ash contents of soy milk based ice cream ranged from 0.94-1.77. Statistical analysis showed that it varied significantly ( $P < 0.05$ ) in all the treatments, while storage and their interaction showed non-significant effect ( $p>0.05$ ) on ash content.

A gradual increase in ash content of all the samples was observed as the gum concentration was increased. (Hematyar et al., 2012) reported 0.72% ash in guar gum so with the increase of gum level the ash may increase.

The pH of soy milk based ice cream ranged between 7.28-7.37. Statistically, storage period showed non-significant effect on the pH that might be due to the fact that soy milk's pH remains unchanged throughout the storage period. The pH has direct influence on the flavor perception in the dairy products. It is influenced by the

**Table 3. Effect of guar gum on the different quality attributes of soy milk based non-dairy-ice cream**

Treatments	Fat (%)	pH	Total Solids (%)	Ash (%)	Acidity (%)	Viscosity (cp)	Over run (%)	Melt down (%)	Protein (%)	Hardness (N)
T <sub>0</sub>	2.52±0.02 <sup>b</sup>	7.28±0.03 <sup>b</sup>	32.17±0.11 <sup>c</sup>	0.9±0.01 <sup>d</sup>	0.29±0.01 <sup>d</sup>	1780.0±0.11 <sup>g</sup>	39.42±0.13 <sup>g</sup>	14.3±0.09 <sup>a</sup>	4.06±0.03 <sup>d</sup>	19.0±0.09 <sup>c</sup>
T <sub>1</sub>	2.45±0.01 <sup>a</sup>	7.29±0.01 <sup>b</sup>	32.53±0.09 <sup>a</sup>	0.9±0.03 <sup>d</sup>	0.94±0.01 <sup>a</sup>	3273.3±0.17 <sup>f</sup>	46.89±0.11 <sup>f</sup>	14.17±0.03 <sup>b</sup>	4.03±0.01 <sup>c</sup>	19.6±0.03 <sup>b</sup>
T <sub>2</sub>	2.63±0.01 <sup>c</sup>	7.33±0.01 <sup>a</sup>	32.56±0.07 <sup>ab</sup>	0.9±0.07 <sup>d</sup>	0.84±0.03 <sup>b</sup>	3463.±0.19 <sup>d</sup>	49.49±0.11 <sup>e</sup>	13.48±0.11 <sup>bc</sup>	4.04±0.05 <sup>bc</sup>	19.8±0.11 <sup>b</sup>
T <sub>3</sub>	2.55±0.03 <sup>b</sup>	7.34±0.05 <sup>a</sup>	32.60±0.1 <sup>b</sup>	1.0±0.01 <sup>b</sup>	0.79±0.02 <sup>b</sup>	4400.0±0.13 <sup>a</sup>	57.27±0.17 <sup>a</sup>	11.64±0.07 <sup>d</sup>	4.02±0.01 <sup>b</sup>	20.5±0.1 <sup>a</sup>
T <sub>4</sub>	2.73±0.01 <sup>d</sup>	7.37±0.01 <sup>bc</sup>	32.63±0.07 <sup>b</sup>	1.19±0.03 <sup>c</sup>	0.75±0.07 <sup>b</sup>	4460.0±0.15 <sup>a</sup>	60.85±0.13 <sup>d</sup>	10.56±0.12 <sup>e</sup>	4.00±0.09 <sup>b</sup>	20.6±0.07 <sup>a</sup>
T <sub>5</sub>	2.53±0.02 <sup>b</sup>	7.31±0.02 <sup>ab</sup>	32.52±0.11 <sup>a</sup>	1.73±0.01 <sup>ab</sup>	0.90±0.01 <sup>a</sup>	3283.3±0.11 <sup>f</sup>	46.72±0.11 <sup>f</sup>	15.54±0.04 <sup>a</sup>	3.89±0.03 <sup>a</sup>	20.5±0.03 <sup>a</sup>
T <sub>6</sub>	2.63±0.04 <sup>c</sup>	7.34±0.04 <sup>a</sup>	32.67±0.09 <sup>c</sup>	1.74±0.07 <sup>b</sup>	0.86±0.02 <sup>b</sup>	3373.3±0.19 <sup>e</sup>	49.00±0.17 <sup>e</sup>	13.70±0.11 <sup>b</sup>	3.99±0.01 <sup>b</sup>	20.4±0.01 <sup>a</sup>
T <sub>7</sub>	2.63±0.06 <sup>c</sup>	7.34±0.01 <sup>a</sup>	32.56±0.05 <sup>ab</sup>	1.76±0.11 <sup>a</sup>	0.80±0.01 <sup>b</sup>	3643.3±0.21 <sup>c</sup>	52.00±0.13 <sup>c</sup>	12.64±0.05 <sup>c</sup>	3.89±0.02 <sup>a</sup>	20.7±0.09 <sup>a</sup>
T <sub>8</sub>	2.77±0.07 <sup>e</sup>	7.36±0.03 <sup>bc</sup>	32.59±0.12 <sup>b</sup>	1.77±0.09 <sup>a</sup>	0.75±0.05 <sup>b</sup>	3840.0±0.16 <sup>b</sup>	55.53±0.11 <sup>b</sup>	10.41±0.09 <sup>e</sup>	4.02±0.07 <sup>c</sup>	20.5±0.11 <sup>a</sup>

**Table 4. Effect of storage on the different quality attributes of soy milk based non-dairy-ice cream**

Storage	Fat	pH	Total Solids	Ash	Acidity	Viscosity	Over run	Melt down	Protein	Hardness
0	2.59±0.01 <sup>a</sup>	7.37±0.03 <sup>a</sup>	32.55±0.09 <sup>b</sup>	1.06±0.01 <sup>a</sup>	0.75±0.01 <sup>a</sup>	3528.9±0.17 <sup>a</sup>	52.743±0.17 <sup>a</sup>	11.07±0.09 <sup>a</sup>	4.04±0.01 <sup>a</sup>	20.17±0.07 <sup>c</sup>
30	2.61±0.02 <sup>b</sup>	7.33±0.01 <sup>b</sup>	32.57±0.05 <sup>b</sup>	1.04±0.01 <sup>a</sup>	0.77±0.02 <sup>ab</sup>	3501.1±0.13 <sup>ab</sup>	49.733±0.19 <sup>b</sup>	13.04±0.11 <sup>b</sup>	4.01±0.01 <sup>ab</sup>	20.21±0.04 <sup>b</sup>
60	2.62±0.01 <sup>b</sup>	7.29±0.01 <sup>c</sup>	32.49±0.07 <sup>a</sup>	1.33±0.21 <sup>b</sup>	0.79±0.01 <sup>b</sup>	3475.6±0.9 <sup>b</sup>	46.591±0.11 <sup>c</sup>	15.33±0.1 <sup>c</sup>	3.93±0.02 <sup>b</sup>	20.25±0.09 <sup>a</sup>

compositional and biochemical changes during the storage period (Kanbakan, Kon, & Ayar, 2004). The normal pH of ice cream is around 7.0 or neutral.

Viscosity is the resistance to flow and is commonly measured in centipoise (cP). The factors which can affect the viscosity include temperature, type, concentration, state of Galacto-mannans (Guar Gum) and fat globule size (Mudgil, Barak, & Khatkar, 2011). Moreover, protein hydration can also increase the viscosity. Viscosity is a factor used to determine the Galacto-mannans (Guar Gum) aggregation, creaming, incorporation of air, freezing rate, flow condition. It can also provide mouth feel and flavor to the ice cream (Hematyar et al., 2012). Statistically, the treatments showed highly significant effect on viscosity of ice cream like in control it was 1780 cp and in commercially available soy milk's ice cream it was within the range of 3273.3 cp to 4460 cp and in local prepared soy milk's ice cream it was 3283.3cp to 3840.0 cp. Storage period showed significant while the interaction and storage showed non-significant effect on the viscosity of soy milk based ice-cream. The results are supported by the findings of (Kaya & Tekin 2001)

Treatments and storage showed highly significant effect on over run of ice cream. Data revealed an increase in over run value with the increase in gum concentration like 60.85 in the samples of the treatment T<sub>4</sub> and 55.53 in T<sub>8</sub>, while it was low in case of control sample.

So, it means gum provide strengthening power to ice cream and resist melting. Meltdown values show the resistance of the ice cream to melt. This property of the ice cream will also define the quality of the product as air which is incorporated form the final volume of the product, which will raise the volume of ice cream and

ultimately melt down will be decreased. This is measured as the time required liquefying a measured amount of the ice cream at room temperature.

Data revealed that treatments and storage period showed highly significant ( $P<0.01$ ) while their interaction showed non-significant effect ( $p>0.05$ ) on melt down property of ice cream. In our study, meltdown value of soy ice cream decreased with the increase in gum concentration. The highest melt down value was observed in T<sub>5</sub> (15.54) as compared to the treatment T<sub>1</sub> (11.870) while both samples contain equal percentage of guar gum (0.3%). Control sample (without gum) showed higher melt down value as compared to other samples. These findings were supported by (Goff 2002). In general, melting rate of ice creams increased with storage that may be due to increase in ice crystal size as a result of ice recrystallization (Muse and Hartel 2004).

Depending upon the protein content, ice cream is divided into two levels, low level with up to 2.4% protein and high level with up to 5.04% protein (Tong 2007). In our study, meltdown value of soy ice cream decreased with the increase in gum concentration. The highest melt down value was observed in T<sub>5</sub> (15.54) as compared to the treatment T<sub>1</sub> (11.870) while both samples contain equal percentage of guar gum (0.3%). Control sample (without gum) showed higher melt down value as compared to other samples.

Hardness is measured as the resistance of the ice cream to deform when an external force is applied on it. Since both the ice crystal size and ice phase volume contribute to the hardness of treatments. This factor may be used as a measure of ice crystal growth (Muse and Hartel

2004). Statistically, treatments showed highly significant effect on the hardness of ice-cream.

Data showed that hardness of soy ice cream increased with the increase in gum concentration in all the treatments. According to table of mean comparison of all the treatments, highest mean of force was observed for T<sub>7</sub> (20.7) which contain 0.5% stabilizer and prepared from locally available soy milk while minimum hardness was observed in case of T<sub>0</sub>.

### 3.1. Sensory evaluation

Ice cream sample made with soy milk of both types was sensory evaluated for its flavor, mouth feel, ice crystals, surface appearance, body/ texture and overall acceptability. All the sensory parameters were affected significantly ( $P < 0.05$ ) by different treatments. The highest scores were awarded to the ice cream sample containing 0.5 % guar gum and in some cases to the samples of the treatments that contain 0.4% guar gum. However, mean score for all the sensory parameters decreased with the passage of time.

### 4. Conclusions and recommendations

Soy milk both commercially available (*silk*) and locally prepared was used successfully to prepare soy milk based non-dairy ice cream. Soy milk was successfully made using soy bean and it gave comparable results with commercially available soy milk. The treatment that contains Guar gum (0.5%) received highest scores for viscosity, meltdown, over-run and sensory characteristics and was recommended for the production of soy milk based high quality ice-cream. Moreover, this ice cream as a frozen dessert also has potential for commercialization.

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