Indian J Dairy Sci 73(2): 111-115
https://doi.org/10.33785/IJDS.2020.v73i02.002

RESEARCH ARTICLE

Development of synbiotic ice cream from goat milk

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Received: 11 November 2019 / Accepted: 25 February 2020 / Published online: 18 May 2020

Abstract: Synbiotic ice cream was developed from goat milk by using inulin as a prebiotic and *Lactobacillus plantarum* (UBLP-40) as a probiotic. The treatment mix was formulated to contain more than 10% fat, 8.6% milk solids not fat, 2% inulin, 15% sugar, 0.4% stabilizer-emulsifier combination and probiotic *Lactobacillus plantarum* culture. Physico-chemical, microbiological and sensory qualities of control and synbiotic ice cream were compared. Synbiotic ice cream showed higher whipping ability ($p<0.05$) than control. Synbiotic ice cream was superior in sensory qualities than control during 30 days of storage. There was no significant difference in fat, protein, meltdown time and weight per litre.

Keywords: Functional ice cream, Goat milk ice cream, Inulin, *Lactobacillus plantarum*, Synbiotic ice cream

Introduction

Ice cream is the most popular dairy product widely consumed by all age groups of people. Probiotics are live microorganisms when administered in sufficient amounts give a number of health benefits to the host. The important criterion for the successful development of probiotic products is selection of resistant probiotic strains which can maintain their survivability during commercial production and storage. Prebiotics are non-digestible food ingredients that stimulate the growth of probiotic bacteria (Bindels et al. 2015). Inulin and inulin-type fructans are soluble fibers that can delay absorption of glucose and enhance glucose metabolism and capable of modulating gastric evacuating and intestinal transit time (Wilson and Whelan, 2017). Synbiotics are appropriate combinations of probiotics and prebiotics (Cencic and Chingwaru 2010). Incorporation of probiotic cultures in goat milk products can also mask the unpleasant goaty flavor due to the production of flavor compounds and can improve the rheological properties of goat milk products (Ranadheera et al. 2019). Ice cream is a better carrier for probiotic bacteria when compared to fermented dairy products. The pH of ice cream is higher than that of regular fermented milk, which will facilitate the survival of probiotic bacteria (Ahmadi et al. 2014).

Approximately 12.2 million metric tons of goat milk is produced annually which contributes to 2% of all world production by the dairy industry. India ranks first in goat milk production. Goat milk has many advantages such as better digestibility, lower allergenic properties and stronger antimicrobial characteristics when compared to cow milk. However, no significant effort has been made in India for the production of functional dairy products from goat milk. Development of commercially viable functional dairy product such as synbiotic ice cream from goat milk will improve the utilization of goat milk. *Lactobacillus plantarum* was found to be a versatile species with many beneficial properties (Behera et al. 2018). Synbiotic ice cream prepared by using probiotic *Lactobacillus plantarum* was found to have superior viscoelastic properties and slower melting rate (Siti Radhiah Omar and Siti Nazirah Omar 2018). Therefore, this study was designed with an objective to develop synbiotic ice cream using inulin as prebiotic and *Lactobacillus plantarum* as probiotic and evaluating the physico-chemical, microbiological and sensory qualities of the product.

Materials and Methods

Fresh goat milk was procured from University Goat and Sheep farm, Mannuthy. Cream was separated from goat milk by using a centrifugal cream separator. Skimmed milk powder (sagar®), sugar

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and flavour (bush®) were purchased from local market. The stabilizer and emulsifier used was cremodan sampoorna® of Danisco. Inulin was procured from Amrutha Herbals private limited, Indore. Probiotic *Lactobacillus plantarum* UBLP-40 (DVS) culture was provided by Unique Biotech, Hyderabad.

Analysis of dairy ingredients

The fat per cent in milk, skim milk and skimmed milk powder were determined by the procedure described by AOAC (2016). The fat content of cream, total solids content of milk, cream, skim milk and skimmed milk powder were estimated by the procedure described by BIS (1981).

Preparation of ice cream

Ice cream was prepared as per the procedure suggested by Akin et al. (2007). The proportionate quantity of different ingredients to meet the minimum standards for fat and total solids as per Food Safety and Standards Act was calculated and the mix was prepared. It was pasteurized at a temperature of 83ºC for 25 seconds. Homogenization of the mix was done at a temperature of 65ºC by using a pressure of 2500 PSI at first stage and 500 PSI at the second stage. The mix after homogenization was immediately cooled to 4ºC and later transferred to a cold storage maintained at a temperature of 4 ± 1ºC for ageing. Vanilla (bush®) flavor at the rate of 2ml per kg of the mix was added to the mix and mixed well. Probiotic culture *Lactobacillus plantarum* was added just before freezing. The ice cream mixes in each treatment group were frozen individually using a softy ice cream freezer (Technogel HMT®). The ice cream was collected in 500 ml poly propylene containers. Then it was stored at -20±1ºC.

Standardization of level of inulin for the preparation of synbiotic ice cream

Three treatment formulations were evaluated during the preliminary trials in which inulin was incorporated at 2(T1), 2.5(T2) and 3(T3) per cent levels. The results of sensory evaluation of different product formulations are presented in Table 1. From the results, two per cent inulin (T1) was selected as it had shown better sensory acceptability with minimum level of inulin.

Synbiotic ice cream mix

Synbiotic ice cream was prepared by using selected level of inulin as prebiotic along with *Lactobacillus plantarum* UBLP-40 (10^{13}cells/g) DVS culture. Inulin was added along with other dry ingredients during the preparation of mix as shown in Table 2.

Physico- chemical properties of ice cream

The titratable acidity of control and treatment groups of ice cream was determined by the procedure outlined by BIS (1981). The pH of the ice cream samples were analysed by digital pH meter (Hanna HI2020). The percentages of total solids, protein and fat were determined by the procedure outlined by AOAC (2000). While the mix was being frozen in a softy ice cream freezer, mix was drawn at five minutes intervals up to ten minutes and weighed. The loss of weight of the mix due to air incorporation was recorded. Hundred grams of ice cream was carefully placed on a four square inch glass plate rested on the brim of glass funnel, fitted on a metal stand with its tail end leading into a 100 ml graduated cylinder. The time taken for complete meltdown was recorded. Weight per litre of ice cream was estimated using the procedure outlined in BIS (1986). The probiotic count of ice cream during 0, 15 and 30 days of storage was performed as per the procedure described by Inoue et al. (1998). Serial dilutions of the ice cream sample was done and one milliliter of diluted inoculum was transferred to sterile Petri dish. Then 20 ml of sterile molten MRS agar maintained at 45 ºC was poured and mixed with inoculum. The plates were incubated at 37 ºC for 48 hours. After incubation the plates showing 30-300 yellow coloured oval to round colonies were selected and counts were taken with the help of the colony counter. The coliform count of ice cream during 0, 15 and 30 days of storage was performed as per BIS (1981). The sensory evaluation was done by using the score card as per Homayouni et al. (2008). The data obtained were subjected to statistical analysis using the software SPSS version 24 as per the procedure suggested by Snedecor and Cochran (1994).

Results and Discussion

Synbiotic ice cream was prepared by using 2 per cent inulin and *Lactobacillus plantarum*. Control ice cream was prepared without these functional ingredients. The control and synbiotic ice cream were compared based on physico- chemical, microbial and sensory qualities.

The mean pH, titratable acidity, total solids, fat, protein, weight per litre, whipping ability and meltdown time values are presented in Table. 3 and 4. The mean pH of control and synbiotic ice creams was 6.383 ± 0.035 and 6.416 ± 0.043 respectively for 0^{th} day of storage. The pH on 30^{th} day of storage was 6.35 ± 0.055 and 6.416 ± 0.056 respectively. There was no significant difference in pH between control and synbiotic ice cream. The mean titratable acidity of control and synbiotic ice cream was 0.137 ± 0.012 and 0.126 ± 0.018 per cent lactic acid on 0^{th} day and 0.156 ± 0.007 and 0.127 ± 0.005 per cent lactic acid on 30^{th} day of storage respectively. There was no significant difference in titratable acidity between control and synbiotic ice cream. The mean total solids for control and synbiotic ice creams were 40.689 ± 0.987 and 40.99 ± 2.32 per cent respectively on 0^{th} day of storage. The total solids on 30^{th} day of storage were 37.917 ± 1.434 and 37.9 ± 0.905 per cent respectively. Even though there was a decrease in total solids content during storage it was not statistically significant. Similar results were reported by Turgut and Cakamakci (2009). In their study, the total solids content of ice cream samples was not influenced by the presence of the probiotic strains and there was

no significant change in total solids content during storage. The mean fat content of control and synbiotic ice creams were 10.1 ± 0.57 and 10.1 ± 0.16 per cent respectively on 0th day of storage. The fat content on 30th day of storage were 10 ± 0.13 and 10.2 ± 0.25 per cent respectively. No significant difference in fat per cent was observed between control and synbiotic ice cream. The mean protein content of control and synbiotic ice creams were 3.94 ± 0.18 and 3.71 ± 0.36 per cent respectively on 0th day of storage. The protein content on 30th day of storage were 3.95 ± 0.203 and 3.73 ± 0.152 per cent respectively. Protein content showed no significant difference between control and synbiotic ice cream. Turgut and Cakamakci (2009) also observed that fat and protein content in ice cream samples were not affected by the presence of probiotic strains. The mean values of weight per litre of control and synbiotic ice creams were 727.66 ± 18.76 and 707.39 ± 15.63 g/l respectively. There was no significant difference in weight per litre between control and synbiotic ice creams ($p>0.05$). The mean values of whipping ability of control and synbiotic ice creams were 31.43 ± 0.98 and 37.65 ± 0.63 per cent respectively. The whipping ability of synbiotic ice cream was significantly higher ($p<0.05$) than that of control ice cream. Akalin and Erisir (2008) had also reported higher overrun in synbiotic ice cream than control. This may be due to the ability of inulin to incorporate air. The mean meltdown time for control and synbiotic ice cream was 50.83 ± 2.89 and 54.83 ± 3.02 minutes respectively on 0th day of storage. The meltdown time on 30th day of storage was 53.17 ± 1.9 and 50.5 ± 3.71 minutes respectively. No significant difference in meltdown time was observed between control and synbiotic ice cream. Silva et al. (2015) had also reported no significant difference in the melting behavior of the probiotic goat milk ice cream when compared to control. However, several earlier researchers have reported increase in meltdown time in synbiotic ice cream. Akin (2005) reported that addition of inulin caused an improvement in meltdown characteristics in synbiotic ice cream.

Table 1 Sensory attributes of synbiotic ice cream incorporated with different levels of inulin

Sensory scores	Control ice cream	Synbiotic ice cream incorporated with inulin		
		T1(2% inulin)	T2(2.5% inulin)	T3 (3% inulin)
Flavour system	9 ± 0.25[a]	9.17 ± 0.3[a]	9 ± 0.36[a]	6.5 ± 0.42[b]
Body and texture	4.17 ± 0.16[a]	4.5 ± 0.22[a]	4.33 ± 0.21[a]	4.5 ± 0.22[a]
Color and appearance	4.83 ± 0.16[a]	4.67 ± 0.21[a]	4.83 ± 0.16[a]	4.5 ± 0.22[a]
Total scores	17.83 ± 0.3[a]	18.33 ± 0.21[a]	18.17 ±0.3[a]	15.5 ±0.71[b]

Means bearing different superscripts within the same row differ significantly ($p<0.01$)

Table 2. Formulation of different ice cream mixes (2 litre)

Ingredients	Control	Synbiotic ice cream
Milk(ml)	1277	1351
Cream (g)	349	287
SMP (g)	74	22
Sugar (g)	290	290
Stabilizer (g)	8	8
Inulin (g)	-	40

Table 3 Physico-chemical properties of synbiotic ice cream

Type of ice cream	Storage days	pH	Titratable acidity(%)	Total solids (%)	Fat(%)	Protein (%)	Meltdown time (minutes)
Control	0	6.383 ± 0.035	0.137 ± 0.012	40.689 ± 0.987	10.1 ± 0.57	3.94 ± 0.180	50.83 ± 2.89
	15	6.383 ± 0.057	0.146 ± 0.008	37.976 ± 1.523	10.1 ± 0.45	3.94 ± 0.197	54.50 ± 3.99
	30	6.350 ± 0.055	0.156 ± 0.007	37.917 ± 1.115	10.0 ± 0.13	3.95 ± 0.203	53.17 ± 1.90
Synbiotic ice cream	0	6.416 ± 0.043	0.126 ± 0.018	40.990 ± 2.32	10.1 ± 0.16	3.71 ± 0.360	54.83 ± 3.02
	15	6.406 ± 0.082	0.132 ± 0.010	38.782 ± 0.620	10.2 ± 0.16	3.71 ± 0.159	51.33 ± 3.72
	30	6.416 ± 0.056	0.127 ± 0.005	37.900 ± 0.905	10.2 ± 0.25	3.73 ± 0.152	50.50 ± 3.71

Table 4 Physical properties of synbiotic ice cream

Type of ice cream	Weight per litre(g/l)	Whipping ability (%)
Control	727.66 ± 18.76	31.43 ± 0.98[b]
Synbiotic ice cream	707.39 ± 15.63	37.65 ± 0.63[a]

Table 5 Microbial quality of synbiotic ice cream

Type of ice cream	Probiotic count (Log cfu/g)		
	0th day	15th day	30th day
Synbiotic ice cream	8.917 ± 0.151	9.146 ± 0.233	8.431 ± 0.365

No significant difference ($p>0.05$)
Means are averages of six replications

Table 6 Coliform count (log cfu/g) of synbiotic ice cream during storage

Type of ice cream	Coliform count (Log cfu/g)		
	0th day	15th day	30th day
Control	1.330±0.470	1.558±0.611	1.418±0.516
Synbiotic ice cream	1.143±0.393	1.460±0.541	1.446±0.552

No significant difference between control and treatment ($p>0.05$)
Means are averages of six replications

Table 7. Sensory evaluation of synbiotic ice cream

Type of ice cream	Storage days	Flavour (1-10)	Body & texture (1-5)	Colour& appearance (1-5)	Total (1-20)
Control	0	9.07 ± 0.2	4 ± 0.13	4.67 ± 0.12	17.73 ± 0.3
	15	8.73 ± 0.2	4.07 ± 0.2	4.53 ± 0.13	17.73 ± 0.3
	30	8.87 ± 0.23	3.93 ± 0.15	4.47 ± 0.13	17.27 ± 0.41
Synbiotic ice cream	0	9.13 ± 0.19	4.33 ± 0.15	4.67 ± 0.12	18.13 ± 0.33
	15	9.2 ± 0.1	4.27 ± 0.15	4.53 ± 0.13	18 ± 0.21
	30	9.07 ± 0.26	4.53 ± 0.13	4.6 ± 0.13	18.2 ± 0.44

The mean probiotic count is presented in Table. 5. The mean values of probiotic count in synbiotic ice cream during 0th, 15th and 30th day of storage were 8.917 ± 0.151, 9.146 ± 0.233 and 8.431 ± 0.365 log cfu/g respectively. No significant difference was observed in probiotic count during the entire storage period of 30 days. The viability of probiotic organism was maintained above the therapeutic minimum throughout the storage period. This could be attributed to the ability of inulin to improve the survivability of probiotic organism. Pandiyan et al. (2012) also found that incorporation of inulin enhanced the growth of *Lactobacillus acidophilus* and it could maintain at a therapeutic minimum of 10^6cells/g for a storage period of 15 days at -18 to -23°C in ice cream.

The mean coliform count of control and synbiotic ice creams were1.33±0.47 and 1.143±0.393 log cfu/g respectively on 0th day of storage. The corresponding values on 15th day of storage were 1.558±0.611 and 1.46±0.541 log cfu/g respectively. The values on 30th day of storage were 1.418±0.516 and 1.446±0.552 log cfu/g respectively. There was no significant difference in coliform count between control and synbiotic ice cream. There was also no change in coliform count during storage. Modzelewska-Kapitula *et al.* (2007) studied the influence of inulin and probiotic *Lactobacillus plantarum* on the microbial quality of soft cheese. Numbers of coli forms were less than 10 cfu/g for the entire storage period. In the present study also coliform count could be maintained within the prescribed limit until the entire storage period of 30 days.

The mean sensory scores are presented in Table. 6. There was no significant difference in flavour, body and texture, colour and appearance and total scores between control and synbiotic ice cream. There was also no significant change in sensory scores during storage. According to Silva et al. (2015) the probiotic goat milk ice cream was highly accepted, and the viability of *B. animalis* was maintained during the storage period of 120 days at "18°C. According to Mituniewicz–Małek, Zielinska and Ziarno (2019), the fermented goat milk produced with *L. plantarum* presented the highest acceptability mainly because of the highest intensity in smell, milky fermentative taste, and smoothness. Similar findings were also reported by Akin et al. (2007). They had reported no adverse effect on the sensory properties of probiotic ice cream incorporated with inulin at 1 or 2 per cent concentrations.

Conclusions

Synbiotic ice cream was successfully developed from goat milk by using inulin as a prebiotic and *Lactobacillus plantarum* UBLP-40 as a probiotic. This ice cream showed higher whipping ability than control and good sensory acceptability. There was no significant difference in pH, titratable acidity, total solids, fat,

protein, meltdown time and weight per litre. The probiotic count could be maintained above the minimum recommended level until 30 days of storage.

Acknowledgements

The authors acknowledge Kerala Veterinary and Animal Sciences University for providing financial support and infrastructure facilities required for the conduct of research work.

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