Iranian Food Science and Technology Research Journal
Vol. 15, No.6, Feb. Mrch. 2020, p. 103-112

نشریه پژوهشهای علوم و صنایع غذایی ایران
جلد 15، شماره 6، بهمن - اسفند 1398، ص. 112-103

Study on rheological, physicochemical and sensory properties of synbiotic ice cream using fibers from some fruit peels and *Lactobacillus casei* LC-01

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Received: 2018.05.14
Accepted: 2019.05.12

Abstract

A nutraceutical food may provide expanded utility beyond its nutritional benefit. These benefits are commonly attributed to the active components of the food. Fruit by-products are rich source of dietary fibers that have beneficial effects on human health. Also they can improve the growth and viability of probiotics in food matrix and therefore suitable to produce synbiotic food products. In this study, the effect of adding fiber obtained from apple, banana and mango peels at levels of 0.5, 1 and 1.5% on physicochemical and sensory features and the viability of *Lactobacillus casei* LC-01 in ice cream during 60 days storage at -18°C was investigated. Based on the results, all ice cream mixes were pseudoplastic fluids. The values of flow behavior index decreased and consistency coefficients increased by increasing the level of all mentioned fibers. The pH and specific gravity of samples containing banana and mango fibers were lower than control and sample with apple fiber. Using fibers had no significant effects on overrun values, whereas viscosity and melting resistance of ice cream samples increased with increasing fiber amounts. The most reduction in *Lactobacillus casei* LC-01 count after freezing and during storage period was associated to control sample and adding all types of examined fibers improved probiotic viability. Minimum cell reduction after freezing and during storage period occurred in sample containing 1.5% mango fiber with 0.03 and 0.48 log cycle respectively. Sensory properties of samples containing apple fiber were good and comparable with control sample.

Key Words: Fiber, Ice cream, Probiotic, Synbiotic

Introduction

The benefits promoted by probiotic bacteria are increasingly explored in various types of foods. However, cell viability in these products is often low and the ability to survive and multiply in the digestive tract strongly influences the benefits that probiotics can produce.

Fruit by-products are rich source of dietary fibers that have beneficial effects on human health. It was demonstrated that some fibers of fruit by-products show functional properties such as water-holding, swelling, gel forming, bile acid binding, and cation-exchange capacities (Lamsal and Faubion, 2009). Among the promising fruit by-products are the peels of apple, banana and passion fruit, mainly because of their content of insoluble and soluble dietary fibers (DF), pectin and fructooligosaccharides. These prebiotics are in fact able to selectively stimulate the growth and activity of the gut microbiota, particularly *lactobacilli* and *bifidobacteria* (Davis and Milner, 2009).

Dietary fiber as by-product from apple, banana or passion fruit processing was shown to increase the viability of *Lactobacillus acidophilus* L10 and *Bifidobacterium animalis* subsp. *lactis*B104, HN019 and B94 and short chain and poly unsaturated fatty acid contents of yoghurt (Do Espírito Santo *et al*., 2012). Citrus fiber presence in fermented milk also enhanced bacterial growth and survival of the tested probiotic *Lactobacillus acidophilus* CECT 903, *Lactobacillus casei* CECT 475 and *Bifidobacterium bifidum* CECT 870(Sendra et al., 2008). Also the addition of açai pulp increased *L. acidophilus* L10, *B. animalis* ssp. *lactis* Bl04 and *B. longum* Bl05 counts at the end of 28 days of cold storage in probiotic yoghurt (Do Espírito Santo et al., 2010).

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DOI: 10.22067/ifstrj.v16i1.72734

Vieira et al. (2017) evaluated the impact of fruit (acerola, orange, passion fruit, and mango) and soybean by-products and amaranth flour on the growth of probiotic and starter microorganisms and also the extent of folate production in MRS media. Orange and passion-fruit by-products were the substrates that most promoted the growth of bacterial population. Also the combination of orange by-product and amaranth flour was the best substrate for production of folate by all tested microorganisms (Albuquerque *et al*., 2016).

Pineapple peel powder was reported to be an effective prebiotic in probiotic yoghurt with improved survival of *Lactobacillus acidophilus*, *Lactobacillus casei* and *Lactobacillus paracasei* spp. *Paracasei* and acceptable physicochemical properties (Sah *et al*., 2016).

The prebiotic potential of soy milk and yacon flour on *Lactobacillus acidophilus* La-5 was shown in apple and strawberry ice cream respectively (Matias *et al*., 2016;Parussolo *et al*., 2017).

However negative effect of mango and guava pulp on *Lactobacillus acidophilus* La-5 and *Bifidobacterium animalis* Bb-12Viability in soy yoghurt and simulated gastrointestinal stress was reported by Bedani et al. (2014).

The objective of this study was to investigate the influence of addition of apple, banana and mango peel powder on the viability of *Lactobacillus casei* LC-01 in probiotic ice cream during 60 days storage at -18˚C. The effect of fiber addition on rheological, physicochemical and sensory properties of ice cream was also conducted.

Materials and Methods

Milk containing 2.5% fat and 8% solid nonfat (Pegah Milk Industry, Mashhad, Iran), cream containing 30% fat (Pegah Milk Industry, Mashhad, Iran), low fat milk powder of 1% fat and 96% total milk solids (Golshad Co, Iran), commercial stabilizer emulsifier blend (Panisol ex, Danisco,Denmark), sugar powder and vanilla were obtained from reputable scientific suppliers.

Apple, banana and mango peels were collected and stored at -25˚C until used. The peels were cut, washed with hot water (90˚C for 5min) and dried at 60˚C until constant weight. Dried peels were milled and sieved to less than 40 µm particles (Larrauri *et al*., 1997).

Activation of probiotic bacteria

Lactobacillus casei LC-01 was activated in MRS broth medium at 37˚C for 24 hours under anaerobic condition. The cells were then collected at 4600g for 5min (Homayouni *et al*., 2008).

Ice cream preparation

Product formulation comprised of 12% SNF, 10% fat, 15% sucrose, 0.4% stabilizer emulsifier blend as well as 0.1% vanillin; total solids being 37.5%. The batch size totaled 500 grams. Apple, banana and mango peel powders were used at 0.5, 1 and 1.5% w/w. Ice cream mixes were prepared according to Marshall and Arbuckle (1999) and the samples were aged at 4˚C for 12 hours. Cell suspension prepared previously was added to the mixes after aging then some of the mixes were collected for rheological and physicochemical analysis and also enumeration of *Lactobacillus casei* LC-01before freezing. The remained mixes were frozen in batch type ice cream maker at -18˚C for 20min followed by packing in 50g containers and storing at -18˚C for completing hardening process.

Rheological measurements

Flow behavior of ice cream mixes was evaluated using rotational viscometer (Brookfield model viscometer DV III ULTRA) equipped with a circulator. Product temperature was controlled at 5±0.5°C by a refrigerated/ heating circulator. Range of shear rate was 0.22-55 s^{-1} and apparent viscosity was expressed in Pa.s at a shear rate of $52.1s^{-1}$ (Morris, 1983).

Physicochemical analysis

pH of ice cream mixes was determined with Metrohm pH meter (Switzerland). The specific gravity of ice cream mix was determined at

25ºC using a pichnometer according to the method of Muhsenin (1978).

The overrun of ice cream samples was estimated using the formula of Marshal and Arbuckle (1996).

Ice cream melting rate was determined according to Sakurai *et al*. (1996). The ice cream (30 g), at -18ºC was placed on a Buchner funnel at ambient temperature (25°C). The weight of the melted material was recorded after 15 minutes and expressed as percentage weight melted.

Enumeration of *Lactobacillus casei* LC-01

Bacterial enumerations were carried out before and after freezing and at days 7, 15, 30 and 60 in triplicate of each batch. MRS-agar medium was used under anaerobic condition at 37˚C for 72 hours. Samples (1 ml) were diluted with 0.1% sterile peptonated water (9 mL). Afterwards, serial dilutions were carried out, and bacteria were counted, applying the pour plate technique. Cell concentration was expressed as CFU g^{-1} of ice cream.

Sensory evaluation

The sensory evaluation of probiotic ice cream was carried out by 18 trained panelists. Ice cream 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, flavor/ taste, body/texture, as well as overall acceptability as prescribed by Herald *et al.* (2008).

Statistical Analysis

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≤0.05) were determined through the Duncan's Multiple Range Test. Excel software was employed for plotting the curves.

Results and Discussion

Flow behavior of ice cream Mixes

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 in 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 decreases (Rha, 1975; Glichsman, 1982).

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

$$\tau = k\gamma^n \qquad (1)$$

Where, τ 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 less than 1 obtained for all samples indicating the shear thinning behavior.

As it can be seen from Table1, using fibers and increasing their amounts decreased flow behavior indices but it is more significant for mango fiber. The minimum n value (0.31) was associated to the sample containing 1.5% of mango fiber.

According to Chinnan *et al.* (1985) psudoplasticity increased by decreasing n. Also Marcotte *et al.* (2001) mentioned that the changes in flow behavior index is related to molecular size. Similarly, Soukoulis *et al.* (2009) showed that the use of dietary fibers in ice cream mix formulation significantly increased viscosity and shear thinning behavior.

Table 1. Flow behavior indices (n), consistency coefficients (k) and correlation coefficients (r^2) of power law model for ice cream mixes containing different fibers

	control	apple			banana			mango		
		0.5%	1%	1.5%	0.5%	1%	1.5%	0.5%	1%	1.5%
n	0.51±0.02a*	0.52±0.023a	0.45±0.019ab	0.41±0.017b	0.51±0.02a	0.45±0.019ab	0.39±0.016b	0.41±0.017b	0.42±0.018b	0.31±0.013c
k ($pa.s^n$)	4.96±0.09e	6.4±0.13d	14.39±0.27dc	17.82±0.3c	8.45±0.17de	18.89±0.33c	31.37±1.65ab	21.43±0.95bc	26.9±1.135b	44.12±2.03a
r^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99

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

Also, it was reported that by incorporating sugar beet fiber at levels of 0.7 to 2% , flow behavior index of ice cream and frozen yoghurt decreased compared to control (Mahdian *et al*., 2014). The minimum consistency coefficient was obtained for control sample and k value was higher in samples containing more amounts of all examined fibers. Maximum k value (44.12 $pa.s^n$) was associated to 1.5% mango fiber ice cream.

Consistency coefficient being an important parameter for estimating viscous nature of food products(Sopade and Kassum, 1992) and 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 ice cream mixes in this study, in comparison with the previously reported values, may be attributed to the incorporation of fibers and the effect of carbohydrates on water absorption and viscosity of the samples. Similarly, consistency coefficients of ice cream and frozen yoghurt mixes containing sugar beet fiber were reported to be more than the mixes without any fiber added (Mahdian *et al*., 2014).

Physico-chemical Properties

The physico-chemical properties of ice cream mixes and of the finished ice cream are presented in Table 2.

Table 2. Physico-chemical properties of ice cream mixes and of the finished ice cream containing different fibers

	control	apple			banana			mango		
		0.5%	1%	1.5%	0.5%	1%	1.5%	0.5%	1%	1.5%
pH	6.48±0.18bc*	6.54±0.19ab	6.55±0.19ab	6.6±0.2a	6.56±0.18ab	6.55±0.17ab	6.52±0.21b	6.55±0.18ab	6.41±0.15c	6.31±0.15d
Specific gravity	1.11±0.05a	1.11±0.04a	1.11±0.05a	1.11±0.03a	1.10±0.02d	1.10±0.06d	1.11±0.06b	1.10±0.05e	1.10±0.04d	1.10±0.05c
Viscosity (pa.s)	0.66±0.009c	0.93±0.01c	1.58±0.04bc	1.78±0.05b	1.19±0.04c	2.12±0.06b	3.76±0.08a	2.11±0.07b	2.74±0.08b	4.25±0.09a
Overrun (%)	35.33±1.58b	73.85±2.51a	48.95±1.88b	48.45±1.92b	42.99±2.08b	45.83±1.73b	38.42±2.04b	52.63±2.53ab	46.18±1.93b	35.53±1.57b
Melting resistance (%)	87.5±5.54c	89.2±5.21bc	93±6.14a	93.5±6.64a	88±5.91c	92.7±6.24ab	93±6.71a	89±5.54bc	93±7.06a	94.2±6.53a

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

No significant differences were observed between pH of control and apple and banana fiber samples (p>0.05).Increasing mango fiber from 0.5%, decreased ice cream pH significantly and the minimum pH was associated to sample containing 1.5% mango fiber. Similarly Mahdian et al reported a decrease in pH of frozen yoghurt containing sugar beet fiber in comparison with control ice cream without fiber (Mahdian *et al*., 2014).

Specific Gravity (SG) of ice cream mixes were not affected by adding apple fiber but using banana and mango fiber decreased SG significantly ($p<0.05$). The specific gravity of ice cream mix as reported by the authors ranged from 1.05 to 1.12 (Marshal and Arbuckle, 1996).

Using fruit fibers and increasing their amounts increased ice cream mix viscosity in comparison with control. In this way, more viscosity values were obtained for mixes containing banana and mango fiber with maximum viscosity (4.25 pa.s) obtained for the mix with 1.5% mango fiber. The increased viscosity of the fiber-enriched ice cream mixes seems to be caused both by the contribution of the soluble matter to the composition of the aqueous phase and by the contribution of insoluble fibers to the increase of total solids, affecting the three dimensional conformation of the hydrated biopolymers (Soukoulis*et al*., 2009). According to Aime *et al*. (2001) consistency coefficients were positively correlated with the apparent viscosity values (r^2= 0.910) so the greater viscosity values obtained for samples containing banana and mango fiber may be the result of higher consistency coefficients for these samples.

Overrun values for ice cream samples containing all fibers were a bit more than control but their differences were not significant ($p>0.05$). In this case, maximum overrun value (73.85%) was associated to 0.5% apple fiber ice cream. 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 decrease overrun (Arbuckle, 1986).

Adding fibers more than 1% in probiotic ice cream formulation increased melting resistance significantly ($p<0.05$). The minimum (87.5%) and maximum (94.2%) melting resistance were associated to control and ice cream containing 1.5% mango fiber respectively. 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. Similar results were reported about using sugar beet fiber in ice cream and frozen yoghurt where increasing mix viscosity and melting resistance took place with increasing fiber amounts(Mahdian *et al.*, 2014).

Lactobacillus casei LC-01 viable counts

The viable counts of *Lactobacillus casei* LC-01 during 60 days storage at -18˚C in ice cream samples containing apple, banana and mango fibers are presented in Tables 3, 4 and 5 respectively.

Table 3. *Lactobacillus casei* LC-01 viable counts before and after freezing and during storage time in ice cream samples containing apple fiber

sample	Storage time (day) 0	1	7	15	30	60
Control	6.25±0.14b*	5.48±0.12c	5.25±0.13c	5.18±0.12c	5.15±0.15c	5.11±0.19c
0.5%	6.65±0.12b	6.43±0.12b	6.18±0.21b	5.75±0.11bc	5.56±0.13c	5.25±0.18c
1%	6.04±0.1b	5.65±0.1b	5.61±0.18b	5.45±0.17c	5.39±0.1c	5.57±0.13c
1.5%	7.56±0.16a	7.41±0.15a	7.48±0.15a	6.53±0.14a	6.95±0.18a	6.71±0.15ab

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

As it can be seen from the data presented in tables, using all examined fibers in probiotic ice cream and increasing their amounts resulted in protection of *Lactobacillus casei* LC-01 against freezing process and also during storage.

Lactobacillus casei LC-01 cell reduction after freezing, was significant just in control sample ($p<0.05$). Considering the minimum viable probiotic counts needed for creating health benefits (10^6 cfu/g), all samples with 1.5% apple and mango fiber had this standard at the end of storage period. Freezing of ice cream mixes containing 0, 0.5, 1 and 1.5% apple fiber has leaded to reduction of 0.78, 0.22, 0.39 and 0.14 log cycle in *Lactobacillus casei* LC-01 counts respectively. Cell reduction after 60 days of storage in those samples was 1.14, 1.4, 0.48 and 0.85 log cycle respectively. Cell reduction in ice cream samples containing 0, 0.5,1 and 1.5% banana fiber was 0.78, 0.21. 0.46 and 0.41 log cycle after freezing and 1.14, 1,16, 0.63, 1.4 log cycle after storage time respectively

Table 4. *Lactobacillus casei* LC-01 viable counts before and after freezing and during storage time in ice cream samples containing banana fiber

	Storage time (day)					
sample	**0**	**1**	**7**	**15**	**30**	**60**
Control	6.25±0.14b*	5.48±0.13c	5.25±0.12c	5.18±0.15c	5.15±0.18c	5.11±0.12c
0.5%	7.46±0.15a	7.25±0.15a	7.28±0.14a	7.2±0.14a	7.36±0.14a	6.3±0.15b
1%	6.95±0.16a	6.49±0.22b	6.51±0.11b	6.33±0.09b	6.21±0.17b	6.33±0.18b
1.5%	6.93±0.11a	6.52±0.23b	6.9±0.21a	6.96±0.12a	6.69±0.11b	5.53±0.13b

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

In the case of probiotic ice cream samples with mango fiber, cell reduction rate was less than samples with apple and banana fibers and also control sample. 0.78, 0.19, 0.05 and 0.03 log cycle reduction was obtained after freezing and 1.14, 0.65, 0.67 and 0.48 log cycle after storage time for samples containing 0, 0.5,1 and 1.5% mango fiber respectively.

Table 5. *Lactobacillus casei* LC-01 viable counts before and after freezing and during storage time in ice cream samples containing mango fiber

Storage time (day)						
sample	**0**	**1**	**7**	**15**	**30**	**60**
Control	6.25±0.14b*	5.48±0.12c	5.25±0.16c	5.18±0.15c	5.15±0.14c	5.11±0.13c
0.5%	6.62±0.25b	6.43±0.15b	6.28±0.16bc	6.38±0.16b	6.3±0.12b	5.97±0.11bc
1%	6.57±0.18b	6.52±0.11b	6.29±0.13b	6±0.14b	5.95±0.16bc	5.9±0.15b
1.5%	7.59±0.19a	7.56±0.1a	7.34±0.19a	7.31±0.12a	7.24±0.18a	7.11±0.19b

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

As it can be seen from the data of Tables 3, 4 and 5, *Lactobacillus casei* LC-01cell reduction after freezing and during 60 days storage at -18˚C was more in control probiotic ice cream with no fiber added and apple, banana and mango peel powder could act as prebiotics which can improve *Lactobacillus casei* LC-01viability in ice cream. In this case mango peel powder had more effect on protection of probiotic cells and minimum cell reduction (0.48 log cycle) was associated to the sample containing 1.5% mango fiber.

Dietary fibers obtained from apple, banana and passion fruit byproducts were tested as prebiotic on the viability of *Lactobacillus acidophilus* L10 and three strains of *Bifidobacterium animalis* subsp. *lactis* in probiotic yoghurt. Apple and banana fibers had more effect on protection of all probiotic bacteria than passion fruit fiber. Also *Lactobacillus acidophilus* showed lower survivability than *Bifidobacteria* at the end of storage period (Do Espírito Santo *et al*., 2012). Previously they had been reported that Açai pulp favored an increase in *Lactobacillus acidophilus* L10, *Bifidobacterium animalis* ssp. *lactis* Bl04 and *Bifidobacterium longum* Bl05 counts at the end of 4 weeks of cold storage (Do Espírito Santo *et al*., 2010).

The functionality of Yacon flour as a source of fructooligosaccharide on the viability of *Lactobacillus acidophilus* NCFM in probiotic ice cream was shown by Parussolo *et al.* (2017). According to Vieira *et al.* (2017), Orange and passion-fruit by-products were the substrates that most promoted the growth of *Lactobacillus* and *Bifidobacteria*. However, negative effect of mango and guava pulp on *Lactobacillus acidophilus* La-5 and *Bifidobacterium animalis* Bb-12 Viability in soy yoghurt and simulated gastrointestinal stress was reported by Bedani *et al.* (2014). In the previous work, we concluded that sugar beet fiber can improve the growth and viability of *Lactobacillus acidophilus* La-5 and *Bifidobacterium bifidum* Bb-12 in probiotic frozen yoghurt and ice cream during storage period (Mahdian *et al.*, 2014).

Sensory properties

Sensory attributes of probiotic ice cream containing varying levels of apple, banana and mango peel powder are presented in Table 6. No significant differences were observed between flavor and texture scores of all samples and all fiber contained ice cream had flavor and texture acceptability comparable with control (p>0.05). The color of probiotic ice cream containing1.5% mango fiber was a bit dark and has the minimum score (4.9). All other samples gained color score comparable with control. Overall acceptability of control ice cream was higher than experimental samples but the difference was not significant with 0.5 and 1% apple fiber and 1.5% banana fiber ice cream (p>0.05).

Table 6. Sensory attributes of probiotic ice cream containing varying levels of apple, banana and mango peel powder

	control	apple			banana			mango		
		0.5%	1%	1.5%	0.5%	1%	1.5%	0.5%	1%	1.5%
Flavor	6.9±1.15ab*	7.1±1.15a	6.1±0.71ab	4.5±0.88ab	5.1±1.2ab	5.2±0.56ab	5.8±1.23ab	4.4±0.35ab	5.2±1.33ab	4.2±0.55b
Texture	7±1.2a	6.4±1.26a	6.2±1.22a	6±1.19ab	6.4±1.35a	5.4±1.23ab	6±1.15ab	5.3±0.54ab	5.2±1.2ab	3.8±0.42b
Color	8±1.18a	7.2±1.45ab	6.7±1.28abc	6.2±1.51abc	6.1±1.43abc	5.9±1.19abc	5.8±1.19bc	6.2±1.25abc	6±1.43abc	4.9±0.61c
Overall acceptance	7.7±1.31a	7±1.37ab	6.3±1.41ab	5.4±0.79bc	5.3±1.21bc	5.3±0.73bc	6.1±1.23abc	5.1±0.7bc	5.1±0.6bc	4.1±0.72c

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

It is reported that using 0.7 and 1% sugar beet fiber in probiotic ice cream formulation had no negative effect on flavor acceptability while decreased color score significantly (Mahdian *et al.*, 2014). Also probiotic yoghurt containing 1.3% citrus fiber with good acceptability was produced by Dello Staffolo *et al.* (2004). Dervisoglu and Yazici (2006) reported that using 0.8% citrus fiber had no significant effect on flavor, texture and overall acceptance of ice cream but flavor score decreased when more amounts used. Similar results have been reported on fermented milks by Sendra *et al.* (2008). Regarding the consumer intent to purchase, 74% of the panelists would buy the ice cream with the fiber from orange by-products as fat replacer (Crizel *et al*., 2013).

Conclusion

Probiotic ice cream containing apple, banana and mango peel powder was non Newtonian time independent fluid with flow behavior indices less than 1. Flow behavior indices decreased and consistency coefficients increased with increasing fiber amounts from 0 to 1.5%. pH and specific gravity of samples containing banana and mango fibers were lower than control and sample with apple fiber added. Using fibers had no significant effects on overrun values where viscosity and melting resistance of ice cream samples increased with increasing fiber amounts. Based on obtained results, apple, banana and mango peel powder would act as prebiotics which can improve growth and viability of *Lactobacillus casei* LC-01 in ice cream during freezing and freeze storage. In that case the most promising prebiotics was mango fiber at level of 1.5%. Sensory properties of samples containing apple fiber were good and comparable with control sample.

Acknowledgments

The authors would like to thank Islamic Azad University, Quchan branch for financial support of this research project

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Iranian Food Science and Technology Research Journal
Vol. 15, No.6, Feb. Mrch. 2020, p. 103-112

نشریه پژوهشهای علوم و صنایع غذایی ایران
جلد 15، شماره 6، بهمن - اسفند 1398، ص. 112-103

بررسی ویژگی‌های رئولوژیکی، فیزیکوشیمیایی و حسی بستنی سین‌بیوتیک با کاربرد فیبر حاصل از پوست میوه‌جات و باکتری *لاکتوباسیلوس کازئی* LC-01

الهام مهدیان[1]*- رضا کاراژیان[2]

تاریخ دریافت: 1397/02/25
تاریخ پذیرش: 1398/02/22

چکیده

یک غذا دارو می‌تواند اثرات سودمند بیشتری علاوه بر مزایای تغذیه‌ای ایجاد نماید. این اثرات عموما به اجزاء فعال موجود در این غذاها مربوط می‌شود. ضایعات میوه‌جات منبع غنی از فیبرهای رژیمی می‌باشند که اثرات مثبتی بر سلامتی انسان دارند. این فیبرها همچنین می‌توانند رشد و فعالیت باکتری‌های پروبیوتیک را در ماتریکس غذایی بهبود داده و بنابراین برای تولید محصولات غذایی سین‌بیوتیک مورد استفاده قرار گیرند.در این تحقیق اثر افزودن فیبر حاصل از پوست موز، سیب و انبه بر خصوصیات فیزیکوشیمیایی و حسی و همچنین قابلیت زنده‌مانی باکتری *لاکتوباسیلوس کازئی* LC-01 در بستنی در مدت 60 روز نگهداری در دمای 18- درجه سانتی‌گراد بررسی و با نمونه شاهد فاقد فیبر مورد مقایسه قرار گرفت. بر اساس نتایج به‌دست آمده مخلوط همه نمونه‌ها رفتار رقیق‌شونده با برش نشان دادند. با افزایش مقدار هر سه فیبر اندیس رفتار جریان کاهش و ضریب قوام افزایش پیدا کرد. مقادیر pH و وزن مخصوص نمونه‌های حاوی فیبر موز و انبه پایین‌تر از نمونه شاهد و نمونه‌های حاوی فیبر سیب بودند. استفاده از فیبرها اثر مشخصی بر ضریب افزایش حجم نمونه‌های بستنی نداشته اما مقادیر ویسکوزیته و مقاومت به ذوب با افزایش مقدار فیبرها افزایش یافت. بیشترین کاهش جمعیت لاکتوباسیلوس کازئی LC-01 بعد از انجماد و طی دوره نگهداری مربوط به نمونه شاهد بوده و افزودن فیبر قابلیت زنده‌مانی این باکتری را بهبود بخشید. کمترین کاهش جمعیت سلولی بعد از انجماد و ذخیره‌سازی مربوط به نمونه حاوی 1/5 درصد فیبر انبه و به‌ترتیب برابر با 0/03 و 0/48 سیکل لگاریتمی بود. خصوصیات حسی نمونه‌های حاوی فیبر سیب خوب و با نمونه شاهد قابل رقابت بود.

واژه‌های کلیدی: فیبر، بستنی، پروبیوتیک، سینبیوتیک.

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