

Probiotic Ice Cream Manufactured with Weight Loss Ingredient

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Abstract

Obesity is directly related to many deaths per year in the United States. The Surgeon General estimated obesity to cost \$ billions a year. An ingredient, namely “Super Citrimax”, is marketed as a weight loss ingredient (WLI). *Lactobacillus acidophilus* is an extensively studied probiotic (good, helpful) bacterium. The objective was to determine the effect of various amounts of the WLI on the physico-chemical, microbiological and sensory characteristics of probiotic ice cream. The WLI “Super Citrimax” was incorporated at the rate of 0, 1.5, 3.0 and 4.5 g per 473 ml (pint) of ice cream. *L. acidophilus* was incorporated into all the pasteurized, homogenized and cooled ice cream mixes at the rate of 0.7% w/v mix. Product manufacture was replicated three times. The meltdown time for the first 15 ml of the ice creams with 3.0 and 4.5 g WLI was significantly lower compared to the control. The meltdown volume of the control after one hour was significantly lower compared to the ice creams with WLI at all concentrations. There were no significant ($p \leq 0.05$) differences between the control and all treatments for standard plate counts. Control had significantly the highest lactobacilli counts followed by the ice creams with 1.5 g WLI. The ice creams with 3.0 and 4.5 g WLI had significantly the lowest lactobacilli counts. The flavor scores for the ice creams with 0, 1.5, and 3.0 g WLI were not different from each other but were higher than the ice cream with 4.5 g. Similar results were obtained for the flavor scores of the heat shocked ice creams. There were no differences in body and texture scores of any of the ice creams. The body and texture scores of the heat shocked ice creams with 0, 1.5, 3.0 g WLI were not significantly different from each other, but scores for the ice creams with 4.5 g were significantly lower than the ice creams with 0 and 1.5 g. Incorporation of WLI up to 3 g per 473 ml of ice cream did not influence its flavor. The use of WLI decreased meltdown time, increased meltdown volume, did not alter the standard plate counts, lowered the lactobacilli counts and did not influence sensory body and texture.

Keywords

Probiotic, Weight Loss, Dairy, Frozen

1. Introduction

According to the 2025 World Health Organization report, 1 in 8 people in the world were obese in 2022 [1]. Some of the obesity complications include heart disease, high blood pressure, elevated risk of cancer, high cholesterol levels, hypertension, and arthritis. With 63% of men and 55% of women being identified as overweight (body mass index greater than 25 kg/m²) or obese (body mass index greater than 30 kg/m²) in the United States, weight loss is a main concern for Americans who want to stay healthy.

Functional foods are “foods that contain some health-promoting component(s) beyond traditional nutrients” [2]. According to the 2024 Functional Foods Market Analysis Report, the global functional foods market size in 2023 was about USD 329.65 billion and is expected to grow to USD 586.06 billion by 2030 [3]. The idea of functional foods (e.g., probiotics) has moved towards the development of dietary additions that may affect gut microbial composition and activities [4].

A weight loss ingredient on the market is SuperCitrimax[®]. SuperCitrimax[®] has a Generally Recognized as Safe status [5] and contains calcium/potassium-hydroxycitric acid (HCA) extract from the dried fruit rind of *Garcinia cambogia* [6]. SuperCitrimax[®] encourages weight management by inhibiting body fat synthesis and curbing the appetite [7] without stimulating the nervous system (which causes jitteriness and increased blood pressure). SuperCitrimax[®] supplement also promotes fat oxidation, enhances serotonin release and its availability in the brain cortex, normalizes lipid profiles, and lowers serum leptin levels in subjects who are obese [8]. In an eight-week study, subjects were given 4667 mg of SuperCitrimax[®] (2800 mg of HCA) per day. Along with a 2000 Kcal diet and supervised exercise, the supplement aided in decreasing their Body Mass Index and body weight by 5% [9]. It is possible that the 3 g per pint of ice cream could meaningfully contribute to the effective daily dose for weight management.

Safety studies were conducted on animals (mice) that had been given varying doses of SuperCitrimax[®]. Researchers looked for “acute oral toxicity, acute dermal toxicity, primary dermal irritation and primary eye irritation.” The study’s results indicated that the LD₅₀ is greater than 5000 mg/kg when given once orally through gastric intubation to fasted male and female Albino rats [7].

In one study on human subjects, 20 overweight adults were given 500 mg of HCA (as CitriMax[®]) three times daily before meals and other participants were given equal amounts of a placebo. After eight weeks, the group taking the HCA showed a 215% greater weight loss than the group taking the placebo. This weight loss was not accompanied by any usual side effects associated with weight loss stimulants and a reduction in cholesterol and triglyceride levels was also ob-

served.

It can be observed through these studies that while taking HCA (in the form of CitriMax[®]), significant weight loss as well as other health advantages are seen in the subjects. InterHealth [5] reported that SuperCitrimax[®] has been used in several beverages such as SoBe Lean, ReeBok Fitness Water, Slim-Lite Diet Beverage and Skinny Water and that SuperCitrimax[®] is 100% soluble, tasteless, odorless, and colorless in solution., but the effect of SuperCitrimax[®] on ice cream characteristics such as meltdown, microbial growth are not known and would be interesting to investigate.

Probiotics are live microbial food additions and have the capability to be very beneficial to human health [10]. Probiotics have been shown to potentially affect and improve many functions of the human body, such as protein and fiber digestion [11]; improve lactose digestion [11]; and lower blood cholesterol [12]. Probiotics potentially aid in the resistance of certain pathogens by either direct destruction of the pathogen, competing with the pathogen for “room” and nutrients in the gastrointestinal tract, or stimulating the immune system to build up its own resistance mechanisms [11].

The minimum limit of beneficial bacteria in probiotic foods is 10^5 cfu/g [13] and microbial counts decreased in a seventeen-week period from 1.5×10^8 cfu/mL to 4×10^6 cfu/mL [13]. At the end of 17 weeks, the counts were over the minimum 10^5 cfu/g (mL), concluding that probiotic bacteria are able to survive in ice cream [13]. But the effect of probiotic bacteria on the quality characteristics of ice cream with a weight loss ingredient is not clear.

The objective of this experiment was to study the effects of various levels of the weight loss ingredient SuperCitrimax[®] on the physico-chemical, microbiological, and sensory characteristics of probiotic ice cream.

2. Materials and Methods

Ice Cream Manufacture. Ice cream mixes were prepared in 2 gallon batches with whole milk (Kleinpeter Dairies, Baton Rouge, LA), cream (38% fat) (Dairy Fresh, Baton Rouge, LA) instant low heat non fat dry milk (Hunter Walton and Co, Piscataway, NJ), SuperCitrimax[®] (InterHealth, Nutraceuticals Inc. Benicia, CA), sugar (local grocery store), and stabilizer CC-452 (Continental Custom Ingredients, Inc. West Chicago, IL). Dry ingredients were weighed according to **Table 1** and blended with milk at 60 C. Blended mixes were homogenized in a two stage homogenizer (first stage 1500 p.s.i. and second stage 500 p.s.i). All homogenized mixes were batch pasteurized at 70 C for 30 min and chilled to 7 C before transfer to cooler at 4 C for overnight aging. Just prior to freezing the mixes were inoculated with *Lactobacillus acidophilus* LA-5 (Chr. Hansen’s Laboratory, Milwaukee, WI) in the form of frozen culture concentrate at 50 g per 2 gallons of ice cream mix and the mixes were flavored with double fold vanilla extract (Virginia Dare, USA). All batches were frozen in a batch freezer till 60% - 80% overrun. Ice creams were portioned into 473 ml containers and hardened in a freezer at -30 C.

Table 1. Mean \pm SE of viscosity and pH values of the various ice creams.

	Viscosity (cps)	pH
Control	151.60 \pm 15.52 ^b	6.77 \pm 0.08 ^a
1.5	212.16 \pm 44.15 ^{a,b}	6.68 \pm 0.09 ^a
3.0	207.33 \pm 25.59 ^{a,b}	6.64 \pm 0.05 ^a
4.5	260.07 \pm 28.32 ^a	6.70 \pm 0.02 ^a

^{a,b}Same letters within the same column are not significantly different ($\alpha = 0.05$).

Experimental Design: The weight loss ingredient was incorporated into the ice cream mixes at 0, 1.5, 3.0 and 4.5 g of SuperCitrimax[®] per pint of ice cream. The control had no SuperCitrimax[®]. All ice cream mixes were inoculated at a constant rate of 50 g per 2 gallons mix with the probiotic bacterium *Lactobacillus acidophilus*. Color (L^* , a^* , b^*), viscosity and pH were determined on ice cream mixes. Meltdown time for first 15 ml, meltdown ml after 60 minutes, sensory flavor and body texture, heat shocked flavor and body texture were evaluated and plate counts, lactobacilli counts were enumerated at weeks 1, 4, 8, 12 after product manufacture. Three replications were conducted.

pH: The pH of the mixes was determined at 8 C using an Orion pH meter model 250 A/610 (Fisher Scientific, Instruments, Pittsburgh, PA) calibrated using commercial pH 4.00 and 7.00 buffers (Fisher Scientific).

Viscosity: The apparent viscosities of the mixes were determined at 22 C using a Brookfield DV II+ viscometer (Brookfield Engineering Lab Inc, Stoughton, MA) with a helipath stand. An RV #2 spindle was used at 50 rpm. The data was acquired using the Wingather software (Brookfield). A hundred data points were averaged per replication.

Color: The $L^*a^*b^*$ values of the mixes were determined at 8°C using a Hunter MiniScan[®] XE Plus, portable color spectrophotometer (Hunter Associates Laboratory Inc. Reston, VA, USA). The instrument was calibrated using the black and white standard tiles that came along with the instrument. The operating conditions were 10° observer, D65 illuminant and 45/0 sensor. An average of five values was taken per sample.

Sensory Characteristics: Sensory evaluations were conducted in 2005 by a four member experienced panel on the ice creams coded with three digit random number codes. The official ADSA Intercollegiate Dairy Products Evaluation Contest Score Card for flavor with a 1 - 10 point scale (10 = no criticism) and for texture with a 1 - 5 point scale (5 = no criticism) was used.

Heat Shock: Samples of each treatment were taken out of the hardening room and placed at room temperature for 30 minutes every day for 5 days during weeks 1, 4, 8 and 12 and then placed back into the hardening room. This procedure would simulate temperature fluctuations (slight melting and refreezing) during storage, transport, retail or consumer handling. Ice cream samples were freshly heat shocked at each time period (weeks 1, 4, 8 and 12). Heat shocked ice creams were evaluated for sensory flavor and body texture.

Meltdown: A 100 g scoop of ice cream was placed on a wire gauge (6 wires/cm²) at 22 C. Liquid drained from the gauge was collected in a graduated cylinder. Time for collection of the first 15 ml and ml collected in one hour were recorded.

Microbial Counts: Serial dilutions of the ice cream were prepared with buffered peptone water (Difco, Detroit, MI, USA). Standard plate counts were determined by plating serial dilutions of ice cream in plate count agar. Pour plates were incubated at 32 C for 24 h. Total lactobacilli counts were determined by plating serial dilutions of ice cream in MRS agar and incubating anaerobically at 40 C for 48 h.

Statistical Analysis: Data were analyzed by ANOVA using the Proc Mixed procedure of Statistical Analysis Systems. Means were separated using the LSD test. Significant differences were determined at $\alpha = 0.05$.

3. Results and Discussion

pH

The data for pH is reported in **Table 1**. The treatment effect for pH was not significant ($p = 0.5292$). There was an expected difference between the control and treatments because the weight loss ingredient was hydroxycitric acid. Acidulants are known to lower the pH and make the product more acidic. Average pH values obtained were between 6.77 and 6.63. Abd-EL-Salam *et al.* [14] manufactured ice cream with several stabilizers and recorded pH values between 6.5 to 6.88. They further reported that pH and acidity was influenced by type of stabilizer used. Hussein *et al.* [15] found that while pectin and sodium alginate had an effect on the pH of ice cream mix, agar-agar and gelatin had no effect. Lactic acid bacteria ferment lactose to give lactic acid. *L. acidophilus* is a lactic acid bacterium. Apparently, not much fermentation took place in the ice cream mix to lower the pH of the mix.

Viscosity

The table with viscosity figures is in **Table 1**. The treatment effect was not significant ($p = 0.1701$). Treatment 4.5 was significantly greater than the control, showing that acidulants can have a mild gelling effect, which can increase viscosity. Abd-El-Salam *et al.* [14] reported that with increased levels of stabilizer, the viscosity of the mix increased. Danków and Cais-Sokolińska [16] stated that hydrolysis of lactose increased the consistency of the ice cream.

Hussein *et al.* [15] found that pectin, sodium alginate agar-agar and gelatin increased viscosity of the ice cream mixes. They further reported that increased concentration of these stabilizers also increased viscosities of ice cream mixes.

*L**

The *L** values are presented in **Table 2**. The *L** values ranged from 93.3 to 94.65. Roland *et al.* [17] manufactured ice cream with fat replacers and reported *L* values between 90.3 and 95.3. They further reported that ice creams with fat replacers were whiter than the control 0.1% fat ice cream. The treatment effect was significant ($p = 0.0158$). The control had significantly higher *L** values than the treatments. Resch *et al.* [18] studied the effect of hydrochloric, lactic, citric and phos-

phoric acids on characteristics of beta-lactoglobulin gels and reported that use of citric acid resulted in opaque coagulum. The weight loss ingredient, hydroxycitric acid, resulted in ice creams which were darker than the control.

a*

The data for a^* color is found in **Table 2**. The a^* values ranged from 0.003 to -0.19 . Roland *et al.* [17] reported that ice creams with fat replacers had “a” values between -0.6 to 0.4 . The treatment effect was significant ($p = 0.0071$). The a^* values for the control were significantly lower compared to other treatments. Also, control, 1.5 and 3.0 were in the green color space, while 4.0 had a marginally inside the red color space.

b*

The data for b^* is shown in **Table 2**. The b^* values ranged from 12.52 to 12.90. Roland *et al.* [17] reported that the “b” values 0.1% fat ice creams manufactured with fat replacers ranged between 4.1 and 5.7. The treatment effect is not significant ($p = 0.2275$). The weight loss ingredient at all levels studied did not affect the yellowness-greenness values of ice creams.

Table 2. Mean \pm SE of L^* a^* b^* values for the various ice creams.

	L^*	a^*	b^*
Control	94.65 ± 0.08^a	-0.19 ± 0.30^b	12.77 ± 0.05^a
1.5	93.59 ± 0.47^b	-0.03 ± 0.05^a	12.90 ± 0.13^a
3.0	93.30 ± 0.15^b	-0.02 ± 0.02^a	12.66 ± 0.19^a
4.5	93.33 ± 0.03^b	0.003 ± 0.009^a	12.52 ± 0.05^a

^{a,b}Same letters within the same column are not significantly different ($\alpha = 0.05$).

Sensory Evaluation

Flavor

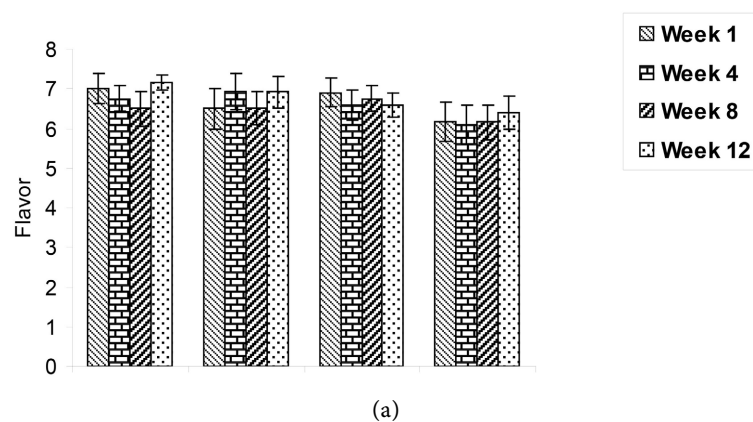
Flavor scores for the ice creams are presented in **Figure 1(a)**. The interaction between treatment*week was not significant ($p = 0.9841$). Both main effects, namely treatment ($p = 0.1272$) and week ($p = 0.7835$), were not significant. The weight loss ingredient can be added at the maximum studied amount without affecting the flavor of ice cream with the *Lactobacillus acidophilus*.

With the addition of the weight loss ingredient hydroxycitric acid (HCA) to the probiotic ice cream, it was expected that this acidulant would impart a sour taste as the amount of HCA increased [19]. However, the flavor scores of the control had no significant difference compared to the ice creams with the added weight loss ingredient. Ice cream ingredients such as nonfat dry milk, gums and emulsifiers are known to alter the flavor of the ice cream. Non-fat dry milk can be used in limited amounts in ice cream manufacture since it imparts off flavors to ice cream [20]. Dervisoglu *et al.* [21] substituted non-fat dry milk with soy protein concentrate (SPC) in the manufacture of strawberry ice cream and reported that flavor was adversely influenced by SPC. Minhas *et al.* [22] reported an improvement in the flavor of ice cream with use of 0.25% Karaya gum and no adverse

effect on flavor with the use of 0.25% ghatti gum. Baer *et al.* [23] studied the effect of the emulsifiers polysorbate 80, 40% α -monoglyceride, 70% α -monoglyceride and lecithin on characteristics of low fat ice creams and reported that ice creams that contained lecithin had the lowest flavor scores. Christiansen *et al.* [24] manufactured probiotic ice creams using *Bifidobacterium bifidum* and *Lactobacillus acidophilus* and reported that probiotic ice creams had a “mild sour, fresh and pleasant flavor”. Taha *et al.* [25] manufactured probiotic ice cream using *Bifidobacterium bifidum* Bb-12, *Lactobacillus acidophilus* LA-5 and *Lactobacillus casei* (1:1:1) and reported that probiotic ice creams had acceptable organoleptic properties. Hagen and Narvhus [26] manufactured probiotic ice cream and reported that incorporation of *Lactobacillus reuteri* in ice cream manufacture resulted in a probiotic/sour flavor. In frozen yogurt acidity was rated the most important attribute [27]. Frozen yogurts with the lowest titratable (0.28 to 0.38) acidity received the highest overall scores [28].

Body/Texture

Body and texture scores for the ice cream are shown in **Figure 1(b)**. The interaction between treatment*week was not significant ($p = 0.9195$). Both main effects, namely treatment (0.7830) and week (0.3774), were not significant, implying that weight loss ingredient did not have not any effect at the maximum studied amount over the shelf life of the ice creams. There are ingredients that alter the body/texture of ice creams. Baer *et al.* [23] studied the effect of four emulsifiers, namely polysorbate 80, 40% α -monoglyceride, 70% α -monoglyceride and lecithin on body/texture of low fat ice creams. They reported that body/texture of the ice creams were improved by all four emulsifiers and that the use of 40% α -monoglyceride resulted in the best body and texture. Resch *et al.* [18] studied the effect of various acidulants namely, hydrochloric, lactic, citric and phosphoric acids on the rheological properties of beta-lactoglobulin gels. They reported that use of citric acid resulted in a very poor thickening capacity. The weight loss ingredient hydroxycitric acid did not have not effect on ice cream body/texture. Alamprese *et al.* [29] manufactured probiotic ice cream with *Lactobacillus johnsonii* La1 and reported that when this microorganism was used at 10^7 cfu/g there were no differences in overrun and firmness of the probiotic ice creams.



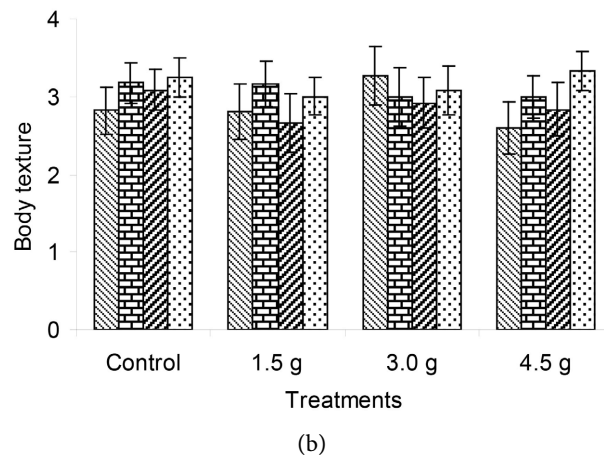


Figure 1. Mean \pm SE flavor (a) and body texture (b) values of the various ice creams.

Heat Shocked Flavor

Heat shocked flavor scores for the ice cream are presented in **Figure 2(a)**. The interaction between treatment*week was not significant ($p = 0.9967$). Both main effects namely treatment ($p = 0.0810$) and week ($p = 0.9523$) were not significant. Prindiville *et al.* [30] studied the effect of milk fat on the sensory properties of chocolate ice cream and reported that heat shock damage in terms of cocoa flavor is lower with an increased level of milk fat in the ice cream. Level of milk fat in the ice creams in the present study was constant and weight loss ingredient usage at all levels did not influence the heat shocked flavor of the ice creams over frozen storage.

Heat Shock Body/Texture

Heat shocked body and texture scores for the ice cream are presented in **Figure 2(b)**. The interaction between treatment*week was not significant ($p = 0.9915$). Both treatment ($p = 0.3624$) and week ($p = 0.2265$) were not significant. Ice crystal size is very important to the structure and quality of ice cream. Small ice crystals impart a smooth creamy texture while large crystals impart a coarse texture. During processing stages, distribution and storage fluctuation in temperatures cause melting and recrystallization which result in increase in the crystal size which causes ice cream to have a coarse texture [31]. Patel *et al.* [32] studied the effect of whey protein concentrate (WPC) 30, 60 90 and milk protein concentrate (MPC) 30, 60, 90 on ice cream characteristics and reported that heat shocked texture scores were similar for all treatments. Baer *et al.* [33] studied the effect of emulsifiers on non fat ice cream and reported 52% α -monoglyceride and 72% α -monoglyceride imparted a desirable resistance to heat shock, while hydroxypropylmethyl cellulose did not improve heat shock stability. Regand and Goff [34] reported 40% to 46% reduction in ice recrystallization in heat shocked ice creams with use of 0.0025% and 0.0035% total protein from acclimated winter wheat grass extract (AWWE). They also reported that ice creams that contained AWWE ice structuring protein had remarkably smoother texture after heat shock storage. The sensory evaluation was conducted by a small panel which is a limitation of this study and that future studies might use larger panels.

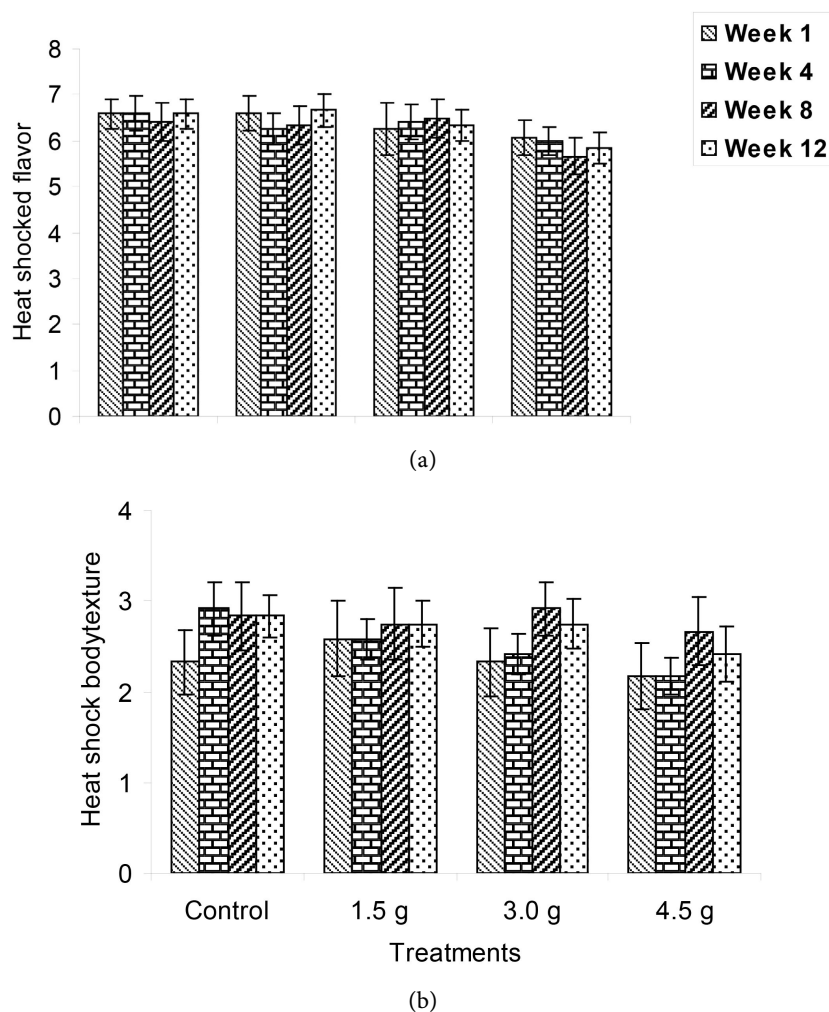


Figure 2. Mean \pm SE heat shocked flavor (a) and body texture (b) values of the various ice creams.

Meltdown Time for First 15 ml and Meltdown ml after 60 Minutes

The time it took for 15 mL of ice cream to melt is presented in **Figure 3(a)**. The interaction between treatment*week was not significant ($p = 0.3098$). Both week ($p < 0.0001$) and treatment effects ($p = 0.0124$) were significant. All of the values for each week were significantly different from each other; with week 12 had the highest mean meltdown time. The meltdown time for the control was significantly larger than the time for the treatments 3.0 and 4.5. The treatments 3.0 and 4.5 were not significantly different from each other. Treatment 1.5 was not significantly different from the control, 3.0, or 4.5.

The volume of ice cream that melted in one hour is presented in **Figure 3(b)**. The interaction between treatment*week was not significant ($p = 0.7084$). Both treatment ($p < 0.0001$) and week effects ($p = 0.0018$) were significant. Treatments 1.5, 3.0, and 4.5 were not significantly different from each other, but were significantly higher than the control. All of the values for each week were significantly different from each other; with week 1 having the largest mean volume.

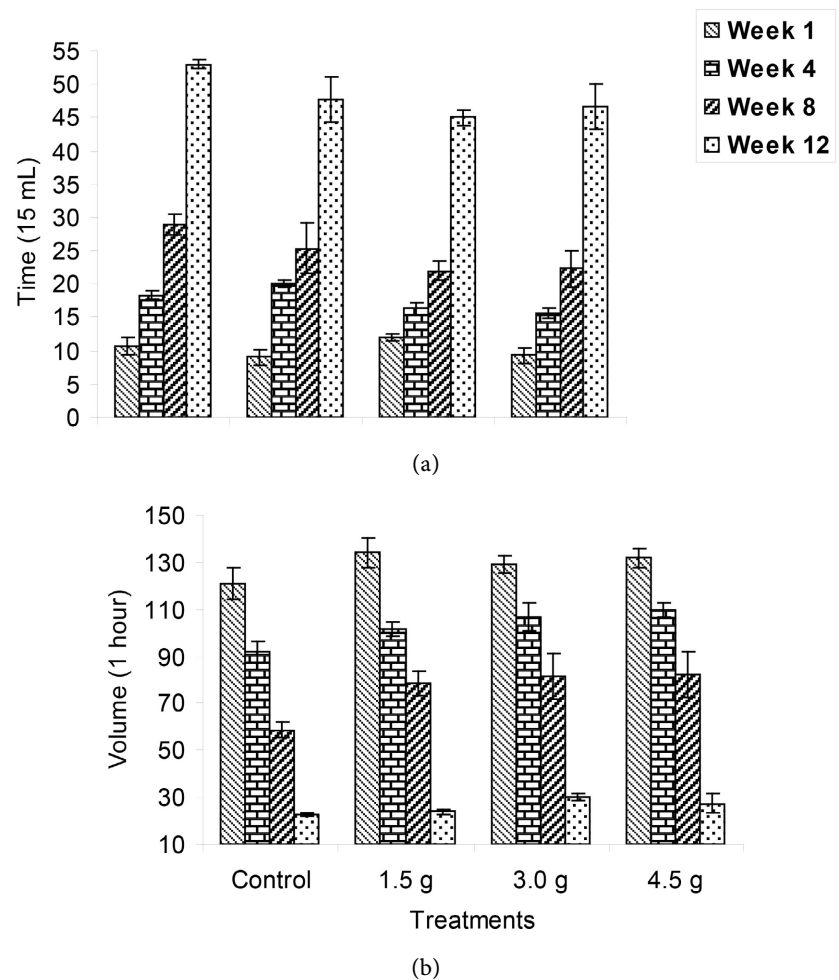


Figure 3. Mean \pm SE meltdown time for first 15 ml (a), meltdown ml after 60 minutes (b) values of the various ice creams.

Ice cream is a frozen foam and emulsion with the majority of the space occupied by air bubbles and ice crystals which constitute the dispersed phase. Typically the structure of ice cream is a three dimensional network of partially coalesced fat globules and air. The proteins and emulsifiers surround the fat globules. A very concentrate unfrozen solution of sugars is the continuous phase. Meltdown of ice cream is basically the melting of the solidified water phase (ice). There are two factors that influence the melting of the ice; they are the outside temperature and rate of heat transfer. During meltdown, heat is transferred from the warm air surrounding the ice cream to melt the ice crystals (starting from the exterior of layer of the ice cream and gradually heat penetrates the interior of the ice cream and causes it to melt) [35]. Different ingredients and different quantities of those ingredients differently effect meltdown of ice cream. Baer *et al.* [33] reported no differences in meltdown among non fat ice creams manufactured with various emulsifiers namely 52% α -monoglyceride, 72% α -monoglyceride, hydroxypropyl-methyl cellulose. Hyvönen *et al.* [36] observed that polydextrose and maltodextrin significantly increased the melting rates of ice cream. They further reported that

increasing fat content slightly slowed the melting in the mouth. Muse and Hartel [35] reported slowest melting rates with 20 DE corn syrup and fastest melting rates with the use of high fructose corn syrup. Roland *et al.* [17] reported that fat replacers did not influence melt down of ice cream. Taha *et al.* [25] manufactured probiotic ice cream using *Bifidobacterium bifidum* Bb-12, *Lactobacillus acidophilus* LA-5 and *Lactobacillus casei* (1:1:1). They incorporated the probiotics as two treatments namely the probiotics being added one hour before freezing and the probiotics left to ferment the mix overnight before freezing. They reported that when probiotics were added one hour before freezing the ice creams has a lower melting resistance.

Microbial Counts

Standard Plate Counts

Total aerobic counts are reported in **Figure 4(a)**. The interaction between treatment*week was not significant ($p = 0.1783$). Treatment was not significant ($p = 0.8176$), but week effect was significant ($p = 0.0310$). Counts at week 1 were significantly lower than weeks 4 and 12. Counts at weeks 4, 8 and 12 were not significantly different from each other. The standard plate counts were far lower than the legal requirement of 50,000 cfu/g. *L. acidophilus* can produce antimicrobials such as bacteriocins, H_2O_2 , or organic acids that may have initially inhibited some aerobes. Danków and Cais-Sokolińska [16] reported hydrolysis of lactose in ice cream. Kailasapathy and Sultana [37] manufactured non fermented probiotic ice creams encapsulated and non encapsulated *L. acidophilus* and reported a mean β -D-galactosidase activity of 9.4 ± 0.5 U/g and 20.9 ± 1.0 U/g, respectively. Giannuzzi and Noemi [38] studied the effect of ascorbic acid in comparison to citric and lactic acid on *Listeria monocytogenes* inhibition at refrigeration temperatures and reported that ascorbic and lactic acids decreased initial microbial counts.

Lactobacilli Counts

The colony forming units (log) of ice cream in MRS Agar are presented in **Figure 4(b)**. The interaction between treatment*week was not significant ($p = 0.8471$). Both treatment ($p < 0.0001$) and week ($p = 0.0461$) were significant. Control had the highest counts of lactobacilli followed by 1.5. Counts of the treatments 3.0 and 4.5 were the lowest and not significantly different from each other. Lactobacilli counts at weeks 4 and 12 were not significantly different from each other and were significantly higher than the counts at week 8.

Giannuzzi and Noemi [38] reported that ascorbic and lactic acids reduce microbial counts and that acidulants such as citric acid limit microbial growth [38]. The control had no weight loss ingredient, hydroxycitric acid, hence perhaps the counts were higher with the control. As the amount of hydroxycitric acid increased from 1.5 to 3.0 the counts further decreased significantly. This lowering in counts at 3.0 was probably because of the antimicrobial effects of hydroxycitric acid [38]. Counts seemed to plateau off in treatment 4.5, indicating that a higher level of weight loss ingredient (past 3.0) did not have a lowering effect on microbial counts. Kaul and Mathur [39] incorporated *Lactobacillus acidophilus* prior to

freezing ice cream mix from buffalo milk and reported counts of 7.07 to 7.87 log cfu/g. They observed a decrease in counts from 7.30 to 7.10 over 10 days of frozen storage at -20 C after which counts appeared to stabilize. Taha *et al.* [25] manufactured probiotic ice cream using *Bifidobacterium bifidum* Bb-12, *Lactobacillus acidophilus* LA-5 and *Lactobacillus casei* and reported a slight loss of viability of all three strains. Hagen and Narvhus [26] manufactured probiotic ice cream and reported a slight decline in viable counts soon after freezing, but did not change significantly during 52 weeks of frozen storage at -20 C . Hekmat and McMahon [13] manufactured probiotic ice cream using *Lactobacillus acidophilus* and *Bifidobacterium bifidum* and reported a decrease in counts from 1.5×10^8 cfu/ml and 2.5×10^8 cfu/ml respectively to 4×10^6 cfu/ml and 1×10^7 cfu/ml respectively after 17 weeks of frozen storage at -29 C . Alamprese *et al.* [29] manufactured probiotic ice cream with *Lactobacillus rhamnosus* and reported no decrease in counts of *L. rhamnosus* in ice cream stored for a year at -16 C . They further reported that the probiotic bacterial counts at the end of 90 days of frozen storage at -18 C decreased by 1.5 - 3.0 log units but were above 10^6 cfu/g [29].

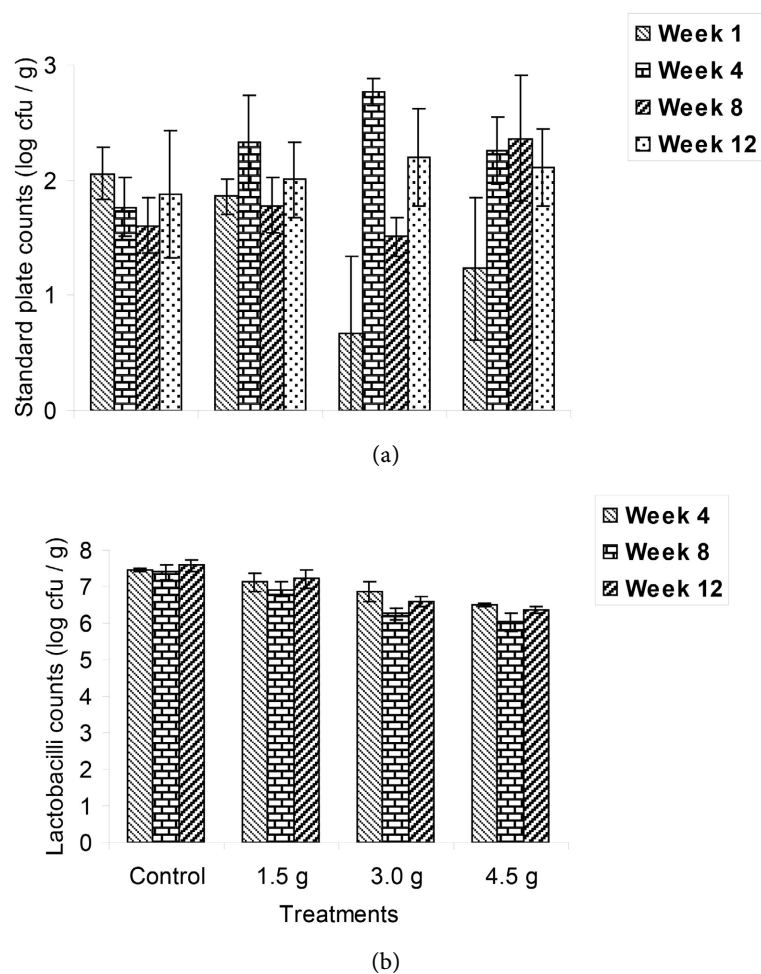


Figure 4. Mean \pm SE aerobic (a) and lactobacilli counts (b) (log cfu/g) of the various ice creams.

4. Conclusion

The weight loss ingredient significantly lowered L* values, increased a* values, lowered meltdown time, increased meltdown volume and lowered lactobacilli counts. The highest concentration shifted the a* color value to the red color space. The weight loss ingredient did not influence pH, viscosity, b* value, flavor, body texture, heat shock flavor, heat shock body texture and standard plate counts. The weight loss ingredient can be recommended for incorporation in ice cream manufacture at an optimum level of 3.0 g per pint of probiotic ice cream.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

- [1] World Health Organization (WHO) (2025) Obesity and Overweight. <https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight>
- [2] Berner, L.A. and O'Donnell, J.A. (1998) Functional Foods and Health Claims Legislation: Applications to Dairy Foods. *International Dairy Journal*, **8**, 355-362. [https://doi.org/10.1016/s0958-6946\(98\)00058-2](https://doi.org/10.1016/s0958-6946(98)00058-2)
- [3] Functional Foods Market Analysis Report (2024-2030). <https://www.grandviewresearch.com/industry-analysis/functional-food-market>
- [4] Ziemer, C.J. and Gibson, G.R. (1998) An Overview of Probiotics, Prebiotics and Synbiotics in the Functional Food Concept: Perspectives and Future Strategies. *International Dairy Journal*, **8**, 473-479. [https://doi.org/10.1016/s0958-6946\(98\)00071-5](https://doi.org/10.1016/s0958-6946(98)00071-5)
- [5] Interhealth NutraIngredients (2003) InterHealth Gets GRAS for Super CitriMax. <https://www.nutraingredients.com/Article/2003/11/24/InterHealth-gets-GRAS-for-Super-CitriMax/>
- [6] Soni, M.G., Burdock, G.A., Preuss, H.G., Stohs, S.J., Ohia, S.E. and Bagchi, D. (2004) Safety Assessment of (-)-Hydroxycitric Acid and Super CitriMax®, a Novel Calcium/Potassium Salt. *Food and Chemical Toxicology*, **42**, 1513-1529. <https://doi.org/10.1016/j.fct.2004.04.014>
- [7] Ohia, S.E., Opere, C.A., LeDay, A.M., Bagchi, M., Bagchi, D. and Stohs, S.J. (2002) Safety and Mechanism of Appetite Suppression by a Novel Hydroxycitric Acid Extract (HCA-SX). *Molecular and Cellular Biochemistry*, **238**, 89-103. <https://doi.org/10.1023/a:1019911205672>
- [8] Shara, M., Ohia, S.E., Schmidt, R.E., Yasmin, T., Zardetto-Smith, A., Kincaid, A., *et al.* (2004) Physico-Chemical Properties of a Novel (-)-Hydroxycitric Acid Extract and Its Effect on Body Weight, Selected Organ Weights, Hepatic Lipid Peroxidation and DNA Fragmentation, Hematology and Clinical Chemistry, and Histopathological Changes over a Period of 90 Days. *Molecular and Cellular Biochemistry*, **260**, 171-186. <https://doi.org/10.1023/b:mcbi.0000026069.53960.75>
- [9] Preuss, H.G., Bagchi, D., Bagchi, M., Rao, C.V.S., Dey, D.K. and Satyanarayana, S. (2004) Effects of a Natural Extract of (-)-Hydroxycitric Acid (HCA-SX) and a Combination of HCA-SX Plus Niacin-Bound Chromium and *Gymnema sylvestre* Extract on Weight Loss. *Diabetes, Obesity and Metabolism*, **6**, 171-180. <https://doi.org/10.1111/j.1462-8902.2004.00328.x>
- [10] Playne, M.J., Bennett, L.E. and Smithers, G.W. (2003) Functional Dairy Foods and Ingredients. *Australian Journal of Dairy Technology*, **58**, 242-264.

- [11] Fuller, R. (1993) Probiotic Foods. Current Use and Future Developments. *International Food Ingredients*, **3**, 23-26.
- [12] Bottazzi, V. (1987) Probiotic Foods Contribute to the Maintenance of Health. *Industria del Latte*, **23**, 31-34.
- [13] Hekmat, S. and McMahon, D.J. (1992) Survival of *Lactobacillus Acidophilus* and *Bifidobacterium Bifidum* in Ice Cream for Use as a Probiotic Food. *Journal of Dairy Science*, **75**, 1415-1422. [https://doi.org/10.3168/jds.s0022-0302\(92\)77895-3](https://doi.org/10.3168/jds.s0022-0302(92)77895-3)
- [14] Abd-El-Salam, M.H., El-Etriby, H. and Sayed, A.F. (1996) Evaluation of Some Stabilizers in the Manufacture of Ice Cream. *Egyptian Journal of Dairy Science*, **25**, 157-164.
- [15] Hussein, A.A., Fahmy, M.A., El-Hoda, H. and Abd El-Rahim, A.M. (1999) Effect of Different Stabilizers on the Properties of Ice Cream. *Assiut Journal of Agricultural Sciences*, **30**, 17-28.
- [16] Danków, R. and Cais-Sokolińska, D. (2002) Quality of Ice Cream with Reduced Content of Lactose. *Prace i Materiały Zootechniczne, Zeszyt Specjalny*, **14**, 55-60.
- [17] Roland, A.M., Phillips, L.G. and Boor, K.J. (1999) Effects of Fat Replacers on the Sensory Properties, Color, Melting, and Hardness of Ice Cream. *Journal of Dairy Science*, **82**, 2094-2100. [https://doi.org/10.3168/jds.s0022-0302\(99\)75451-2](https://doi.org/10.3168/jds.s0022-0302(99)75451-2)
- [18] Resch, J.J., Daubert, C.R. and Foegeding, E.A. (2005) The Effects of Acidulant Type on the Rheological Properties of Beta-Lactoglobulin Gels and Powders Derived from These Gels. *Food Hydrocolloids*, **19**, 851-860. <https://doi.org/10.1016/j.foodhyd.2004.10.034>
- [19] Berry, S.K. (2001) Role of Acidulants in Food Industry. *Journal of Food Science and Technology*, **38**, 93-104.
- [20] Kilara, A. and Chandan, R.C. (2009) Ice Cream and Frozen Desserts. In: Chandan, R.C., Kilara, A. and Shah, N.P., Eds., *Dairy Processing & Quality Assurance*, Wiley-Blackwell, 357-386. <https://doi.org/10.1002/9780813804033.ch16>
- [21] Dervisoglu, M., Yazici, F. and Aydemir, O. (2005) The Effect of Soy Protein Concentrate Addition on the Physical, Chemical, and Sensory Properties of Strawberry Flavored Ice Cream. *European Food Research and Technology*, **221**, 466-470. <https://doi.org/10.1007/s00217-005-1207-3>
- [22] Minhas, K.S., Sidhu, J.S. and Mudahar, G.S. (1997) Effect of Different Stabilizers on the Sensory Quality of Plain Ice Cream Made from Buffalo Milk. *Advances in Food Science*, **19**, 104-110.
- [23] Baer, R.J., Wolkow, M.D. and Kaspersen, K.M. (1997) Effect of Emulsifiers on the Body and Texture of Low Fat Ice Cream. *Journal of Dairy Science*, **80**, 3123-3132. [https://doi.org/10.3168/jds.s0022-0302\(97\)76283-0](https://doi.org/10.3168/jds.s0022-0302(97)76283-0)
- [24] Christiansen, P.S., Edelsten, D., Kristiansen, J.R. and Nielsen, E.W. (1996) Some Properties of Ice Cream Containing *Bifidobacterium Bifidum* and *Lactobacillus Acidophilus*. *Milchwissenschaft*, **51**, 502-504.
- [25] Taha, S.H., El-Fattah, A.M.A., Sofie, El-Dairy, Y. and Attalla, N.R. (2005) Probiotic Ice Cream: Manufacture, Properties and Survival of Added Probiotic Microorganisms. *Egyptian Journal of Dairy Science*, **33**, 105-113.
- [26] Hagen, M. and Narvhus, J.A. (1999) Production of Ice Cream Containing Probiotic Bacteria. *Milchwissenschaft*, **5**, 265-268.
- [27] Davidson, R.H., Duncan, S.E., Hackney, C.R., Eigel, W.N. and Boling, J.W. (2000) Probiotic Culture Survival and Implications in Fermented Frozen Yogurt Characteristics. *Journal of Dairy Science*, **83**, 666-673.

- [https://doi.org/10.3168/jds.s0022-0302\(00\)74927-7](https://doi.org/10.3168/jds.s0022-0302(00)74927-7)
- [28] Speck, M.L. (1983) Evidence of Value of Live Starter Culture in Yogurt. *Cultured Dairy Products Journal*, **18**, 25-26.
- [29] Alamprese, C., Foschino, R., Rossi, M., Pompei, C. and Corti, S. (2005) Effects of *Lactobacillus rhamnosus* GG Addition in Ice Cream. *International Journal of Dairy Technology*, **58**, 200-206. <https://doi.org/10.1111/j.1471-0307.2005.00214.x>
- [30] Prindiville, E.A., Marshall, R.T. and Heymann, H. (1999) Effect of Milk Fat on the Sensory Properties of Chocolate Ice Cream. *Journal of Dairy Science*, **82**, 1425-1432. [https://doi.org/10.3168/jds.s0022-0302\(99\)75369-5](https://doi.org/10.3168/jds.s0022-0302(99)75369-5)
- [31] Miller-Livney, T. and Hartel, R.W. (1997) Ice Recrystallization in Ice Cream: Interactions between Sweeteners and Stabilizers. *Journal of Dairy Science*, **80**, 447-456. [https://doi.org/10.3168/jds.s0022-0302\(97\)75956-3](https://doi.org/10.3168/jds.s0022-0302(97)75956-3)
- [32] Patel, M.R., Baer, R.J. and Acharya, M.R. (2006) Increasing the Protein Content of Ice Cream. *Journal of Dairy Science*, **89**, 1400-1406. [https://doi.org/10.3168/jds.s0022-0302\(06\)72208-1](https://doi.org/10.3168/jds.s0022-0302(06)72208-1)
- [33] Baer, R.J., Krishnaswamy, N. and Kasperon, K.M. (1999) Effect of Emulsifiers and Food Gum on Nonfat Ice Cream. *Journal of Dairy Science*, **82**, 1416-1424. [https://doi.org/10.3168/jds.s0022-0302\(99\)75368-3](https://doi.org/10.3168/jds.s0022-0302(99)75368-3)
- [34] Regand, A. and Goff, H.D. (2006) Ice Recrystallization Inhibition in Ice Cream as Affected by Ice Structuring Proteins from Winter Wheat Grass. *Journal of Dairy Science*, **89**, 49-57. [https://doi.org/10.3168/jds.s0022-0302\(06\)72068-9](https://doi.org/10.3168/jds.s0022-0302(06)72068-9)
- [35] Muse, M.R. and Hartel, R.W. (2004) Ice Cream Structural Elements That Affect Melting Rate and Hardness. *Journal of Dairy Science*, **87**, 1-10. [https://doi.org/10.3168/jds.s0022-0302\(04\)73135-5](https://doi.org/10.3168/jds.s0022-0302(04)73135-5)
- [36] Hyvönen, L., Linna, M., Tuorila, H. and Dijksterhuis, G. (2003) Perception of Melting and Flavor Release of Ice Cream Containing Different Types and Contents of Fat. *Journal of Dairy Science*, **86**, 1130-1138. [https://doi.org/10.3168/jds.s0022-0302\(03\)73695-9](https://doi.org/10.3168/jds.s0022-0302(03)73695-9)
- [37] Kailasapathy, K. and Sultana, K. (2003) Survival and β -D-Galactosidase Activity of Encapsulated and Free *Lactobacillus acidophilus* and *Bifidobacterium lactis* in Ice Cream. *Australian Journal of Dairy Technology*, **58**, 223-227.
- [38] Giannuzzi, L. and Zaritzky, N.E. (1996) Effect of Ascorbic Acid in Comparison to Citric and Lactic Acid on *Listeria monocytogenes* Inhibition at Refrigeration Temperatures. *LWT—Food Science and Technology*, **29**, 278-285. <https://doi.org/10.1006/fstl.1996.0041>
- [39] Kaul, J. and Mathur, B.N. (1982) Development and Assessment of Unfermented Ice Cream Containing *Lactobacillus acidophilus*. *Indian Journal of Dairy Science*, **35**, 267-274.