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Impact of polyols on microbiological viability and sweetness perception in frozen yogurt

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This study evaluated the effect of replacing sucrose in frozen yogurt with polyols: 18% maltitol (YIC-2) and a combination of 9% maltitol and 9% blend of erythritol with steviol glycosides (YIC-3), on the survival of *Lactobacillus* spp., *Streptococcus thermophilus*, and *Bifidobacterium* spp. over 60 days at –18 °C. The control sample with 18% sucrose (YIC-1) showed the highest survival of *Bifidobacterium* spp. (6.33±0.13 log CFU/g), followed by the maltitol variant (YIC-2) at 6.25±0.25 log CFU/g. Both maintained counts above the 6 log CFU/g threshold, indicating probiotic potential. The combination of 9% maltitol, 9% erythritol, and steviol glycosides (YIC-3) showed a significant decline to 5.40± 0.20 log CFU/g, below the therapeutic minimum. These results suggest that erythritol may limit the survival of sensitive probiotic *Bifidobacterium* strains during long-term storage (beyond 14 days). The sensory triangle test revealed statistically significant differences between YIC-1 and YIC-2 ($p = 0.0004$) and between YIC-1 and YIC-3 ($p = 0.024$), but no significant difference between YIC-2 and YIC-3 ($p = 0.939$).

Keywords: polyols, frozen yogurt, *Bifidobacterium* spp., lactic acid bacteria, sensory profile

INTRODUCTION

Ice cream is a frozen dairy product high in fat and sugar, providing significant energy but lacking therapeutic benefits. The nutritional composition of conventionally made ice cream includes 36.0–43.0% dry matter and 8.0–15.0% non-fat milk solids. It contains 8.0–20.0% fat, 4.0–4.8% protein, 12.0–20.0% sugar, 0.1–0.7% stabilizers and emulsifiers [1]. Increased consumption of foods high in added sugars leads to excess calorie intake. It often causes the overproduction of insulin, which inhibits lipolysis and glycogenolysis while promoting the synthesis of triglycerides and glycogen, thereby contributing to chronic diseases such as obesity and hypertension [2, 3].

The availability of numerous sugar substitutes and sweeteners has enabled the development of reduced-energy, sugar-free dietary foods [4]. Ice cream is a suitable food matrix for incorporating lactic acid starter cultures and polyols, meeting the demand for healthier products [5-8]. Frozen yogurts resemble ice cream in texture but are distinguished by a pronounced lactic acid taste [8]. By the end of storage, these products must contain a sufficient number of viable lactic acid bacteria from the starter culture [9]. Various authors have investigated technological approaches to producing lactic acid ice creams with different ratios of fermented milk to ice cream mix [10, 11]. According to research, the viability of probiotic cultures in frozen yogurts remains higher throughout storage than in fermented milks, since low storage temperatures (–18 to –20 °C) slow metabolism and cellular aging [12, 13]. A concentration of 10^6 CFU/g of probiotic bacteria in the final product has been proposed as a "therapeutic minimum" [14]. According to the International Dairy Federation [15], to achieve probiotic potential, the number of viable *Bifidobacteria* spp. should not be less than 10^6 CFU/g, and at least 10^7 CFU/g for other starter culture microorganisms.

Sugar alcohols (polyols) are generally recognized as safe (GRAS) and approved by the European Food Safety Authority [16, 17]. Their inclusion in food products allows classification as "sugar-free" in accordance with European regulations [18]. Genovese *et al.* [19, 20] reported that polyols can successfully replace sugar in functional ice cream without negatively affecting taste or physical stability. Polyols have a mild sweetness and sugar-like texturizing properties [21, 22]. Maltitol provides about 90% of the sweetness of sucrose, has a glycemic index of 35, and an energy value of 2.4 kcal/g, while also contributing to the desired texture of frozen desserts. According to Regulation (EU) No

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1169/2011 [23], erythritol is considered practically non-caloric (0 kcal/g) compared to 2.4 kcal/g for other polyols. A key distinguishing feature of erythritol is its glycemic index of 0 [24], but its lower sweetness (60–80% of sucrose) often requires combination with intense sweeteners [17, 24].

The objective of this study was to determine the viability of *Lactobacillus* spp., *Streptococcus thermophilus*, and *Bifidobacterium* spp. in sugar-free frozen yogurt over 60 days of storage at –18 °C, and to investigate the influence of maltitol, alone and in combination with erythritol and steviol glycosides, on perceived sweetness when used as sucrose replacers.

MATERIALS AND METHODS

Frozen yogurt formulations

Three variants of frozen yogurts were developed: one control sample containing 18% sucrose (YIC-1), and two sugar-free variants – one with 18% maltitol (YIC-2), and another with a combination of 9% maltitol and 9% blend of erythritol with steviol glycosides (YIC-3). The steviol glycosides are used only to adjust sweetness in the erythritol-steviol glycoside mixture (Bioenergie, Gerhard Wagner GmbH, Austria). Because of their high sweetening potency and the minimal amounts used, these intense sweetening agents do not affect the total solids content and the physicochemical properties of the frozen yogurt mix.

For the preparation of the ice cream mix, the following raw materials were used: farm cow's milk (3.90 ± 0.12% fat, 3.00 ± 0.03% protein, 4.70 ± 0.02% lactose, 8.30 ± 0.03% solids-not-fat), fresh cream containing 58.0±0.10% fat, 1.8±0.1% protein, 2.40±0.1% lactose, 4.55±0.12 solids-not-fat (Manole Milk Ltd., Bulgaria), 0.70% of an emulsifier–stabilizer blend (Cremodan SE 38, Danisco Ingredients, Denmark), and milk protein concentrate powder MPC85 (Lactoprima Pro, Balt Milk, Kaunas, Lithuania). The milk base was standardized to 34.0±0.5% total solids, 4.0 ± 0.5% protein, and 10.0 ± 0.5% fat. Depending on the type of fermented ice cream, the following sweeteners were added: 18% sucrose (Zahira, AGRANA Zucker GmbH, Austria), 18% maltitol P200 (Roquette, France), and a combination of 9% maltitol and 9% blend of erythritol with steviol glycosides (Bioenergie, Gerhard Wagner GmbH, Austria).

A two-stage homogenization of the standardized ice cream mix with sugar and a sugar substitute was performed using a homogenizer (150 L/h, Gaulin, Italy) at 63–65°C and 20 MPa pressure. The homogenized ice cream mixes were pasteurized at 85°C for 10 min, then cooled to 8 ± 1°C. Physical aging of the ice cream mixes was conducted at 8°C for 16 h.

For the preparation of probiotic yoghurt, the same milk base (10.0±0.5% fat, 4.0±0.5% protein, 0.7% stabilizer) was used, but without the addition of any sweetening agents. The homogenized milk mix (63–65°C, 20 MPa) was pasteurized at 92 °C for 10 min and cooled to 38±1°C. DVS starter culture ABY-3 with probiotic potential (Chr. Hansen, Denmark) was used for fermentation. The microbial composition of the starter culture included *Lactobacillus delbrueckii* subsp. *bulgaricus*, *Streptococcus thermophilus*, and probiotic strains *Bifidobacterium animalis* subsp. *lactis* (BB-12®) and *Lactobacillus acidophilus* (LA-5®). The lactic acid fermentation was carried out at 38±1°C until a pH of 4.6–4.7 was reached.

Before freezing, the ice cream mixes were blended with the probiotic yoghurt in a 1:1 ratio. The resulting fermented ice cream mixtures were frozen in an ice cream machine (Gelato Chef 2200, 150 W, 1.8 L) for 40 min at t = −6 ÷ −5°C. After freezing, the frozen yogurt samples were packaged in 250 g-containers and stored at −18°C for 60 days.

Chemical analyses

Total solids were determined gravimetrically by drying at 104±1°C to constant weight (Kern XM5 moisture analyzer, Germany). Fat content was determined according to the BDS EN ISO 7328:2009 standard [25]. Protein content was determined by the Kjeldahl method using a conversion factor of 6.38 [26]. The contents of sugars (sucrose, lactose, glucose, galactose, and fructose) were determined by high-performance liquid chromatography (HPLC) according to the method described by Petkova *et al.* [27]. Analyses were performed using an HPLC system (Hewlett Packard 1100) equipped with a refractive index detector (RID) and operated with Chromeleon 7.3 software. Separation was achieved on a C18 column (5 μm) using acetonitrile/water (80:20, v/v) as the mobile phase at a flow rate of 1.4 mL/min and a column temperature of 40 °C. pH was measured potentiometrically (InoLab pH 720, WTW GmbH, Germany). Overrun (%) was determined gravimetrically according to Marshall *et al.* [30].

Microbiological analyses

Viable counts were determined in yogurt, mixes (before and after freezing), and stored frozen yogurt (0, 14, 25, 45, and 60 days).

Lactobacillus spp. and *S. thermophilus* were enumerated according to BDS ISO 7889:2005 [28] by colony count at 37°C. MRS agar (Merck, Darmstadt, Germany) was used for *Lactobacillus* spp., and M17 agar (Merck, Darmstadt, Germany) for *S. thermophilus*. Plates were incubated at 37°C for 72 h (*Lactobacillus* spp.) and 48 h (*S. thermophilus*). Plates with 15–300 colonies were used for calculation, and results were expressed as log CFU/g.

Bifidobacteria spp. were enumerated according to ISO/FDIS 29981 [29] using BSC propionate agar base (HiMedia Laboratories Pvt. Ltd., India) supplemented with mupirocin (HiMedia) to inhibit non-target bacteria. Bifido Selective Supplement A (HiMedia), containing 25 mg mupirocin in 5 mL, was added to the agar cooled to 45–50°C before pouring plates. Inoculated plates were incubated anaerobically at 37°C for 72 h using Anaerocult® A and Anaerotest® (HiMedia). The results were expressed as log CFU/g.

The survival rate (SR, %) of microorganisms was calculated according to Equation (1):

$$SR\ (\%) = \frac{\log \mathrm{CFU\ Nt}}{\log \mathrm{CFU\ No}} \times 100 \qquad (1)$$

where CFU_0 is the initial viable count before freezing and CFU_t is the viable count at the end of storage.

Sensory evaluation

A triangle test was applied as a discriminatory sensory method for detecting differences between similar products. The test involved 20 trained panelists. Each panelist received a triad of samples containing two identical and one different sample, presented in plastic cups coded with three-digit numbers to ensure impartiality. Panelists were informed that two of the samples were identical and one was different, and they were instructed to identify the odd sample, even if they were unsure. Each sample (50 g) was served at t = –10 ± 2 °C. Results from the triangle test were processed and analyzed statistically using XLSTAT Sensory 2022.

Statistical analysis

All analyses were conducted in quadruplicate, and the results are presented as mean values ± standard deviation (SD). One-way analysis of variance (ANOVA) was applied to compare the means of frozen yogurt samples during the storage period. Differences were considered statistically significant at $p<0.05$. Data processing was performed with Statgraphics 19.0.

RESULTS AND DISCUSSION

Table 1 shows the physicochemical parameters of the control frozen yogurt sample (YIC-1) with 18% sucrose, as well as the frozen yogurt samples with complete sucrose replacement – YIC-2 (18% maltitol) and YIC-3 (a combination of 9% maltitol, 9% blend of erythritol, and steviol glycosides). All samples showed similar total solids contents, ranging from 34.10% to 35.77%, with no meaningful differences. The protein content (3.57%÷3.67%) and fat content (10.59%÷10.84%) were also very similar across the three formulations, indicating that replacing sucrose with polyols does not significantly change the main chemical properties of frozen yogurt with no added sugar.

Table 1. Physicochemical characteristics of frozen yogurt with 18% sucrose (YIC-1, control sample) and samples with 18% maltitol (YIC-2) and a combination of 9% maltitol, 9% blend of erythritol, and steviol glycosides (YIC-3).

Indices	YIC-1	YIC-2	YIC-3
Dry matter, %	35.8±0.9^{b}	34.1±0.5^{a}	34.8±0.5^{ab}
Fat, %	10.6±0.1^{a}	10.7±0.1^{ab}	10.8±0.1^{b}
Protein, %	3.6±0.02^{b}	3.6±0.01^{a}	3.7±0.01^{b}
Sugars, %	20.0±0.1^{a}	3.2±0.1^{b}	3.4±0.1^{c}
pH	5.4±0.1^{a}	5.5±0.1^{a}	5.5±0.1^{a}
Overrun, %	40.8±0.7^{b}	22.6±1.9^{a}	79.5±2.3^{c}

Note: Data are expressed as mean values (n = 4) ± standard deviation (SD). Mean values within the same row followed by different lowercase letters (a, b, c) are significantly different ($p < 0.05$).

The most significant differences ($p<0.05$) were in sugar content (sucrose, lactose, glucose, galactose, and fructose). The control sample with sucrose had a sugar level of 20.01±0,1%, whereas YIC-2 with 18% maltitol and YIC-3 with a combination of 9% maltitol and 9% erythritol showed sugar levels of 3.20±0.1% and 3.40±0.1%, respectively. Similar results have been reported by other studies involving maltitol and erythritol in dairy frozen desserts, which maintained the nutritional profile while lowering simple sugars [9].

In terms of overrun, significant differences were established ($p<0.05$). The lowest value was recorded for YIC-2 (22.61%), while YIC-3 exhibited a nearly fourfold higher overrun (79.55%). This can be attributed to the different cryoscopic activity of the polyols and their effects on mix viscosity, which determine the ability to retain air bubbles during freezing [30, 31].

In the studied frozen yogurt samples (pH 4.90±0.01), the concentration of viable microbial cells from the starter culture was measured using the standard plate count method. The results, shown as log CFU/g, were as follows: *Lactobacillus* spp. – 8.27±0.24 log CFU/g, *Streptococcus thermophilus* – 9.49±0.01 log CFU/g, and *Bifidobacterium* spp. – 8.60±0.11 log CFU/g. These values demonstrate a high level of viable cells for microbial species typical of fermented dairy products with probiotic potential. They are well above the commonly accepted minimum of 6 log CFU/g needed for probiotic effectiveness [32, 33].

The microbial viability was assessed after preparing fermented frozen yogurt mixes with sucrose and sugar substitutes, after freezing (1 day), and throughout storage up to day 60 (Table 2). Before freezing, a decrease in *Lactobacillus* spp., *Streptococcus thermophilus*, and *Bifidobacterium* spp. was noted in the mixes due to diluting the probiotic yogurt 50:50 with an ice cream base lacking live bacterial microorganisms (Table 2). This caused a mechanical reduction in logarithmic counts – about 12% for lactobacilli, 0.6% for streptococci, and 15% for bifidobacteria. Despite this, all frozen yogurt samples (YIC-1, YIC-2, YIC-3) maintained microbial counts above the minimum probiotic threshold of 10^6–10^7 CFU/g viable cells [32].

After freezing, *Lactobacillus* spp. and *S. thermophilus* showed high survival rates (96.82–98.91% and 95.77 – 96.85%, respectively) across all samples. *Bifidobacterium* spp. survival rates varied significantly ($p<0.05$), from 79.59% to 85.42%, with YIC-1 (sucrose) having the highest (99.68%) and YIC-3 (maltitol–erythritol) the lowest (79.59%) survival rate. This trend aligns with findings by Muzammil *et al.* [34] that freezing causes partial viability loss mainly due to mechanical stress from mixing and air incorporation [35]. *Lactobacillus* spp. and *S. thermophilus* are facultative anaerobes, unlike bifidobacteria, which are strict anaerobes. The overrun during freezing was highest in YIC-3 (79.55±2.3%), possibly explaining the lower bifidobacteria survival, while YIC-2 (maltitol) had the lowest overrun (22.61±1.9%), aiding better probiotic maintenance.

Table 2. Viable cell counts of the starter culture (log CFU/g) in frozen yogurt with 18% sucrose (YIC-1, control), 18% maltitol (YIC-2), and a combination of 9% maltitol, 9% erythritol, and stevia (YIC-3) during 60 days of storage at –18 °C.

Frozen yogurt sample	**Starter culture microbial species (log CFU/g)**		**Storage period (days)**				
		Before freezing	**1**	**14**	**25**	**45**	**60**
YIC-1	*Lactobacillus* spp.	7,25±0,10^{X}	7,15 ±0,07^{b,X}	7,07 ±0,15^{b,Y}	6,77 ±0,14^{a,X}	6,76 ±0,03^{a,X}	6,57 ±0,3^{a,X}
	S. thermpophilus	9,43±0,30^{Y}	9,11 ±0,27^{a,X}	9,07 ±0,34^{a,X}	8,94 ±0,48^{a,X}	8,99 ±0,05^{a,X}	8,80 ±0,33^{a,Y}
	Bifidobacterium spp.	7,31±0,13^{X}	7,0 ±0,40^{b,XY}	6,90 ±0,33^{b,X}	6,98 ±0,48^{b,X}	6,60 ±0,22^{ab,X}	6,33 ±0,13^{a,X}
YIC-2	*Lactobacillus* spp.	7,31±0,12^{X}	7,23 ±0,20^{b,X}	6,80 ±0,08^{a,X}	6,70 ±0,01^{a,X}	6,62 ±0,32^{a,X}	6,49 ±0,33^{a,X}
	S. thermpophilus	9,52±0,30^{Y}	9,29 ±0,49^{b,X}	8,92 ±0,42^{ab,X}	8,69 ±0,22^{ab,X}	8,66 ±0,22^{a,X}	8,31 ±0,58^{a,XY}
	Bifidobacterium spp.	7,34±0,30^{X}	6,40 ±0,17^{b,Y}	6,24 ±0,17^{b,X}	6,29 ±0,27^{b,X}	6,29 ±0,11^{b,X}	6,25 ±0,21^{a,Y}
YIC-3	*Lactobacillus* spp.	7,23±0,1^{X}	7,00 ±0,07^{c,X}	6,82 ±0,13^{b,X}	6,69 ±0,10^{a,X}	6,62 ±0,07^{ab,X}	6,62 ±0,10^{a,X}
	S. thermpophilus	9,45±0,59^{Y}	9,05 ±0,27^{b,X}	8,90 ±0,37^{bx}	8,64 ±0,18^{b,X}	8,66 ±0,27^{b,X}	7,72 ±0,62^{a,X}
	Bifidobacterium spp.	7,30±0,23^{X}	5,81 ±0,25$^{b, X}$	5,76 ±0,26^{b,X}	5,66 ±0,20^{ab,X}	5,44 ±0,06^{a,X}	5,40 ±0,20^{a,X}

*Values of log (CFU/ g) are expressed as mean ± standard deviation (SD). Mean values within the same row and column followed by different lowercase letters are significantly different ($p < 0.05$). **Letter designations are used as follows: X, Y, Z indicate differences in the concentration of starter culture microorganisms between the frozen yogurt samples during storage, while a, b, c indicate differences in the concentration of starter culture microorganisms within the same sample during storage.

Table 3. Sensory differentiation of fermented frozen yogurts sweetened with sucrose (YIC-1), maltitol (YIC-2), and maltitol–erythritol–stevia (YIC-3)

Parameter	Frozen yogurt samples		
	YIC-1 vs YIC-3	YIC-1 vs YIC-2	YIC-2 vs YIC-3
Number of panelists (N)	19	19	20
Number of correct answers	11	14	4
% correct responses	57.89	73.68	20.0
Significance threshold	11	11	11
d-prime (d′)	1.869	2.717	0.0
p-value	0.024	0.000381	0.939
Statistical power (%)	59.6	96.1	3.8
Statistical significance	Yes	Yes	No

On day 1, *Lactobacillus* spp. levels were similar (7.2–7.3 log CFU/g) across the variants (p>0.05). They slightly decreased during storage, with YIC-2 and YIC-3 reaching 6.49 and 6.62 log CFU/g, respectively, while YIC-1 remained relatively stable at 6.57 log CFU/g by day 60. Although the differences were not statistically significant (p>0.05), sucrose seemed to offer a more stable environment for *Lactobacillus*.

S. thermophilus started at 9.1–9.2 log CFU/g and remained viable after freezing. The most notable decline (SR=85.30%) was in YIC-3, dropping from 9.05 to 7.72 log CFU/g. YIC-1 and YIC-2 also decreased gradually, ending at 8.80 and 8.31 log CFU/g, with survival rates of 96.60% and 89.45%, respectively. This indicates better stability in *S. thermophilus* with sucrose and maltitol compared to the maltitol–erythritol mix.

All samples initially had *Bifidobacterium* spp. levels around 7.30–7.34 log CFU/g, indicating good initial inoculation. After 60 days, *Bifidobacterium* spp. of YIC-1 decreased to 6.33 log CFU/g but remained above the probiotic threshold. YIC-2 remained similar at 6.25 log CFU/g, while YIC-3 declined to 5.40 log CFU/g, falling below the effective probiotic level. This reduction in YIC-3 may be linked to erythritol, which, at 9%, despite being moderate, can affect probiotic viability due to its physicochemical properties [36]. Previous research shows that erythritol may inhibit *Lactobacillus* and *Bifidobacterium* at higher concentrations by creating osmotic stress and antimicrobial effects. Nevertheless, in this study, the combination with maltitol did not cause a sharp initial decline, suggesting that moderate erythritol levels are acceptable in fermented frozen dairy products without losing probiotic benefits. However, viability remains lower than with sucrose (YIC-1) or maltitol alone (YIC-2). All samples showed a steady, moderate decline in *Bifidobacterium* spp. during 60-day storage, with no sudden drops. This could be due to the osmotic properties of sucrose and maltitol, which help reduce freezing stress and minimize mechanical damage [37]. Disaccharides and polyols can act as cryoprotectants, forming a stable glassy matrix that shields cell membranes and proteins from freezing damage [38, 39]. These mechanisms help improve probiotic resilience during freezing or lyophilization [40].

A triangle test was used to evaluate perceptible differences between fermented frozen yogurt samples containing sucrose (YIC-1) and those with sugar substitutes—maltitol (YIC-2) and a mixture of maltitol, erythritol, and steviol glycosides (YIC-3). For the statistical analysis, the Thurstonian model was applied, and the d-prime (d′) value was calculated to measure the panelists' sensitivity to differences among the samples (Table 3).

When comparing frozen yogurt samples YIC-1 (sucrose) and YIC-3 (maltitol, erythritol, and steviol glycosides), 57.89% of assessors correctly identified the odd sample, which exceeds the chance level of 33.33%. The d-prime value was 1.869, indicating a perceptible ability to distinguish between the sample pairs. Statistical analysis showed a p-value of 0.024, below the significance level (α=0.05). Therefore, the null hypothesis (H_0) that there is no difference between YIC-1 and YIC-3 was rejected in favor of the alternative hypothesis (H_a). This confirms that sucrose (YIC-1) is perceived differently from the low-intensity sweeteners maltitol, erythritol, and steviol glycosides (YIC-3). The power of the test was 59.60%, which is acceptable for sensory testing. These results demonstrate that participants could significantly (p<0.05) distinguish the sucrose-sweetened frozen yogurt from those sweetened with maltitol, erythritol, and steviol glycosides.

The comparison between sucrose (YIC-1) and maltitol (YIC-2) showed that 73.68% of participants correctly identified the odd sample, well above the chance level of 33.33%. The calculated d-prime of 2.717 indicates high sensitivity to differences between YIC-1 and YIC-2. The p-value was 0.000381, which is far below 0.05, confirming the significance of the findings. The test's power was 96.06%, demonstrating strong reliability. This indicates that panelists could clearly distinguish between the sucrose-sweetened sample (YIC-1) and the maltitol-sweetened sample (YIC-2).

When comparing the maltitol sample (YIC-2) and the maltitol-erythritol-stevia combination (YIC-3), only 20% of participants correctly identified the two samples, which is below the expected random-guess rate of 33.33%. The d-prime was 0, suggesting no perceptible difference according to the Thurstonian model. The p-value was 0.939, well above 0.05, indicating no significant difference, and the null hypothesis was not rejected. The test's power was only 3.76%, implying a very low likelihood of detecting a difference if it exists. These results suggest that participants perceived YIC-2 and YIC-3 as practically indistinguishable.

The differences in sweetness between sucrose and the sweeteners maltitol, erythritol, and stevia are influenced by their chemical structures and interactions with sweetness receptors in the mouth. Sucrose has a balanced, intense, and long-lasting sensation. Conversely, polyols like maltitol and erythritol have lower sweetness levels, approximately 70–90% and 60–70% of the sweetness of sucrose, respectively, and shorter perception duration. Moreover, erythritol imparts a cooling sensation, further altering the overall flavor profile.

CONCLUSIONS

The replacement of sucrose with maltitol in frozen yogurt preserved the viability of probiotic cultures (*Lactobacillus* spp., *S. thermophilus*, and *Bifidobacterium* spp.) above the recommended therapeutic minimum throughout 60 days of storage at –18 °C. The combination of maltitol and erythritol with steviol glycosides led to a decline in the survival of *Bifidobacterium* spp. below the probiotic threshold after 60 days of storage, which may be associated with the presence of erythritol at a concentration of 9%, known to affect sensitive strains under prolonged storage conditions. Sensory analysis confirmed that sucrose- and maltitol-sweetened yogurts were clearly distinguishable, while the difference between maltitol and maltitol-erythritol-steviol glycosides formulations was not perceptible. These findings indicate that maltitol is a suitable sucrose substitute for developing frozen yogurt with probiotic potential, whereas formulations containing erythritol require further optimization to ensure microbial stability.

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