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Effect of Sucralose and Maltitol on the Physicochemical Properties of Dietetic Frozen Bifido Yoghurt

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A B S T R A C T

Frozen yogurt is a unique dessert with physical properties of ice cream, and nutritional and sensory characteristics of yoghurt. A study was carried out to prepare dietetic frozen yoghurt by incorporating two per cent of traditional yoghurt cultures and 1% *Bifidobacterium bifidum* culture and also by replacing sugar with artificial sweeteners viz., sucralose and maltitol. Six types of frozen yoghurt mixes prepared with sugar, 50 per cent sucralose, 100 per cent sucralose, 50 per cent maltitol, 100 per cent maltitol and a combination of sucralose and maltitol (50%: 50%) were designated as FYM0, FYM1, FYM2, FYM3, FYM4 and FYM5 and were subjected to determination of physicochemical properties. The pH and titratable acidity of frozen yoghurt mixes increased as the level of substitution of sucralose increased. No significant (P>0.05) difference was observed in other properties such as specific gravity, viscosity, melting time, over run values between different frozen yoghurt mixes. The frozen yoghurt mixes with 50 per cent sucralose (FYM1) recorded the highest overall acceptability next to control frozen yoghurt mix. At end of 5 weeks of storage the count of yoghurt bacteria and *B. bifidum* were 6.0147 ± 0.005 and 5.2626 ± 0.012 respectively. It is concluded that, except for pH and acidity, varying levels of substitution of these artificial sweeteners did not affect the physico chemical properties of different frozen yoghurt mixes.

Introduction

Frozen yoghurt can be regarded as a healthy alternative to ice cream for people suffering from obesity, cardiovascular diseases and lactose intolerance due to its low fat content and reduced lactose concentration. It is a complex fermented frozen dairy dessert that combines the physical characteristics of ice cream with sensory and nutritional properties of fermented milk products. It is often consumed by lactose-sensitive people in place of ice cream, as the live cultures can help to digest the lactose.

Incorporation of probiotic bacteria into fermented dairy products is gaining popularity for their health benefits, e.g. improvements in lactose digestion, prevention of intestinal infections, suppression of carcinogenesis and reduction of serum cholesterol concentrations (Davidson *et al.*, 2000; De and Schrezenmeir 2008). Probiotics play a major role in health and wellbeing beyond basic nutrition (Vanaja *et al.*, 2011). The calorific values of different dietetic yoghurts sweetened with various sweeteners (aspartame, fructose and sucralose) were lower than the product sweetened with sucrose (Fonseca and Neves, 1998). Similar to western countries, Indian consumers are also becoming health conscious and tending to avoid sweets with high sugar content. In the modern context, more and more people choose low sugar for health reasons owing to prevailing diabetic conditions or motivated by calorie consciousness. Considering the above facts in this investigation, an attempt has been made to prepare a refreshing, tangy dietetic dessert that combines the physical characteristics of ice cream with sensory and nutritional properties of yoghurt and the result of the physicochemical analyses of the developed is presented in this article.

Materials and Methods

Preparation of dietetic frozen bifido yoghurt

The frozen yoghurt was prepared as per the procedure outlined by Guven and Karaca (2002). Six lots were prepared using fresh skim milk which was taken in a stainless steel vessel. Skim milk powder at the rate of 4 per cent (w/v) and sugar at the rate of 15 per cent (w/v) were added to it and homogenized at 1000 psi. The contents were mixed well and pasteurized at 85^{o}C for 30 minutes, cooled to room temperature and inoculated with 2 per cent of yoghurt cultures containing *Lactobacillus delbrueckii* ssp. *bulgaricus*, and *Streptococcus salivarius* ssp. *thermophilus* (Chr. Hansen, Denmark) and 1% *Bifidobacterium bifidum* culture (NDRI, Karnal). It was then mixed well and incubated at 42^{o}C for 2 to 3 hours. Afterwards the coagulum was broken and to this 0.3 per cent carboxy methyl cellulose (CMC) as stabilizer and 0.3 per cent glycerol mono stearate (GMS) as emulsifier was added. The flavor was added to the mix before freezing. The mix was thoroughly mixed and then frozen in an ice cream freezer and drawn from the freezer at -4^{o}C and packed in 100 ml cups and hardened at -20^{0}C.

Different types of frozen yoghurt mixes

The sugar was replaced by artificial sweeteners viz., sucralose (Sugar free Natura-Cadila Health Care Liimited, Ahemedabad, India) and maltitol (Titan Biotech ltd, Bhiwadi, Rajasthan, India) at different levels for the following experimental design which is also given comprehensively in Table 1.

FYM0-Frozen yoghurt mix with sugar (control)

FYM1- Frozen yoghurt mix with 50 per cent of sucralose

FYM2- Frozen yoghurt mix with 100 per cent of sucralose

FYM3- Frozen yoghurt mix with 50 per cent of maltitol

FYM4- Frozen yoghurt mix with 100 per cent of maltitol

FYM5- Frozen yoghurt mix with a combination of sucralose and maltitol (50%:50%)

Physico chemical analyses of dietetic frozen yoghurt

Acidity was estimated as per the procedure described in IS: SP: 18 (part XI)-1981 and pH was estimated by digital pH meter. The specific gravity of frozen yoghurt was estimated by gravimetric method using specific gravity bottle. Melting time and over run was estimated by the procedure outlined by Guven and karaca (2002)

$$\text{Over run} = \frac{\text{Volume of frozen yoghurt} - \text{Volume of frozen yoghurt mix}}{\text{Volume of frozen yoghurt mix}} \times 100$$

Estimation of viscosity (Pipette method)

Mark A and B on the 10 cc pipette. The viscosity of the frozen yoghurt mix was determined by comparing the flow of frozen yoghurt mix and water through the pipette. (Water is taken in as the reference liquid). Fill up the pipette with frozen yoghurt mix up to 'A' mark and keep the pipette vertically. Start the stop clock when the level of the frozen yoghurt mix crosses the A mark. Find out the time taken for the frozen yoghurt mix to flow from the mark A to B mark. In the same manner take water in the pipette as before and find out the time of flow of water from the mark A to B. Using the RV formula, the viscosity of frozen yoghurt mix was calculated by using the viscosity of water as 1.005 cp.

$$\frac{n_o}{n_1} = \frac{t_o p_o}{t_1 p_1}$$

n_o – Viscosity of water in CP
n_1 – Viscosity of frozen yoghurt mix
t_1 - Time of flow of frozen yoghurt mix

$$n_1 = no \frac{t_o p_o}{t_1 p_1}$$

t_o – Time of flow of water
p_o – Sp. gravity of water
p_1 – Sp. gravity of frozen yoghurt mix

Results and Discussion

Physico chemical properties of different frozen yoghurt mixes during storage period

Titratable acidity

Table 2 shows the mean ± SE values of titratable acidity in different frozen yoghurt mixes (FYM0, FYM1, FYM2, FYM3, FYM4 and FYM5) during storage period of 0, 1, 2, 3, 4 and 5 weeks at -20^{0}C. The mean ± SE values of titrable acidity in different frozen yoghurt mixes were 0.4409 ± 0.0046, 0.4462 ± 0.0046, 0.4498 ± 0.0043, 0.4408 ± 0.0045, 0.4398 ± 0.0043 and 0.4459 ± 0.0046 respectively. Statistical analysis showed a highly significant ($P < 0.01$) difference in titratable acidity values between different frozen yoghurt mixes and no significant ($P> 0.05$) difference in titratable acidity values between different storage periods.

pH

Table 3 shows the mean ± SE values of pH in different frozen yoghurt mixes (FYM0, FYM1, FYM2, FYM3, FYM4 and FYM5) during storage period of 0, 1, 2, 3, 4 and 5 weeks at -20^{0}C. The mean ± SE values of pH in different frozen yoghurt mixes were 5.3269 ± 0.0094, 5.3380 ± 0.0108, 5.4796 ± 0.0033, 5.3278 ± 0.0107, 5.3278 ± 0.0111 and 5.3385 ± 0.0108 respectively. Statistical analysis showed a highly significant ($P < 0.01$) difference in pH values between different frozen yoghurt mixes and no significant ($P>0.05$) difference in pH values between different storage periods.

Specific gravity, viscosity, melting time and overrun

Table 4 shows the mean ± SE values of specific gravity, viscosity, melting time and over run in different frozen yoghurt mixes

(FYM0, FYM1, FYM2, FYM3, FYM4 and FYM5). The mean ± SE values of specific gravity in different frozen yoghurt mixes were 1.0535 ± 0.001, 1.0533 ± 0.001, 1.0536 ± 0.001, 1.0534 ± 0.001, 1.0535 ± 0.001and 1.0536 ± 0.001 respectively. The mean ± SE values of viscosity in different frozen yoghurt mixes were 34.454 ± 0.008, 34.456 ± 0.007, 34.489 ± 0.020, 34.456 ± 0.004, 34.455 ± 0.009 and 34.456 ± 0.009 respectively.

The mean ± SE values of melting time in different frozen yoghurt mixes were 57.607 ± 0.082, 57.608 ± 0.082, 57.607 ± 0.082, 57.606 ± 0.082, 57.607 ± 0.082 and 57.607 ± 0.082 respectively.

The mean over run values of different frozen yoghurt mixes were 24.512 ± 0.760, 24.167 ± 0.600, 24.00 ± 0.577, 24.166 ± 0.600, 24.500 ± 0.765 and 24.501 ± 0.428 respectively.

Flow diagram of preparation of dietetic frozen yoghurt

Fresh cow milk
↓
Skimming at 40^0C
↓
Addition of skim milk powder (4%) and
Sugar (15%)
↓
Homogenization (1000 psi)
↓
Pasteurization (85^0C for 30 min)
↓
Cooling (42^0C)
↓
Inoculation (2% yoghurt culture)
↓
Incubating at 42^0C /2-3 hrs
↓
Breaking the coagulum
↓
Addition of Stabilizer (0.3%) and Emulsifier (0.3%) and Flavors
↓
Mixing
↓
Freezing the mix
↓
Drawn from the freezer (-4^oC)
↓
Packaging
↓
Storage and hardening at -20^oC

Table.1 Ingredients used per litre of different frozen yoghurt mixes

Types of Frozen yoghurt mixes	Percentage Substitution level of sweeteners	Skim Milk (ml)	SMP (g)	Sugar (g)	Artificial sweeteners	Yoghurt & bifido cultures (ml)	Stabilizer & Emulsifier (g)	Flavor (ml)
FYM0	0	900	40	150	–	30	6	3
FYM1	50	900	40	75	11sugar free Natura pellets	30	6	3
FYM2	100	900	40	–	22 pellets	30	6	3
FYM3	50	900	40	75	75	30	6	3
FYM4	100	900	40	–	150	30	6	3
FYM5	50 +50	900	40	–	75g Maltitol + 11 pellets	30	6	3

Table.2 Titratable acidity of different frozen yoghurt mixes during storage period (Mean ± SE) @

Storage / FY Mixes	0 week	1 week	2 weeks	3 weeks	4 weeks	5 weeks	Mean ± SE
FYM0	0.433	0.431	0.433	0.431	0.432	0.432	$0.4409^{a} \pm 0.0046$
FYM1	0.443	0.442	0.443	0.440	0.442	0.445	$0.4462^{b} \pm 0.0046$
FYM2	0.468	0.469	0.469	0.466	0.465	0.459	$0.4498^{c} \pm 0.0043$
FYM3	0.433	0.433	0.432	0.432	0.434	0.433	$0.4408^{a} \pm 0.0045$
FYM4	0.433	0.432	0.433	0.434	0.434	0.433	$0.4398^{a} \pm 0.0043$
FYM5	0.443	0.443	0.444	0.445	0.443	0.443	$0.4459^{b} \pm 0.0046$

Table 3 pH of different frozen yoghurt mixes during storage period (Mean ± SE) @

Storage / FY Mixes	0 week	1 week	2 weeks	3 weeks	4 weeks	5 weeks	Mean ± SE
FYM0	5.314	5.314	5.312	5.315	5.313	5.314	$5.3269^{a} \pm 0.0094$
FYM1	5.331	5.334	5.334	5.332	5.331	5.331	$5.3380^{b} \pm 0.0108$
FYM2	5.476	5.481	5.471	5.472	5.481	5.484	$5.4796^{C} \pm 0.0033$
FYM3	5.315	5.317	5.314	5.314	5.313	5.313	$5.3278^{a} \pm 0.0107$
FYM4	5.318	5.316	5.315	5.313	5.315	5.313	$5.3278^{a} \pm 0.0111$
FYM5	5.332	5.331	5.334	5.332	5.331	5.331	$5.3385^{b} \pm 0.0108$

Table.4 Physico chemical properties of different frozen yoghurt mixes (Mean ± SE) @

Properties	FYM0	FYM1	FYM2	FYM3	FYM4	FYM5	F value
Specific gravity	$1.0535^{a} \pm 0.001$	$1.0533^{a} \pm 0.001$	$1.0536^{a} \pm 0.001$	$1.0534^{a} \pm 0.001$	$1.0535^{a} \pm 0.001$	$1.0536^{a} \pm 0.001$	1.06^{NS}
Viscosity (centipoises)	$34.454^{a} \pm 0.008$	$34.456^{a} \pm 0.007$	$34.489^{a} \pm 0.020$	$34.456^{a} \pm 0.004$	$34.455^{a} \pm 0.009$	$34.456^{a} \pm 0.009$	2.48^{NS}
Meltdown (minutes)	$57.607^{a} \pm 0.082$	$57.608^{a} \pm 0.082$	$57.607^{a} \pm 0.082$	$57.606^{a} \pm 0.082$	$57.607^{a} \pm 0.082$	$57.607^{a} \pm 0.082$	0.16^{NS}
Overrun(per cent)	$24.512^{a} \pm 0.760$	$24.167^{a} \pm 0.600$	$24.00^{a} \pm 0.577$	$24.166^{a} \pm 0.600$	$24.500^{a} \pm 0.763$	$24.501^{a} \pm 0.428$	1.06^{NS}

Physico chemical properties of different frozen yoghurt mixes during storage period

Titratable acidity

There was no significant (P > 0.05) difference in titratable acidity values between storage period of 0, 1, 2, 3, 4 and 5 weeks. This was in conformity with the findings of Baig and Prasad (1996). He indicated that the titratable acidity and pH in frozen yoghurt during storage at -20^{0}C for 90 days almost remained constant. This indicates that there was no biochemical activity by starter bacteria during storage of the product at -20^{0}C. There was a highly significant difference (P < 0.01) in titratable acidity values between different frozen yoghurt mixes. The frozen yoghurt mix with 100 per cent sucralose (FYM2) recorded higher titratable acidity values among all other mixes. The frozen yoghurt mix with 50 per cent sucralose (FYM1) and the mix with a combination of sucralose and maltitol (FYM5) recorded higher titratable acidity values next to the frozen yoghurt mix with 100 per cent sucralose (FYM2). There was no much difference in titratable acidity values of mixes with sugar (FYM0) and maltitol (FYM3 and FYM4). These findings indicate that as the concentration of sucralose increased, there was an increase in titratable acidity. This resembled the findings of Marshall *et al.,* (2003), who recorded that, as the level of substitution of the high intensity sweetener sucralose increased, their titratable acidity and pH values were also increased. This might be attributed to the chloride radicals in the sucralose structure. These findings also indicate that the addition of maltitol in 50 per cent (FYM3) and 100 per cent (FYM4) did not induce any change in the acidity as compared with the sucralose. However, the titratable acidity values in different frozen yoghurt mixes fall within the range prescribed by Inoue *et al.,* (1998), who opined that the ice cream type frozen yoghurt with titratable acidity of 0.4 to 0.5 per cent was the most preferred by the panellists.

pH

There was no significant (P > 0.05) difference in pH values between different storage period of 0, 1, 2, 3, 4 and 5 weeks. This was in accordance with the findings of Baig and Prasad (1996). There was a highly significant difference (P < 0.01) in pH values between different frozen yoghurt mixes. The frozen yoghurt mix with 100 per cent sucralose (FYM2) recorded higher pH values among all other mixes. The frozen yoghurt mix with 50 per cent Sucralose (FYM1) and the mix with a combination of sucralose and maltitol (FYM5) recorded higher pH values next to the frozen yoghurt mix with 100 per cent sucralose (FYM2). There was no much difference in pH values of mixes with sugar (FYM0) and maltitol (FYM3 and FYM4).

These findings indicate that as the concentration of sucralose increased, there was an increase in pH values. These results agree with the findings of Marshall *et al.,* (2003). The pH values of control frozen yoghurt mix (FYM0) and the frozen yoghurt mix with 50 (FYM3) and 100 per cent maltitol (FYM4) did not show much difference in pH values as compared to the sucralose. However the pH values in different frozen yoghurt mixes fall within the range prescribed by Inoue *et al.,* (1998), who found that the ice cream type frozen yoghurt with pH of 5.0 to 5.5 was the most preferred by the panellists.

Specific gravity

There was no significant (P>0.05) difference in specific gravity values between different frozen yoghurt mixes. These findings were in close agreement with the findings of Vijayalakshmi (2005), who reported that the specific gravity of frozen yoghurt ranged from 1.056 to 1.086.

Viscosity

There was no significant (P>0.05) difference in viscosity values between different frozen yoghurt mixes. The viscosity values between different frozen yoghurt mixes recorded in the study were slightly lower than the value obtained by Vijayalakshmi (2005), who found that the viscosity of frozen yoghurt ranged from 41.99 to 51.99 (centipoises) at an acidity of 0.7 per cent. The decrease in viscosity values of different frozen yoghurt mixes may be attributed to the fact that, the product with lower acidity will have the lower viscosity values (Ordonez *et al.,* 2000).

Melting time

There was no significant (P>0.05) difference in melting time between different frozen yoghurt mixes. The melting times recorded in the study were in accordance with the findings of Vijayalakshmi (2005), who observed that the complete melting time of frozen yoghurt ranged from 57 to 80 minutes.

Overrun

There was no significant (P>0.05) difference in overrun values between different frozen yoghurt mixes. The overrun values recorded in the study were in accordance with the findings of Guven and Karaca (2002), who inferred that the overrun of vanilla frozen yoghurt ranged from 22.15 to 31.63 (per cent).

The frozen yoghurt mixes with 50 per cent sucralose (FYM1) recorded the highest overall acceptability scores next to control frozen yoghurt mix. The pH and titratable acidity of frozen yoghurt mixes increased as the level of substitution of sucralose increased. But they remained constant between different storage periods. Statistical analysis showed no significant (P>0.05) difference in other properties such as, specific gravity, viscosity, melting time, over run values between different frozen yoghurt mixes. The count of both yoghurt bacteria and *Bifidobacterium bifidum* did not differ significantly (P>0.05) between different frozen yoghurt mixes. A highly significant (P < 0.01) difference in the count of both yoghurt bacteria and *Bifidobacterium bifidum* was noticed between different storage periods at -20ºC. The reduction in the count of yoghurt bacteria and *B. bifidum* was nearly 1 log units during the storage period. At end of 5 weeks of storage the count of yoghurt bacteria and *B.bifidum* were 6.0147 ± 0.005, 5.2626 ± 0.012 respectively. It is concluded that, except for pH and acidity, varying levels of substitution of these artificial sweeteners did not affect the physico chemical properties of different frozen bifido yoghurt mixes. As there is a growing interest among the health conscious consumers for food products that can provide health benefits, hopefully, the developed dietetic product with probiotic cultures will cater to their need.

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