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NUTRITIONAL AND SENSORY PROFILE OF LOW FAT PREBIOTIC YOGHURT-FUNCTIONAL FOOD FORMULATED WITH INULIN AND FRUCTO-OLIGOSACCHARIDES

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ABSTRACT

A suitable protocol was developed for low fat prebiotic yoghurt with inclusion of standard starter cultures, and inulin/ Fructo –Oligo -Saccharides (FOS) as prebiotics. The nutritional composition, texture profile and sensory acceptability of Control Yoghurt (CY), Inulin prebiotic Yoghurt (IY) and FOS Prebiotic Yoghurt (FY) were studied. The nutritional profile of the products studied includes proximate and mineral composition, carbohydrate profile and *in vitro* calcium availability. The proximate principles analyzed were much higher in IY followed by FY and control samples. The carbohydrate profile determined included the total soluble sugars, reducing and non-reducing sugars. The prebiotic (which are fructose polymers) containing yoghurt exhibited a high sugar profile. The FY showed higher mineral profile of Ca, Mg and P followed by IY. *In vitro* calcium availability was found to be higher in yoghurt samples containing inulin. Both IY and FY recorded higher sensory acceptability scores than CY. These samples also exhibited better water holding capacity and lower whey syneresis. Consumer texture profile analysis further confirmed improvement in textural parameters in prebiotic containing yoghurt samples. Low fat prebiotic yoghurts developed is suitable for patients and elderly owing to its better digestibility and high nutrient availability, for boosting the immune system and is expected to produce beneficial clinical and systemic effects.

Key words: Yoghurt, Prebiotic, Inulin, Fructooligosaccharides, minerals, texture profile, sensory acceptability.

INTRODUCTION

Yoghurt is a fermented milk product produced by using thermophilic and lactic bacteria consisting of *Streptococcus thermophillus* and *Lactobacillus bulgaricus*. Yoghurt basically originated in Turkey and is widely used because of its nutritional, therapeutic and probiotic properties. The cultures produce lactic acid from lactose during fermentation reducing the pH of milk and cause milk protein to coagulate, thickening the product. From the nutritional point of view, milk and yoghurt are similar products. However, reports have confirmed that mineral availability especially, Ca, P, Mg and Zn to be improved in yoghurt over milk (Blanc, 1981; Balasubramanyam et al., 1984). Nutritional quality of proteins in fermented milk such as yoghurt has been reported to have higher *in vitro* digestibility (Breslaw and Kleyn, 1973) and higher biological value (Simhaee and Kesha-Varz, 1974).

Prebiotics are defined as non-digestible food ingredients that beneficially affect the host by selectively stimulating the growth and the activity of one or more limited number of beneficial bacteria in the colon and thus improve host health (Gibson and Roberfroid, 1995). Prebiotic substances such as inulin and Fructooligosaccharides/FOS have low calorific value making them suitable for addition in diabetic and low-caloric foods. These substances through physiologic effects similar to fiber improve intestinal function and blood lipid parameters. Hence, they could be used to fortify dairy products that are very low in dietary fibre. Further, these are known to impart smooth creamy texture, fat-like mouth feel and body to dairy products. FOS is also often used with high intensity sweeteners to replace sugar (Niness, 1999). Coudray et al., (1997) have reported that inulin increased calcium absorption and balance in humans.

Keeping in view the above points, the study aimed at the development of low-fat functional dairy foods in the form of prebiotic yoghurt and to study the effect of prebiotic addition on nutritional composition, texture profile, product quality and sensory acceptability.

MATERIALS AND METHODS

The milk product selected for the present study was ‘set yoghurt’. The product was prepared using double toned milk (Fat = 1.5%; SNF = 9%) obtained from the local dairy. The prebiotic substances – Fructo-oligosaccharide / Raftilose and Inulin / Raftiline (Orafti, Belgium) was procured through S.A. Pharmachemical Pvt.

Ltd., Mumbai. Sugar and skim milk powder (Sagar brand) were obtained in one lot from the local market.

PRODUCT FORMULATION DESIGN

Low-fat milk cultured with the yoghurt starter cultures – *S. thermophilus* and *L.bulgaricus* at 1% level each was treated as control (CY).

Prebiotic yoghurts were prepared by adding either inulin (IY) or fructooligosaccharides (FY) to the milk cultured with *S. thermophilus* (ST) and *L. bulgaricus* (LB). The range of prebiotic addition was based upon tolerance levels and the levels reported to show physiological effects. Doses of 4.5 g / d have been concluded to be enough to show efficient prebiotic effect (Gibson and Roberfroid, 1995). The tolerance levels for infants and adults at large have been found to be 9 to 10 g / d (Coussement, 1999). Considering the above facts inulin was added at 6%, and FOS at 7%, respectively, to the cultured milk (Table 1).

Table 1 Product formulation schedule

Code	Variation	Components*
1. CY	Control yoghurt	ST + LB (1% each)
Prebiotic Yoghurt 2. IY	Inulin Yoghurt	ST + LB (1% each) + Inulin (6%)
3. FY	Fructo-oligosaccharide (FOS) Yoghurt	ST + LB (1% each) + FOS (7%)

*4% sugar and 2.5% milk powder added to all variations.

PRODUCT PREPARATION PROTOCOL

Required quantity of low-fat milk was taken and boiled. Specified amounts of milk powder, sugar and/ a prebiotic was added according to the variation. The milk was then maintained at 85^{o}C for 15 min and cooled to 40 – 45^{o}C. It was then transferred to sterile containers and inoculated with the selected combination and the cultured samples were incubated at 37^{o}C for 14-16hrs and stored at 4 $\pm$ 2^{o}C (Fig-1). The effects of prebiotic addition to yoghurt were evaluated in terms of product quality, nutrient composition, texture profile and organoleptic acceptability.

Low fat milk (locally available)

↓

Adding specified amounts of milk powder, sugar and/ a prebiotic

↓

Boiling (85^{o} C for 15 min)

↓

Cooling (40 -45^{o} C)

↓

Transferring into sterile containers

↓

Inoculating as per combinations

↓

Cultured sample incubated at 37^{o}c for 14-16 hrs

↓

Stored at 4^{o}c

Fig 1 Product preparation protocol

PRODUCT QUALITY AND NUTRITIONAL EVALUATION

The pH, titrable acidity (Ranganna 1986), total yield, total solid content, whey syneresis and water holding capacity (WHC) (Kovalenko and Briggs, 2002) of the variations were determined. Moisture, crude fat, total ash, and total carbohydrates were estimated as per standard AOAC methods and total protein by biuret method (Reinhold, 1953). The products were analyzed for calcium (Hawk et al., 1975), phosphorus (Raghuramulu et al., 1983), magnesium (Ranganna, 1986), and *in vitro* Ca availability (Kim and Zemel, 1986). Total sugars and soluble sugars (Dubios et al., 1956) were also analyzed.

SENSORY ACCEPTABILITY

The sensory acceptability of yoghurt variations were evaluated in terms of appearance, flavor, taste, consistency and overall acceptability by panel members using a 9- point hedonic rating scale from 9 (extreme like) to 1(extreme dislike) (Ranganna,1986).

TEXTURE PROFILE ANALYSIS

Consumer Texture Profile Analysis (CTPA) (Bourne, 1982) was carried out using a score sheet for different yoghurt variations prepared. The panel members had to indicate in one of the six boxes along the side of each term, the degree to which the member feel the sample to have that particular characteristic. The scores of each characteristic were averaged for each of the product and a texture profile line graph was plotted by placing the terms describing the positive attributes on top and the negative attributes at the bottom. A line graph sloping from left to right towards the top indicated good acceptability of the product.

STATISTICAL ANALYSIS

Results are expressed as means of three independent trials with standard deviation. Experimental data were processed by one-way ANOVA using the Duncan's multiple range test (DMRT) by setting the statistical significance at 95% level.

RESULTS AND DISCUSSION

PRODUCT QUALITY CHARACTERISTICS

The various physico-chemical and other parameters determined to assess product quality are presented in table 2.

The level of acidity is determined for development of an optimum quality product in terms of flavor and keeping quality. The recommended values of pH and titrable acidity for yoghurt are from 3.5 to 4.5 and from 0.9 to 1.0 %, respectively (Rao and Dastur, 1955). The pH was found to be similar in all the variations (4.51 to 4.59). Similar effect was observed in acidity of yoghurt samples (0.84 to 0.9%).

The yoghurt samples prepared using inulin (IY) and fructo-oligosaccharides (FOS) showed higher product quality characteristics compared to control yoghurt (CY). In terms of total yield, a non significant marginal increase of 5% and 6.7% was observed in IY & FY compared to product yield (100.8gm/100 ml) in CY. However, the IY & FY samples showed 75% and 61% higher (p<0.05) total solids, compared to CY. This increase in total solids could be attributed to the significant reduction in the volume of whey syneresis from 25 ml in CY to 9.5 ml and 9.1 m in IY & FY samples, respectively. This observation was supported by the increased water holding capacity (WHC) recorded in IY (94%) and FY (93%) compared to 61% WHC in CY.

PROXIMATE COMPOSITION

The proximate principles analyzed are presented in table 3. Addition of prebiotics to yoghurt resulted in a significantly (at P<0.05) lower moisture content. The values of prebiotic yoghurts IY (0.76%) and FY (0.8%), respectively, were significantly (P<0.05) more than the control yoghurt (0.65%). Total ash content of 0.7% has been reported by Gupta et al., (1997) for normal yoghurt. The total lipid content of control yoghurt was determined to be 2.3%. This is closer to the value of 1.6% reported in low fat yoghurt by Tamine and Robinson (1985). In prebiotic yoghurts IY and FY the lipid content was significantly high and found to be 4.7 and 4.35% respectively.

The protein content of the fresh control yoghurt was determined as 3.95%. A significantly higher protein content of 9% and 10.1% in prebiotic yoghurt variations (FY and IY) were observed, respectively. It can be, thus, observed that all the content of the proximate principles analysed (total ash, protein and lipids) were much higher in variations containing the prebiotic substances. No information is available on the proximate composition of inulin / FOS added dairy products.

CARBOHYDRATE PROFILE

Addition of prebiotics to yoghurt samples showed higher levels of total soluble sugars, reducing sugars and non reducing sugars compared to control yoghurt sample as indicated in table 4. The higher values in prebiotic containing samples could be attributed to the addition of inulin / FOS, which are fructose polymers.

MINERAL COMPOSITION

Yoghurt, which is a dairy product, is an important source of minerals such as Ca, P and Mg. Effect of addition of prebiotics were analysed on these mineral content (Table 5). Addition of prebiotics to normal yoghurt resulted in higher levels of Ca in FY (308 mg %) and IY (276.5 mg %) compared to control yoghurt (123 mg %). These values were found to be closer to the values 120-140 mg) reported for normal yoghurt (Joshi & Pandey, 1999) and 150 mg % reported in low fat yoghurt (Tamine & Robinson, 1995). Addition of prebiotics to normal yoghurt also revealed higher levels of P in IY (154%) & FY (156 %) samples than CY (86.9%). The levels of P as reported by Joshi & Pandey (1999) ranged between 90 to 110 mg percent. With regard to magnesium, a lower value of 14.8mg% was recorded in IY compared to 16.4 mg % found in FY and CY.

IN VITRO CALCIUM AVAILABILITY

Calcium availability is reported to be higher in dairy products than other Ca sources. In the present investigation *in vitro* Ca availability was determined in the yoghurt variations (Table 5). Addition of prebiotics was found to further improve Ca availability in yoghurt sample. The values ranged from 28.6% in IY, 27.1% in FY to the least value of 26% in CY sample. This is in accordance with the values of 25-30% reported for dairy products (Miller, 1989: Nickell et al., 1996). Earlier investigations in humans have shown that inulin (Caudray et al., 1997) and FOS (Griffin et al., 2002) improve ca absorption.

Table 2: Product quality characteristics of yoghurt variations

Yoghurt Variations	pH	Titrable acidity % (in terms of lactic acid)	Yield (g/100ml) Milk	Total Solids (g %)	Quantity of Whey syneresis (ml)	WHC (%)
CY*	4.51	0.9	100.8 ± 3.8[a]	15.8 ± 1.10[a]	25 ± 0[b]	61 ± 2[b]
IY	4.59	0.84	105.3 ± 5.3[a] (↑5%)	27.7 ± 0.4[c] (↑75.3%)	9.5 ± 2[a] (↓62%)	94 ± 6[a] (↑54%)
FY	4.52	0.9	107.6 ± 5.6[a] (↑6.7%)	25.5 ± 1.4[b] (↑61.4%)	9.1 ± 2.2[a] (↓63.6%)	93 ± 1.6[a] (↑52%)

*CY – Control Yoghurt; IY – Inulin Yoghurt; FY – Fructooligosaccharide (FOS) Yoghurt

Values are Mean ± SD of 3 replicates; expressed on fresh weight basis. Mean not sharing a common superscript in a column differ significantly (P<0.05). Figures in parentheses denote per cent increase ↑ or decrease ↓ over the control.

Table 3: Proximate composition of yoghurt variations (gm/ 100 g)

Yoghurt variations	Moisture	Total ash	Total lipid	Protein
CY*	84.2 ± 1.1[c]	0.65 ± 0.01[ab]	2.3 ± 0.6[a]	3.95 ± 0.00[a]
IY	72.1 ± 0.3[a] (↓14.4%)	0.81 ± 0.04[c] (↑24.1%)	4.7 ± 1[a] (↑104.3%)	10.1 ± 0.15[b] (↑155%)
FY	74.5 ± 1.4[b] (↓11.6%)	0.76 ± 0.04[c] (↑16%)	4.35 ± 0.15[a] (↑89.1%)	9 ± 0.4[b] (↑127%)

* CY – Control Yoghurt; IY – Inulin Yoghurt; FY – Fructooligosaccharide (FOS) Yoghurt

Values are Mean ± SD of 3 replicates; expressed on fresh weight basis. Means not sharing a common superscript in a column differ significantly (P<0.05). Figures in parentheses denote per cent increase ↑ or decrease ↓ over the control.

Table 4: Carbohydrate profile of yoghurt variations (gm / 100 g)

Yoghurt variations	Total sugars	Reducing sugars	Non-reducing sugars
CY*	6.1 ± 0.1[a]	3.8 ± 0.6[ab]	2.3 ± 0.6[a]
IY	9.7 + 1.2[b] (↑ 59%)	4.5 + 0.1[b] (↑18.42%)	5.2 ± 1.1[b] (↑126.0%)
FY	10.0 ± 0.2[b] (↑63.9)	4.6 ± 0.1[b] (↑21.05%)	5.4 ± 0.1[b] (↑134.8%)

* CY – Control Yoghurt; IY – Inulin Yoghurt; FY – Fructooligosaccharide (FOS) Yoghurt
Values are Mean ± SD of 3 replicates; expressed on fresh weight basis. Means not sharing a common superscript in a column differ significantly (P<0.05). Figures in parentheses denote per cent increase ↑ or decrease ↓ over the control.

Table 5: Mineral composition of yoghurt variation (mg / 100 g)

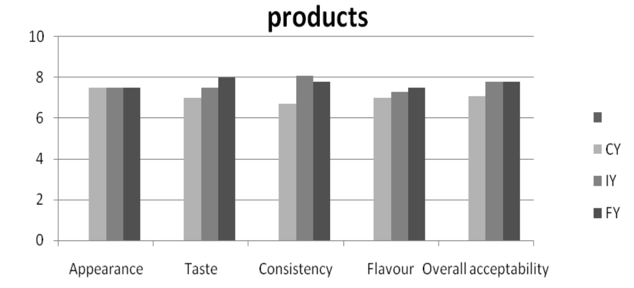
Yoghurt variation	Calcium	Phosphorous	Magnesium	*In vitro* calcium availability (%)
CY*	123 ± 3.7[a]	86.9 ± 4.7[a]	16.4 ± 2[b]	26.9
IY	276 ± 11.7[b] (↑124%)	154.5 ± 11.9[b] (↑77.8%)	14.8 ± 0.45[a] (↓10.2%)	28.6
FY	308 ± 13.0[c] (↑150%)	156.4 ± 2.4[b] (↑80%)	16.4 ± 2.25[b] (↓0.00%)	27.1

*CY – Control Yoghurt; IY – Inulin Yoghurt; FY – Fructooligosaccharide (FOS) Yoghurt
Values are Mean ± SD of 3 replicates; expressed on fresh weight basis. Mean not sharing a common superscript in a column differ significantly (P<0.05). Figures in parentheses denotes per cent increase ↑ or decrease ↓ over the control

ORGANOLEPTIC EVALUATION

Organoleptic evaluation (Fig 2) of the yoghurt samples indicated similar acceptability scores for appearance (7.5). The yoghurt sample with FOS recorded the highest score of 8 for taste followed by IY (7.5) and CY (7) samples. FOS is known to contribute to some sweetness as it is 30-60% as sweet as sucrose (Wiedmann and Jager, 1997). The consistency score was significantly higher in IY (8.1) and FY (7.8) samples compared to CY (6.7). The prebiotics used in the present study are also reported to contribute body to dairy foods (Wiedmann and Jager, 1997). The flavor scores were also slightly higher compared to control though not significant. Overall acceptability was greater in the prebiotic yoghurt samples (7.8) compared to control (7.1).

Fig 2 Organoleptic acceptability of yoghurt products



TEXTURE PROFILE ANALYSIS

Texture is an important sensory attribute of dairy products like yoghurt. A consumer texture profile analysis score sheet (6 point scale) was therefore developed for 'set yoghurt' based the commonly used texture descriptions for yoghurt like mouthfeel, lumpiness to smoothness, curdiness, thickness-thinness etc. A line graph was plotted based on mean values obtained for the various parameters studied (Fig-3). The texture profile indicated similarity between IY and FY. Prebiotic yoghurts were better in terms of smoothness, thickness, curdiness, gumminess and showed lower degree of thinness and lumpiness. The better texture profile of yoghurts prepared using the prebiotics could be attributed to their water binding capacity, their ability to contribute to body of dairy products and to their ability to act as fat replacers (Coussement, 1999).

CONCLUSION

The results of the study, thus, indicated that addition of prebiotics to normal yoghurt improved product characteristics, nutritional profile, texture profile and organoleptic acceptability, significantly. The investigation thus, resulted in the development of low-fat prebiotic yoghurt with improved functionality and enhanced therapeutic potential. These dairy products would be suitable for infants and elderly owing to better digestibility and higher nutrient availability. They could also serve as dietary supplements for boosting the immune system and could aid in effecting beneficial clinical and systemic effects. Addition of prebiotics has been also reported to improve the viability of probiotic bacteria in the human intestine and on ingestion are known to exhibit many beneficial effects in the body.

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