J. Agr. Sci. Tech. (2017) Vol. 19: 1241-1252

Effect of Inulin, Oligofructose and Oligofructose-Enriched Inulin on Physicochemical, Staling, and Sensory Properties of Prebiotic Cake

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ABSTRACT

A major challenge currently facing the food industry is the need for increased nutritional value in foods. A feasible and nutritional method to achieve this aim in bakery products is the addition of prebiotics which makes possible the sale of more nutritional food with equal sensory features. The main aim of the present study was to assess the effects of oligofructose, inulin and oligofructose-enriched inulin on the features of prebiotic cake. In the control sample, the highest symmetry and volume was observed, along with the lowest apparent density and specific gravity. The crumb was observed to become less yellowish and more reddish when fructans were added, except during the addition of 2.5% oligofructose-enriched inulin. In the storage period of the product, the control sample had the highest hardness and least moisture. Samples with 2.5% inulin/oligofructose and 10% oligofructose/inulin demonstrated an increased level of protein, total fiber, and ash, respectively. The highest and the lowest scores in terms of sensory evaluation of the cakes (one day post-baking) were attained by the 2.5% oligofructose/inulin and 10% inulin, respectively.

Keywords: Dietary fibre, Fructans, Nutritional value, Prebiotic cake, Sensory evaluation.

INTRODUCTION

In the current era, demand for healthier food products with outstanding sensory features is rising (Ang, 2001). One of the ways in which a healthy product can be produced is by supplementing certain fiber and prebiotic ingredients. Prebiotics are defined as ‘‘selectively fermented ingredients that allow specific changes, both in the composition and/or activity in the gastrointestinal microbiota that confers benefits upon host well-being and health” (Gibson *et al*., 2004). Inulin-type fructans have a special function in increasing the level of Lactobacillus and bifidobacterium (Kolida and Gibson, 2007). They form *D*-fructose units which have β (1→2) linkages. This component can be found in various foods including celery, garlic, onions, wheat, chicory, soybeans, asparagus, artichokes and Jerusalem artichokes. In accordance with their Degree of Polymerization (DP), these prebiotics are divided into oligofructose (DP< 10), oligofructose-enriched Inulin and inulin (DP= 10-65) (Roberfroid, 2007). The daily prebiotic dosage of inulin is 5-8 grams (Kolida and Gibson, 2007). The variation in structure between inulin and oligofructose gives them different applications. Through small crystallites, inulin shapes into gels. It is not sensed as being sweet (10% sweetness relative to sugar) and can be used as a replacement of fat. Fructo-oligosaccharides are sweeter (35% sweetness relative to sugar) and more soluble, often being used as sugar replacements in

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foods (Niness, 1999). Functional foods, particularly bakery products, have had more and more usage of inulin and oligofructose within them as a method of increasing moisture content, supplementing fiber and substituting sugar (Franck, 2002; Wang, 2009). It has been recorded in previous studies that prebiotics have the ability of improving the flavor, such as vanilla flavor, lemon flavor, and citrus aroma in different foods (Arcia *et al*., 2011; Tárrega *et al*., 2010). Sponge cake, as a bakery product, has a shelf life of around four weeks and includes 15-25% fat. Major problems observed in this product are its lack of fiber, staling, and moisture retaining in the cake flour. These cause irreversible changes in the product quality in terms of its properties and reduce its shelf life (Matsakidou *et al*., 2010). Baking on gravels and higher baking temperature decreased the staling kinetic (Izadi Najafabadi *et al*., 2015). Being hydrocolloids of dietary fiber, inulin-type fructans can also delay staling and raise the amount of fiber in the functional product in addition to their role as prebiotics. Some studies have been observed in which inulin-type fructans have been added to cakes (Moscatto *et al*., 2006; Ronda *et al*., 2005). Volpini-Rapina *et al*. (2012) evaluated the sensory properties of produced cakes after adding inulin and oligofructose/inulin, and assessed the stickiness, hardness, dough beigeness and crust brownness (Volpini-Rapina *et al*., 2012). Other research has demonstrated that adding prebiotics to cake lessens hardness and cohesiveness (Moscatto *et al*., 2006), increasing firmness and decreasing acceptability of sponge cakes (Ronda *et al*., 2005). No study has evaluated the effect of inulin-type fructans in different percentages on sensory acceptability, staling, chemical value and physical qualities of prebiotic cake. The main aim of the present study was to assess the effects of oligofructose, inulin and oligofructose-enriched inulin on the features of prebiotic cake.

MATERIALS AND METHODS

Wheat flour, refined sugar, semi-solid oil, baking powder, vanilla, whey powder, milk powder and fresh whole eggs were purchased from the local market. Inulin and oligofructose were provided by Pyson Company (China). The properties of used flour for the sponge cakes are shown in Table 1.

Cake Preparation

Formulations used for the sponge cakes are given in Table 2. To get functional food, inulin, oligofructose and oligofructose/inulin were added to the formulation. A control cake, without prebiotics, was also baked. The cakes were prepared under equal equipment and conditions (1,500 g cake butter). After that, 40 g of cake batter were placed into a 4×5×8 centimeter of metallic, lard-coated pan, and baked for 20-25 minutes at 180-190˚C. Then, cakes were packaged in polyethylene with heat sealing packaging and kept at room temperature (25˚C) until the next analysis.

Physicochemical Evaluation

Based on the number of AACC standard (2000), the moisture (44-15), protein (46-13), wet gluten (38-11), symmetry (10-91) and ash (08-01) were measured. In accordance with AACC (2000) and with the modifications suggested by Lee *et al*. (1995), the total dietary fiber content of produced cake was calculated. Specific gravity was evaluated by dividing the weight of a standard measure of the batter by the weight of an equal volume of water. The cake volume through seed displacement was

Table 1. Flour characteristics based on the dry weight.

Feature [a]	Percent
Moisture	11.86 ± 0.63
Protein	11.41 ± 0.03
Wet gluten	23.6 ± 0.88
Ash	0.445 ± 0.03
Zeleny sedimentation	24 ± 0.54

[a] (Mean data±SD).

Table 2. The formulations used for prebiotic cakes.

Ingredient	Gram based on the weight of the cake batter	Method
Oil Refined sugar	263 330	The creaming was done to produce light colour cake batter. (In about 10 minutes)
Eggs	330	Was added in 4-5 section.
Flour	425.6	Powder ingredients Sift together and add to make the dough become semi-smooth
Baking powder	7.5	
Milk powder	9.2	
Vanilla	2.3	
Whey powder	18.4	
Fructans	-	
Water	114	After adding water, the dough was smooth

determined (Lin *et al*., 2003). The ratio of the weight to volume is known as the apparent density (Kocer *et al*., 2006). The cakes were sliced and placed into a box in order to evaluate factors such as their redness (a> 0) or greenness (a< 0), yellowness (b) and brightness (L). A camera (14.5 megapixels) was used to take crumb images. The photos were evaluated using an image processing software (model 6) (Sun, 2008). Using the proposed reform method of Hess *et al*. (1983) and a texture analyzer (Instron, Model 1140, UK), the texture of the cakes was evaluated after the removal of crust from the samples. The force needed for 40% compression was documented under the following conditions: 50 mm min^{-1} probe speed, 1 inch sample thickness, and 5-50 N of force exerted by the load cell device. According to F_{max}, the maximum compressive force exerted on the sample was reported.

Sensory Evaluation

Using a verbal hedonic scale featuring five points (1: Disliked extremely, 5: Liked extremely) according to the AACC (2000) method 10-90 with modifications by Ronda *et al*. (2005), the acceptability of the softness and hardness, porosity, color of crust and crumb, flavor, and the dry or doughy cake texture during chewing were evaluated. The effect of time on the texture and quality of samples was determined by a total of 10 consumers who were chosen amongst the university professors, students and staff, each of whom evaluated 10 samples at 1, 7, and 14 days post baking. In separate booths and under white light, sensory analysis was performed at a temperature of 22˚C. The cakes were placed into plastic packages which had hypothetical codes. The following equation was used to calculate the final score:

Final score= Total experience/Total coefficients

Statistical Analysis

A one-way analysis of variance was conducted by processing the data with the Minitab Analysis System, and the existence of significant differences (P< 0.05) between mean values was tested for by using Šidák's multiple range test. All processes were repeated three times.

RESULTS AND DISCUSSION

Specific Gravity

Specific gravity of batter was always higher when inulin-type fructans were added (Figure 1). Although the differences were not significant (P< 0.05) between samples

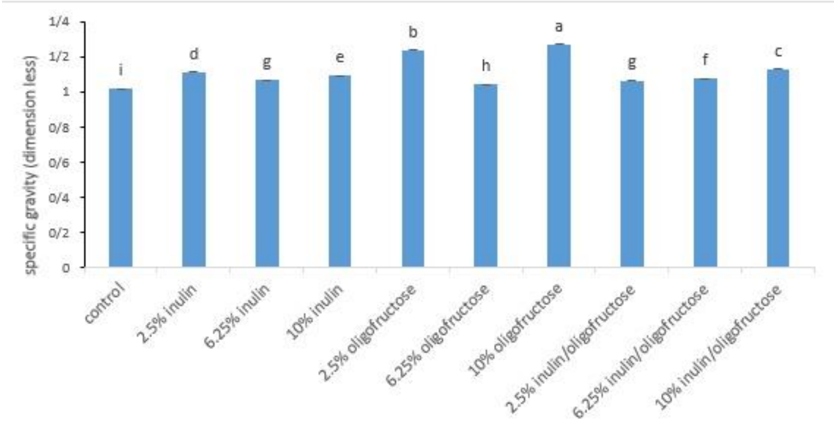

Figure 1. Effects of prebiotics on specific gravities of cake batters.

including 6.25% inulin and 2.5% oligofructose-enriched inulin. Specific gravity of the batter is negatively affected by the air bubbles introduced into the batter during mixing (Baeva *et al*., 2000). Therefore, this increase in specific gravities can be directly related to the decrease in the air volume incorporated into the batter. The trapped air in the batter is the determining factor, since it is related to the final volume and texture of the cakes (Campbell and Mougeot, 1999).

Physical Evaluations of Prebiotic Cake

Physical characteristics of cakes containing different levels of inulin-type fructans are shown in Table 3. Results indicated that the cake volume decreased when each of prebiotic percentages increased to a maximum level (10%). In general, control sample had the maximum volume and the decrease in volume of prebiotic cakes caused by fructans. The results obtained were in agreement with those of other authors (Meyer and Peters, 2009). Additionally, as oligofructose is a substitute for sugar, a significant decrease in the specific volume of the cake was seen in comparison with the control which contained sugar (Ronda *et al*., 2005). In another research, a significant fall in bread volume was exemplified when 6 or 10% inulin was added as a fat substitute (Brasil *et al*., 2011). The control sample had the

Table 3. Physical properties of cakes batter and cake manufactured with and without (control) prebiotics.[a]

Treatment	Physical properties		
	Volume (cm^3)	Apparent density($g\ cm^{-3}$)	Symmetry (cm)
Control	88.67 ± 2.96^{a}	0.3950 ± 0.0136^{c}	11.667 ± 0.882^{a}
2.5% Inulin	80 ± 3.21^{abc}	0.43433 ± 0.00689^{bc}	10 ± 1^{ab}
6.25% Inulin	77.67 ± 3.48^{abc}	0.43500 ± 0.00950^{bc}	7 ± 1^{abc}
10% Inulin	61.67 ± 1.45^{d}	0.5227 ± 0.0115^{a}	4 ± 0.577^{c}
2.5% Oligofructose	83.67 ± 2.03^{ab}	0.40933 ± 0.00338^{c}	8 ± 0.557^{abc}
6.25% Oligofructose	83.33 ± 1.45^{ab}	0.40500 ± 0.00889^{c}	10 ± 1^{ab}
10% Oligofructose	71.00 ± 2.65^{bcd}	0.40800 ± 0.00777^{c}	4.667 ± 0.882^{bc}
2.5% Inulin/Oligofructose	87.33 ± 1.45^{a}	0.40167 ± 0.00145^{c}	9 ± 1^{abc}
6.25% Inulin/Oligofructose	82.00 ± 3.51^{ab}	0.41167 ± 0.00867^{c}	5.33 ± 1.2^{bc}
10% Inulin/Oligofructose	68.667 ± 0.333^{cd}	0.46600 ± 0.00173^{b}	4 ± 1.73^{c}

[a] Values are the average of triplicates±standard deviation. For each characteristic, data followed by different letters are significantly ($P< 0.05$) different.

largest volume and least specific gravity due to the inverse relationship between volume and specific gravity (DesRochers *et al*., 2004). Gas is allowed to be retained by the reduction in the rate of gas diffusion which results from increased batter specific gravity, which is descriptive of the effect of inulin-type fructans on cake volumes. The presence of hydroxyl groups within the inulin fiber structure caused increased water absorption with the addition of inulin (Silva, 1996). The amount of trapped air in the batter and cake volume can be decreased if specific gravity is increased.

Apparent density of cake was always higher when fructans were added. The differences were significant ($P< 0.05$) in the presence of 10% inulin compared to other samples. The highest apparent density value was that of cakes with 10% addition of inulin. Control sample had the lowest values of that quality (0.3950), although it had only significant differences ($P< 0.05$) with the samples including 10% inulin and 10% oligofructose-enriched Inulin. Ayoubi *et al*. (2008) showed that the addition of other hydrocolloids on the cake significantly reduced the sample apparent density.

The evaluations regarding symmetry indicted that the addition of different percentage of prebiotics significantly ($P< 0.05$) decreased cake symmetry. A reduction in cake symmetry from 11.667 cm to 4 cm was observed when flour was supplemented with 10% inulin and 10% inulin/oligofructose. Symmetry in the cake could mainly be due to good dispersion of the cake ingredients (baking powder) during the preparation of the batter, and also due to the regular and uniform distribution of air bubbles, which cause the dispersal of the gas achieved from improvers. Although, previous research suggests that hydrocolloids increase the number of holes in cakes and uniforms them. As a result, hydrocolloids could increase the symmetry of the cake. Gomez *et al.* (2007) measured the effect of different hydrocolloids on the characteristics of the cake and reported that the addition of xanthan and locust bean gums on the cake samples increased symmetry, but guar reduced the symmetry. Samples containing pectin had the same symmetry as the control sample. It was demonstrated by Ronda *et al*. (2005) that fructans had no effect on crust uniformity. However, the appearance uniformity of sponge cake was enhanced when adding oligofructose in comparison to cake with sucrose.

Color Properties of Sponge Cake

As can be observed by adding fructans, color became darker (lower L-values), more reddish (higher a-values), and less yellowish (lower b-values), except when 2.5% oligofructose-enriched inulin was added (Table 4). However, in the case of both factors (L* and a*), samples had no significant differences ($P< 0.05$), while the sample containing 10% oligofructose had significant differences ($P< 0.05$) compared to the control and the lowest b-value was related to this sample. The changes in color could be attributed to the Maillard reaction in which a larger number of reducing ends are involved. Due to having lower molecular weight fructans, shorter chain inulins are efficient in darkening color (Peressini and Sensidoni, 2009). Inulin increases the speed of baking as pointed out by Poinot *et al*. (2010) who analyzed the volatiles produced during baking, in addition to color. Generally, the Maillard reaction is increased by fibers (inulin and oligofructose) through decreasing moisture absorption and pH (can act as a buffer) (Gomez *et al*., 2010). In bread with 3-10% inulin, darker colors were reported (Poinot *et al*., 2010). When applying oligosaccharides in the production of sugar-free sponge cakes, Ronda *et al*. (2005) found that the cake was darker than the control. In samples which had sensory acceptability when using inulin as a substitute for fat and sugar, no significant difference in color was observed (Rodríguez-García *et al*., 2014). Relative to the standard cake, dough beigeness and crust

Table 4. Colour characteristics of cakes containing different levels of prebiotics.[a]

Treatment	Colour factor *L**	*a**	*b**
Control	68.25±1.436[a]	-4.5±1.258[a]	46.75±1.601[ab]
2.5% Inulin	62.25±2.462[a]	-1.5±1.555[a]	42.75±1.931[abc]
6.25% Inulin	65±1.08[a]	-1.5±1.443[a]	37.25±0.854[bc]
10% Inulin	66±1.958[a]	0.25±1.493[a]	44±2.582[abc]
2.5% Oligofructose	67.25±2.78[a]	0.5±1.848[a]	43.25±3.198[abc]
6.25% Oligofructose	66.25±1.652[a]	2.25±0.946[a]	43±1.291[abc]
10% Oligofructose	68.25±1.652[a]	0.00±1.225[a]	35.5±2.217[c]
2.5% Inulin/Oligofructose	63.75±2.394[a]	2.25±1.315[a]	49.5±3.227[a]
6.25% Inulin/Oligofructose	65±2.799[a]	0.00±1.472[a]	42.5±0.957[abc]
10% Inulin/Oligofructose	61±1.291[a]	2±1.826[a]	40.25±1.652[abc]

[a] Values are the average of triplicates±standard deviation. For each characteristic, data followed by different letters are significantly ($P < 0.05$) different.

brownness of cakes were enhanced when adding prebiotics (Volpini-Rapina *et al*., 2012).

Effect of Prebiotics on Water Retention during and after Baking

Moisture analysis of the sponge cakes (Figure 2) showed that on the first day after baking, the lowest moisture content was observed in the sample including 2.5% inulin that was significantly different ($P < 0.05$) in comparison with samples including 6.25 and 10% inulin. Whereas on the seven and fourteen days after baking, control sample had the lowest moisture. Karolini-Skaradzińska *et al*. (2007) found that the capability to absorb water reduced to 4% after the addition of inulin, with a matching result being documented by Peressini and Sensidoni (2009). Inulin generates a barrier around starch grains and thus limits water fixation, which may explain the decrease in moisture amount (Tudorica *et al*., 2002). Hence, the stickiness of the cake increased after the addition of fructans, probably due to the uptake of water by inulin during baking (Ronkart *et al*., 2009).

Influence of Prebiotics on Cake Texture

On the first day after baking, the softer textures were observed in the sample including 6.25% oligofructose-enriched

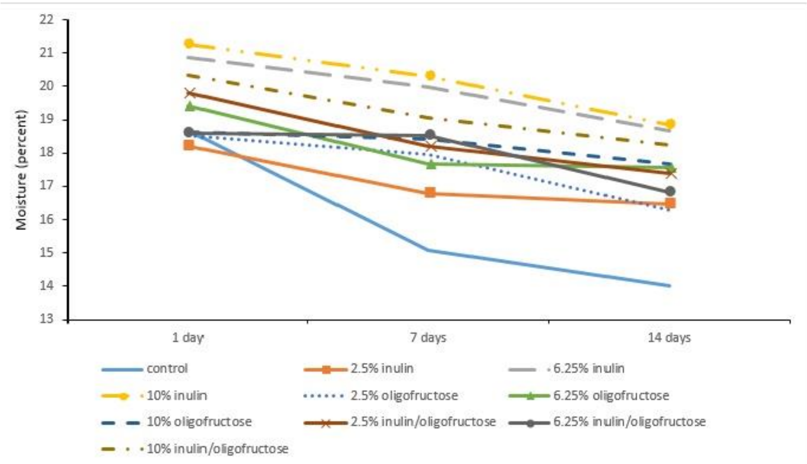

Figure 2. Effect of inulin-type fructans used on moisture of prebiotic cake and its evolution 1, 7, and 14 days after baking.

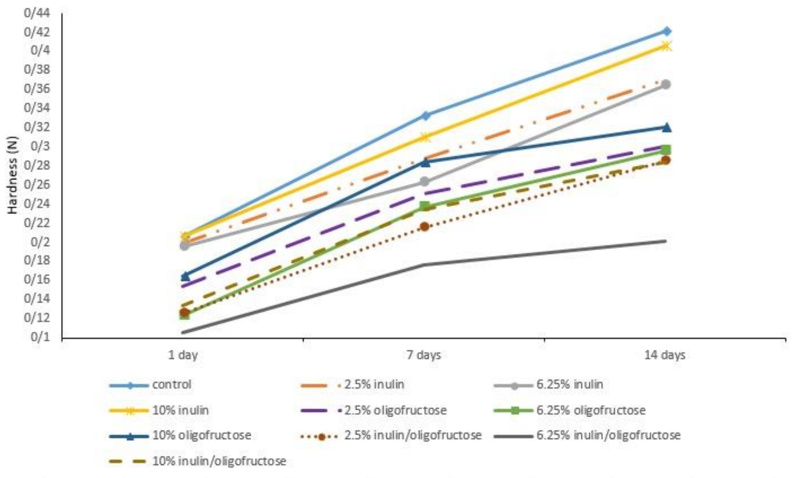

Figure 3. Effect of inulin-type fructans used on firmness of prebiotic cake and its evolution 1, 7, and 14 days after baking.

inulin that had no significant differences with the samples including 6.25% oligofructose, 2.5, and 10% oligofructose-enriched inulin (Figure 3). On the seven and fourteen days after baking, sample with 6.25% inulin/oligofructose had the lowest hardness, while the highest hardness was detected in the control sample. By and large, softer textures were recorded in cakes with oligofructose compared with those containing inulin. Evaluation of hardness in the time of storage demonstrated that the various percentages of fructans tested had diverse and essential effects on the shelf life of the cake. Figure 3 demonstrates the immense effect of fructans in increasing the time taken for cake hardening within the period studied. Nevertheless, a notable increase in hardness was observed at day fourteen. The different percentages of fructans tested featured different water binding capacities (related to water loss facilities during storage) and the resulting interaction influences starch retrogradation, explaining the aforementioned effect on hardness. The addition of inulin to bread has been reported to increase hardness by Wang *et al.* (2002) and Poinot *et al*. (2010). The texture of baked goods can be hindered by fructans. In comparison to cake with sucrose, oligofructose was reported to increase sponge cake firmness (Ronda *et al*., 2005). The increased hardness of prebiotic cakes may be due to the lower size of bubbles within the dough as less air is incorporated into the dough while baking (Ronkart *et al*., 2009).

Chemical Evolution of Prebiotics Cake

Table 5 summarizes the chemical composition of cakes enriched with different levels of prebiotics. The results showed that the sample containing 5% oligofructose with 5% inulin had the highest value of ash. The lowest value of ash was related to the control sample. The highest cake protein was 7.31% and was obtained at 2.5% inulin with oligofructose, while the lowest protein value was 6.11% and belonged to sample with 10% inulin. Pasta protein value has been reported to decrease significantly when up to 10% inulin was added in a study by Fuad and Prabhasankar (2010). A similar result has been reported by Afshin-pajuheh *et al*. (2011), who documented an 8% reduction in protein content when up to 5% inulin was added to pasta, in addition to a reduction in ash content. However, the differences observed between these values were not significant ($P< 0.05$).

The sample which incorporated 5% oligofructose and 5% inulin had the maximum cake fiber content (12.300%), whereas the control sample featured the

Table 5. Chemical properties of cakes manufactured with and without (control) prebiotics. [a]

Treatment	Nutritional properties of sponge cakes		
	Ash	Total fibre	Protein
Control	0.760±0.050^{g}	1.601±0.070^{i}	7.101±0.050^{ab}
2.5% Inulin	0.800 ±0.006^{f}	4.660±0.080^{h}	6.990±0.141^{abc}
6.25% Inulin	0.901±0.060^{e}	6.430±0.020^{fg}	7.036±0.040^{abc}
10% Inulin	1.099±0.065^{bc}	9.501±0.011^{c}	6.111±0.026^{d}
2.5% Oligofructose	0.901±0.055^{e}	6.730±0.010^{f}	6.928±0.010^{abc}
6.25% Oligofructose	1.001±0.026^{c}	7.660±0.100^{e}	7.151±0.007^{ab}
10% Oligofructose	1.201±0.025^{ab}	10.230±0.020^{b}	6.621±0.125^{bcd}
2.5% Inulin/Oligofructose	0.931±0.090^{d}	9.201±0.015^{dc}	7.310±0.100^{a}
6.25% Inulin/Oligofructose	1.101±0.034^{b}	11.801±0.005^{ab}	7.101±0.070^{ab}
10% Inulin/Oligofructose	1.360±0.003^{a}	12.300±0.060^{a}	6.511±0.034^{cd}

[a] Values are the average of triplicates±standard deviation. For each characteristic, data followed by different letters are significantly (P< 0.05) different.

minimum fiber value (1.601%). Throughout the world, due to being a soluble fiber, fructans are incorporated in foods in order to add fiber (Wang *et al.*, 2002). The incorporation of inulin in foods has effects in calcium absorption, along with its promotion of the growth of healthy bacteria within the colon (Staffolo *et al*., 2004).

Sensory Evaluation

The lowest score for cake softness/hardness, dry/doughy, crumb color and flavor was achieved by the sample with 10% inulin, with the highest scores being given to the samples 2.5% oligofructose/inulin (Figure 4). Regarding the porosity, crust and crumb color of the 10% oligofructose and 2.5% oligofructose/inulin samples received the lowest and highest scores, respectively. Brasil *et al*. (2011) reported adding 6% inulin as fat replacer did not significantly affect any of the sensory attributes, while a 10% addition resulted in significantly altered volume, crust color, crumb porosity and texture. It has been reported by Volpini-Rapina *et al*. (2012) that compared to the standard cake, cakes with inulin and oligofructose/inulin were stickier, crumbier and harder. Additionally, dough beigeness and crust brownness were enhanced when adding prebiotics. The Maillard reaction may be favored due to the structure of fructans, which may explain the browning of the crust and dough. Namely, fructans are polymers of fructose, a reducing sugar (Damodaran *et al.*, 2008), connected by linear or branched β (2→1) or *β* (2→6) linkages (Carabin and Flamm, 1999). Significant differences relative to the control sample were found regarding overall acceptability at one day post-baking (Table 6) in samples with 10% oligofructose, 10% inulin, and 2.5% oligofructose/inulin. It has been indicated by Volpini-Rapina *et al*. (2012) that the acceptability of prebiotic cakes and commercial cakes are lower than that of the standard cake. During storage, at 7 and 14 days post-baking, overall acceptability, flavor, softness/hardness, and chewiness were evaluated. The minimum and maximum scores for overall acceptability at 7 and 14 days post-baking were recorded for the 10% inulin and 2.5% oligofructose/inulin samples, respectively. It has been documented by Dutcosky *et al*. (2006) that, besides their effect on chewiness and cinnamon odour, oligofructose and inulin are influential upon brightness, sweetness, hardness, chewiness, crunchiness, and dryness.

CONCLUSIONS

In this study, the formulation of prebiotic cake was achieved. The incorporation of fructans in sponge cake can decrease volume

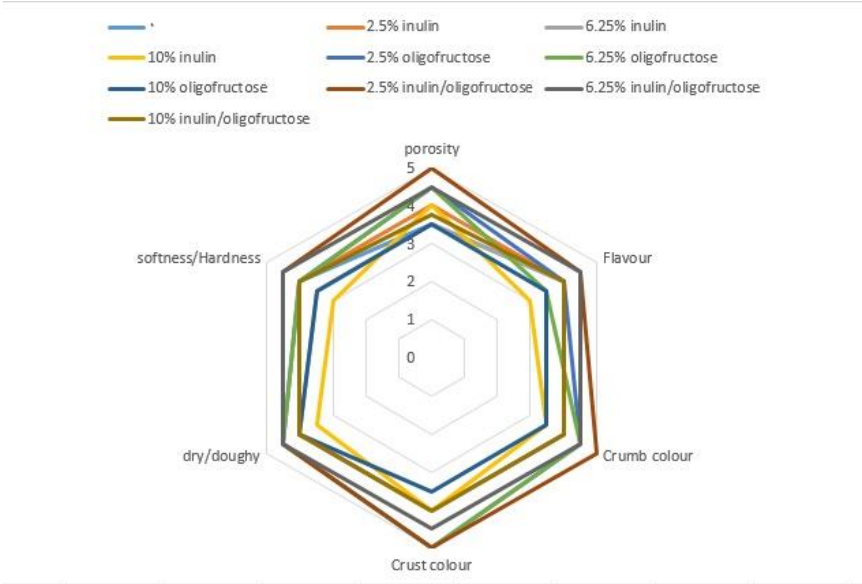

Figure 4. Spider-graph for the sensory profile of prebiotic cakes.

Table 6. Overall acceptability of sponge cakes containing different levels of prebiotic during storage.[a]

Prebiotic levels (%)	Time (Day) 1	7	14
Control	3.956±0.121^{bcde}	3.750±0.125^{bcd}	3.190±0.233^{cd}
2.5% Inulin	4.008±0.293^{bcd}	3.792±0.191^{abcd}	3.333±0.289^{bcd}
6.25% Inulin	3.875±0.261^{cde}	3.583±0.072^{cde}	3.041±0.072^{cd}
10% Inulin	3.400±0.163^{e}	3.125±0.125^{e}	2.733±0.275^{d}
2.5% Oligofructose	4.325±0.086^{abc}	4.208±0.315^{ab}	3.525±0.090^{abc}
6.25% Oligofructose	4.275±0.129^{abc}	4.042±0.260^{abc}	3.358±0.204^{bcd}
10% Oligofructose	3.623±0.258^{de}	3.250±0.125^{de}	2.733±0.287^{d}
2.5% Oligofructose/Inulin	4.666±0.087^{a}	4.358±0.204^{a}	4.167±0.289^{a}
6.25% Oligofructose/Inulin	4.541±0.028^{ab}	4.316±0.170^{ab}	3.996±9.125^{ab}
10% Oligofructose/Inulin	3.983±0.275^{bcde}	3.458±0.191^{cde}	3.207±0.261^{cd}

[a] Values are the average of triplicates±standard deviation. For each characteristic, data followed by different letters are significantly (P< 0.05) different.

and symmetry, but increase softness, retention of moisture, apparent density, and specific gravity. Some undesirable effects such as additional darkness were also observed. The sample containing 10% oligofructose/inulin had the highest value of ash and total fiber. The highest cake protein was obtained at 2.5% inulin with oligofructose. The highest and lowest scores in terms of sensory evaluation of the cakes (one day post-baking) were obtained by the 2.5% oligofructose/inulin and 10% inulin, respectively. No greater than 6.25% prebiotic content is recommended when incorporating each of inulin and oligofructose separately in sponge cake. Overall, the greatest improvement in the characteristics of the produced cake was at 2.5% fructans incorporation.

ACKNOWLEDGEMENTS

This paper Supported by the Research Vice-Chancellor of Tabriz University of Medical Sciences, Tabriz, Iran.

REFERENCES

1. AACC. 2000. *Approved Method of the AACC*. American Association of Cereal Chemistry, St. Paul, MN.
2. Afshin-pajuheh, R., Saeedi, M. R. Abdollahzadeh, A., Enayati, A., Amini, M. and Yaghoubi, A. 2011. The Effect of Inulin Addition on Rheological Characteristics of Pasta Dough. *Innov. Food Sci. Technol.,* **3:** 15-27. (in Persian)
3. Ang, J. F. 2001. Powdered Cellulose and Development of New Generation Healthier Foods. *Cereal Food World,* **46:** 107.
4. Arcia, P. L., Costell, E. and Tárrega, A. 2011. Inulin Blend as Prebiotic and Fat Replacer in Dairy Desserts: Optimization by Response Surface Methodology. *J. Dairy Sci.,* **94:** 2192-2200.
5. Ayoubi, A., Najafi, M. and Karimi, M. 2008. The Effects of Adding Whey Protein Concentrates (WPC) and Guar and Xanthan Gums on Quality and Physicochemical Properties of Cake. *Iran. Food Sci. Technol. Res. J.,* **4:** 33-46. (in Persian)
6. Baeva M. R., Panchev, I. N. and Terzieva, V. V. 2000. Comparative Study of Texture of Normal and Energy Reduced Sponge Cakes. *Die Nahrung,* **44:** 242-246.
7. Brasil, J. A., da Silveira, K. C., Salgado, S. M., Souza Livera, A. V., de Faro, Z. P. and Guerra, N. B. 2011. Effect of the Addition of Inulin on the Nutritional, Physical and Sensory Parameters of Bread. *Brazil. J. Pharm. Sci.,* **47:** 185-191.
8. Campbell, G. M. and Mougeot, E. 1999. Creation and Characterization of Aerated Food Products. *Trend. Food Sci. Technol.*, **10:** 283-296.
9. Carabin, I. G. and Flamm, W. G. 1999. Evaluation of Safety of Inulin and Oligofructose as Dietary Fiber. *Regul. Toxicol. Pharm.,* **30:** 268-282.
10. Damodaran, S., Parkin, K. L. and Fennema, O. R. 2008. *Fennemás Food Chemistry*. 4th Edition, CRC Press, Boca Raton.
11. DesRochers, J. L., Seitz, K. D., Walker, C.E., Wrigley, C. and Colin, W. 2004. *Cakes: Chemistry of Manufacture*. Encyclopedia of Grain Science, Elsevier, PP. 129-133.
12. Dutcosky, S. D., Grossmann, M. V. E., Silva, R. S. S. F. and Welsch, A. K. 2006. Combined Sensory Optimization of a Prebiotic Cereal Product Using Multicomponent Mixture Experiments. *Food Chem.,* **98:** 630-638.
13. Franck, A. 2002. Technological Functionality of Inulin and Oligofructose. *Br. J. Nutr.,* **87:** S287-S291.
14. Fuad, T. and Prabhasankar, P. 2010. Role of Ingredients in Pasta Product Quality: A Review on Recent Development. *Crit. Rev. Food Sci. Nutr.,* **50:** 787-798.
15. Gibson, G. R., Probert, H. M., Van Loo, J., Rastall, R. A. and Roberfroid, M. B. 2004. Dietary Modulation of the Human Colonic Microbiota: Updating the Concept of Prebiotics. *Nutr. Res. Rev.,* **17:** 259-275.
16. Gomez, M., Moraleja, A., Oliete, B., Ruiz, E. and Caballero, P. A. 2010. Effect of Fiber Size on the Quality of Fiber Enriched Layer Cakes. *LWT - Food Sci. Technol.,* **43:** 33-38.
17. Gomez, M., Ronda, F., Caballero, P. A., Blanco, C. A. and Rosell, C. M. 2007. Functionality of Different Hydrocolloids on the Quality and Shelf-Life of Yellow Layer Cakes. *Food Hydrocoll.,* **21:** 167-173.
18. Hess, A. and Setser, C. S. 1983. Alternative Systems for Sweetening Layer Cake Using Aspartame with and without Fructose. *Cereal Chem.,* **60:** 337-341.
19. Izadi Najafabadi, L., Hamdami, N., Le-Bail, A., Monteau, J. Y. and Keramat, J. 2015. Impact of Baking Bed and Baking Temperature on Staling of Sangak Bread. *J. Agr. Sci. Tech.,* **17:** 375-386.
20. Karolini-Skaradzinska, Z., Bihuniak, P., Piotrowska, E. and Wdowik, L. 2007. Properties of Dough and Qualitative Characteristics of Wheat Bread with Addition of Inulin. *Pol. J. Food Nutr. Sci.,* **57(4):** 267-270.
21. Kocer D., Hicsasmaz Z., Bayindirli, A. and Katnas S. A. 2006. Bubble and Pore Formation of the High-Ratio Cake Formulation with Polydextrose as a Sugar- and Fat-Replacer. *J. Food Eng.,* **78:** 953-964.
22. Kolida, S. and Gibson, G. R. 2007. Prebiotic Capacity of Inulin-Type Fructans. *J. Nutr.,* **137:** 2503S-2506S**.**
23. Lee, S. C., Rodriguez, F. and Storey, M. 1995. Determination of Soluble and Insoluble Dietary Fiber in Psyllium Containing Cereal Products. *J. AOAC Int.,* **78:** 724-729.
24. Lin, S. D., Hwang, C. F. and Yeh, C. H. 2003. Physical and Sensory Characteristics

of Chiffon Cake Prepared with Erythritol as Replacement for Sucrose. *J. Food Sci.,* **68:** 2107-2110.

25. Matsakidou, A., Blekas, G. and Paraskevopoulou, A. 2010. Aroma and Physical Characteristics of Cakes Prepared by Replacing Margarine with Extra Virgin Olive Oil. *LWT - Food Sci. Technol.,* **43:** 949-957.
26. Meyer, D. and Peters, B. 2009. Enhancing the Nutritional Value of Bread with Inulin. *Agro Food Ind. Hi-Tech,* **20:** 48-50.
27. Moscatto, J. A., Borsato, D., Bona, E., Oliveira, A. S. and Hauly, M. C. O. 2006. The Optimization of the Formulation for a Chocolate Cake Containing Inulin and Yacon Meal. *Int. J. Food Sci. Technol.,* **41:** 181-188.
28. Niness, K. R. 1999. Inulin and Oligofructose: What Are They? *J. Nutr.,* **129(7):** 1402S-Peressini, D. and Sensidoni, A. 2009. Effect of Soluble Dietary Fibre Addition on Rheological and Bread Making Properties of Wheat Doughs. *J. Cereal Sci.,* **49:** 190-201.
29. Peressini, D. and Sensidoni, A. 2009. Effect of Soluble Dietary Fibre Addition on Rheological and Bread Making Properties of Wheat Doughs. *J. Cereal Sci.,* **49:** 190-201.
30. Poinot, P., Arvisenet, G., Grua-Priol, J., Fillonneau, C., Le-Bail, A. and Prost, C. 2010. Influence of Inulin on Bread: Kinetics and Physico-Chemical Indicators of the Formation of Volatile Compounds during Baking. *Food Chem.,* **119(4):** 1474-1484.
31. Roberfroid, M. B. 2007. Inulin-Type Fructans: Functional Food Ingredients. *J. Nutr.,* **137:** 2493S-2502S.
32. Rodríguez-García J., Salvador, A. and Hernando, I. 2014. Replacing Fat and Sugar with Inulin in Cakes: Bubble Size Distribution, Physical and Sensory Properties. *Food Bioprocess Technol*., **7:** 964-974.
33. Ronkart, S. N., Paquot, M., Fougnies, C., Deroanne, C. and Blecker, C. S. 2009. Effect of Water Uptake on Amorphous Inulin Properties. *Food Hydrocoll.,* **23:** 922-927.
34. Ronda, F., Gomez, M., Blanko, C. A. and Caballero, P. A. 2005. Effect of Polyols and Nondigestible Oligosaccharides on the Quality of Sugar-Free Sponge Cakes. *Food Chem.,* **90:** 549-555.
35. Silva, R. F. 1996. Use of Inulin as a Natural Texture Modifier. *Cereal Food World,* **41:** 792-795.
36. Staffoloa, M. D., Bertolaa, N., Martinoa, M. and Bevilacquaa, A. 2004. Influence of Dietary Fiber Addition on Sensory and Rheological Properties of Yogurt. *Int. Dairy J.,* **14:** 263-268.
37. Sun, D. 2008. Computer Vision technology for Food Quality Evaluation. Academic Press, New York.
38. Tárrega, A., Rocafull, A. and Costell, E. 2010. Effect of Blends of Short and Long-Chain Inulin on the Rheological and Sensory Properties of Prebiotic Low-Fat Custards. *LWT-Food Sci. Technol.,* **43:** 556-562.
39. Tudorica, C. M., Kuri, V. and Brennan, C. S. 2002. Nutritional and Physicochemical Characteristics of Dietary Fiber Enriched Pasta. *J. Agric. Food Chem.,* **50:** 347-356.
40. Volpini-Rapina, L. F., Ruriko Sokei, F. and Conti-Silva, A. C. 2012. Sensory Profile and Preference Mapping of Orange Cakes with Addition of Prebiotics Inulin and Oligofructose. *LWT - Food Sci. Technol.,* **48:** 37-42.
41. Wang, Y. 2009. Prebiotics: Present and Future in Food Science and Technology. *Food Res. Int.,* **42:** 8-12.
42. Wang, J. S., Rosell, C. M. and de Barber, C. B. 2002. Effect of the Addition of Different Fibres on Wheat Dough Performance and Bread Quality. *Food Chem.,* **79:** 221-226.

اثر افزودن اینولین، فروکتوالیگوساکارید و اینولین غنی شده با فروکتوالیگوساکارید بر ویژگی‌های فیزیکوشیمیایی، بیاتی و حسی کیک پری‌بیوتیک

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چکیده

امروزه یکی از عمده‌ترین چالش‌های موجود در صنعت غذا نیاز به افزایش ارزش تغذیه‌ای مواد غذایی است. روش عملی و تغذیه‌ای برای رسیدن به این هدف در محصولات نانوایی، افزودن پری-بیوتیک‌ها می‌باشد که امکان فروش موادی با ارزش تغذیه‌ای بالاتر با ویژگیهای حسی برابر را افزایش می‌دهند. از اینرو، هدف از مطالعه حاضر بررسی اثر افزودن اینولین، فروکتوالیگوساکارید و اینولین غنی شده با فروکتوالیگوساکارید بر ویژگیهای کیک پری‌بیوتیک است. بالاترین میزان تقارن و حجم و کمترین دانسیته ظاهری و جرم مخصوص در نمونه کنترل مشاهده شد. با افزون فروکتان‌ها، رنگ بافت کیک تیره‌تر شد بجز در مورد نمونه دارای ۲/۵ درصد اینولین غنی شده با فروکتوالیگوساکارید. در مدت نگهداری، نمونه کنترل بیشترین میزان سفتی و کمترین رطوبت را داشت. در نمونه‌هایی با ۲/۵ درصد و ۱۰ درصد اینولین غنی شده با فروکتوالیگوساکارید افزایش در میزان پروتئین، فیبر کل و خاکستر مشاهده شد. در ارزیابی حسی بیشترین و کمترین امتیاز به ترتیب مربوط به نمونه‌هایی با ۲/۵ درصد اینولین غنی شده با فروکتوالیگوساکارید و ۱۰ درصد اینولین بود.