J Food Sci Technol (March–April 2012) 49(2):192–199
DOI 10.1007/s13197-011-0277-4

ORIGINAL ARTICLE

Physicochemical properties and sensory evaluation of fructoligosaccharide enriched cookies

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Revised: 22 June 2010 / Accepted: 06 July 2010 / Published online: 11 February 2011

Abstract Short dough cookies were enriched with fructoligosaccharide (FOS), a prebiotic soluble fiber and a low calorie sweetener, at levels of 40%, 60%, and 80% sugar replacement basis. Cookies were analyzed for diameter, height, spread ratio, hardness, moisture and acidity of the extracted fat. The mean peak force at 0 month was determined to be 7139±166 g, 7109±75 g, 6970±24 g and 6538±128 g for control (100% sucrose), 40%, 60% and 80% sugar replacement levels cookies respectively. The spread ratio of control cookies was found to be 4.400 and that of FOS based cookies at 40%, 60% and 80% sugar replacement levels was found to be 4.520, 4.983 and 5.205, respectively. Sensory data on a 9 point hedonic scale indicated that the panelists liked FOS cookies (up to 60% sugar replacement) over control cookies because of improved color, texture and appearance. The total fiber content (including oligofructose) of cookies (60% sugar replacement) was 12.1%. As per FDA these cookies can be categorized as 'Good Source' of fiber. Thus, FOS appears to be suitable as a partial replacer of sucrose up to 60% providing increase in the dietary fiber and reduction in the caloric content of cookies.

Keywords Cookies · Fructoligosaccharide · High fiber · Prebiotic · Low caloric · Sucrose

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Introduction

Health, convenience and indulgence continue to dominate the eating habits of our society. Despite the general knowledge about the relation between dietary fiber and health, a big gap exists between mean daily intake and the recommended daily intake. The World Health Report (2002) indicates that mortality, morbidity and disability attributed to the major noncommunicable diseases currently account for about 60% of all deaths and 47% of the global burden of disease, with figures expected to rise to 73% and 60%, respectively, by 2020. Factors that increase the risks of noncommunicable disease include elevated consumption of energy-dense, nutrient-poor foods that are high in fat, sugar and salt. The above scenario has manifested itself into problems like diabetes, obesity, cardiovascular disease, and osteoporosis.

New developments are taking place, given the benefits of new knowledge in nutrition science, new process technologies and the modern consumers demand for reduced calorie foods with multiple health benefits. Also, the focus is on disease prevention and optimizing health by the use of functional food ingredients. Functional foods have been defined as foods and food components that provide a health benefit beyond basic nutrition (for the intended population). Examples may include conventional foods; fortified, enriched or enhanced foods; and dietary supplements (MacAulay et al. 2005).

Inulin and fructoligosaccharide (FOS) have been classed as functional food ingredients (Arai 2002). These are present in > 36,000 plant species as plant storage carbohydrates including wheat, onion, banana, garlic, chicory, asparagus, artichoke etc (Carpita et al. 1989). Inulin is a polydisperse β (2-1) fructan. The fructose units in this mixture of linear fructose polymers and oligomers are each linked by β (2-1) bonds. The degree of polymerization (DP) is in the range of 2 to 60. The low molecular weight fractions of inulin (DP 2-20) are known collectively as fructoligosaccharide (FOS). These have been generally recognized as safe (GRAS) by FDA. From an analytical and a physiological point of view both inulin and FOS have been classed as dietary fibers (Coussement 1999). They meet the analytical definition of dietary fiber used by AOAC (AACC Report 2001) i.e. "remnants of plant cells resistant to hydrolysis by the alimentary enzymes of man". Due to the non digestibility of inulin and FOS, they are found to be suitable for consumption by diabetics. They have been found to have very low influence on serum glucose, do not stimulate insulin secretion and have no effect on glucagon secretion (Yamashita et al. 1984; Rumessen et al. 1990). Inulin and FOS have been termed "prebiotics" (Gibson et al. 1995) because they are non digestible food ingredients that selectively stimulate growth of health-stimulating intestinal bacteria such as *bifidobacteria* (Bouhnik et al. 2004; Wiele et al. 2007). The caloric value of inulin and FOS is estimated to be 1.0 and 1.5 kcal/g respectively (Roberfroid 1999).

Inulin and FOS can be used for either their nutritional advantages or technological properties, but they are often applied to offer a dual benefit: an improved organoleptic quality and a better-balanced nutritional composition. The difference in chain length between inulin and FOS account for their distinctly different functional attributes. As macro nutrient substitutes, inulin and FOS are used mainly to replace fat and sugars, respectively. FOS has technical properties that are comparable to those of sugar and glucose syrups. It provides ~ 30–50% sweetness compared with table sugar (Coussement 1999). These have been utilized in many food products. Wang et al. (2002) found that the addition of fiber inulin to wheat flour modified the rheological properties of the dough to a less extent than bran. Improved proofing stability was obtained with inulin. The fiber-rich breads obtained were also considered acceptable by the sensory panel. In a study by O'Brien et al. (2003) it was found that breads containing the inulin gel were similar in quality characteristics to the control breads containing fat. Fat mimetics, namely Raftiline, Simplesse, C*deLight and polydextrose could be used as fat replacers to prepare tenderer low-fat cookies (Zoulias et al. 2002). Commercially available Raftilose (oligofructose) was used in the recipes where the sugar was reduced by 20–30%. It was found that dough hardness and peak force were found to be significantly lower than those obtained for the control biscuit ($P<0.05$). At the lower and medium levels of sugar replacement, oligofructose can be used successfully to reduce sugar in short dough biscuits (Gallagher et al. 2003).

Inulin/FOS have been also utilized in yoghurt (El Nagar et al. 2002; Guven et al. 2005; Kipa et al. 2006; Donkor et al. 2007; Brennan and Tudorica 2008), icecream (Akin et al. 2007; Akalm et al. 2008; Aykan et al. 2008), cake (Moscatto et al. 2006), cereal bars (Dutcosky et al. 2006), imitation cheese (Hennelly et al. 2006) and pasta (Brennan et al. 2004) etc.

The objective of the study was to develop and evaluate quality attributes of cookies enriched with FOS. Specifically the physiochemical properties (spread ratio, moisture, acidity of the extracted fat and hardness) with varying levels of FOS were investigated. The storage and sensory acceptability study of such cookies was also undertaken. Further, in all the studies so far inulin has been utilized as a fat replacer and limited data is available concerning utilization of FOS as a sugar replacer in cookies.

Materials and methods

Raw material source and analysis

Soft refined wheat flour was procured from Delhi Flour Mill, Delhi, India. Bakery Shortening SH-03 (*trans* free) was provided by Adani Wilmar Limited, Gujarat, India. Refined sugar was procured locally. FOS (Beneo Raftilose® P95, Orafti, Belgium, U.K) was procured from DPO Food Specialities Pvt. Ltd, Thane, Maharashtra, India. Food grade sodium chloride, sodium bi carbonate, ammonium bicarbonate, lecithin, orange flavor and butylated hydroxy toulene (BHT) were procured from Pioneer Chemicals, Delhi, India. All raw materials were analyzed for physical and chemical quality as per AOAC (2005) procedures to ensure good quality of the finished products.

Cookie formulations

Short dough cookies were prepared using the basic formulae given by Lawson (1997). Cookies were prepared in a batch size of 2 kg each using Marcato's 'Cookie Maker' purchased from Satellite Plastic Industries, Mumbai, India. Each batch comprised of 10 baking trays containing 166 cookies. Sugar was ground to pass through 60 mesh ASTM sieve. Bakery shortening (32 g) and sugar (40 g) were creamed for 5 min together with lecithin (0.5 g), BHT (0.02 g) and flavour (1 g) using an electric hand mixer at medium speed. Refined wheat flour (100 g), sodium chloride (0.8 g), sodium bicarbonate (0.4 g), ammonium bicarbonate (0.2 g) mixture was then incorporated. Standardized amount of water was added and the dough was kneaded for 7 min. The dough was divided into smaller portions and filled into the cookie maker. The cookies were moulded on to the greased baking tray, baked at 180°C for 25 min and cooled for 1 h at ambient temperature.

Cookies were packed in 100 g pouches comprising of a two layered laminated material made up of metallized biaxially oriented poly propylene (BOPP) of 18 micron thickness and poly ethylene (PE) of 12 micron thickness. Grammage of metallized BOPP film was 15.4 g/m^2 and of PE film was 16.8 g/m^2. The printing and the adhesive constitute 3 micron thickness each. Cookies were stored at ambient temperature for further analysis.

Control cookies (F1) were prepared with 100% sucrose. Cookies were enriched with FOS at levels of 40% (F2), 60% (F3), and 80% (F4) sugar replacement basis. The levels selected for incorporating FOS were based on study by Franck (2002) which suggests a dosage level of 2–25% w/w for baked good and as per FDA, products to be labeled "Good Source" of fiber must contain a minimum of 2.5 g per reference amount (10% or more of Daily Value [DV]) and products to be labeled "High Fiber" must contain a minimum of 5 g per reference amount (20% or more of DV). Also, as per the Prevention of Food Adulteration Act (PFA), 1955, India: Biscuits may contain oligofructose (dietary fiber) up to 15% maximum; and every package of biscuits, bread and cakes containing oligofructose shall bear the following declaration, namely:—"Contains Oligofructose (dietary fiber)..... g/ 100 g".

Physical evaluation of cookies

Cookie diameter, height and spread ratio

Cookie diameter (cm) was measured by laying six cookies edge to edge with the help of scale and then rotating them by 90°and re-measuring. The average diameter of the cookies was the average of the two readings divided by six. These measurements were taken on 3 sets of cookies from the same batch for each variation and values are presented as mean±S.D. Cookie height (cm) was determined by stacking six cookies on top of one another, restacking and re-measured. The average height of the cookies was the average of the two readings divided by six. These measurements were taken on 3 sets of cookies from the same batch for each variation and values are presented as mean±S.D. Spread ratio which is defined as a ratio of average diameter to average height of the cookies was then calculated.

Cookie texture

A texture analyzer (TAXT2i/50, Stable Microsystems, (U.S.A)) equipped with a 50 kg load cell was used for cookie texture evaluation. Cookies were evaluated for hardness within 24 h by measuring the peak force during penetration using a 5 mm cylinder probe. The analyzer was set at a 'return to start' cycle, a pre-test, test and post-test speed of 1.00 mm/s, 0.5 mm/s and 10.00 mm/s respectively and a penetration distance of 5 mm. A force/penetration plot was made for every test. Measurements were conducted three times and results are expressed as mean±S.D values.

Cookie storage studies

Cookies packed in 100 g pouches comprising of a two layered laminated material made up of metallized BOPP and PE were stored at ambient temperature and were analyzed at an interval of 1 month for physical and chemical parameters including hardness, moisture and acidity of extracted fat up to 8 months. Cookies were analyzed for moisture content and acidity of the extracted fat as per Bureau of Indian Standards (BIS) 1011: 2002 "Specification of Biscuits". Moisture content of cookies (%) was estimated using air oven drying method (105±1°C for 4 h). Acidity of extracted fat of cookies (%, as oleic acid) was estimated after extracting fat from the samples using soxhlet apparatus. Extracted fat was titrated with standard potassium hydroxide solution using phenolphthalein as an indicator.

Sensory acceptability tests

This was conducted by a ten member untrained panel consisting of postgraduate students of the Department of Foods and Nutrition, Lady Irwin College, University of Delhi, New Delhi, India. Hedonic sensory attributes evaluated in this study were acceptability in terms of color, texture, flavor, appearance and overall acceptability (OAA) of cookies. The panelists were between 19 and 22 years old. All panelists were regular consumers of cookies. A 9 point hedonic scale, anchored by "dislike extremely" and "like extremely" was employed. Session was conducted at room temperature in a sensory room equipped with white fluorescent lighting. The panel session was held mid-morning, about 4 h after breakfast. Cookies were served on plates to panelists. Samples were provided randomly to the panelists. Sensory evaluation score cards were prepared and products were evaluated by panelists. Sensory evaluation procedures were explained to the panelists before testing commenced. Panelists were asked to read through the instructions and the questions on the sensory form and the meaning of each attribute was explained to the panelists to avoid misinterpretation. The panelists were given time to ask for clarification of the sensory evaluation procedure when uncertain or unclear about the process. Water at room temperature was provided to rinse the mouth between evaluations. Mean±SD scores of panelists for each variant of cookies were estimated.

Macro nutritive composition of cookies

Macro nutritive composition of cookies included fat estimation by soxhlet extraction, protein using Kelvac (Kes 12 l) nitrogen estimator (Pelican Equipments, India), moisture content by air oven method (AOAC: 2005), total dietary fiber using AOAC 991.43: 2005, ash content (AOAC: 2005) and carbohydrates (by difference) content of cookies were determined. Total fructans were determined by AOAC 999.03: 2005 enzymatic spectrophotometric method using Megazyme K-Fruc Kit, Ireland. Caloric value of cookies was estimated using Atwater factors by multiplying the proportion of protein, fat and carbohydrate by their respective physiological fuel values of 4, 9 and 4 kcal/g and taking the sum of all the products. FOS calorific value was taken as 1.5 kcal/g.

Statistical analysis

Statistical analysis were performed using software SPSS 16 for windows version to calculate means±SD of values measured for each sample. To separate the responses of fiber at different levels, Analysis of variance (ANOVA) with the least significant difference test (LSD-test) was applied. The level of significance used was 95% ($p<0.05$). For the graphical treatment data was imported into graphics package of MS Excel.

Results and discussion

In the current study use of fructoligosaccharide in cookies as sucrose replacer and medium for fiber enrichment has been investigated. The technology for high fiber, low calorie cookies has been developed at laboratory scale keeping in mind the consumer's interest in functional foods.

Physical evaluation of cookies

Cookie diameter

Cookie spread occurs as sugars dissolve during baking. Sucrose is not completely dissolved prior to baking, so the undissolved sugars will dissolve during baking, which allows greater spread to occur. Cookies made with 100% sucrose (F1) had an average diameter of 5.500±0.03 cm. The mean diameter for F2, F3 and F4 cookies made was 5.560±0.009 cm, 5.730±0.034 cm and 5.830±0.032 cm respectively. FOS containing cookies were found to be larger in diameter than control cookies made with sucrose. Thus, increasing the FOS concentration tends to increase the diameter of cookies. This may be because of higher solubility of FOS (http://www.orafti.com) as compared to sucrose and maintaining its dissolved nature longer during baking, which would also facilitate flow of the dough. Cookie diameter was found to be significantly ($p<0.05$) affected by treatments (Table 1).

Cookie height

Gluten development contributes to an expansion in height of baked products, but cookies don't increase dramatically in height, because sugar preferentially attracts water over the gluten proteins. Therefore, the amount and type of sugar in the formulae can affect the height of cookies. Similar observations were made by Kissel et al. (1973) and Vetter et al. (1984). The mean height of F1 cookies was 1.250±0.003 cm and that of F2, F3 and F4 cookies was 1.230±0.003 cm, 1.150±0.004 cm and 1.120± 0.005 cm respectively. Thus, cookies height tends to decrease with increasing levels of FOS (Table 1). This could be ascribed to the fact that FOS is more hygroscopic than sucrose (Franck 2002). Therefore, it takes up more water and leaves less water for gluten development and allows for decreased height of cookie. Also less soluble sugars allows for greater gluten development and thus more height of cookie. FOS enriched cookies were found to have diameter significantly ($p<0.05$) different from control.

Cookie spread ratio

Cookie spread represents a ratio of diameter to height. Thus, sugar's effects on the diameter (sugar dissolution) and height (inhibiting gluten development) are combined into a single parameter. Cookies having higher spread ratio are considered most desirable (Finney et al. 1950; Kissel and Prentice 1979). Also, larger cookie diameter and higher spread are considered as the desirable quality attributes (Yamamoto et al. 1996). The spread ratio of F1 cookie made with 100% sucrose was found to be 4.400. The spread ratio of F2, F3 and F4 cookies was found to be 4.520, 4.983 and 5.205 respectively (Table 1). Baking with FOS resulted in cookies with increased diameter due to higher solubility of the sweetener. Because FOS has more affinity for water as compared to sucrose, the less extensive gluten network caused a decrease in cookie height. Thus, a higher cookie spread ratio resulted for cookies baked with FOS as compared to sucrose control cookies.

Cookie texture

Development of cookies that stays soft throughout distribution and onto the consumer's shelf has been

Table 1 Physical evaluation of cookies

Sample	Diameter (cm) #	Height (cm) #	Spread ratio	Hardness (Peak force) (g) #
F1[a]	5.500±0.055	1.250±0.101	4.400	7139±166
F2[b]	5.560±0.014*	1.230±0.070*	4.520	7109±75
F3[c]	5.730±0.008*	1.150±0.012*	4.983	6970±24*
F4[d]	5.830±0.020*	1.120±0.102*	5.205	6539±128*

[a] 0% sugar replacement

[b] 40% sugar replacement

[c] 60% sugar replacement

[d] 80% sugar replacement

Mean±SD of three determinations

*Significantly different from control (F1) ($p<0.05$)

pursued for many years. Cookies become sensorily dry to taste and crumbly even when packaged to prevent loss of moisture. One widely accepted theory of cookie firming involves sucrose recrystallization and the resulting redistribution of moisture to the other components, which then leads to a firmer, drier texture. Thus, by inhibiting/reducing sugar crystallization cookie hardening can be prevented. High fructose corn syrup, raffinose and trehalose have been used successfully to prevent sucrose recrystallization. It has been attributed to maintenance of higher plasticizer volume by added sugars (Belcourt and Labuza 2007).

Cookies made with 100% sucrose had higher hardness as indicated by higher mean peak force of 7139±166 g as compared to FOS enriched cookies. In view of the greater height and lesser diameter the peak force was observed to be higher in case of control cookies. As to the texture, FOS cookies had lower hardness as compared to control sucrose cookies. The mean peak force for F2, F3 and F4 cookies was found to be 7109±75 g, 6970±24 g and 6538±128 g respectively (Fig. 1). Hardness of all cookies except cookies with 40% FOS was found to be significantly ($p<0.05$) different from control cookies. Thus, as FOS is substituted for sucrose the peak force required to penetrate cookie tends to decline indicating softer nature of FOS cookies. This can be attributed and correlated to the higher spread ratio of these cookies. Further as FOS doesn't recrystallize being highly soluble, it binds more water and therefore gives softer cookies. Also, lower the force required crisper is the texture of such baked products indicating better quality and higher acceptability. This observation correlated well with the findings of study by Gallagher et al. (2003) where raftilose was used as a sugar replacer in short dough cookies and sugar was reduced by 20–30%. It was found that sugar replacer didn't exert same hardening effect on dough as granulated sugar. Significant lower hardness levels for dough, as well as cookies ($p<0.01$), were found when the level of sugar replacer used increased. Thus, indicating softer eating characteristics.

The textural change in cookies was studied over a period of 7 months of storage. Control cookies had mean peak force 7139±166 g at 0 month and 10276±170 g at 7 month (Fig. 1). Thus, hardness tends to increase in these cookies as they are stored. This can be attributed to sucrose recrystallization as discussed above. For FOS cookies, stored over a period of 7 months, peak force was found to decrease with time. The mean peak force of F2 cookies was found to be 7109±75 g at 0 month and 5594±38 g at 7 month. The mean peak force of F3 cookies was found to be 6970±24 g at 0 month and

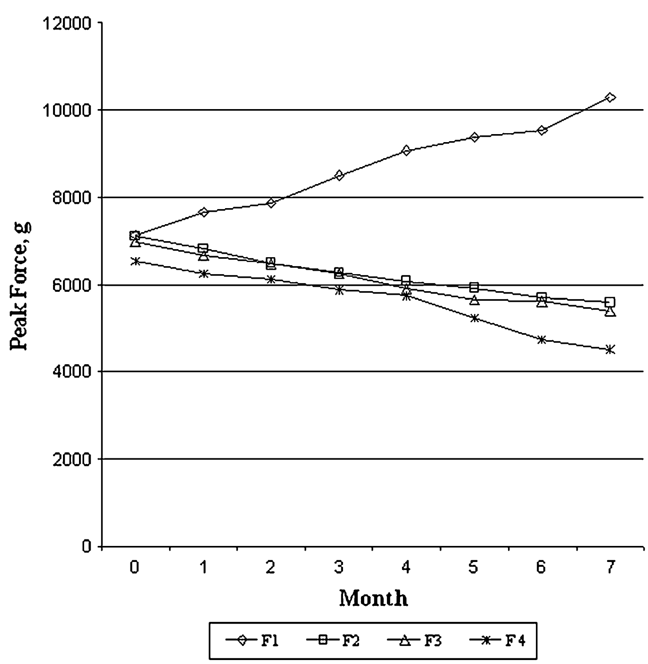

Fig. 1 Changes in instrumental hardness (peak force, g) of cookies during storage

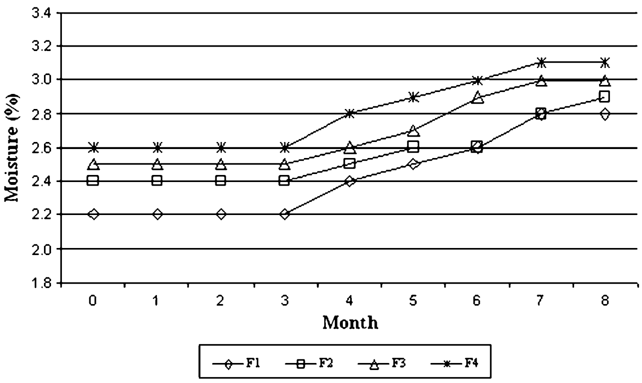

Fig. 2 Changes in moisture content (%) of cookies during storage

5396±167 g at 7 month. The mean peak force of F4 cookies was found to be 6538±128 g at 0 month and 4503±141 g at 7 month (Fig. 1). The decline in peak force over storage in FOS cookies could be ascribed to FOS not being recrystallized.

Cookie storage studies

Cookie moisture content

The moisture content of cookies was determined over 8 months for the storage study. The moisture content of F1 cookies was determined to be 2.2±0.1% at 0 month whereas that of F2, F3 and F4 cookies was 2.4±0.0%, 2.5±0.1% and 2.6±0.0% respectively (Fig. 2). Samples containing FOS had higher initial moisture as compared to the control samples. Moisture was found to be significantly ($p<0.05$) affected by treatments. FOS being hygroscopic in nature has greater water retention capacity as indicated by higher initial moisture content of cookies. FOS has good humectant properties leading to softer cookie as it holds more moisture (De Soete 2000). Also, because of higher water retention, water activity of FOS cookies is reduced and it would ensure higher microbiological stability. Oligofructose has been shown to have humectant properties, reduces water activity and thereby ensures high microbiological stability (Crittenden and Playne 1996). All samples depicted marginal increase in moisture content over the period of 8 months. However, the moisture content of all samples was found to be well below the BIS upper limit of 5% at the end of the study.

Acidity of the extracted fat of cookies

The acidity of extracted fat was found to be 0.21±0.014% (as oleic acid) in case of F1 control cookies. Over the period of 8 months it was estimated to increase to 1.22±0.028%. The acidity of extracted fat of cookies with FOS was found to vary from 0.21±0.014% to 1.23±0% (Table 2). As per the BIS specifications, the acidity of the extracted fat (as oleic acid), percent by mass, maximum limit for cookies is 1.2. All the samples were observed to have acidity of the extracted fat within the maximum limit up to 7 months. Thus, indicating a shelf life of 7 months.

Sensory acceptability tests

The results of the sensory analysis (Table 3) revealed that cookies made with 100% sucrose (F1) were rated lower by panelists as compared to the ones made with FOS on color and texture attributes. OAA score for F1 cookies was 8.2±0.78 on a 9 point hedonic scale. The mean score for texture of F2, F3 and F4 cookies was 7.5±0.72, 7.8±0.78 and 7.9±0.87 respectively as compared to 7.2±0.78 for F1. At 40%

Table 2 Changes in acidity of the extracted fat (as oleic acid) of cookies, % by mass during storage[#]

Sample	Month								
	0	1	2	3	4	5	6	7	8
F1[a]	0.21±0.014	0.26±0.014	0.31±0	0.39±0.028	0.51±0	0.66±0.014	0.84±0.017	1.09±0.120	1.22±0.028
F2[b]	0.21±0.014	0.26±0	0.31±0.028	0.39±0.014	0.51±0.028	0.66±0	0.84±0.035	1.09±0.028	1.22±0
F3[c]	0.21±0.021	0.26±0	0.31±0.028	0.39±0.014	0.51±0.028	0.66±0	0.84±0.035	1.09±0.021	1.22±0
F4[d]	0.22±0.021	0.27±0.014	0.32±0.021	0.40±0.014	0.52±0.021	0.67±0.007	0.85±0.035	1.10±0	1.23±0

[a] 0% sugar replacement

[b] 40% sugar replacement

[c] 60% sugar replacement

[d] 80% sugar replacement

[#] Mean±SD of two determinations

*Significantly different from control (F1) ($p<0.05$)

Table 3 Sensory scores of cookies (n=10) [#]

Sample	Color	Flavor	Texture	Appearance	OAA
F1[a]	7.1±0.56	8.1±0.73	7.2±0.78	7.4±0.96	8.2±0.78
F2[b]	7.2±0.78	7.8±0.63	7.5±0.72	7.3±0.82	8.1±0.56
F3[c]	7.3±1.15	7.6±0.51	7.8±0.78*	7.3±0.67	8.0±0.66
F4[d]	7.3±1.15	6.3±0.48*	7.9±0.87*	7.4±0.51	7.1±0.73*

[a] 0% sugar replacement

[b] 40% sugar replacement

[c] 60% sugar replacement

[d] 80% sugar replacement

[#] Mean±SD scores on 9 point hedonic scale

*Significantly different from control (F1) (p<0.05)

and 60% substitution level of FOS the color, texture and appearance were rated better. However, when sugar was substituted for FOS, at 80% level the flavor component was found to be most affected as indicated by the lower score of 6.3±0.48 as compared to 8.1±0.73 for F1 (Table 3). Cookies made with FOS scored higher on the texture and color parameters as compared to control samples. They were crisper and thus, had higher acceptability scores. The sensory data correlated well with the objective data. FOS enriched cookies had a golden sheen which lead to higher score on color parameter. Moderate reducing power of FOS can give rise to slight browning reaction during baking, which could impart better color to such products. In a study by Gennaro et al. (2000) Raftilose P® was found to have reducing capacity and thus, it may be expected to be susceptible to maillard reaction. The mean score of panelists for color attribute of F2, F3 and F4 cookies was 7.2±0.78, 7.3±1.15 and 7.3± 1.15 respectively.

Macro nutritive composition of cookies

The macro nutritive composition of cookies is provided in Table 4. Total fiber including oligofructose is 8.7 g, 12.1 g and 15.9 g respectively at 40%, 60% and 80% sugar replacement levels as compared to 1.3 g in control cookies (F1), which accounts to 577%, 831% and 1123% higher fiber than the F1 cookies. As per FDA a food to be labeled as 'Good Source' of particular nutrient should provide 2.5 g/ serving to 4.9 g/serving i.e. 10% to 19% of DV and as 'High Fiber' or an 'Excellent Source' should provide 5 g and above/ serving i.e. 20% or more of DV. The fiber content per serving (=30 g) of F2, F3 and F4 cookies is 2.6, 3.6 and 4.8 g. Thus, these cookies can be labeled as 'Good Source' of fiber as per FDA. Incorporation of FOS as a sugar replacer also led to a decrease in carbohydrate, sugar and caloric content of cookies (Table 4).

Conclusions

The study revealed that cookies can be successfully formulated using fructoligosaccharide as a partial replacer for sucrose. The physical properties of the FOS enriched cookies were affected in a positive way by demonstrating a decrease in height, an increase in diameter, a higher spread ratio and lesser hardness, leading to softer eating characteristics which are desirable in cookies. The formulated cookies were well accepted by the panelists Texture of such cookies was extremely liked by panelists. One serving of cookies (=30 g) provided 2.6 g to 4.8 g total fiber including oligofructose, which met the US FDA definition of a 'Good Source' of dietary fiber. Thus, the use of FOS in cookies was effective for technological and nutritional advantages of cookies and may have additional health benefits including prebiotic effect and enhanced mineral absorption.

Table 4 Macro nutritive composition of cookies (per 100 g)

Nutrition facts	F1[a]	F2[b]	F3[c]	F4[d]
Moisture, g	2.2	2.4	2.5	2.6
Protein, g	7	7	7	7
Fat, g	19	19	19	19
Carbohydrate, g	69.0	61.4	57.8	54.0
Ash, g	1.5	1.5	1.5	1.5
Total Dietary Fiber, g	0.6	0.6	0.6	0.6
Oligofructose, g	0.7	8.1	11.5	15.3
Total fiber, g	1.3	8.7	12.1	15.9
Calories, kcal	476	456	448	438

[a] 0% sugar replacement

[b] 40% sugar replacement

[c] 60% sugar replacement

[d] 80% sugar replacement

Acknowledgements This study was supported by research grant from University Grants Commission (UGC), New Delhi, India.

References

Report AACC (2001) The definition of dietary fiber. Cereal Food World 46:112–126

Akalm SA, Karagozlu C, Unal G (2008) Rheological properties of reduced-fat and low-fat ice cream containing whey protein isolate and inulin. Eur Food Res Technol 227:889–895

Akin MB, Akin MS, Kirmaci Z (2007) Effects of inulin and sugar levels on the viability of yogurt and probiotic bacteria and the physical and sensory characteristics in probiotic ice-cream. Food Chem 104:93–99

Arai S (2002) Global view on functional foods: asian perspectives. Br J Nutr 88(suppl 2):S139–S143

Aykan V, Sezgin E, Zeynep B, Seydim G (2008) Use of fat replacers in the production of reduced-calorie vanilla ice cream. Eur J Lipid Sci Technol 110:516–520

Belcourt LA, Labuza TP (2007) Effect of raffinose on sucrose recrystallization and textural changes in soft cookies. J Food Sci 72:C65–71

Bouhnik Y, Raskine L, Simoneau G, Vicaut E, Neut C, Flourie B (2004) The capacity of nondigestible carbohydrates to stimulate fecal bifidobacteria in healthy humans: a double-blind, randomized, placebo-controlled, parallel-group, dose-response relation study. Am J Clin Nutr 80:1658–1664

Brennan CS, Kuri V, Tudorica CM (2004) Inulin-enriched pasta: effects on textural properties and starch degradation. Food Chem 86:189–193

Brennan CS, Tudorica CM (2008) Carbohydrate-based fat replacers in the modification of the rheological, textural and sensory quality of yoghurt: comparative study of the utilisation of barley beta-glucan, guar gum and inulin. Int J Food Sci Technol 43:824–833

Carpita NC, Kanabus J, Housley TL (1989) Linkage structure of fructans and fructan oligomers from Triticum aestivum and Festuca arundinacea leaves. J Plant Physiol 134:162–168

Coussement PAA (1999) Inulin and Oligofructose: safe intakes and legal status. J Nutr 129:S1412–S1417

Crittenden RG, Playne MJ (1996) Production, properties and applications of food grade oligosaccharides. Trends Food Sci Technol 7:353–361

De Soete J (2000) Prebiotic ingredients in chewing gum—the use of inulin and oligofructose. Manufacturing Confectioner 80:67–69

Donkor ON, Henriksson A, VasiljEvic T, Shah NP (2007) Rheological properties and sensory characteristics of set-type soy yogurt. J Agric Food Chem 55:9868–9876

Dutcosky SD, Grossmann MVE, Silva RSSF, Welsch AK (2006) Combined sensory optimization of a prebiotic cereal product using multicomponent mixture experiments. Food Chem 98:630–638

El Nagar G, Clowes G, Tudorica CM, Kuri V, Brennan CS (2002) Rheological quality and stability of yog-ice cream with added inulin. Int J Dairy Technol 55:89–93

Finney DF, Morris VH, Yamazaki WT (1950) Macro vs. micro cookie baking procedures for evaluating the cookie quality of wheat varieties. Cereal Chem 27:42–46

Franck A (2002) Technological functionality of inulin and oligofructose. Br J Nutr 87(suppl 2):S287–S291

Gallagher E, O'Brien CM, Scannell AGM, Arendt EK (2003) Evaluation of sugar replacers in short dough biscuit production. J Food Eng 56:261–263

Gennaro SD, Birch GG, Parke SA, Stancher B (2000) Studies on the physicochemical properties of inulin and inulin oligomers. Food Chem 68:179–183

Gibson GR, Beatty ER, Wang X, Cummings JH (1995) Selective stimulation of bifidobacteria in the human colon by oligofructose and inulin. Gastroenterol 108:975–982

Guven M, Yasar K, Karaca B, Hayaloglu AA (2005) The effect of inulin as a fat replacer on the quality of set-type low-fat yogurt manufacture. Int J Dairy Technol 58:180–184

Hennelly PJ, Dunne PG, O'Sullivan M, O'Riordan ED (2006) Textural, rheological and microstructural properties of imitation cheese containing inulin. J Food Eng 75:388–395

Kipa P, Meyer D, Jellema RH (2006) Inulin improve sensoric and textural properties of low-fat yoghurts. Int Dairy Journal 16:1098–1103

Kissel L, Prentice M (1979) Protein and fiber enrichment of cookie flour with brewer's spent grains. Cereal Chem 50:261–265

Kissel LT, Marshall BD, Yamazaki WT (1973) Effect of variability in sugar granulation on the evaluation of flour cookie quality. Cereal Chem 50:255–264

Lawson R (1997) Mathematical modeling of cookie and cracker ovens. In: Faridi H (ed) The Science of Cookie and Cracker production. CBS Publishers and Distributors, India, p 388

MacAulay J, Petersen BJ, Shank F (2005) Institute of Food Technologists (IFT) Expert Report. Functional foods: Opportunities and Challenges. http://members.ift.org/IFT/Research/IFTExpertReports/functionalfoods_report.htm. Accessed 21 Dec 2009

Moscatto JA, Borsato D, Bona E, Oliveira AS, Hauly MCO (2006) The optimization of the formulation for a chocolate cake containing inulin and yacon meal. Int J Food Sci Technol 41:181–188

O' Brien CM, Mueller A, Scannell AGM, Arendt EK (2003) Evaluation of the effects of fat replacers on the quality of wheat bread. J Food Eng 56:265–267

PFA (1955) Prevention of Food Adulteration Act with Prevention of Food Adulteration Rules, 1955 and Commodity index with Exhaustive Short Notes. Form of labels, Rule 42, 24th edn. Pp.136, 387. Delhi, India: International Law Book Company, 2008.

Roberfroid MB (1999) Caloric value of inulin and oligofructose. J Nutr 129:S1436–S1437

Rumessen JJ, Bode S, Hamberg O, Gudmand-Hoyer E (1990) Fructans of Jerusalem artichokes: intestinal transport, absorption, fermentation and influence on blood glucose, insulin and C-peptide responses in healthy subjects. Am J Clinic Nutr 2:675–681

Vetter JL, Bright H, Utt M, Mcmaster G (1984) Cookie formulating: sugar, mixing affect specific gravity, spread. Baker's Digest 58 (6–7):9

Wang J, Rosella CM, Barbera CB (2002) Effect of the addition of different fibers on wheat dough performance and bread quality. Food Chem 79:221–226

Wiele T, Boon N, Possemiers S, Jacobs H, Verstraete W (2007) Inulin-type fructans of longer degree of polymerization exert more pronounced in vitro prebiotic effect. J Appl Microbiol 102:452–460

World Health Report (2002) Reducing risks, promoting healthy life. Geneva: WHO http://www.who.int/whr/2002/en/index.html. Accessed 20 Nov 2009

Yamamoto H, Worthington ST, Hou G, Ng PKW (1996) Rheological properties and baking qualities of selected soft wheats in the United States. Cereal Chem 73:215–221

Yamashita K, Kawai K, Itakura M (1984) Effect of fructoligosaccharides on blood glucose and serum lipids in diabetic subjects. Nutr Res 4:961–966

Zoulias EI, Oreopoulou V, Kounalaki E (2002) Effect of fat and sugar replacement on cookie properties. J Sci Food and Agric 82:1637–1644