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PREBIOTIC POTENTIAL EVALUATION OF XYLOOLIGOSACCHARIDES IN DEVISING FUNCTIONAL FOOD

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ABSTRACT
Good quality ingredients such as whole grains, lean proteins, healthy fats, fruits, vegetables, dairy alternatives, fermented foods, natural sweeteners and prebiotic rich foods along with healthy diet intake are basic concerns of consumers at present age. Prebiotic, a food supplement offers significant nutritional and health benefits by promoting the growth of beneficial bacteria like *Bifidobacterium* and *Lactobacillus.* Prebiotics also exhibit additional advantages like reduced sweet taste and high heat stability. Xylooligosaccharides (XOS) belong to the class of functional oligosaccharides having prebiotic activity and extraordinary properties to prevent systemic body disorders. In this study, prebiotic potential of xylooligosaccharides was determined and results showed their effect on increased growth rate and activity of beneficial intestinal bacteria. Furthermore, XOS were used in 3, 6 and 9 % levels to formulate functional baked cookies and their effect on product quality was determined. Results indicated that due to incorporation of xylooligosaccharides, physiochemical and nutritional properties of cookies were altered leading to increased dietary fiber content and moisture level. Moreover, diameter and weight of cookies increased while the height decreased. Similarly, texture (breaking strength and fracturability) along with the color properties (L*, a* and b* value) of cookies were also affected by the addition of XOS. Decrease trend in breaking strength and fracturability of cookies were observed on increasing XOS concentration while color became darker. Sensory evaluation revealed that cookies with 6 % xylooligosaccharides were rated acceptable by panelists for color, taste, aroma, texture, appearance and overall acceptability. Storage study revealed that texture properties decreased and for color properties there was decrease in L* value and increase in a* and b* value during storage. Furthermore, moisture level was observed to be increased during the storage period. Moreover, sensory attributes showed changes after 60 days interval during storage period of 120 days.

Keywords: Xylooligosaccharides, prebiotic, functional oligosaccharides, cookies.

1. Introduction
Functional food market is gaining its importance and flourishing because of adding valuable ingredients in food. According to this scenario, consumers look forward for the products with reduced

salt and fat contents having functional food ingredients such as prebiotics which help in improving health and immune system. Also, prevalence of non-communicable diseases (NCD's) specifically obesity and hypertension are on the rise and considered as serious public health issues nowadays. Regarding this, consumers are becoming well aware about their dietary habits and acquiring knowledge about the relationship between health and nutrition. Functional foods are considered as foods with specified therapeutic health benefits along with positive effect on consumers well-being by improving the nutritional value of products (Palaniappan *et al*., 2021). Prebiotics are selective substrates with non-digestible properties that are fermented by host beneficial microorganisms and provide health benefit to consumer (Abouloife *et al*., 2024). Nowadays, people are more aware of their overall health welfare being dependent on gut health. Different prebiotics including inulin, xylooligosaccharides, galactooligosaccharides and fructooligosaccharides have been used to fortify variety of food products (Kumari *et al*., 2024). Oligosaccharides are made up of two to ten monosaccharide units and can be used as sweetener in food products due to their sweet taste and uphold the structure of products by maintaining their consistency. Another property of oligosaccharides is their non-digestibility which allow them to use as a functional prebiotic substrate for beneficial bacteria i.e., *Bifidobacteria* and *Lactobacilli* present in human intestinal tract. As healthy eating is being highly focused these days which led consumers interest to utilize functional food as a new prebiotic supplement source. Among all oligosaccharides xylooligosaccharides are being used as new favorable nutrient of healthy human diet (Dyshlyuk *et al*., 2024).

Xylooligosaccharides (XOS) positively effect on reducing blood cholesterol level prevalence of colorectal cancer and disorders like Crohn's disease. On the other hand, they increase calcium and mineral absorption along with the level of short chain fatty acids (SCFAs) in body. Another advantage of XOS include reduction of apolipoprotein B and low-density lipoprotein (LDL) minimizing the risk of atherosclerosis. Moreover, they also have beneficial effect on type 2 diabetes mellitus and obesity. Additionally, less calories yet sweet taste of XOS is also of great interest in the field of low-calorie functional food products (Marim and Gabardo, 2021).

Bakery products are considered as common and diverse group of modern food items such as bread, cookies, cakes and pastries typically formed by baking different blends of flour, salt, sugar, fat and additives (Ou *et al.*, 2019). At present, baked food products contain high amount of sugar, starch and fat which can lead to diabetes, obesity, hypertension and different heart disease. Considering this, modern researchers are improving and redeveloping recipes of bakery products to increase their value and wellbeing. This process can be of great challenge as redevelopment of product can adversely affect its quality and physical characteristics leading towards decreased consumers acceptability (Hu *et al*., 2024). Cookies have low moisture level i.e. 1-5 % which make them more stable product than cakes and breads. Quality of cookies mostly depend upon the quantity, type and granulation of sugar being used (Riaz *et al*., 2018).

The objective of this research is to investigate the prebiotic potential of XOS and utilizing these xylooligosaccharides for cookies enrichment partially replacing sucrose. Different concentrations of XOS are used in cookie formation and optimum acceptable level of XOS addition was found by carrying different laboratory tests. The results helped to formulate highly prebiotic, fibrous and nutritional cookies to be used by consumers as ready to eat functional food.

2. Procurement of Raw Materials

Commercial XOS (95%) obtained from corn cobs and all analytical chemicals along with bacterial cultures of *Lactobacillus acidophilus and Lactobacillus plantarum* strains were purchased from Sigma Aldrich (Sigma Aldrich, Japan) and Merk (KGaA Merk, Germany). Raw material for cookies was purchased from local market of Faisalabad, Pakistan.

2.1. Xylooligosaccharides Fermentation

Prebiotic potential of xylooligosaccharides was verified before using it for cookies enrichment by following the method of Ayyappan *et al*. (2016). For this purpose, XOS fermentation was performed by utilizing two lactic acid bacterial strains such as *Lactobacillus acidophilus and Lactobacillus* *plantarum*. Both lactic acid bacterial cultures were sustained in deMan, Rogosa and Sharpe (MRS) broth and re-cultured at the interval of 7 days. MRS media used for in vitro XOS fermentation contained elements in g/L involving 20 g Dextrose/20 g XOS,10 g protease peptone, 10 g beef extract, 5 g yeast extract, 2 g di-potassium phosphate, 1 g polysorbate, 5 g sodium acetate, 2 g ammonium citrate, 0.1 g magnesium sulphate, 0.05 g manganese sulphate initially with pH 7. Culture suspension (100 µL) was inoculated in MRS broth with dextrose or with XOS providing 200 colony forming unit (CFU) and then incubated at 37 °C for 24 h. MRS containing dextrose worked as blank and control was reserved with MRS without dextrose and XOS. Although MRS having XOS was taken as test. Measurement of pH with pH meter (PHS-25CW Microprocessor pH/mV Meter) and absorbance at 600 nm by Double Beam UV- visible spectrophotometer was done in culture broth at every 3 h and growth features of microorganisms were monitored. After 24 h of incubation cultures were removed, centrifuged (3000 g at 25 °C for 20 min) and washed twice with distilled water. Then drying was done in oven at 85 °C for dry cell mass determination.

2.2. XOS enriched cookies formulation

Specified quantity of all raw materials (Table 1) were weighed and formulation of cookie started by mixing unsalted butter (fat) and sugar/XOS till appeared fluffy. Control cookies were made by using sucrose while in experimental cookies three levels of XOS i.e. 3, 6 and 9% were used as partial sucrose replacement. Dry ingredients like flour, salt and sodium bicarbonate were mixed followed by addition of egg whites while stirring simultaneously. This formulation was then added in previously made sugar-fat blend followed by mixing in dough mixture for 30 min in order to obtain uniform and steady dough. This dough was then added into round shaped cookie molds to obtain circular shaped cookies. Each cookie dough average weight was 7g approximately. Afterwards, baking was done at 185 °C for 15-20 min followed by cooling. Cookies were prepared and analyzed in three badges (Ayyappan *et al*., 2016).

Table 1. Treatment plan for the development of cookies

Ingredients	CC(%)	$CXOS_3$ (%)	$CXOS_6$ (%)	$CXOS_9$ (%)
Wheat flour	27.5	27.5	27.5	27.5
Unsalted butter	27.5	27.5	27.5	27.5
Sugar	27.5	24.5	21.5	18.5
Refined wheat flour	7	7	7	7
Salt	0.2	0.2	0.2	0.2
Sodium bicarbonate	0.2	0.2	0.2	0.2
Egg white	10	10	10	10
XOS	-	3	6	9

CC (control cookies)
$CXOS_3$ (3 % XOS cookies)
$CXOS_6$ (6 % XOS cookies)
$CXOS_9$ (9 % XOS cookies)

2.3. Proximate configurations of cookies

Moisture content along with ash, crude protein, crude fat and fiber contents of cookies were determined in triplicates. Total carbohydrates were calculated by subtracting the sum of moisture, ash, protein, fat and fiber from 100 and results were specified as g/100 g of cookies (AACC, 2019).

2.4. Cookie dimensions

Dimensions of cookies were measured in terms of diameter, height and weight. Measurement of diameter, height and weight was done according to the method described by Ayyappan *et al*. (2016).

2.5. Storage study

Cookies were placed in polypropylene boxes and stored at room temperature (25 °C) for 120 days. Texture of cookies that includes breaking strength and fracturability was measured by texture analyzer according to the method of AACC (2019). Color of the experimental cookies in terms of L*, a*and b* were measured by colorimeter (Huang *et al.*, 2018). Moisture of cookies was analyzed by using moisture analyzer at 105 °C by following the method of Ayyappan *et al*., (2016). Sensory properties of cookies including color, taste, aroma, texture, appearance and overall acceptability were also evaluated (Ogundele and Hiam, 2024). All parameters were analyzed and checked after every 30 days interval during the entire storage period. Analytical data was obtained in triplicates and compared with fresh cookies.

2.6. Statistical analysis

Data was stated as mean standard deviation of three replicates and analyzed with Statistix 8.1 software by using analysis of variance CRD and factorial design up to two-way ANOVA for storage. Mean values were calculated by using Tukey's test at probability level of less than 5% ($p<0.05$).

3. Results and Discussion

3.1. Prebiotic XOS Potential

Xylooligosaccharides have nowadays gained commercial importance as prebiotics due to its various benefits including stimulation of beneficial bacterial growth in order to prevent GIT disorders. They are more efficient than fructooligosaccharides as dietary supplement. They have wide range of temperature, pH and organoleptic characteristics which make them suitable for incorporating in foods. In vitro, studies were carried out in MRS medium to identify two bacterial strains (*L. plantarum* and *L. acidophilus*) ability to ferment xylooligosaccharides as single carbon source. Growth of both bacterial strains shows utilization of glucose and XOS. Table 2 and 3 shows that due to fermentation pH decreased in tested strains. *L. plantarum* showed increased acidity and lower pH by utilizing XOS. Dry weight which is cell mass of *L. plantarum* greatly increased and reached the value of 9.8 mg/ml at 24 h as compared to *L. acidophilus* with lower cell mass of 5.8 mg/ml. From the results, it is obvious that *L. plantarum* strain utilized xylooligoaccharides more effectively. Ayyappan *et al*. (2016) also showed that *L. plantarum* and *L. acidophilus* both showed increased growth rate by utilizing XOS than glucose while *L. Plantarum* was found to be more efficient than *L. acidophilus* in cookie production. Figure 1 and Figure 2 present growth characteristics of lactic acid bacteria *L. acidophilus* and *L. plantarum* and results confirmed the prebiotic potential of XOS which were used for cookie production. Similarly, Thakuria and Sheth (2020) also showed that *L. plantarum* growth was increased by utilizing 0.5, 1 and 2% of XOS in culture media.

Table 2. Characteristics of *L. acidophilus* in MRS medium with glucose and with XOS

Lactic acid bacteria (*L. acidophilus*)	pH	Cell Mass (mg/ml broth)
LAC (MRS with glucose)	5.8 ± 0.05^{a}	5.7 ± 0.07^{a}
LAX (MRS with XOS)	5.6 ± 0.08^{a}	5.8 ± 0.05^{a}

LAC (*L. acidophilus* control)
LAX (*L. acidophilus* XOS)
Mean ± Standard Deviation of LAB strain

Table 3. Characteristics of *L. plantarum* in MRS medium with glucose and with XOS

Lactic acid bacteria (*L. plantarum*)	pH	Cell Mass (mg/ml broth)
LPC (MRS with glucose)	5.3 ± 0.08^{a}	7.9 ± 0.09^{b}
LPX (MRS with XOS)	5.0 ± 0.05^{b}	9.8 ± 0.05^{a}

LPC (*L. plantarum* control)
LPX (*L. plantarum* XOS)
Mean ± Standard Deviation of LAB strain

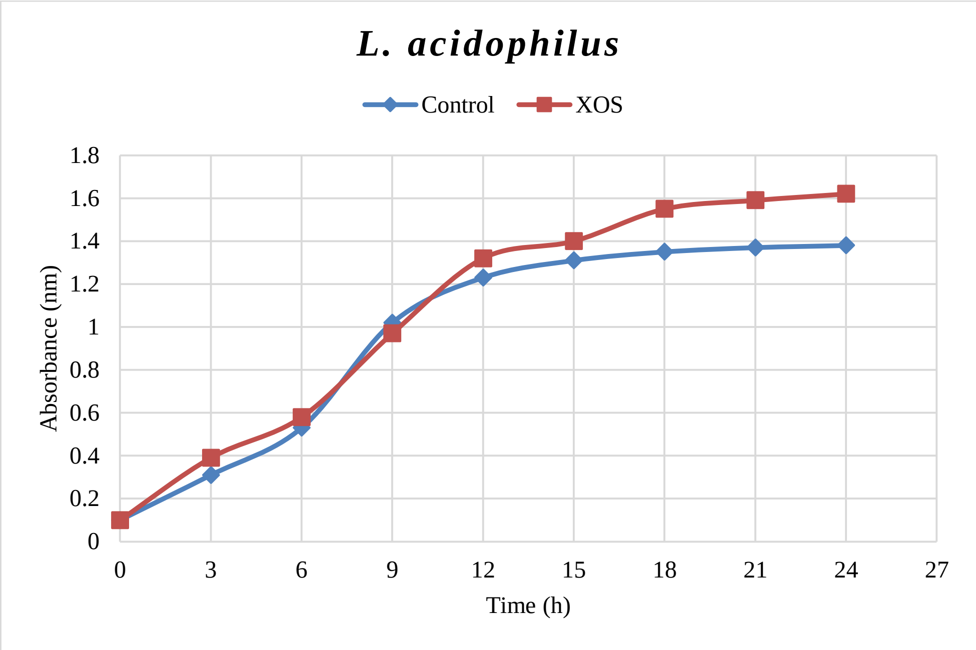

Figure 1. Growth characteristics of *L. acidophilus*

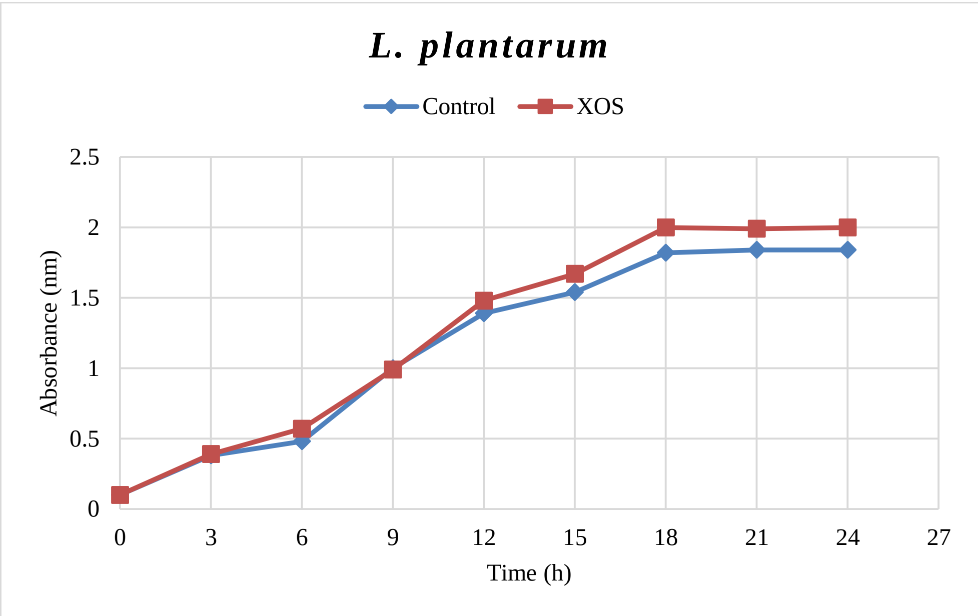

Figure 2. Growth characteristics of *L. plantarum*.

3.2. Proximate configurations of cookies

Proximate analysis showed that moisture and fiber content significantly increased with the increase of 3, 6 and 9 % XOS while ash, protein, fat and total carbohydrates showed non-significant changes (Table 4). Ayyappan *et al*. (2016) showed similar results that revealed increased moisture and fiber content in cookies due to XOS enrichment. Santiago-Garcia *et al*. (2017) also observed increased moisture content by adding fructans oligosaccharides in cookies. In another study, Nazi and Maidin (2024) added carbohydrate rich peanut skin powder in cookies and observed significant increase in their fiber content.

Table 4. Proximate configuration of XOS enriched cookies

Composition of cookies	Moisture (%)	Ash (%)	Crude Protein (%)	Crude fat (%)	Crude fiber (%)	Total carbohydrate (%)
CC	2.64 ± 0.05^{c}	0.51 ± 0.05^{a}	4.83 ± 0.06^{b}	24.14 ± 0.17^{a}	0.20 ± 0.07^{b}	67.17 ± 0.17^{a}
$CXOS_3$	2.73 ± 0.07^{bc}	0.55 ± 0.06^{a}	4.89 ± 0.07^{ab}	23.77 ± 0.15^{ab}	0.59 ± 0.08^{a}	67.07 ± 0.2^{a}
$CXOS_6$	2.87 ± 0.09^{b}	0.57 ± 0.07^{a}	4.96 ± 0.08^{ab}	23.62 ± 0.13^{b}	0.61 ± 0.05^{a}	66.77 ± 0.1^{ab}
$CXOS_9$	3.20 ± 0.05^{a}	0.60 ± 0.05^{a}	5.02 ± 0.06^{a}	23.51 ± 0.17^{b}	0.64 ± 0.06^{a}	66.41 ± 0.14^{b}

CC (control cookies)
$CXOS_3$ (3 % XOS cookies)
$CXOS_6$ (6 % XOS cookies)
$CXOS_9$ (9 % XOS cookies)

3.3. Cookie dimensions

During baking heat and leavening agents work to affect cookies dimensions. Dough when heated causes expansion of trapped air bubbles with increased vapor pressure. In these cookies, sodium bicarbonate released carbon dioxide (CO_2) which could be the reason of increased diameter. Cookies diameter also changes on addition of XOS as moisture level increases due to humectant property of XOS which in return affect cookie's structure. XOS may also interact with leavening agent for change in cookie dimensions. Results in Table 5 administrated that XOS addition increases the cookies diameter. Cookies having 3 and 6 % XOS showed less difference in diameter but 9 % XOS enriched cookies showed significant increase in diameter. On the other hand, height was decreased making cookies significantly flattened with the increased concentration of XOS (Table 5). Diameter and height are indirectly related to each other, therefore as maximum diameter was observed in 9 % enriched cookies, their height was less from other treatments (3 % and 6 % XOS cookies). Similar to diameter weight of cookies were also increased as the level of XOS increased. This could be due to increased water holding capacity of XOS (Table 5). Results were similar to Ayyappan *et al*. (2016) whose study showed significant increase in diameter and weight of cookies with significant decrease in height.

Table 5. Dimensions of XOS enriched cookies

Treatments	Diameter (mm)	Height (mm)	Weight (g)
CC	54.43 ± 0.11^{b}	5.25 ± 0.06^{a}	6.40 ± 0.06^{b}
$CXOS_3$	54.44 ± 0.08^{b}	5.13 ± 0.07^{ab}	6.49 ± 0.05^{ab}
$CXOS_6$	54.48 ± 0.08^{b}	5.06 ± 0.06^{ab}	6.53 ± 0.05^{ab}
$CXOS_9$	54.76 ± 0.10^{a}	4.96 ± 0.09^{b}	6.56 ± 0.06^{a}

CC (control cookies)
$CXOS_3$ (3 % XOS cookies)
$CXOS_6$ (6 % XOS cookies)
$CXOS_9$ (9 % XOS cookies)

3.4. Storage study

3.4.1 . Cookies Texture (Breaking Strength and Fracturability)

Breaking strength of cookies significantly decreased with increase content of XOS (Table 6) as cookies became soft due to high moisture content caused by XOS. Substituting sucrose with XOS caused decline in peak force while increasing softness of cookies. In case of controlled cookies higher peak force was observed as cookies height is more and diameter is less than XOS enriched cookies. During storage breaking strength significantly decrease as cookies could be affected by atmospheric moisture.

Fracturability of XOS enriched cookies showed significant decrease by increasing the percentage of xylooligosaccharides (Table 7). XOS appeared to increase moisture content of cookies due to their water binding capacity causing softness in cookies and decrease in fracturibility. During storage, there is significant decrease in fracturability due to atmospheric moisture absorption in cookies and making them soggy causing increased fracturibility level. Ayyappan *et al*. (2016) also showed significant decrease in cookies breaking strength and fracturability upon adding XOS in cookies.

Table 6. Breaking strength (g) of XOS enriched cookies

Treatments	**Storage**					**Means**
	0 Day	**30 Day**	**60 Day**	**90 Day**	**120 Day**	
CC	1379±1.52[a]	1374±2.51[ab]	1370±1.52[b-f]	1364±3.05[d-g]	1362±2.51[efg]	1370[a]
$CXOS_3$	1376±2.08[ab]	1372±2.64[a-d]	1369±2.08 [b-f]	1365±2.64 [c-g]	1362±3.60[fg]	1367[a]
$CXOS_6$	1373±2.64[abc]	1364±5.13[b-e]	1362±2.30[efg]	1353±3.51[hi]	1346±4.35[ij]	1361[b]
$CXOS_9$	1363±2.08[efg]	1359±2.30[gh]	1352±2.51[hij]	1349±1.52[ij]	1344±4.04[j]	1353[c]
Means	1373[a]	1370[a]	1363[b]	1357[c]	1352[d]	

CC (control cookies)
$CXOS_3$ (3 % XOS cookies)
$CXOS_6$ (6 % XOS cookies)
$CXOS_9$ (9 % XOS cookies)

Table 7. Fracturability (mm) of XOS enriched cookies

Treatments	**Storage**					**Means**
	0 Day	**30 Day**	**60 Day**	**90 Day**	**120 Day**	
CC	28.66 ±0.23[a]	28.48±0.13[a]	28.25±0.16[a]	27.35±0.11[b]	27.14±0.14[bc]	27.98[a]
$CXOS_3$	27.28±0.12[b]	27.25±0.15[b]	27.14±0.17[bc]	26.89±0.10[bc]	26.28±0.15[de]	26.97[b]
$CXOS_6$	27.36±0.11[b]	27.28±0.15[b]	27.18±0.15[bc]	26.68±0.20[cde]	26.15±0.10[e]	26.93[b]
$CXOS_9$	26.86±0.14[bc]	26.81±0.15[bcd]	26.55±0.25[cde]	25.49±0.30[f]	24.98±0.35[f]	26.16[c]
Means	27.54[a]	27.46[ab]	27.32[b]	26.60[c]	26.13[d]	

CC (control cookies)
$CXOS_3$ (3 % XOS cookies)
$CXOS_6$ (6 % XOS cookies)
$CXOS_9$ (9 % XOS cookies)

3.4.2. Cookies Color

Cookies color appeared to change significantly after addition of xylooligosaccharides**.** Color was represented in L*, a* and b* value where L* represent lightness. High L * value represents lighter color and low L* value represents darker color. Similarly a* represents red-green axis and b* represents yellow-blue axis. High a* value gave reddish color which could come from browning of cookies. High b* value showed more yellow to golden brown color of cookies. Table 8, 9 and 10 represent color of fresh and stored cookies. There was decrease in L* value and increase in a* and b* value due to addition of XOS. Similar effects were seen during storage period of 120 days where significant changes in color were observed after 60 days interval. Huang *et al*. (2018) incorporated feruloylated oligosaccharides (FOs) in biscuits and showed increase in a* and b* value with decrease in L* value.

Table 8. Color (L*) of XOS enriched cookies

Treatments	Storage					Means
	0 Day	30 Day	60 Day	90 Day	120 Day	
CC	63.92±0.40^{a}	63.87±0.13^{a}	63.52±0.14^{ab}	63.44±0.10^{ab}	63.36±0.14^{abc}	63.62^{a}
CXOS$_3$	63.87±0.10^{a}	63.77±0.15^{ab}	63.49±0.15^{ab}	63.39±0.20^{abc}	63.19±0.11^{bcd}	63.54^{a}
CXOS$_6$	63.58±0.12^{ab}	63.47±0.15^{ab}	62.73±0.19^{de}	62.20±0.12^{ef}	61.84±0.15^{fg}	62.76^{b}
CXOS$_9$	62.84±0.14^{cd}	62.69±0.26^{de}	61.36±0.35^{gh}	60.82±0.19^{h}	60.15±0.13^{i}	61.57^{c}
Means	63.55^{a}	63.45^{a}	62.77^{b}	62.46^{c}	62.14^{d}	

CC (control cookies)
CXOS$_3$ (3 % XOS cookies)
CXOS$_6$ (6 % XOS cookies)
CXOS$_9$ (9 % XOS cookies)

Table 9. Color (a*) of XOS enriched cookies

Treatments	Storage					Means
	0 Day	30 Day	60 Day	90 Day	120 Day	
CC	9.71±0.12^{k}	9.87±0.05^{jk}	10.11±0.05^{ijk}	10.62±0.38^{hi}	10.92±0.04^{gh}	10.25^{c}
CXOS$_3$	10.11±0.05^{ijk}	10.34±0.05^{ij}	10.45±0.05^{gh}	10.92±0.05^{efg}	11.38±0.28^{a}	11.16^{b}
CXOS$_6$	10.47±0.05^{hi}	10.60±0.20^{hi}	11.31±0.20^{fg}	11.63±0.10^{ef}	12.67±0.35^{bc}	11.29^{b}
CXOS$_9$	11.72±0.05^{ef}	11.86±0.05^{de}	12.34±0.10^{cd}	12.56±0.05^{abc}	12.93±0.05^{ab}	12.28^{a}
Means	10.50^{d}	10.67^{d}	11.17^{c}	11.55^{b}	12.33^{a}	

CC (control cookies)
CXOS$_3$ (3 % XOS cookies)
CXOS$_6$ (6 % XOS cookies)
CXOS$_9$ (9 % XOS cookies)

Table 10. Color (b*) of XOS enriched cookies

Treatments	Storage					Means
	0 Day	30 Day	60 Day	90 Day	120 Day	
CC	26.47±0.15^{m}	26.51±0.10^{m}	26.91±0.10^{jkl}	27.37±0.11^{ghi}	27.79±0.10^{c-f}	27.01^{c}
CXOS$_3$	26.54±0.10^{lm}	26.61±0.10^{klm}	27.11±0.10^{hij}	27.45±0.15^{fgh}	27.91±0.11^{cd}	27.12^{c}
CXOS$_6$	26.97±0.11^{jk}	27.01±0.13^{ij}	27.37±0.10^{ghi}	27.70±0.11^{d-g}	28.13±0.15^{bc}	27.43^{b}
CXOS$_9$	27.53±0.16^{efg}	27.63±0.10^{d-g}	27.91±0.12^{cde}	28.33±0.10^{b}	28.78±0.13^{a}	28.03^{a}
Means	26.88^{d}	26.94^{d}	27.32^{c}	27.71^{b}	28.15^{a}	

CC (control cookies)

$CXOS_3$ (3 % XOS cookies)
$CXOS_6$ (6 % XOS cookies)
$CXOS_9$ (9 % XOS cookies)

3.4.3. Cookies Moisture

Miosture content of cookies increased with the addition of xylooligosaccharides as shown in Table 11. Moisture content of 3, 6 and 9% cookies were compared with control. Results indicated that mean values for treatments CC, $CXOS_3$, $CXOS_6$ and $CXOS_9$ were 3.95, 4.12, 4.25 and 4.53 respectively. Mean values also increased during storage from day 0-120. increased with XOS. As XOS have water binding property which caused water retention making cookies soft and moist. Due to this hygroscopic property of XOS, moisture was retained in cookies during storage preventing them from becoming hard during storage. Ayyappan *et al*. (2016) showed similar results where moisture content increased on incorporating xylooligosaccharides in cookies.

Table 11. Moisture (%) of XOS enriched cookies

Treatments	Storage					Means
	0 Day	30 Day	60 Day	90 Day	120 Day	
CC	2.65±0.07^{k}	2.94±0.06^{ijk}	3.42±0.11^{gh}	4.67±0.05^{bc}	5.12±0.10^{a}	3.95^{b}
$CXOS_3$	2.70±0.07^{jk}	3.09±0.06^{hij}	3.41±0.07^{gh}	3.84±0.09^{ef}	4.22±0.12^{de}	4.12^{c}
$CXOS_6$	2.87±0.05^{ijk}	3.22±0.09^{ghi}	3.61±0.45^{fg}	4.05±0.09^{de}	4.45±0.08^{cd}	4.25^{b}
$CXOS_9$	3.20±0.05^{hi}	3.62±0.04^{fg}	4.07±0.04^{de}	4.41±0.10^{cd}	4.87±0.10^{ab}	4.53^{a}
Means	2.85^{e}	3.51^{d}	4.18^{c}	4.90^{b}	5.63^{a}	

CC (control cookies)
$CXOS_3$ (3 % XOS cookies)
$CXOS_6$ (6 % XOS cookies)
$CXOS_9$ (9 % XOS cookies)

3.4.4. Sensory attributtes of cookies

Xylooligosaccharides did not cause off-taste or after-taste in cookies. Addition of XOS affected taste giving sweetness and darker color as compared to control. Therefore, xylooligosaccharides said to increase the baked characteristics of cookies. Figure 3, 4, 5, 6, 7 and 8 represent the sensory scoring of cookies by panelists on 9 point Hedonic scale elaboratring that 6 % XOS level was acceptable in terms of color, taste, aroma, texture, appearance and overall acceptability of cookies. High incorporation of XOS more than 6 % effected sensory properties of cookies. Juhasz *et al*. (2020) also showed similar results in sensory properties of cookies due to incorporation of xylooligosaccharides.

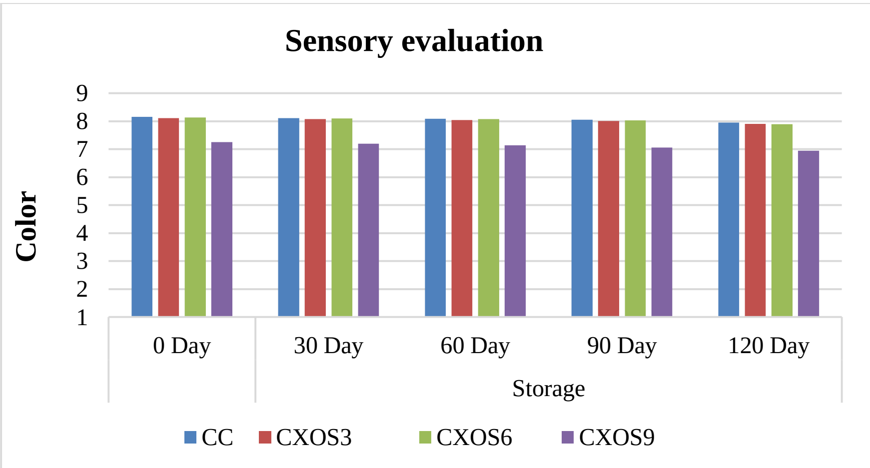

Figure 3. Color of XOS enriched cookies during storage

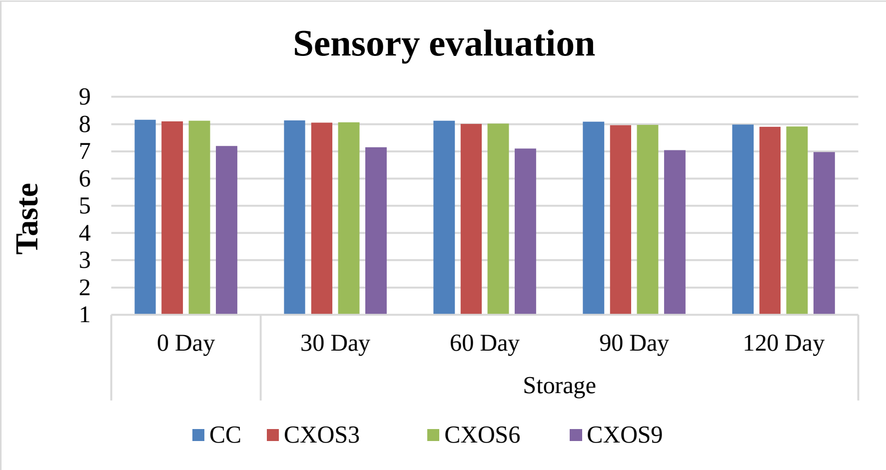

Figure 4. Taste of XOS enriched cookies during storage

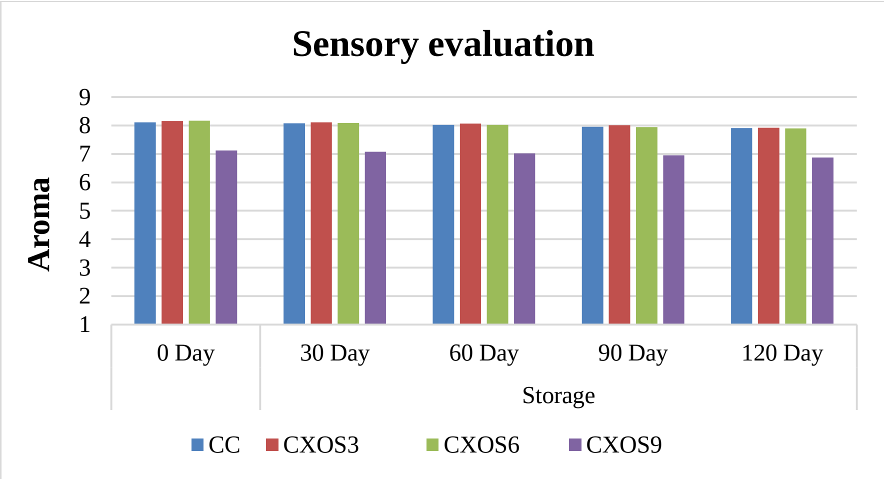

Figure 5. Aroma of XOS enriched cookies during storage

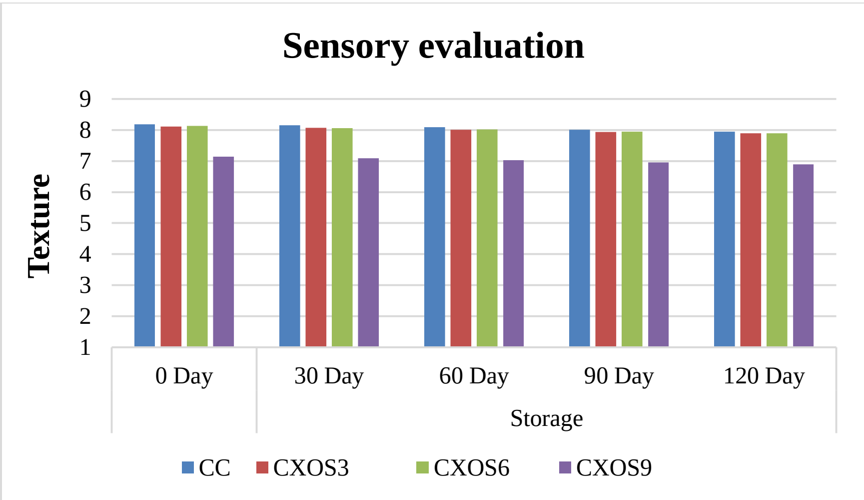

Figure 6. Texture of XOS enriched cookies during storage

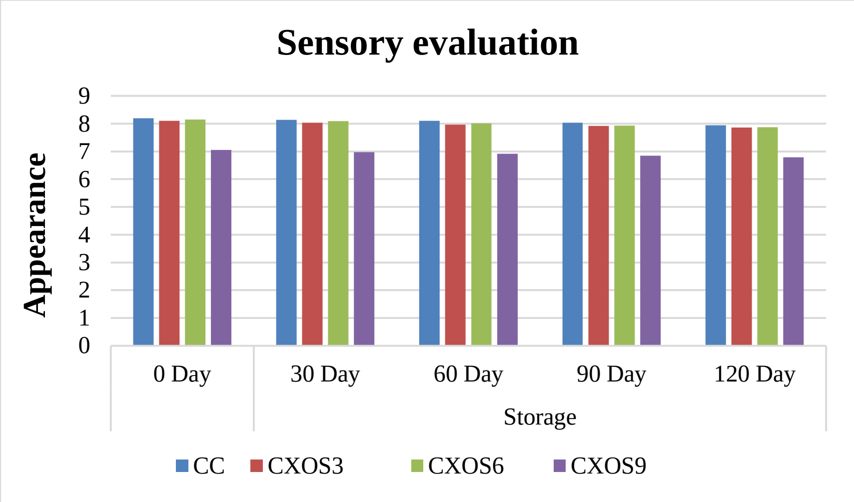

Figure 7. Appearance of XOS enriched cookies during storage

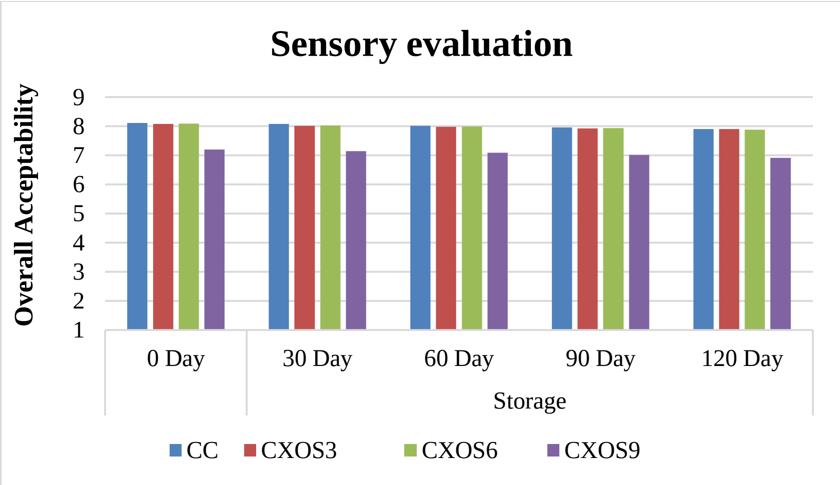

Figure 8. Overall acceptability of XOS enriched cookies during storage

4. CONCLUSION

Prebiotic potential of xylooligosaccharides (XOS) and their effect on cookies were elaborated in this study showing that xylooligosaccharides had positive effect on growth and activity of beneficial intestinal bacteria. Furthermore, cookies were formulated by adding xylooligosaccharides in different concentrations as prebiotic. Results showed that XOS did not affect physical properties of cookies other than moisture percentage which increases on addition of xylooligosaccharides. Color and texture of cookies changed slightly due to incorporation of XOS with good shelf stability at room temperature (25 ℃) in polypropylene boxes. Therefore, these cookies can be a good scource for body to incorporate prebiotic for healthy gut environment and help to prevent systemic body disorders.

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