

## Impact of Xylitol on Physicochemical and Sensory Parameters of Rusks

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**Abstract:** Rusks are mostly used at breakfast in Asian countries like India and Pakistan. Effect of replacement of xylitol on physicochemical and sensory parameters of rusks at various levels of sugar replacement from 0-100% was studied. Physicochemical and sensory characteristics were studied at storage intervals of 0, 10, 20 and 30 days to find out the best treatment for mass production. The moisture content was increased significantly while storage affects non-significantly fat, ash, protein, fiber and NFE contents. Physical analysis showed that hardness was the highest in 100% sucrose containing rusks which decreased significantly with the increase in xylitol. Fracturability increased from 100% sucrose to 100% xylitol revealing that rusks with 100% sucrose are crunchier. Color increased significantly with increasing xylitol, water activity values decreased with an increase of xylitol in rusks. Sensory evaluation revealed that T2 (50% sucrose and 50% xylitol) got the highest score for fresh rusks at 0 day that gradually decreased with the storage but remained the highest.

**Key words:** Xylitol • Replacement • Physicochemical • Sensory evaluation • Rusks

### INTRODUCTION

Xylitol known as birch sugar obtained from the reduction of xylose, also found naturally in the fiber of many fruits and vegetables including berries, corn husks, oats [1] and mushrooms [2] having sweetness level similar to that of table sugar. It has 40% fewer calories and 75% fewer carbohydrates [3]. It is absorbed and metabolized very slowly as compared to sucrose [4]. One-third of the xylitol consumed by the body is absorbed in liver, remaining two-third find its way to intestinal tract, where it is attacked by the intestinal bacteria and broken down into short chain fatty acids [5]. Xylitol metabolize independent of insulin and not involve glucose 6-phosphate dehydrogenase [6] so it can be used as a sugar substitute to treat the diabetic patients [7].

Xylitol owing to no unpleasant aftertaste, non fermentability by most yeasts, molds and bacteria, higher osmotic pressure at low concentration is used as preservative agent in jams and jellies, having low viscosity is utilized in chocolate and yogurt and it gives ice cream a softer consistency [8]. Literature shows that xylitol as a sole sweetener in bakery products is not a suitable option especially in cookies due to poor solubility of xylitol in cookies dough resulting in brown

spots while in case of buns, xylitol is not fermented by *Saccharomyces cerevisiae* resulting in small volumes, moist interiors and dense textures [8].

Rusks are widely used in Asian countries especially at breakfast. Until now, no work has been done on rusks for sugar replacement with xylitol. In current project, keeping in mind the nutritional importance of xylitol for diabetic patients, its physicochemical properties, effect on shelf life on bakery products, sugar is replaced at different concentrations with xylitol to check its impact on the physicochemical, sensory attributes and overall acceptance for rusks.

### MATERIALS AND METHODS

**Procurement of Raw Materials:** Commercial scale xylitol was purchased from Sigma® while wheat flour (maida), ghee, sugar, yeast, salt and eggs were purchased from local market of Faisalabad-Pakistan.

**Preparation of Rusk:** Rusks were prepared from commercially flour with sucrose and xylitol in the ratios of 100:0 (T0), 75:25 (T1), 50:50 (T2), 25:75 (T3) and 0:100 (T4). Rusks were prepared according to method followed by (Yaseen, 2000) with certain modifications.

Hedonic Scale Rating

Product: Rusk Date: .....

Name of Judge: .....

Characteristics	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>
Color					
Taste					
Flavor					
Texture					
Crispness					
Overall acceptability					

Signature.....

**Instruction for judges**

Chew a sample of rusk and score for color, taste, flavor, texture, crispness and overall acceptability using the following scale.

**Key for ranking:**

Dislike extremely	1	Dislike very much	2
Dislike moderately	3	Dislike slightly	4
Neither dislikes nor like	5	Like slightly	6
Like moderately	7	Like very much	8
Like extremely	9		

Fig. 1: Hedonic Scale for sensory evaluation

The recipe followed is flour (500 g), sugar (150 g), yeast (7.5 g), salt (7.5 g), oil (25 g), ghee (50 g) and egg (1). The ingredients were weighed accurately. Water and yeast were mixed in a separate pan and then transferred to the kneader containing flour sugar, shortening and salt. After homogeneous mixing, the batter was placed in a proofer for the action of yeast, at moisture level 15% for 15 min. After the said time it was again transferred to the mixer and oil was added and continue mixing until batter become somewhat elastic. Batter was transferred to pans and gives proofing time of 15 min. Afterward rusks were baked in baking oven for 10-12 min at 218°C. Rusks were cooled down and cut into pieces and again baked until required color was obtained.

**Physical Analysis of Rusks**

**Texture Analysis:** Rusks were analyzed for texture analysis according to method followed by Piga *et al.*, [9] by means of a texture analyzer (Mod.TA-XT2, Stable Microsystems, Surrey, UK) with a 5 kg load cell. Data was analyzed using the Texture Expert program version 1.21.

**Water Activity:** Water activity of rusks were analyzed using an electronic Hygropalm water activity meter (Model Aw-Win, Rotronic, equipped with a Karl-Fast probe) at regular storage interval of 10 days according to method employed by Stekelenburg and Labots, [10].

**Color:** Color of rusks was analyzed by a hand held colorimeter tristimulus colorimeter (Color Test Meter II Neuhaus Neotec), colorimeter was calibrated using standards (54 CTn for dark and 151 CTn for light) before measurement [11].

**Chemical Analysis of Rusks:** The rusks were analyzed for moisture, crude protein, crude fat, crude fiber, nitrogen free extract (NFE) and ash content according to the methods described in AOAC, [12].

**Sensory Analysis of Rusks:** Rusks were analyzed for sensory attributes; color, taste, flavor, texture, crispness and overall acceptability using 9 point hedonic scale (Fig. 1) by 25 students of National Institute of Food Science and Technology, University of Agriculture, Faisalabad-Pakistan.

**Statistical Analysis:** Analysis of variance (ANOVA) was carried out on the data using registered version 8.0 of Statistix software. The least significance difference (LSD) test was used to determine the difference at 5% level of significance,  $P < 0.05$  [13].

**RESULTS AND DISCUSSION**

Results are compared with the literature available on cookies prepared solely and in replacement with polyols, since no data is available on rusks.

**Chemical Analysis of Rusks:** Chemical studies of rusks showed that during the whole storage, there were significant changes in the moisture content and non-significant changes were observed in fat, ash, protein, fiber and NFE (Table 1 and 2). There is a significant change in moisture contents ranging from T0 (2.62) having lowest score to T4 (2.83) having highest score.

**Physical Tests of Rusks:** The results pertaining to physical tests of rusks are presented in Table 3 and 4. The results indicated that hardness decreased significantly from 4950.6 g (T0) to 3090.3 g (T4).

The progressive decrease in the hardness during whole storage period was due to increase in moisture content of rusks since xylitol is hygroscopic in nature. This is favored by less gluten development and less crystallization properties of the xylitol. Olinger and Velasco, [14] investigated cookies with polyols and reported that cookies are softer when prepared with polyols. Zarina *et al.*, [15] reproduced the similar results for cookies prepared by xylitol.

Fracturability represents the crispiness of product. The product having lower value is crispier than product having high value. The results indicate that fracturability value increase from T0 (71.90 mm) to T4 (74.26 mm). This showed that the treatment having more hardness is less crispy and vice versa. Fracturability is significantly affected by storage as shown in Table 4. Minimum value obtained at 0 day (73.34 mm) that gradually increases to 73.84 mm after 30 days of storage. The significant change can be associated with the increase in moisture content. Zarina *et al.*, [15] results concrete the findings of this study.

The results for color are presented in Table 3. The values are indicative of the lightness of samples. Lower color values indicate a darker surface color. Xylitol is chemically inert due to lack of an active carbonyl group.

Table 1: Effect of different treatments on the means of proximate composition of rusks

Treatments	Moisture (%)	Fat (%)	Fiber (%)	Protein (%)	Ash (%)	NFE (%)
T <sub>0</sub>	2.62 <sup>c</sup>	11.585	0.36	7.546	1.473	76.508
T <sub>1</sub>	2.71 <sup>bc</sup>	11.563	0.356	7.528	1.459	76.470
T <sub>2</sub>	2.76 <sup>ab</sup>	11.561	0.354	7.495	1.444	76.428
T <sub>3</sub>	2.78 <sup>ab</sup>	11.555	0.358	7.426	1.443	76.447
T <sub>4</sub>	2.83 <sup>a</sup>	11.550	0.356	7.519	1.424	76.281

Table 2: Effect of storage period on the means of proximate composition of rusks

Storage (days)	Moisture (%)	Fat (%)	Fiber (%)	Protein (%)	Ash (%)	NFE (%)
0	2.68 <sup>b</sup>	11.577	0.359	7.504	1.457	76.495
10	2.73 <sup>ab</sup>	11.562	0.358	7.505	1.451	76.457
20	2.75 <sup>ab</sup>	11.560	0.354	7.508	1.447	76.403
30	2.81 <sup>a</sup>	11.553	0.351	7.490	1.441	76.352

Table 3: Effect of different treatments on the means of physical characteristics of rusks

Treatments	Hardness (g)	Fracturability (mm)	Color CTn	Water activity (aW)
T <sub>0</sub>	4950.6 <sup>a</sup>	71.90 <sup>c</sup>	173.00 <sup>d</sup>	0.24 <sup>a</sup>
T <sub>1</sub>	4816.8 <sup>b</sup>	73.76 <sup>b</sup>	174.08 <sup>d</sup>	0.22 <sup>b</sup>
T <sub>2</sub>	3755.3 <sup>c</sup>	73.81 <sup>b</sup>	177.83 <sup>e</sup>	0.20 <sup>c</sup>
T <sub>3</sub>	3840.1 <sup>c</sup>	74.09 <sup>a</sup>	182.42 <sup>b</sup>	0.17 <sup>d</sup>
T <sub>4</sub>	3090.3 <sup>d</sup>	74.26 <sup>a</sup>	187.75 <sup>a</sup>	0.16 <sup>e</sup>

Table 4: Effect of storage on the means of physical characteristics of rusks

Storage (days)	Hardness (g)	Fracturability (mm)	Color CTn)	Wateractivity(aW)
0	4586.6 <sup>a</sup>	73.34 <sup>b</sup>	178.93	0.15 <sup>d</sup>
10	4388.6 <sup>b</sup>	73.38 <sup>b</sup>	178.73	0.20 <sup>c</sup>
20	3903.4 <sup>c</sup>	73.70 <sup>a</sup>	180.00	0.22 <sup>b</sup>
30	3483.7 <sup>d</sup>	73.84 <sup>a</sup>	178.40	0.22 <sup>a</sup>

Table 5: Effect of different treatments on the means of sensory attributes of rusks

Treatments	Color (CTn)	Flavor	Taste	Texture	Crispiness	Overall acceptability
T <sub>0</sub>	6.25b	6.67b	7.08bc	6.67b	7.25b	6.42bc
T <sub>1</sub>	6.33b	6.42bc	7.25b	6.67b	6.75bc	7.17ab
T <sub>2</sub>	7.83a	8.25a	8.50a	8.25a	8.58a	7.92a
T <sub>3</sub>	6.08b	6.00bc	6.33c	5.58c	6.00cd	6.25c
T <sub>4</sub>	5.00c	5.67c	5.00d	5.17c	5.50d	4.75d

It can't participate in browning reactions. So there is no caramalization during heating, as is typical of sugars [16, 14]. Since xylitol doesn't form millard reaction, so the color of rusks prepared with xylitol is lighter in color (187.75 CTn) than made from sucrose (173 CTn). Zoulias *et al.*, [17] and Zarina *et al.*, [15] observed similar trend for polyol. Storage (Table 4) has non-significant effect on the color values of the rusks.

Water activity is the ratio of vapor pressure of water in food to the vapor pressure of pure water. Water activity indicates the microbial stability of the product and freshness. Effect of different treatments on the water activity of rusks is presented in Table 3. Xylitol exerts higher osmotic pressure thus provides lower water activity in the product as shown by T<sub>4</sub> (0.16) than T<sub>0</sub> (0.24). Bond and Dunning, [18] reported that owing to lower water activity, xylitol gives microbial stability to the product than sucrose. Storage (Table 4) has significant effect on the water activity this is due to hygroscopic nature of xylitol.

**Sensory Analysis of Rusks:** Sensory evaluation is an important tool in a product development. Acceptance of a food product depends upon the consumer's perception of the color, texture and flavor into overall impression of quality. Quality scores pertaining to sensory evaluation of rusks are presented in Table 5. Analysis of variance reveals that various sensory attributes like color, flavor, taste, texture and crispiness differ significantly due to treatments. Each attribute is discussed one by one.

Color is the first perception of eye perceived by the consumer. The results showed a significant difference among treatment, Judges ranked T<sub>2</sub> (7.83) first followed

by T<sub>1</sub> (6.33). Treatments T<sub>0</sub> and T<sub>3</sub> got fairly good score while T<sub>4</sub> (5.00) obtained minimum score when averaged overall means. Flavor of rusks showed highly significant difference among treatments, judges preferred T<sub>2</sub> (8.25) followed by T<sub>0</sub> and T<sub>1</sub> with values 6.67 and 6.42 respectively. While T<sub>4</sub> (5.67) was at the lower side. Taste also observed significant difference among treatment. The mean values of taste for all the treatments revealed that T<sub>2</sub> and T<sub>1</sub> were much liked by the judges and got maximum score, 8.50 and 7.25, respectively whereas T<sub>4</sub> got the minimum score 5.00. Texture of rusk significantly changes among treatments, T<sub>2</sub> obtained maximum score 8.25 while T<sub>4</sub> got lowest score 5.17. The scores for texture of T<sub>0</sub>, T<sub>1</sub> and T<sub>3</sub> are 6.67, 6.67 and 5.58 respectively when averaged overall means. Crispness refers to the outside texture of baked product that increases with the amount of baking time. The results disclosed that treatments have significant difference, T<sub>2</sub> was preferred by the judges and obtained maximum score 8.58 while T<sub>4</sub> having 100% xylitol got lowest score 5.50. The mean values of crispness for T<sub>0</sub>, T<sub>1</sub> and T<sub>3</sub> are 7.25, 6.75 and 6.00 respectively.

Overall acceptability was also determined on the basis of quality scores obtained from color, taste, flavor, texture and crispness. T<sub>2</sub> having 50% sucrose and 50% xylitol was much liked by the judges and got maximum score 7.92 followed by T<sub>1</sub> that obtained 7.16. T<sub>0</sub> and T<sub>3</sub> obtained mean score of 6.42 and 6.25 respectively whereas T<sub>4</sub> got the minimum score 4.75.

The results of this study are favored by the work of Zarina *et al.*, [15], Pasha *et al.*, [19] and Winkelhausen *et al.*, [20] which showed that xylitol addition affects the sensory properties of cookies. Matz, [21] explained that type and quantity of sweetener has a significant effect on appearance, flavor and texture of biscuits.

Table 6: Effect of storage period on the means of sensory attributes of rusks

Storage (days)	Color (CTn)	Flavor	Taste	Texture	Crispiness	Overall acceptability
0	7.20a	7.53a	7.67a	7.33a	7.67a	7.27a
10	6.53ab	6.87ab	7.13ab	6.80ab	7.07ab	6.73a
20	6.13bc	6.47b	6.67b	6.27bc	6.60bc	6.33bc
30	5.33c	5.53c	5.87c	5.47c	5.93c	5.67c

The storage results of various sensory characteristics are presented in Table 6. Statistical analysis for color of rusks revealed that there was a significant effect of storage on treatments. Influence of storage showed that there was a significant decrease in likeness of color. The fresh rusks obtained maximum mean score (7.20) by panelists at 0 day which gradually decreased to (5.33) after 30 days of storage. One assumption for the deterioration of color might be the absorbance of moisture from the atmosphere and oxidation of fat. Pasha *et al.*, [19] prepared cookies using different ratio of sucrose, fructose, sorbitol and mannitol and found that likeness of color changed significantly during storage from 7.57 to 5.12 after 60 days. The results are also in accordance with Zarina *et al.*, [15] who prepared cookies using xylitol and observed significant decrease in color score from 6.80 to 5.10 after 60 days of storage. The panelists gave a maximum mean score of 7.53 for flavor at 0 day (Table 6) that was gradually decreased to 5.53 after 30 days. The gradual decrease in flavor is due to oxidation of fat during storage. The change in flavor score during the storage for various treatments is in proximity with the findings of Pasha *et al.*, [19] who reported that flavor score changed significantly from 7.52 to 5.15 at 0 to 60 days of storage. Zarina *et al.*, [15] reported a decrease in flavor from 7.20 to 5.40 after 60 days of storage for cookies. During storage, taste was significantly affected in decreasing order. The range is 7.67 to 5.87 from 0 to 30 days of storage. This might be due to hygroscopic nature of xylitol. Similar decreasing trend in the taste was observed by Pasha *et al.*, [19] in cookies prepared by different polyols ranging from 7.55 to 5.15 after 60 days of storage. Zarina *et al.*, [15] reported the same trend in cookies from 6.60 at 0 day to 4.66 after 60 days. Panelists observed significant change in texture of rusks during 30 days of storage with a mean score of 7.33 at 0 day to 5.47 after 30 days. The findings are in accordance with Pasha *et al.*, [19] who reported that texture of cookies decreased significantly from 7.45 to 5.15 after 30 days of storage. Crispiness affects significantly with moisture, panelists observed significant decrease in crispiness during 30 days of storage with maximum mean score 7.67 at 0 day to 5.93 after 30 days.

Overall acceptability depending on taste, flavor, texture, color and crispiness also changed significantly during 30 days with highest mean score of 7.27 at 0 day that gradually decreased to 5.66 after 30 days. Similar trend 7.40 to 5.12 was observed by Pasha *et al.* (2002) in cookies made by using different polyols. Zarina *et al.*, [15] who reported significant decrease in overall acceptability of cookies from 6.20 to 4.53 after 60 days of storage due to replacement of sucrose with xylitol.

## CONCLUSION

It is concluded from the present study that bakery products prepared by xylitol in replacement with sucrose are sensorially accepted by the consumers with extended shelf life. Xylitol proved its practical applicability as sugar and alternative sweetener in bakery products.

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