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ORIGINAL ARTICLE

Baking quality, sensory properties and shelf life of bread with polyols

Suresh Bhise · A. Kaur

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Abstract The polyols namely glycerol, sorbitol and mannitol were incorporated at 2, 4 and 6 % level in flour for bread making and their effect on textural properties, bread making quality and sensory acceptability of bread was studied. The effect of incorporation revealed the increased bake absorption, bread weight and decreased specific volume. The overall acceptability scores were maximum for bread prepared with glycerol at 2 % level, followed by sorbitol at 4 % level and mannitol at 4 % level. During storage of packed bread, moisture content and water activity were higher for bread prepared from polyols as compared to control and it was observed that moisture content was higher in bread packed in Polypropylene. Formation of free fatty acid content (% oleic acid) was observed to be higher in the breads stored at ambient condition and packed in Low density polyethylene packaging material. The overall acceptability of bread decreased with the increased storage period.

Keywords Bread · Polyols · Sensory acceptability · Shelf life

Introduction

Bakery is the third largest food industry of India. The increase in the growth rate is due to setting of more automatic plants, increased availability of raw materials of consistent quality, introduction of newer bakery products and reduction of product cost. Research work has been carried out on improvement in quality of raw materials, use of additives to improve quality but work on extension of shelf life of these products is lacking. Bread has shelf life of 5 days. Shelf life of bakery product is mostly characterized by onset of staling and ropiness formed by microbial spoilage. Other factor affecting shelf life are rancidity, crystallization, grittiness, synersis of jams and jellies, development of off flavors and odors other than rancidity, chocolate bloom, structural weakness, fade color or moisture migration. To extend the shelf life of bakery products, the above factor must be controlled by suitable preservation methods.

Polyols or sugar alcohols, a group of reduced calorie sweeteners, are the natural and nutritive sweeteners. These are neither sugars nor alcohols; rather they are a group of low digestible carbohydrates which can be used instead of sucrose. They occur naturally in foods and come from plant products such as fruit and berries. They are used in food as sweeteners and bulking agents. Polyols have slightly reduced sweetness and caloric values compared to sucrose. Polyols are available either in solid crystalline form or syrups and are emerging as a sugar replacer as well as a sugar substitute. Polyols offer the baker a versatile range of ingredients to boost the available portfolio of products. Polyols provide the functional benefits to bakery goods when the sugars used are replaced with polyols (Ghosh and Sudha 2012).

Sorbitol, xylitol and mannitol reduce or do not promote the risk of tooth decay, which causes less increase in the blood sugar and insulin levels than carbohydrates, and act as humectants, thus depressing the water activity and inhibit the yeast growth (Lenovich et al. 1988).

The acceptability of the product by the consumer is the critical factor in the market growth. Though the problems are challenging but not impossible to encompass, thus with the increased availability of polyols and innovations in food technology, additional good tasting, reduced calorie, sugar-free bakery products are expected to be available. These products will assist in maintaining good oral health, managing weight and controlling blood glucose levels, thus reducing the risk of a variety of lifestyle related diseases (Ghosh and Sudha 2012).

S. Bhise (✉) · A. Kaur
Department of Food Science & Technology, Punjab Agricultural University, Ludhiana 141004, Punjab, India
e-mail: sureshbhise_cft@yahoo.co.in

A. Kaur
e-mail: foodtechak@gmail.com

The present day consumer looks for new bakery products, better appeal, taste and convenience from bakery foods. Preservation in bakery means the retardation of spoilage including the texture staling. A hygroscopic substance has the effect of keeping the food stuff moist (sorbitol, xylitol, maltitol). Polyols elicit a low glycemic response beneficial to all consumers, including those with diabetes and that ensure products retain the appropriate moistness and mouth feel during storage. Sorbitol has an antioxidizing effect and prevents fatty foods from turning rancid. Therefore, incorporation of polyols could be very useful to improve the texture and prolong the shelf life without staling (Storey et al. 2007).

Keeping these points in mind, the present study was planned with the objectives to optimize and to find out the best level on the basis of quality, to find the overall acceptability of the bread on the basis of sensory evaluation by panelists and to study the shelf life of bread prepared after incorporation of polyols in suitable packaging material.

Materials and methods

Raw materials

Flour, sugar, polyols (glycerol, sorbitol and mannitol), salt, yeast and other ingredients for product preparation were procured from local market.

Chemical analysis of flour

Chemical characteristics namely protein, fat, ash free fatty acids, wet gluten, dry gluten and sugars of flour were analyzed using standard procedures (AACC 2000).

Treatments

Bread was prepared after incorporation of polyols such as glycerol, sorbitol and mannitol at levels of 0–6 %.

Product preparation

Bread was prepared according to standard procedure (AACC 2000) without addition of preservatives. The formula for bread is as given below:

Ingredients	Quality (g)
Flour	100
Compressed yeast	3.0
Sugar	2.5
Bakery shortening	2.0
Salt / NaCl	1.0
Water	Optimum

The dough was prepared and baking schedule is given under:

Mixing	Optimum (3 min)
Fermentation	45 min
Remixing	25 s
Recovery	20 min
Sheeting and moulding	3 min
Proofing (at 86 °F, RH 75 %)	55 min
Baking	25 min at 450 °F

Sensory evaluation

Prepared bread was evaluated for sensory properties such as appearance, color, texture, flavor and overall acceptability by panel of semi trained judges (Larmond 1970).

Calorific value

Calorific value was determined by using Bomb Calorimeter, Parr Calorimeter Assembly-6100 (Parr Instrument Company, Moline, Ilinois 61265, U.S.A).

Shelf life

After preparation, the control and polyols incorporated breads were packed in different packaging materials (Low density polyethylene and polypropylene) and were stored for 10 days at ambient (30±1 °C) and refrigerated (4–6 °C) conditions. Periodic analysis for moisture, water activity and free fatty acid were carried out to asses the shelf life.

Statistical analysis

Data obtained was analyzed statistically using techniques of analysis of variance (ANOVA) (Singh et al. 1991).

Results and discussion

Flour characteristics

The flour had 11.99 % protein, 0.85 % fat, 0.44 % ash, 0.035 % free fatty acid (as% oleic acid), 28.92 % wet gluten, and 8.42 % dry gluten, 203.75 mg maltose/10 g flour total sugars and 30.26 mg maltose/10 g of reducing sugars. On the basis of the protein content, the flour was found to be suitable for its use in production of bread. The results obtained were in close association with the findings of Pasha et al. (2002).

Bread baking quality

The effect of incorporation of glycerol, sorbitol and mannitol at 2, 4 and 6 % level on baking qualities of bread are presented in Table 1. Bread prepared after incorporation of glycerol, sorbitol and mannitol showed statistically significant variations regarding bake absorption, loaf volume, loaf weight and specific volume.

Bake absorption increased with increased incorporation level of glycerol as compared to control. With the incorporation of sorbitol at 2, 4 and 6 % level for bread making, bake absorption increased from 75 % at 2 % level to 76 % at 6 %. Similarly, bake absorption increased with increased levels of mannitol incorporation as compared to control which was 68 %. This might have been due to increased water absorption capacity of polyols (glycerol, sorbitol and mannitol). Loaf height for control sample was 9.26 cm. With the incorporation of sorbitol and mannitol at 2, 4 and 6 % for bread making, loaf height increased from 8.93 cm at 2 % to 10.13 cm at 6 % level and 9.13 cm at 2 % to 9.40 cm at 6 %, respectively. Loaf height for bread incorporated with glycerol decreased from 9.66 cm at 2 % to 8.83 cm at 6 % level of incorporation. Increased loaf height with polyols addition suggested that the addition of polyols improved the gas retention properties of gluten.

Loaf weight for control sample was 135.26 g. With the incorporation of glycerol and mannitol at 2, 4 and 6 % in flour for bread making, loaf weight vary from 154.55 g, 145.71 g and 149.61 g respectively, and 144.10 g, 154.84 g and 156.57 g respectively. Maximum loaf weight was 148.13 g at 4 % level of sorbitol incorporation as compared to control which was 135.26 g.

Loaf volume for control sample was 662.33 cc. Significant variations were found in loaf volume for bread incorporated with different levels of glycerol, sorbitol and mannitol at 2, 4 and 6 % in flour for bread making. Loaf volume decreased with increased level of glycerol, sorbitol and mannitol incorporation in flour for bread making. Loaf volume was maximum when 2 % glycerol (748 cc), 4 % sorbitol (687.66 cc) and 4 % mannitol (717.33 cc) were incorporated. Significant variation was found in specific volume for bread incorporated with different levels of glycerol, sorbitol and mannitol for bread making. Specific volume of bread decreased with the increased level of incorporation of glycerol, sorbitol and mannitol. Maximum specific volume was observed at 2 % glycerol, 4 % sorbitol and 4 % mannitol which were 4.84 cc/g, 4.64 cc/g and 4.63 cc/g, respectively. Specific volume decreased with increased level of incorporation of polyols. This might have been due to dilution of gluten protein after the incorporation of fibre (Pomeranz et al. 1977).

Baik and Chinachoti (2003) reported that glycerol could osmotically attract water from starch and gluten matrix. Sorption isotherms of bread crumb and glycerol showed increase in water absorption. Bread with 8.8 % level of glycerol showed higher water sorption curve indicating greater affinity to words water than control. The force required to compress the bread decreased with the addition of glycerol. Glycerol functioned as a humectants resulting in a softer crumb structure. Loaf volume increased with increasing levels of glycerol.

Statistically, non significant variations were observed with regard to overall acceptability score for bread prepared after incorporation of glycerol, sorbitol and mannitol at 0, 2, 4 and 6 %. The breads were evaluated by semi trained panel of judges on nine point hedonic scale. Scores for the overall acceptability for control bread were 7.87. Maximum score for the overall acceptability were recorded at 2 % glycerol, 4 % sorbitol and 4 % mannitol incorporation and were 8.45, 8.20 and 8.46, respectively.

Table 1 Effect of incorporation of polyols on baking quality, overall acceptability and textural property of bread

Polyols	Level (%)	Bake absorption (%)	Loaf height (cm)	Loaf weight (g)	Loaf volume (cc)	Specific volume (cc/g)	Overall acceptability	Hardness (N)	Resilence
Control	0	68.0	9.26	135.26	652.33	4.82	7.87	5.89	0.32
Glycerol	2	72.0	9.66	154.55	748.00	4.84	8.45	4.30	0.70
	4	73.0	9.26	145.71	677.33	4.64	8.42	4.25	0.65
	6	73.0	8.83	147.61	562.33	3.81	7.42	4.23	0.77
Sorbitol	2	75.0	8.93	145.86	632.00.	4.33	8.00	5.62	0.70
	4	76.0	9.13	148.13	687.66	4.64	8.20	5.22	0.76
	6	76.0	10.13	142.10	607.66	4.27	7.40	5.44	0.68
Mannitol	2	74.5	9.13	144.70	663.66	4.58	8.00	5.94	0.66
	4	75.0	9.36	154.84	717.33	4.63	8.46	5.22	0.67
	6	75.0	9.40	156.57	607.33	3.87	7.92	7.25	0.66
LSD (p<0.05)		0.68	5.79	1.73	32.79	0.23	NS	0.12	0.17

LSD Least significant difference

Textural properties of bread

The effect of incorporation of glycerol (2, 4 and 6 %), sorbitol (2, 4 and 6 %) and mannitol (2, 4 and 6 %) on the textural properties of bread is presented in Table 1. The textural properties were calculated from the force time diagram measured by the texture profile analysis. Significant variations were observed for the hardness and resilence of bread prepared from incorporation of glycerol, sorbitol and mannitol for bread making. Hardness for control sample was 5.89 N. With the incorporation of glycerol at 2, 4 and 6 % in flour for bread making, hardness for bread decreased from 4.30 N at 2 % level to 4.23 N at 6 % level of incorporation. With the incorporation of sorbitol at 2, 4 and 6 % in flour for bread making, hardness for bread found lowest at 4 % (5.22 N). Hardness for bread was found lowest at 4 % mannitol (5.22 N).

The force required to compress the bread decreased with the addition of glycerol. Glycerol functioned as humectants (Pyler 1988) and resulted in softer crumb. Loaf volume increased with increasing levels of glycerol. The larger loaf would have a less dense gluten network giving less resistance to compression. Cauvain and Cyster (1996) found that added glycerol resulted in a softer crumb structure. The firming mechanism postulated that interactions occur between the swollen starch granules and the continuous protein network in bread. These interactions or cross links originate during the baking process. Ageing permits more linkages to form and strengthens linkages already present in the baked bread (Martin and Hosney 1991).

Resilence for the control bread was 0.32. Resilience for bread was found maximum at 2 % glycerol (0.70), 4 % sorbitol (0.76) and 4 % mannitol (0.66) level of incorporation.

Selection and study of best level of polyols

On the basis maximum score for overall acceptability, more value for bake absorption, bake weight and bake volume, 2 % glycerol, 4 % sorbitol and 4 % mannitol were selected as best level for further studies. The effect of incorporation of 2 % glycerol, 4 % sorbitol and 4 % mannitol on baking quality of bread is presented in Table 2. Statistically significant variations were observed with regard to bake absorption, loaf height, loaf weight, loaf volume and specific volume of bread.

Significant variations were observed on bake absorption for bread incorporated with 2 % glycerol, 4 % sorbitol and 4 % mannitol. Bake absorption for bread incorporated with 2 % glycerol, 4 % sorbitol and 4 % mannitol were 72.5 %, 73.0 % and 73.8 %, respectively. Loaf height for the control bread was 9.33 cm. Loaf heights for bread incorporated with 2 % glycerol, 4 % sorbitol and 4 % mannitol were 9.37 cm, 9.43 cm and 9.03 cm, respectively. Loaf weight of bread varied significantly. Loaf weight for bread incorporated with 2 % glycerol, 4 % sorbitol and 4 % mannitol were 140.99 g, 156.07 g and 150.31 g, respectively. Loaf volume of bread varied significantly with respect to control. Loaf volume for control bread was 643.33 cc. Loaf volume of bread incorporated with 2 % glycerol, 4 % sorbitol and 4 % mannitol were 640.50 cc, 653.33 cc and 639.23 cc, respectively. Specific volume for control bread was 4.70 cc/g. Specific volume of bread incorporated with 2 % glycerol, 4 % sorbitol and 4 % mannitol were 4.54 cc/g, 4.19 cc/g and 4.25 cc/g, respectively. Among the polyol bread, maximum specific volume was observed at 2 % level of glycerol incorporation (4.54 cc/g).

Scores for the overall acceptability of control bread was 7.92. More scores were given to overall acceptability of bread incorporated with polyols. Score for the overall acceptability of bread prepared after incorporation of 2 % glycerol, 4 % sorbitol and 4 % mannitol were 7.87, 8.07 and 8.30, respectively. Polyol breads were liked more as compared to control and among the polyol breads; bread with 4 % mannitol was the best.

Erythritol had a high digestive tolerance and was non-caloric, non carcinogenic and non glycaemic and had antioxidant properties, it fits well into the functional food concepts to which it confers a healthy image (Storey et al. 2007).

Calorific value

Polyols incorporated breads were evaluated for their calorie content. Calorie content of control bread was more than polyol bread. Calorie content of polyols incorporated bread was lower than control. Calorie reduction (%) for bread prepared after incorporation of 2 % glycerol, 4 % sorbitol and 4 % mannitol

Table 2 Effect of incorporation of best level of polyols on baking quality, overall acceptability and calorie reduction (%) of bread

Polyols	Level (%)	Bake absorption (%)	Loaf height (cm)	Loaf weight (g)	Loaf volume (cc)	Specific volume (cc/g)	Overall acceptability	Calorie reduction (%)
Control	0	68.0	9.33	136.84	643.33	4.70	7.92	0
Glycerol	2	72.5	9.37	140.99	640.50	4.54	7.87	9.31
Sorbitol	4	73.0	9.43	156.07	653.33	4.19	8.07	3.91
Mannitol	4	73.8	9.03	150.31	639.23	4.25	8.30	16.20
LSD ($p<0.05$)		0.24	0.17	0.23	1.12	0.36	NS	0.17

LSD Least significant difference

Table 3 Effect of packaging material, storage condition and period on moisture content (%) of bread prepared by adding polyols

Days	Storage condition															
	Ambient (30±1 °C)								Refrigeration (4–6 °C)							
	Packaging material															
	LDPE				PP				LDPE				PP			
	Control	2 % glycerol	4 % sorbitol	4 % mannitol	Control	2 % glycerol	4 % sorbitol	4 % mannitol	Control	2 % glycerol	4 % sorbitol	4 % mannitol	Control	2 % glycerol	4 % sorbitol	4 % mannitol
0	35.22	36.33	41.47	40.79	35.73	41.56	41.32	41.58	36.28	41.37	43.19	41.81	36.74	41.08	42.70	40.39
2	34.45	35.95	38.32	39.65	35.44	35.21	40.48	41.16	36.61	41.69	43.39	42.08	37.08	41.25	43.02	41.34
4	35.21	35.32	34.49	37.51	34.73	34.71	34.68	40.20	36.59	42.13	43.59	42.19	37.22	41.57	43.34	41.81
6	33.59	34.23	34.12	35.63	34.38	34.40	33.96	39.30	36.56	43.50	43.80	42.29	37.37	41.79	43.72	42.51
8	31.50	33.57	33.18	34.67	34.09	34.19	33.54	38.31	36.62	42.87	43.97	42.43	37.64	42.25	44.22	43.23
10	31.32	41.76	40.79	33.58	33.63	33.69	33.22	37.05	36.57	43.31	44.26	42.63	37.91	42.61	44.73	44.29
LSD (p<0.05)	0.58				0.47				0.62				0.23			

LSD Least significant difference, *LDPE* Low density polyethylene, *PP* Polypropylene

Table 4 Effect of packaging material, storage condition and period on water activity of bread prepared by adding polyols

Days	Storage condition															
	Ambient (30±1 °C)								Refrigeration (4–6 °C)							
	Packaging material															
	LDPE				PP				LDPE				PP			
	Control	2 % glycerol	4 % sorbitol	4 % mannitol	Control	2 % glycerol	4 % sorbitol	4 % mannitol	Control	2 % glycerol	4 % sorbitol	4 % mannitol	Control	2 % glycerol	4 % sorbitol	4 % mannitol
0	0.83	0.80	0.81	0.80	0.84	0.80	0.81	0.80	0.83	0.81	0.81	0.80	0.83	0.80	0.81	0.80
2	0.83	0.82	0.83	0.82	0.83	0.82	0.83	0.82	0.84	0.82	0.82	0.82	0.84	0.82	0.82	0.82
4	0.85	0.83	0.83	0.84	0.85	0.83	0.83	0.84	0.87	0.84	0.83	0.83	0.84	0.83	0.84	0.83
6	0.85	0.86	0.84	0.86	0.85	0.86	0.84	0.86	0.87	0.87	0.84	0.85	0.85	0.86	0.85	0.85
8	0.87	0.86	0.86	0.87	0.87	0.86	0.86	0.87	0.89	0.88	0.88	0.86	0.89	0.88	0.86	0.87
10	0.91	0.87	0.88	0.89	0.91	0.87	0.88	0.89	0.92	0.83	0.90	0.87	0.94	0.89	0.88	0.90
LSD (p<0.05)	0.012				0.012				0.009				0.011			

Table 5 Effect of packaging material, storage condition and period on overall acceptability of bread prepared by adding polyols

Days	Storage condition															
	Ambient (30±1 °C)								Refrigeration (4–6 °C)							
	Packaging material															
	LDPE				PP				LDPE				PP			
	Control	2 % glycerol	4 % sorbitol	4 % mannitol	Control	2 % glycerol	4 % sorbitol	4 % mannitol	Control	2 % glycerol	4 % sorbitol	4 % mannitol	Control	2 % glycerol	4 % sorbitol	4 % mannitol
0	8.35	8.54	8.47	8.69	8.44	8.49	8.53	8.69	8.56	8.56	8.48	8.69	8.47	8.49	8.72	8.64
2	8.27	8.49	8.37	8.54	8.35	8.37	8.20	8.44	8.36	8.49	8.42	8.55	8.38	8.37	8.63	8.48
4	8.05	8.28	8.27	8.34	7.99	8.14	8.11	8.34	8.17	8.34	8.37	8.41	7.86	8.33	8.38	8.13
6	7.62	7.95	7.97	8.20	7.87	7.91	7.86	8.18	7.90	8.18	7.99	7.93	7.78	7.97	7.31	7.24
8	7.40	7.83	7.75	7.86	7.73	7.88	7.77	7.72	7.58	7.83	7.89	7.81	7.70	7.62	7.04	7.07
10	6.33	7.45	7.23	7.72	7.18	7.33	7.15	7.30	6.72	6.86	6.95	7.45	6.66	7.03	6.54	6.24
LSD ($p<0.05$)	0.08				0.23				0.11				0.10			

were 9.31 %, 3.91 % and 16.20 %, respectively (Table 2). Reductions in calorific values of cookies using erythritol as sugar replacer have been reported by Lin et al. (2010).

Shelf life study

Shelf life of best level of breads prepared after incorporation of polyols was studied. Breads were analysed for moisture, water activity, free fatty acid and overall acceptability under ambient temperature (30±1 °C) and refrigerated temperature (4–6 °C) conditions. Breads were stored in different packaging material, under different temperature conditions and their moisture content, water activity, free fatty acid and overall acceptability were estimated after 2 days interval for 10 days.

Moisture content

The bread stored under ambient conditions showed a higher rate of moisture loss than those stored under refrigerated conditions (Table 3). Higher moisture content was found in bread prepared after incorporation of 4 % sorbitol as compared to control. Sorbitol had high capacity to absorb and hold more water than other polyols sources. Statistically significant variations were observed in the moisture content of bread prepared with polyols with respect to days of storage, temperature of storage and packaging material. Interactions between type of bread and days of storage, type of bread and temperature of storage, days of storage and temperature of storage and type of bread, days of storage and temperature of storage were found to be significant.

The bread prepared after incorporation of 4 % sorbitol had maximum moisture content. Bread packed in low density polyethylene showed a higher rate of moisture loss than those packed in polypropylene packaging material. Moisture retention property of polyols keeps bread fresher for longer period of time. Higher moisture retention in bread is economical & also required to lengthen shelf life. Bread moisture content-after baking indicates the quality and can be directly correlated to shelf life of produce. Hardness of breads increased over time. The initial rate of firming was rapid, showing down over time. The lower compression force value for the yeast leavened bread could be due to yeast leavening resulting in a lighter, more open crumb structure with larger holes (Lombardg et al. 2000). Polyols had slightly reduced sweetness compared to sucrose. They had lower solubility and higher crystallization effects. Most of the polyols start to absorb moisture in the range of 70–90 % RH at 20 °C (Kearsley and Deis 2006).

Water activity

Statistically significant variations were observed in the water activity of bread prepared with polyols with respect to days of storage, packaging material and temperature of storage (Table 4). Increases in water activity of bread prepared from polyols were less than that of control bread. Glycerol bread had lower water activity (0.83) than bread prepared from sorbitol (0.88) and mannitol (0.89). At refrigeration storage, water activity increased with the storage time, same findings were noted by Frazier and Westhoff (1978). Water activity for breads at both storage conditions was less than 0.6. Arya (1980) reported that storage at less than 0.57 a_w did not cause perceptible change in flavor for 24–52 days.

Petrizzellig (1988) developed shelf life of intermediate moisture dough or pastry made from 30 to 40 % native starch, 15–25 % fat, 5–10 % water and 2–5 % glycerol or 4–7 % sorbitol with emulsifier, salt and flavoring. The water activity of product was 0.6–0.8. Water activity has marked effect on the growth of microorganisms. (Breene et al. 1988). Labuza et al. (1972) reported that reducing water activity below 0.7 prevented microbial spoilage. Polyols contained one or more free hydroxyl group. Rossel et al. (2001) reported that the hydroxyl group of the fibre structure which allow more water interaction through hydrogen bonding.

Free fatty acid (as % oleic acid)

Statistically significant variations were observed in development of free fatty acids in the breads stored under ambient conditions but in different packaging materials. The development of free fatty acids was lower in case of bread and it was found to be highest on the 10th day of storage. Bread stored under ambient condition showed higher amount of free fatty acid than bread stored under refrigeration conditions. Bread packed in low density polyethylene had higher values of free fatty acids than bread packed in polypropylene. This could have been because of the fact that polypropylene had less water vapor transmission rate as compared to low density polyethylene. The interactions between type of bread and days of storage, days of storage and packaging material and type of bread, days of storage and packaging material were found to be significant whereas interaction between type of breads and packaging material were found to be non-significant. Free fatty acid content was more for bread stored under ambient condition than bread stored at refrigeration conditions because of the fact that polypropylene had less water vapor transmission rate as compared to low density polyethylene. Gain of moisture by the product promoted oxidation of fats. Similar results were obtained by Singh et al. (2000) who reported that free fatty acid content of all biscuits increased gradually with the increase in the storage period.

Overall acceptability

Statistically significant variations were observed in the overall acceptability of breads stored under ambient conditions but in different packaging material (Table 5). Overall acceptability of bread decreased with increased storage period from 2 to 10 days due change in texture of bread. Overall acceptability decreased more in bread stored under ambient temperature conditions than that for refrigeration temperature. Overall acceptability for bread stored under ambient condition was less than that of refrigeration condition because of increased hardness of bread. Eleonora et al. (2007) was concluded that the cookies with xylitol could be stored longer without change in its original flavor and textural attributes. It was observed in sensory evaluation that with the increase in the percentage of erythritol replacement there was a decrease in the mean scores for the surface color of cookies. Cookies with 100 % erythritol had a light surface color, whereas sucrose cookies had yellowish brown color (Lin et al. 2010).

Conclusion

The effect of incorporation of glycerol, sorbitol and mannitol at 2, 4 and 6 % on bread baking and sensory properties of bread revealed the increased bake absorption, increased bread weight and decreased specific volume. The overall acceptability scores were maximum for bread prepared with mannitol at 4 % level, followed by glycerol at 2 % level and sorbitol at 4 % level. With the increasing level of incorporation of polyols, there was definite improvement in the texture of bread. Shelf life of control bread was 4 days which increased to 10 days by incorporation of polyols in bread making.

References

AACC International (2000) Approved methods of the American Association of Cereal Chemists. American Association of Cereal Chemists, St Paul

Arya SS (1980) Effect of water activity on storage changes in total carotenoids and lipids in Bengalgram (*Cicer arietinum*) dhal and flour. J Food Sci Technol 18:139–142

Baik MY, Chinachoti P (2003) Water self-diffusion coefficient and staling of white bread as affected by glycerol. Cereal Chem 80:740–744

Breene WM, Taoukis PS, Labuza TP (1988) The role of water activity in foods. Adv Cereal Sci Technol 9:91–94

Cauvain S, Cyster J (1996) Campden and Chorleywood food research association review. J Sponge Cake Technol 2:1–43

Eleonora W, Ruzica J, Elena V, Slobodanka K (2007) Sensory and microbiological quality of a baked product containing xylitol as an alternative sweetener. Int J Food Prop 10:639–649

Frazier WC, Westhoff DC (ed) (1978) Food Microbiol. pp181–2 Tata McGraw-Hill

Ghosh S, Sudha ML (2012) A review on polyols: new frontiers for health-based bakery products. Int J Food Sci Nutr 63:372–379

Kearsley MW, Deis RC (2006) Sorbitol and mannitol. In: Mitchell H (ed) Sweeteners and sugar alternatives in food technology. Blackwell Publishing Limited, Oxford, pp 249–261

Labuza TP, Mc Naly LD, Gallaghar J, Hawkes I, Hurdato F (1972) The stability of intermediate moisture food. J Food Sci 37:154

Larmond E (1970) Methods of sensory evaluation of food. Canadian department agricultural publications 1284, Ottawa, pp 55–57

Lenovich LM, Buchanan RL, Worley NJ, Restino L (1988) Effect of solute type on Sorbate resistance in *Zygosaccharomyces rouxii*. J Food Sci 53:914–916

Lin SD, Lee CC, Mau JL, Lin LY, Chiou XY (2010) Effect of erythritol on quality characteristics of reduced calorie Danish cookies. J Food Qual 33:14–26

Lombardg E, Weinert IAG, Minnaar A, Taylor JRN (2000) Preservation of South African steamed bread using hurdle technology. Lebensm-Wiss u-Technol 38:138–143

Martin ML, Hosney RCA (1991) A mechanism of bread firming II. Role of starch hydrolyzing enzymes. Cereal Chem 68:503–507

Pasha I, Butt MS, Anjum FM, Shehzadi N (2002) Effect of dietetic sweeteners on the quality cookies. Int J Agric Bio 4:245–248

Petrizzellig (1988) Long shelf life Patisserie dough. French Patent, Abstr in FSTA AN: 8808–V0079

Pomeranz Y, Shogren MD, Finny KF, Bechtel DB (1977) Fibre in bread making- effects on functional properties. Cereal Chem 54:25–41

Pyler EJ (1988) Baking: science and technology, vol 1. Sosland Publishing Co., Meriam

Rossel CM, Rojaz JA, Benedito BD (2001) Influnce of hydrocolloids on dough rheology and bread quality. Food Hydrocolloid 15:75–78

Singh S, Singh T, Bansal ML, Kumar R (1991) Statistical methods for research workers. Kalyani Publishers, New Delhi

Singh R, Singh G, Chauhang S (2000) Development of soy fortified biscuits and shelf life studies. J Food Sci Technol 37:300–303

Storey D, Lee A, Bornet F, Brouns F (2007) Gastrointestinal tolerance of erythritol and xylitol ingested in a liquid. Eur J Clin Nutr 61: 349–354