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A comparison of the effect of sorbitol, raisin and prune concentrate on dough rheology, quality and shelf life of barbari bread

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Abstract

In recent days, there has been a general increase in the number of consumers who reject all synthetic additives in food; however research has revealed many novel applications for plum and raisin products as functional natural bakery ingredients. Raisin and prune concentrate and commercial sorbitol were incorporated into the Barbari bread formulation at different levels and their effects on the rheological, baking properties and shelf life of breads were evaluated. Supplemented dough absorbed more water than control. The presence of sorbitol, raisin and prune concentrate slightly increased dough development time. Firmness of breads decreased about the 15% for bread containing 4% raisin concentrate and 40% for bread containing 4% prune concentrate, and 40% for 1% sorbitol. Addition of raisin and prune concentrate showed more reduction in water activity in compare with control. Breads containing raisin concentrate, prune concentrate were sensory rated higher than those with sorbitol and control. Results showed that, raisin and prune concentrate could be used as a natural ingredient to prolong the shelf life and improve baking quality of Barbari bread.

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Introduction

Flat breads are the main dietary staple in many Middle East and North African countries. Barbari is the oldest and most popular flat bread in Iran (Razavizadegan *et al*., 2012). Consumer demand is toward consumption of high quality fresh bread. However, this product has a short shelf life. Therefore, application of some additives are necessary to improve dough machinability, crumb texture and freshness of the product during storage (Barcenas and Rosell, 2006; Azizi *et al*., 2003; Caballero *et al*., 2007). Water is one of the most important components of bread. The nature of water bonding with bread components and its interaction with the surrounding atmosphere affects the physical or textural characteristics of the product as well as the bread's shelf stability (Ergun *et al*., 2010).Humectants are additives that bind water and control a_w, Water activity reduction achieved by adding humectants to food enhances stability, maintains texture, and reduces microbial activity. Salt and sugar are the oldest, most widely used humectants. Other commonly used humectants include sorbitol, glycerol, and propylene glycol. As food additives, humectants must meet several criteria for acceptance: safety, lack of adverse odors and flavors, nutritional value, economy, and ease of use. A primary benefit is the reduction of microbial activity in foods, achieved through reduction of a_w to less than 0.90, while retaining moisture (Gliemmo *et al*., 2006). Sorbitol is commonly used as humectants and stabilizer in bakery and pastry applications, extending shelf life by maintaining the moisture content of foodstuff (Asghar *et al*.,2012). In the other hand, consumption of functional foods, and other health foods, has been on the rise in recent years as consumers' focus has become more health oriented. Consumers have become more concerned with natural foods, and foods that contain only natural ingredients. Most consumers also desire natural additives more than their chemical counterparts due to the rising concern that diseases such as cancer may be caused by unnatural ingredients (Sarah and Davis, 2004). Prune and raisin concentrate is a familiar sight on grocery shelves but until recently it has not been used widely in concentrated form as a food ingredient (Castaldi and Degen, 2003). Successful applications of the concentrates have included a range of bakery products. In many eases, the properties derived from prunes and raisins are used to replace other additives, it has been theorized that prune and raisin concentrate might inhibit mold development in bakery products due to its high malic acid content as well as traces of benzoic and salicylic acids. In addition, the concentrate has been used as a natural sweetener, colorant, and humectant in bakery products (Sanders, 1991; Sabanis *et al*., 2009).

However, prune and raisin concentrate has some disadvantages. Being a viscous and sticky liquid, it is difficult to handle, to weigh accurately, to mix it with other ingredients, and too open the bread cell structure (Sabanis *et al*., 2009).Up to date, no systematic study has been reported the comparison of between chemical humectants (Sorbitol, Glycerine, Propylene Glycol and Polysorbate60) and natural ones on the rheological properties of dough and final quality of Barbari bread.

The aim of this work was to compare the quality of dough and bread containing chemical (sorbitol and natural pure and raisin concentrate) humectants. In addition whether these natural humectant can be effectively used in place of sorbitol or other sugar alcohols for improving quality and shelf life of Barbari bread.

Material and methods

Materials

Commercial wheat flour with 14% moisture, 11.1% protein, 1.76% lipid, 0.8% ash, 28.7% wet gluten and 412 s falling number was procured from Zarrin Mill Factory Mashhad, Iran. Sorbitol was obtained from Pars Behbood Asia Co., Mashhad, Iran. All of the bread recipes also contained active dry yeast (Razavi Co., Mashhad, Iran), vegetable oil (Narges Co., Shiraz, Iran), salt and sugar (Local market).

Raisin concentrate (RC) and prune concentrate (PC) were prepared following the manufacture method reported by Ariaii *et al.*, (2009) and Barrett *et al.*, (2004) respectively.

Methods

Flour Analysis

Moisture (44–16 A), ash (08–07), fat (30–10), wet gluten (38–11) and falling number (56–81) were determined according to AACC-approved methods (AACC 2000). Flour protein was tested using a Kjeltec auto protein tester (model 1030, Tecator Co., Hoeganaes, Sweden).

Farinograph Study

Dry mixes with a total weight of 300 g were studied in a Brabender Farinograph (O. H. Duisburg, Germany) using a 300 g bowl. For each mix, the amount of water (absorption) required to obtain a stability period at 500 Brabender Units (BU) was determined. The dough development time (DDT, time to reach maximum consistency, in minutes), dough stability (time dough consistency remains at 500 BU) and Mixing Tolerance Index (MTI, consistency difference between height at pick and that 5 min later) were also determined. For this study, the selected sorbitol and concentrates were added at two levels (1% and 2%) and three levels (2%,4%,6%) w/w of flour, respectively this procedure was applied to each dough formulation at least 3 times and the average values were adopted.

Barbari Bread Preparation

The bread was baked according to method described by Razavizadegan *et.al.*, (2012). All ingredients (100% flours, 1% sugars, 1% salt, 1% active dry yeast and 1% vegetable oil), were mixed for 10 minutes. RC and PC were added to the flour at three levels (2%, 4% and 6%) w/w flour basis and compared with sorbitol (S) addition at two levels (1% and 2%).

Water Activity

Water activity meter (Novasina ms1-aw,Axair Ltd, Switzerland) was used to determine the water activity (a_w) of Barbari bread at 25 °C after 1,3 and 5 days . Before evaluation, it had been calibrated with standard salt solutions (AOAC, 1995). The experimental error in aw determination was 0.005 units (Roa and DE 1991).

Moisture Determination of Bread under Storage

A Moisture analyzer MX-50 model (A&D Co., Limited, Tokyo, Japan) was applied to quantify determination of bread's moisture content after 1,3 and 5 days according to AACC-approved methods (AACC, 2000).

Specific Volume

Specific volume was determined an hour after baking based on rapeseed displacement method (Bárcenas and Rosell, 2006; Sabanis *et al.*, 2008).

Image Analysis

For each treatment, three samples (crust) were scanned with desktop flatbed scanner (HP, Scanner G3010; at Optical Resolution of 4800 dpi×9600 dpi) and the images were saved as BMP format. To study the effect of processing parameters on color components of bread, the RGB color space images were converted to L*a*b* space. For determination of the bread porosity using image analysis, the color images were first greys called and then threshold using isodata algorithm. The porosity was measured from the ratio of white to the total numbers of pixels (Karimi *et al.*, 2012; Razavizadegan *et al.*, 2014).

Texture Determination

The change in the texture of Barbari flat bread due to staling was measured by using the penetration test. A QTS texture analyzer (CNS Farnell, Hertfordshire, UK) was used to measure the force required for penetration of a round-bottom (2.5 cm diameter×1.8 cm height) probe at a velocity of 30 mm/min and descended 30 mm (a sufficient distance to pass through the slice of 10×10 cm of bread) into the bread. Trigger value 0.05 N. Three replicates from three different sets of baking were analyzed (Pourfarzad *et al.*, 2009).

Sensory Assessment

Sensory evaluation was conducted on the breads to the study possible effects of treatments on the sensory profile of each type of bread. The sensory bread attributes were evaluated using the flat bread evaluation method described by Rajabzadeh (1991). Sensory evaluation was performed by 10 trained panellists and the overall quality of bread was evaluated using a ranking scale with scores ranging from 1 (least pleasure) to 5 (best pleasure).In this study, some sensory properties including odor, taste and flavor, upper surface properties and overall quality (total acceptance) of Barbari bread were evaluated. Also bread staling was evaluated following AACC method 64-301(2000) for panel selection and staling studies, following rating scale is used 1 (very stale) to 6 (very fresh).

Statistical Analysis

Results were reported as the average of three replications (all treatments were evaluated in three batches). In order to assess significant differences among samples, a complete randomized design of triplicate analyses of 5 samples was performed using the MSTATC program (version 1.41). Duncan's new multiple range tests were used to study the statistical differences of the means with 95% confidence.

Result and discussion

Effect of sorbitol, prune and raisin concentrate on farinograph parameters

The effect of PC, RC and S on the farinograph measurements is summarized in table1.The results showed that there is a significant difference in water absorption of some treatments in comparison with the control. The values were significantly ($P<0.05$) differed ranging from 55.3 to 58.9. It can be seen that the water absorption increased with using PC, RC and S. Prune and raisin concentrate are unique among natural humectants due to the combination of fibre (half of which is soluble), sorbitol and other reducing sugars (glucose and fructose) that retain and then hold moisture (Castaldi and Degen, 2003). While sorbitol is an effective humectant, it is only 60% as sweet as sucrose. As the sorbitol prune and raisin concentrate is not readily fermentable, unlike honey or high fructose corn syrup, it remains largely as a humectant in yeast-leavened baked goods (sanders,1991).Bread contain 6% PC and control, had the highest and lowest water absorption respectively.The time required for the dough development or time necessary to reach 500 BU of dough consistency (DDT) was modified in a different manner by each treatments. 4%PC, 6%PC, 6%RC and 2% S considerably increased DDT, while this parameter was practically not affected by the presence of 1% S, 2 and 4% RC and 2% PC. The effect has been attributed to the hydroxyl groups in the humectants structure which allow more water interactions through hydrogen bonding and high content of dietary fibre, both soluble and insoluble, in PC and RC that increased DDT. The stability value was an indication of flour strength, with higher values suggesting stronger dough. Stability was affected a little by the addition of all treatments and ranged from 5.4 to 6 min. A decrease of dough stability was produced by adding high levels (6%) of PC and RC concentration. The mixing tolerance index increased with the addition of higher levels of PC, RC and S, but decrease of stability and increase in MTI had not noticeable effect to dough weakening. Results that obtained from farinograph tests almost match with the findings of Asghar *et al.,* (2012).

Table 1. Effect of sorbitol, prune and raisin concentrate on farinograph characteristics of dough, different letters show the statistical significant differences ($p<0.05$).

Samples	Water absorption (%)	DDT (min)	Stability (min)	MTI (BU)
Control	55.3^{h}	5.3^{f}	5.9^{b}	70^{f}
%2PC	56.4^{f}	5.5^{d}	6.0^{a}	75^{e}
%4PC	58.0^{b}	5.8^{a}	5.8^{b}	80^{d}
%6PC	58.9^{a}	5.6^{c}	5.5^{d}	95^{b}
%2RC	56.1^{g}	5.4^{e}	5.8^{b}	75^{e}
%4RC	56.8^{e}	5.5^{d}	5.6^{c}	85^{c}
%6RC	57.5^{d}	5.6^{c}	5.4^{e}	100^{a}
%1S	56.9^{e}	5.5^{d}	5.8^{b}	75^{e}
%2S	57.8^{c}	5.7^{b}	5.7^{c}	80^{d}

Water Activity

During storage an important factor that can evidently change is water activity (a_w) of bread. The effect of S, PC and RC on water activity of Barbari bread after 1, 3 and 5 days were depicted in table 2. The results showed that there is a significant difference in water activity of all breads. The values were significantly ($p<0.05$) differed in the range of 0.79 – 0.94 and 0.72 – 0.87 at first and third day of storage. It can be seen that the water activity increased with using S, PC and RC. Ingredients with high solubility and low molecular weight have the greatest effect on reducing a_w. High molecular weight soluble ingredients used in confections, such as proteins, hydrocolloids, and gums, generally have little effect on reducing a_w. A humectant is a substance that promotes retention of water and helps to keep a confection moist and typically a molecule that contains hydroxyl groups with an affinity to form hydrogen bonds with molecules of water. Table 2 showed that the highest and lowest amounts of a_w were in control and 6% PC, respectively.

Table 2. Effect of sorbitol, prune and raisin concentrate on firmness, water activity, moisture and porosity of Barbari, different letters show the statistical significant differences ($p<0.05$).

Samples	Firmness (gr)			Water activity (%)			Porosity (%)	Moisture (%)
	1 day	3 day	5 day	1 day	3 day	5 day		
Control	736^a	1150^a	1690^a	0.91^a	0.90^a	0.90^a	20.43^i	22.17^i
%2PC	558^d	804^c	1205^c	0.88^c	0.89^b	0.89^a	23.68^d	23.98^e
%4PC	522^f	773^d	1112^d	0.86^d	0.86^d	0.85^c	24.22^c	24.34^c
%6PC	502^g	708^g	1092^f	0.84^f	0.83^g	0.83^e	20.89^h	24.67^b
%2RC	667^b	918^b	1336^b	0.89^b	0.88^c	0.87^b	22.98^e	23.38^h
%4RC	643^c	804^c	1189^d	0.86^d	0.85^f	0.85^c	24.05^a	23.87^f
%6RC	602^d	763^e	1144^e	0.85^e	0.85^f	0.84^d	21.12^g	24.21^d
%1S	525^e	745^f	1196^d	0.86^d	0.85^f	0.84^d	24.37^b	23.44^g
%2S	501^h	705^h	1010^f	0.84^f	0.83^g	0.83^e	21.23^f	25.35^a

Moisture Content

S, PC and RC had the significant effects on moisture content of Barbari bread. Moisture content of the control sample was 22.17%. After different treatments were used, moisture content increased from 22.17% to 25.35%. Moisture content of S (2%), PC (6 and 4%) and RC (6%) samples were significantly higher than other samples, respectively. Therefore, it seems that S, PC and RC exhibit a capacity to retain water. Castaldi and Degen, (2003) reported that dried plums are an effective bakery humectant. This is due to the combination of fibre (half of which is soluble), sorbitol and other reducing sugars (glucose and fructose) that retain and then hold moisture. Many additives (e.g. emulsifiers or humectants) include hydrophilic groups such as hydroxyl and carboxyl groups, which increase the ability to retain water (Casper *et al.*, 2007).

Table 3. Effect of sorbitol, prune and raisin concentrate on a* (high values indicate red color and b* (high values indicate yellow color) of Barbari crust, different letters show the statistical significant differences ($p<0.05$).

Samples	a*	b*
Control	4.00^g	58.37^i
%2PC	8.44^f	62.97^e
%4PC	9.85^d	65.55^b
%6PC	10.09^c	67.81^a
%2RC	9.63^e	60.11^h
%4RC	11.01^b	61.99^e
%6RC	12.65^a	62.59^d
%1S	9.89^d	60.23^g
%2S	10.11^c	61.89^f

Crumb Firmness

The resistance of the bread crumb to deformation is the textural attribute referred to as firmness and it is an important factor in bakery products since it is strongly correlated with consumers' perception of bread freshness (Ahlborn *et al.*, 2005). Significant difference in firmness were detected between treated samples and control ($p<0.05$), which varied between 531 and 736 gr at first day (table2). Statistical results showed that firmness of samples treated with S, PC and RC were significantly lower than control. Crumb firmness of samples reduced by addition of all treatment between 1 and 5 days storage in comparison with the control (fig1).Result did not show significant differences between samples contain 1 and 2% S and 4 and 6% PC. Breads with 2% S exhibited the lowest crumb firmness. The polyols' highly hygroscopic nature has been implicated in its ability to retard staling by forming an entangled amorphous matrix around the starch molecules via disrupting the hydrogen bond between neighbouring protein strands and via reducing interchange attractive forces. Such a matrix may also contribute to the increased chain mobility, flexibility and homogeneity of the water distribution in the sample. The inverse relationship between the firmness and the moisture content has been previously reported (He and Hoseney, 1990). Smaller loaves (as those with sucrose) were denser and had tightly packed crumb structure, resulting in higher crumb firmness values. Similar findings were obtained by Gallagher *et al.*, (2003) in gluten free bread. PC and RC are unique in their naturally high sorbitol and polyols content. Sorbitol is an effective humectant, and thus helps to keep bakery products soft and moist over an extended shelf life. The reducing sugars, fructose and glucose, and dietary fibre work with sorbitol to provide further humectancy.The antistaling effect of S, PC and RC maybe related to their ability to retain the water and influence of polyols on the retrogradation rate of starch (Porfarzad *et al.*, 2009; Sanders, 1991 and Sabanis *et al.* 2008).

Table 4. Effect of sorbitol, prune and raisin concentrate on sensory parameters of Barbari, different letters show the statistical significant differences ($p<0.05$).

Samples	Texture	Aroma	Color	Taste	Overall acceptance	Staling(1-6)		
						1 day	3 days	5 days
Control	3.33^{d}	3.66^{c}	3.66^{c}	4.00^{b}	3.86^{c}	4.66^{c}	4.33^{c}	3.50^{d}
2% PC	3.87^{cd}	3.86^{c}	4.15^{b}	4.33^{ab}	4.33^{b}	4.86^{c}	4.50^{c}	4.33^{c}
4% PC	4.66^{a}	4.33^{ab}	4.50^{a}	4.50^{a}	4.50^{a}	5.90^{a}	5.33^{ab}	5.00^{b}
6% PC	4.12^{c}	3.86^{c}	4.33^{ab}	4.15^{b}	4.23^{b}	5.60^{a}	5.50^{a}	5.15^{a}
2% RC	4.00^{c}	4.33^{ab}	4.15^{b}	4.33^{ab}	4.50^{a}	5.15^{b}	5.00^{b}	4.87^{b}
4% RC	4.33^{b}	4.66^{a}	4.66^{a}	4.66^{a}	4.66^{a}	5.70^{a}	5.33^{ab}	5.00^{b}
6% RC	4.15^{c}	4.33^{ab}	4.33^{ab}	4.33^{ab}	4.15^{c}	5.80^{a}	5.66^{a}	5.33^{a}
1% S	4.33^{b}	4.44^{a}	4.33^{ab}	4.15^{b}	4.33^{b}	5.40^{ab}	5.33^{ab}	5.15^{a}
2% S	4.50^{a}	4.33^{ab}	4.00^{b}	3.33^{c}	4.00^{c}	5.80^{a}	5.33^{ab}	5.33a

Bread Porosity

Crumb porosity is an important characteristic for bakery products, in addition to color and aroma, and contributes to consumers' acceptance. It depends on the physicochemical characteristics of the dough (water content, viscosity, consistency and stickiness). As reported in Table 2, the porosity of treatments increased when compared to the control. Results showed that porosity of the best samples might be ranked as: 4% RC > 1% S > 4%PC > 2%PC > 2%RC > Control. However, increasing prune and raisin concentrate to 6% and sorbitol to 2% decreased porosity. It demonstrated that prune and raisin concentrate are a viscous and sticky liquid and produce too open the bread cell structure (Sabanis *et al.*, 2009). It is presumably due to coalescence of gas cells as a result of expansion during the proofing step (Razavizadegan *et al.*, 2014).

Bread Crust Color

Among all physical properties of foods, color is the most important optical feature in the discernment of product quality (Peressini and Sensidoni , 2009) and it has a high influence on consumer preference (Ribotta *et al*., 2010). Lightness is a suitable descriptor of the color changing process because it represents the intensity of samples, and is decoupled from color parameters characterized by *a** and *b** values (Gonzalez and Woods, 2002). The average values of a*, b* and L* extracted from bread images presented in table 3 and figure 2, respectively. The results indicated that the effects of treatments wer statistically significant on color components of a* and b*. However, lightness (L*) of bread increased by sorbitol, prune and raisin concentrate addition. PC and RC increased Maillard reaction. Maillard reaction taking place during baking between reducing sugar and amino acid chains of proteins (Raidi and Klein, 1983). Another chemical reaction that causes browning of baked products during baking is caramelization, which depends on direct heat degradation of sugars. Fig 2 showed that the highest and lowest amounts of L* were in 6% RC and control respectively, which could be attributed to the positive effect of sugars to enhance lightness of bakery products.

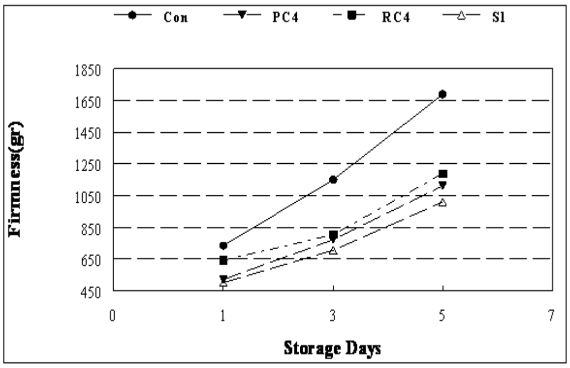

Fig. 1. Effect of sorbitol, prune and raisin concentrate on firmness of Barbari.

Specific Volume

Specific volume is one of the most important quality properties of the bread that indicates dough inflating ability and oven spring. Specific volume analysis of Barbari bread is summarized in fig.3. Results indicated that specific volume was enhanced by using PC, RC and S. The highest specific volume of Barbari bread was related to 4% RC. This increasing behavior may be pertaining for this reason that moisture content of RC and the presence of a naturally occurring organic acid in grapes called tartaric, which contributes to the leavening action. Sabanis *et al*., (2009) reported that specific volume in loaf increased by using dry and juice concentrate of raisin. 4% PC also increased the specific volume of loaves significantly in comparison with other treatments. It could be for vitamin C and organic acids that present in prune and help to strengthen the gluten network .Also both of them (RC and PC) act as a humectant to improve bread volume. Addition of S also made an increase in specific volume , a possible explanation to this result is that hygroscopic additives (e.g. humectants or hydrocolloids) can improve dough development and bread volume (Lazaridou *et al*., 2007).The lowest amount of specific volume was seen in control sample (fig 3). In high levels of RC and PC (6%) specific volume decreased for negative effect of sugars on yeast.

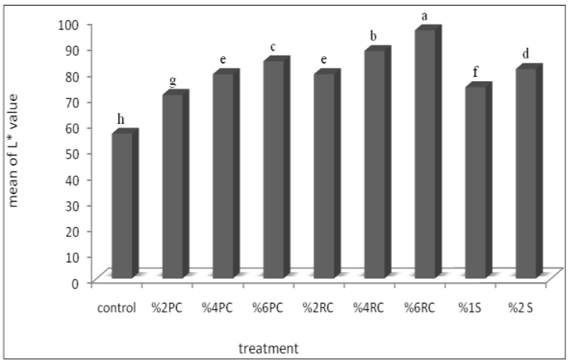

Fig. 2. Effect of sorbitol, prune and raisin concentrate on L* (low values indicate darker color) of Barbari crust, different letters show the statistical significant differences ($p<0.05$).

Sensory Attributes of the Barbari Bread

Data for the effects of S, RC, PC and their levels on bread sensory properties are presented in table 4. The values reported are the mean values of each descriptor contributing to color, aroma, texture, taste and overall acceptance ratings. Results of bread staling after 3 and 5 days also summarized in table 4. The most acceptable bread was the one with 4% RC and PC which had a fine taste, fruity flavor, brown color, good aroma and fresh appearance. RC contained acids that are beneficial in bringing out flavors and complementing other ingredients. Among them tartaric acid enhances the taste and the aromatic perception of bread and makes it taste crisper. PC also contains about 1.5% malic acid. Even when present in small amounts, malic acid has been shown to be an effective flavor and aroma potentiator. Malic acid coats the mouth during mastication, thus extending food flavor during the chewing process. This leads to improvements in sensory satisfaction .The brown color of the crust, which is nearly a good factor in Barbari bread, was more intense in 6% RC, but breads with 4% RC and PC were more desirable. PC and RC increased Maillard reaction and caramelization (Sanders, 1991). Moreover, the addition of RC, PC and S, due to their humectant properties, made a soft and good texture and feel to the mouth. Control sample received lower crumb texture, taste, and overall acceptability scores because of their rough crust and crumb and an intense taste. Best treatments for texture were using 4% PC and 2% S. The most score in overall acceptance belonged to 4% RC and PC treatments.

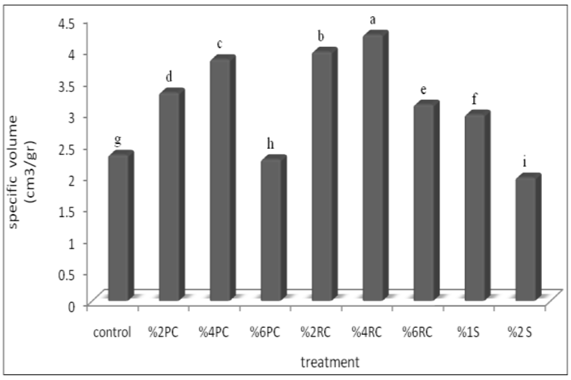

Fig. 3. Effect of sorbitol, prune and raisin concentrate on specific volume of Barbari bread, different letters show the statistical significant differences ($p<0.05$).

Statistical results indicated that using 6% PC and RC made the most freshness in Barbari bread after 3 and 5 days (table 4). It was shown that humectants delay staling in bread, by interaction with starch, and also water holding capacity (Karimi *et al.*, 2013).Also organic acids (like malic and tartaric) help to inhibit microbial spoilage and can serve as the natural acid component.

Conclusion

Although the nutritional properties of prune and raisin concentrate widely recognized, little work has actually been performed to elucidate their functional properties in bakery products.

The timing is right for researchers to focus on the use of natural products to replace chemical additives. This study indicated that the use of prune and raisin concentrate in dough products as a natural substitute for sorbitol, chemical colorant, leavening and preservative agents, gave breads with a higher volume, appealing brown color, increased softness and shelf life.

Breads containing RC and PC were rated higher than those containing S and control sample in sensory properties; they exhibited higher taste, texture, color, aroma and overall acceptance as well as longer preservation time. The best treatments were addition of 4% PC and RC, to dough.

Thus, prune and raisin concentrate can be effectively used in place of sorbitol or other sugar alcohols while maintaining a "natural" formulation, additionally serve as a natural preservative in yeast-leavened baked products. With their other attributes of natural color, dough strengthening, flavor enhancement, sweetening, and humectancy, they can be considered a multi-purpose natural food ingredient.

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