

Influence of Natural Humectants on Rheological Properties and Staling of Bread

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ABSTRACT: Researchers have revealed many novel applications for plum and raisin products as functional natural bakery ingredients. Raisin and plum concentrate were incorporated into the bread formulation at different concentrations and their effects on the rheological, baking properties and shelf life of breads were evaluated. The results showed that the use of plum concentrate at 6% had the highest water absorption, tolerance index, extension time and stability. Firmness of breads decreased by 15% for bread containing 4% raisin concentrate and 40% for bread containing 4% plum concentrate. Minimum firmness was obtained in the sample containing 6% plum concentrate. The addition of raisin and plum concentrates reduced the bread color and brownness of the crust color. The effect of plum concentrate on the color was greater than that of raisin concentrate. Bread containing 4% plum concentrate had the highest volume. By increasing the level of raisin concentration to 4%, the textural properties and general appearance was improved. Although no significant difference was found between the raisin and the plum concentrate in the general acceptance and color, the sensory properties of the sample containing 4% plum concentrate had higher scores by the panel test.

Keywords: *Barbari Bread, Dough Properties, Plum, Raisin, Staling.*

Introduction

Bread is regarded as the most popular and appealing food products worldwide, due to its relatively high nutritional value (Sabanis *et al.*, 2009). It has a short shelf life; therefore, some additives, in particular natural ones, are necessary to improve dough machinability, crumb texture and freshness during storage (Barcenas and Rosell, 2006; Caballero *et al.*, 2007). Among the additives, humectants can bind water and control water activity. In this aspect, water

activity decreases less than 0.9, with steady moisture content, resulting in increased stability, stabilizing texture, and reducing microbial activity. There are large numbers of positive properties which make the humectants more acceptable such as safety, appropriate odors and flavors, nutritional value, and suitable use (Gliemmo *et al.*, 2006). As consumers are concerned with functional and health products in the recent years, they prefer natural additives rather than synthetic due to this possible side effects (Sarah and Davis, 2004). Although

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plum and raisin are widely used, their concentrated form have not been employed commonly (Castaldi and Degen, 2003). The effect of raisin on quality, rheological properties and shelf life of the cup cake has been investigated. The results indicated that adding raisin caused a reduction in hardness and increased the porosity (Balagi *et al.*, 2017). Shahinfar *et al.* (2017) examined the effect of dried plum on the physical, textural and sensory properties of cakes. It was indicated that the addition of this natural additive to the cake formula increased the specific volume, porosity, and brightness and reduced the firmness of the cake. Considering the plum and raisin's characteristics, it is theorized that it can prevent the mold growth in bakery products due to the presence of malic, benzoic, and salicylic acids (Sanders, 1991; Sabanis *et al.*, 2009).

A significant point concerned is the addition of additive at appropriate concentration; otherwise, handling it will be difficult, due to their viscous and sticky properties (Sabanis *et al.*, 2008). The present study evaluates the effect of plum and raisin concentrates, as natural additives, on the rheological properties, and shelf life of bread.

Materials and Methods

- Materials

Wheat flour with 14% moisture, 11.1% protein, 1.76% lipid, 0.8% ash, 28.7% wet gluten and 412 s falling number was obtained from Razavi Mill Factory, Mashhad, Iran and stored in a cold and dry place. Active dry yeast and oil and salt were purchased from Iran Malas Company and local market respectively. All the chemicals used in the study were supplied from Merck chemical company, Germany.

- Methods

- Flour analysis

Moisture (44-16 A), ash (08-07), fat (30-

10) and wet gluten (38-11) were determined according to AACC-approved methods (AACC 2000). Flour protein was tested using a Kjeltex auto protein tester (model 1030, Tecator Co., Hoeganaes, Sweden).

- Preparation of plum and raisin concentrate

Raisin concentrate (RC) and plum concentrate (PC) were prepared according to Ariaai *et al.*, (2009) and Barrett *et al.*, (2004) respectively.

- Dough rheology

The effect of plum and raisin concentrate on dough rheology were analyzed using farinography (Duisburg, Germany) following AACC (2000) NO 54-21 method. The parameters tested for analysis were: water absorption, dough development time (DDT), stability, mixing tolerance index (MTI), and valorimeter value.

- Barbari bread preparation

The bread was baked according to the method described by Razavizadegan *et al.* (2014). All ingredients, 100% wheat flour, 1% dry yeast, 2% salt, 1% sugar, 1% vegetable oil, and water (based on the Farinograph absorption) were mixed for 10 minutes in the bowl of a spiral mixer. RC and PC were added to the flour at three concentrations (2%, 4% and 6%).

- Texture measurement

The change in the texture of Barbari 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 was 0.05 N for the beginning test. Three replicates from three different sets of baking were analyzed (Pourfarzad *et al.*, 2009).

- *Specific volume*

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

- *Image analysis*

In order to measure the bread color and quality, image processing encompassing the determination of three parameters (L^* , a^* , b^*) has been utilized in most of the studies related to food science and technology. Thus, a flatbed scanner (HP 48.50, China) with a resolution of 300 DPI was used to obtain the images of the bread slices, which were save as BMP format. Then, the LAB indicators were computed by using image J software. Finally, RGB color space was converted to $L^*a^*b^*$ space (Razavizadegan *et al.*, 2014).

- *Sensory analysis*

Sensory evaluation of bread was carried out by 10 trained panellists (Selection of faculty research center, by triangle test) using a hedonic scale of five points for overall acceptability (Gacula *et al.*, 1984). Bread staling was evaluated following AACC method 64-301(2000).

- *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 seven samples were 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.

Results and Discussion

- *Farinograph properties of dough*

The effect of PC, RC on the farinograph properties is summarized in Table1.The

results showed that there is a significant difference in water absorption of some treatments in comparison with control. It can be observed that the water absorption has increased using PC, RC. Plum 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 the moisture (Castaldi and Degen, 2003). While sorbitol is an effective humectant, it is only 60% as sweet as sucrose. As the sorbitol of plum 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 containing 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 is called Dough Development Time (DDT). This parameter is increased as the concentration is increased to 6%. 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 increases DDT. The stability value is an indication of flour strength, higher values suggest stronger dough. Adding plum and raisin concentrates significantly increased the stability and thus strengthened the dough as compared to the control. The addition of 4% concentrate increased the stability of the dough, but higher concentration such as 6% reduced the stability (Table 1). The effect of plum concentrate addition on dough stability was higher than raisin concentrate. Mixing tolerance index (MTI) indicates weakness or strength of the dough. Increasing the amount of plum and raisin concentrates, increased MTI. There were not significant differences between plum and raisin concentrations concerned with MTI ($P < 0.05$).

Table 1. Effect of plum and raisin concentrates on farinograph characteristics of dough

| n | Mixing Tolerance Index (Bu) | Stability (min) | Extension time (min) | Water absorption (%) |
|---------------|-----------------------------|-------------------------|------------------------|-------------------------|
| Control | 60.6±1.0 ^{7d} | 6±0.9 ^f | 7.3±0.5 ^a | 48.52±1.2 ^f |
| Control+2% RC | 63.1±1.2 ^c | 7.9±0.6 ^e | 6.23±0.64 ^b | 50.14±1.36 ^e |
| Control+4% RC | 78.24±2.3 ^b | 9±0.9 ^b | 5.4±0.5 ^d | 52.61±1.2 ^d |
| Control+6% RC | 78.6±1.89 ^b | 8.7±0.61 ^c | 4.2±0.08 ^e | 54.7±1.43 ^c |
| Control+2% PC | 63.25±1.6 ^c | 8.31±0.7 ^d | 6.09±0.81 ^b | 54.73±1.72 ^c |
| Control+4% PC | 79.14±1.9 ^a | 10.14±1.08 ^a | 5.63±0.64 ^c | 59.84±2.15 ^b |
| Control+6% PC | 79.41±2.09 ^a | 9.97±1.12 ^a | 4.33±0.4 ^d | 61.21±1.9 ^a |

Different letters show the statistical significant differences ($p < 0.05$).

- Crumb firmness

The resistance of 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). Statistical results showed that firmness of samples treated with PC and RC were significantly lower than the control (Table 2). Presented in Table 2, the least amount of bread firmness was related to the level of 6% concentrates of plum and raisins. Plum concentrate had a greater impact on the firmness of the bread. The polyols' highly hygroscopic nature has been implicated in its ability to retard the 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. PC and RC are unique in their naturally high sorbitol and polyols contents. 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 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).

- 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 Figure.1. Results indicated that specific volume was enhanced by using PC and RC. 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 acid, 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 might be due to vitamin C and organic acids that are present in plum that help to strengthen the gluten network. Both (RC and PC) act as humectants to improve bread volume. The lowest amount of specific volume was observed in control sample (Figure1). In high levels of RC and PC (6%) specific volume decreased for negative effect of sugars on yeast.

Table 2. Effect of plum and raisin concentrates on firmness of bread

| Bread sample | Firmness (grn) | |
|---------------|-----------------------|-----------------------|
| | 72h after baking | 2h after baking |
| Control | 229±3.8 ^a | 200±2.14 ^a |
| Control+2% RC | 193±2.4 ^b | 180±2.00 ^b |
| Control+4% RC | 170±1.9 ^d | 163±1.87 ^d |
| Control+6% RC | 154±1.52 ^e | 149±1.9 ^e |
| Control+2% PC | 180±2.04 ^c | 172±1.56 ^c |
| Control+4% PC | 143±1.63 ^f | 139±2.18 ^f |
| Control+6% PC | 126±1.2 ^g | 120±1.4 ^g |

Different letters show the statistical significant differences (p<0.05).

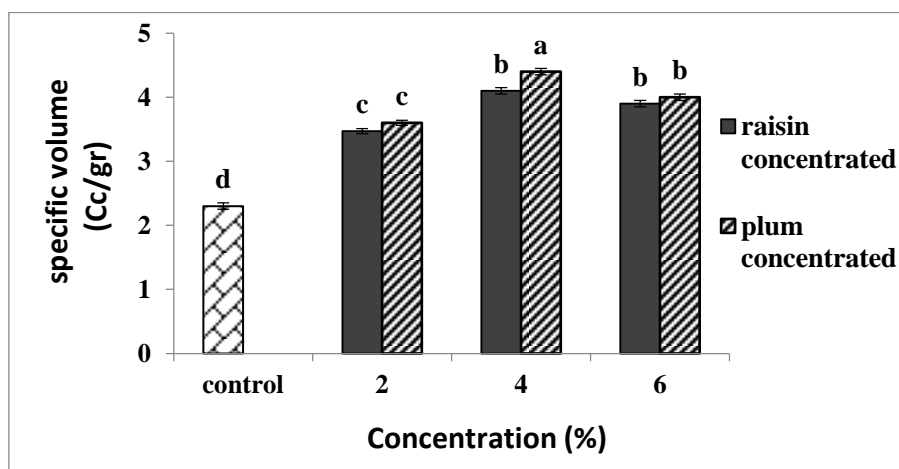


Fig. 1. Comparison the effect of plum and raisin concentrates on specific volume. Different letters show the statistical significant differences (p<0.05).

- Bread crust color

Lightness is a suitable descriptor of the color changing process because it represents the intensity of the samples, and is decoupled from color parameters characterised by a* and b* values (Gonzalez and Woods, 2002). Figure 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. The results indicated that the effects of treatments were statistically significant on color components of a* and b*(Figures 3,4). However, lightness (L*) of bread increased by plum and raisin concentrate addition. PC and RC increased Maillard reactions. Maillard reactions taking place during baking between reducing sugar and amino acid chains of proteins (Sabanin

et al., 2009). Another chemical reaction that causes browning of baked products during baking is caramelization, which depends on direct heat degradation of sugars.

- Sensory evaluation

Investigating the results of sensory tests including general appearance, color, texture and taste, showed that the use of raisin and plum concentrates increased the sensory score attributes to the judges. By increasing the concentration of raisin concentrate to 4%, the score of texture and overall appearance increased. The samples containing plum concentrate at 4% level improved sensory properties however increasing the concentration to 6% reduced the sensory characteristics. The use of raisins had a greater effect on taste and overall acceptance, are compared to the

samples containing plum concentrate had higher color and texture scores. 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 (Dimitrios and Constantiona, 2008). Plum contains sorbitol, which is used as a flavoring in food and can be effective in improving the taste and texture of the product. There are also plum pectin that can

inhibit evaporation of the flavor and evaporate molecules and gradually release them during the chewing, thereby improving the aroma and taste of the product. PC also contains about 1.5% malic acid and when present in small concentrations, it can be an effective to 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 (Cauvin and Yong, 2007).

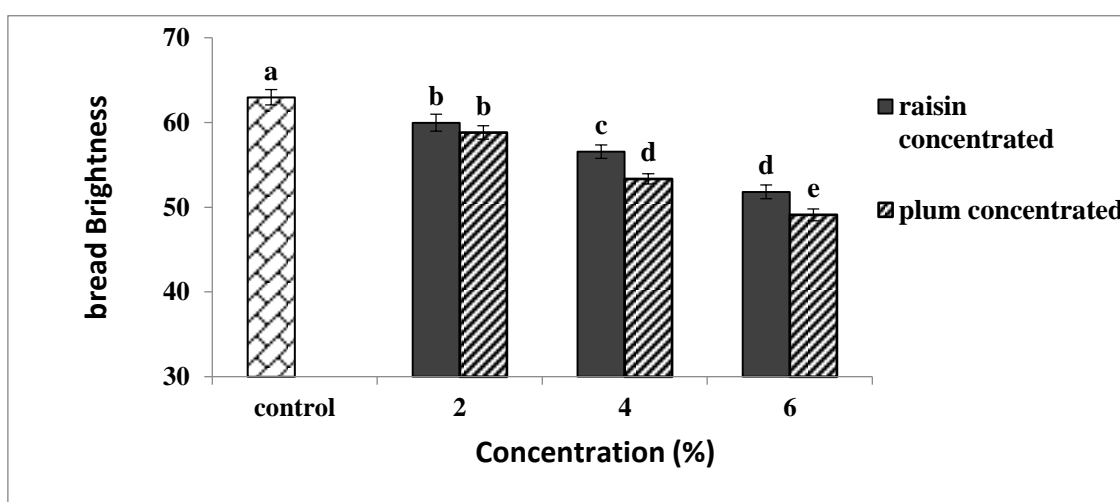


Fig. 2. Comparison the effect of plum and raisin concentrates on lightness of bread
Different letters show the statistical significant differences ($p < 0.05$).

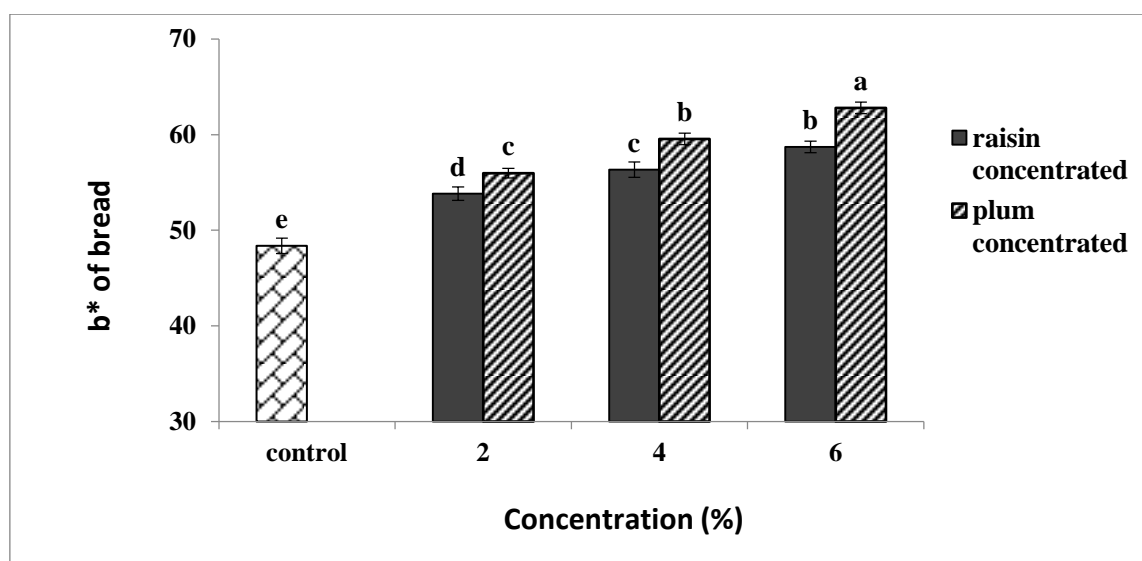


Fig. 3. Comparison of the effect of plum and raisin concentrates on b index
Different letters show the statistical significant differences ($p < 0.05$).

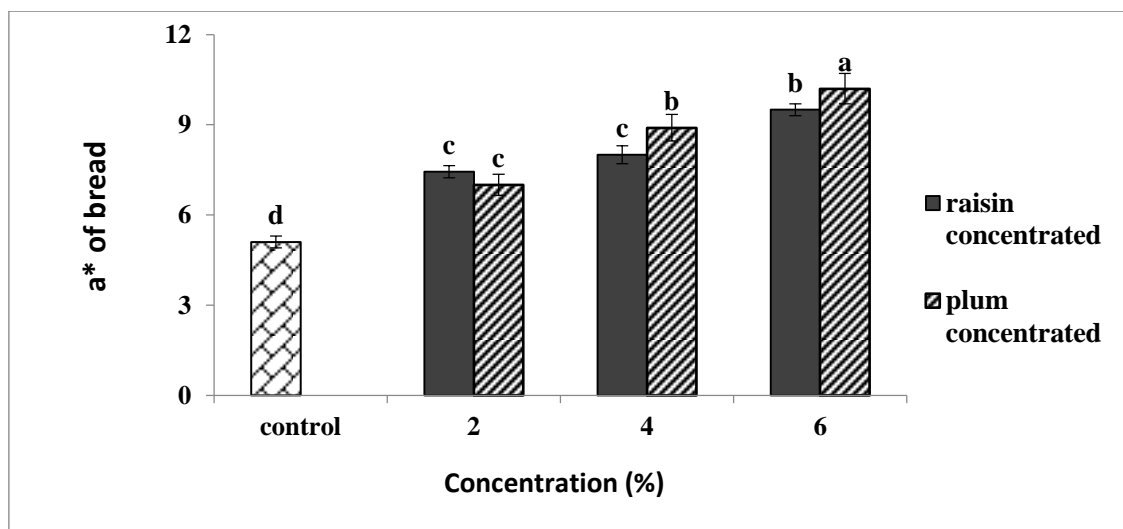


Fig. 4. Comparison of the effect of plum and raisin concentrates on a index. Different letters show the statistical significant differences ($p < 0.05$).

Table 3. Effect of plum and raisin concentrated on sensory properties

| Bread sample | taste | color | Texture | Total acceptance |
|---------------|-----------|-----------|-----------|------------------|
| Control | 3.3±0.09e | 3.5±0.08e | 3.2±0.02e | 3.3±0.1e |
| Control+2% RC | 3.8±0.08c | 3.9±0.09b | 3.5±0.04c | 3.6±0.05c |
| Control+4% RC | 4.3±0.09a | 4±0.08a | 4.2±0.08a | 4.1±0.07a |
| Control+6% RC | 4±0.07b | 3.3±0.05d | 4±0.07c | 3.4±0.04c |
| Control+2% PC | 3.5±0.06d | 3.7±0.06c | 3.7±0.06d | 3.7±0.05d |
| Control+4% PC | 4.1±0.07b | 4±0.1a | 4.3±0.09b | 4±0.08b |
| Control+6% PC | 3.3±0.04e | 3.9±0.06b | 4.1±0.06b | 3.25±0.03c |

Different letters show the statistical significant differences ($p < 0.05$)

Conclusion

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 plum and raisin concentrates 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 control sample in sensory properties; they exhibited improved taste, texture, color, aroma and overall acceptance as well as longer preservation time. The best treatments were at 4% PC and RC addition to dough.

Thus, plum and raisin concentrate can be effectively used to replace sorbitol or other

sugar alcohols while maintaining a "natural" formulation, additionally serve as a natural preservative in yeast-leavened baked products. Therefore due to other attributes they possess such as dough strengthening, flavour enhancement, sweetening and humectancy, they can be considered as a multi-purpose natural food ingredients.

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