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Development of a Novel Edible Surface Coating Made by *Lepidium sativum* Seed Gum and Comparison of its Effect with Traditional Glazes of Sorghum Gluten-Free Bread

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Abstract

Glazing process can improve the baked texture and overall quality of bread. In this study, the effects of traditional glazes (water, oil, cheese powder, xanthan gum) on the physicochemical and sensory parameters of sorghum gluten-free bread were compared with *Lepidium sativum* seed gum. Specific volume, porosity, water activity, moisture, firmness and sensory parameters of breads were evaluated. Results showed cheese powder had the lowest moisture and vegetable oil treated samples had the lowest water activity. *Lepidium sativum* seed gum and xanthan gum provided the high effect on specific volume and porosity. Evaluation of crumb firmness implicated water, *Lepidium sativum* seed gum diminished the bread staling and these treated samples had the lowest firmness. Application of glazing ingredients did not have any significant ($P>0.05$) effect on odor and taste. *Lepidium sativum* seed gum as a novel glaze was more effective than xanthan gum and its application was better than the usual glazes to improve the crust and overall quality of gluten-free bread.

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Key words
Glaze
Gluten-free bread
Lepidium sativum
Porosity

Introduction

The proposition of a diet for celiac people is not easy, since the most commonly baked products are usually prepared with wheat flour and are consumed on an every-day basis by most people but the effective treatment for this patient's lifetime is a strict adherence to gluten-free diet (Gallagher, Kunkel, Gormley, & Arendt, 2003). Gluten-free flours reduced the freshness and other parameters of loaves of bread. Meanwhile, studies on the use of methods to improve quality and acceptability of gluten-free loaves of bread were very rare(Shittu, Aminu, & Abulude, 2009). Among these, application of glazes seems to be one of the effective processes to improve gluten-free bread quality. However, only very limited researchers have reported the effect of glazing on quality of bakery products especially the items that have gluten-free and wheatless flours (Casper, Oppenheimer, Weber, Erickson, & Ray, 2006; Hahn, Huang, Goedeken, & Sierzant, 2001; Hayes-Jacobson, 2003). Glazing process can also be increased the baked specific volume (Lonergan, 1999). Lang, Eberhardt, Entenmann, & Shipman (1987) found that glazes can be used to provide a glossy appearance. Lonergan (1999) reported that glazing was comprised of about 20-90% water, 0.1-5% of reducing sugar, 0.1-15%

of an edible hydrocolloids, and 10-80%vegatable oil. The glazing concentration of 8-10% or 3-10% of dough weight was recommended. According to these studies, finding new sources that could improve the quality and quantity of bakery products is still a need. *Lepidium sativum* is annual herb, which belongs to the Cruciferae family, which grows widely in the Middle East, Europe and USA (Karazhiyan *et al*., 2009). *Lepidium sativum* seed exhibits a quick adsorption when soaked in water and produces a large amount of mucilaginous substance (Sahraiyan, Naghipour, Karimi, & Davoodi, 2013). The macromolecular component of *Lepidium sativum* seed gum (as a new hydrocolloid) is nearly as rigid as xanthan with regard to chain conformation emulsifying and foaming properties which reminds unchanged after heating. Heating increased in viscosity of solution of this gum (Naji & Razavi, 2014; Sahraiyan *et al*., 2013). In addition, *Lepidium sativum* seed is an important medicinal source use in traditional medicine for the treatment of various diseases, such as antibacterial, anti-asthmatic, aphrodisiac, and aborti-facient (Doke & Guha, 2015). Therefore in the present study the behavior and alterations in physicochemical and sensory parameters of sorghum gluten-free bread affected by using glazing method and compared *Lepidium sativum* seed gum as a novel gum with xanthan gum, cheese powder, vegetable oil, and water.

Materials and methods

Materials

Sorghum flour with 11% moisture, 10.11% protein, 3.2% lipid, 1.35% ash and 0% wet gluten were procured from Khorasan Razavi agricultural and natural Resources research education center Mashhad, Iran. *Lepidium sativum* seeds with 7.1% moisture, 11% ash, 2.09% protein, 2.2% fat and 77.5% carbohydrate were procured from the traditional medicinal plant market. The seeds were manually cleaned to remove all foreign matter such as dust, dirt, stones, chaff, immature and broken seeds then Aqueous *Lepidium sativum* seed gums were extracted from whole seeds using distilled water (Karazhiyan, Razavi, & Phillips, 2011). Cheese Powder (Pegah Co., Tehran, Iran), vegetable oil (Narges Co., Shiraz, Iran), fresh yeast (Razavi Co., Mashhad, Iran), Guar and xanthan gum (Pars Behbod Asia Co, Mashhad, Iran) and other ingredients such as salt, sugar, powdered egg whites and soybean isolated protein were procured from local market.

Methods

Preparation of bread with gluten free flour (Sorghum bread)

Gluten-free breads were produced by sorghum flour (100 parts), guar gum (1.5 parts), xanthan gum (1 part), soybean isolated protein (9 parts), egg white powder (4 parts), fresh yeast (4 parts), salt and sugar (1 part), vegetable oil (1 part) and water (100 parts because of gluten-free bread). The gluten-free bread. These breads were produced by mixing all ingredients (6 min), fermenting for 30 min at 45 °C and 85% relative humidity, dough dividing (loaf weight was 500 g) and rounding, sheeting (size of dough was 70 cm length, 25 cm width and 2 cm thickness). Then, resting in fermentation cabinet for 20 min and baking at 220 °C for 13 min. The size of dough before baking was 71.0×25.5×3.1 cm and the weight of dough was 497 g. After cooling the samples were packed in polyethylene bags and stored at 25 °C (Maleki, Vetter, & Hoover, 1981).

Preparation of glazing

The glazing composition (Table 1) (vegetable oil, water, cheese powder, and xanthan and *Lepidium sativum*) were added to the cold water under agitation. The mixture was heated to 80 °C and stored at temperature 25 °C before using (4 h). The formulations (Control (without glaze) vegetable oil (100%), water (100%), vegetable oil+cheese powder (90+10%), vegetable oil+water+xanthan (20+75+5%) and vegetable oil+water+*Lepidium sativum* seed gum (20+75+5%) may be applied to the top of surface of dough by wiping (1 mL of coating was equivalent 0.1 mm thick (Razavizadegan Jahromi *et al*., 2012)) before the final proofing step (Lang *et al*., 1987).

Table 1. Preparation of different glazing formulas

Materials	Formula (g)				
	1	2	3	4	5
Vegetable oil	100	-	90	20	20
Water	-	100	-	75	75
Cheese powder	-	-	10	-	-
Lepidium sativum	-	-	-	5	-
Xanthan	-	-	-	-	5

Bread quality

Moisture

Moisture was determined following AACC methods (AACC, 2000). The following equation was applied to determine the moisture. For this purpose, 10 g of whole bread was placed into an oven (Jeto Tech, model OF-O2G, South Korea) with the temperature of 100-105 °C for 2 h after 1 and 3 days of storage (5 °C).

$$MC = \frac{m1-m2}{m0} \times 100 \quad (1)$$

Where m_0 indicates the samples' weight, m_1 expresses the weight of sample before placing in oven and m_2 demonstrates the plate's plus sample's weight after passing oven stage.

Porosity

To evaluate the porosity value of gluten-free bread's internal part, the piece of bread in the size (area) of 2×2 cm of internal part of the produced bread were provided with the use of an electric saws (model 41600, 120 w, England), then using a scanner (model HP Scanjet G3010, American), the required images were taken with the clarity of 300 pixel. The taken images were analyzed by Image J (ordered by National Institute of Health-the USA), with activation of part Bit of the software, and the grey images were created. To convert the grey images to Binary ones, a Binary section of the software got activated. These images are a collection of bright and dark points where the proportion of bright points to dark ones is an index of the porosity of the samples. It is obviously understood that, the more porosity of the achieved breads might exist. Actually with activation of the relevant part of the software, this proportion might be determined and as a result, the porosity value of the samples could be measured Specific volume was determined by rapeseed displacement method. It was determined at 2 h's after baking (Bárcenas & Rosell, 2006; Sabanis, Tzia, & Papadakis, 2008).

Water activity (aw)

The water activity has been detected with the use of an equipment (Novasina ms1-aw, model AXZIR Ltd, Switzerland) after 1 and 3 days of storage (5 °C) (Sahraiyan *et al*., 2013). For this purpose, 5 g of whole bread was placed into cell for 80 s.

Crumb texture evaluation

A texture analyzer (Farnell Model QTS-CNS, 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 (Pourfarzad *et al*., 2011).

Sensory analysis

For this purpose, 10 different panelist from the faculty of Khorasan Razavi Agricultural Research and Education Center (Mashhad-Iran) according to triangular test and Gasola and sink 1984 approach, were determined. The pieces in the size (area) of 5×5 cm of the produced bread were provided with the use of an electric saws, then used for the sensory analysis. A hedonic scale of nine points

(1: dislike extremely, 9: like extremely) was used for overall acceptability. Here, the overall quality of breads was evaluated by considering the upper surface properties, odor, taste and overall quality.

Statistical analysis

All samples were evaluated in three batches. In order to assess significant differences among treatments, a complete randomized design of triplicate analyses of six 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.

Results and discussion

Water activity

Water activity was indicated in Fig. (1). The values were significantly (P<0.05) differed in the range of 0.74-0.89 and 0.69-0.82 at first and third days of storage. *Lepidium sativum* had the highest water activity in the first day but only *Lepidium sativum* seed gum had the effect to keep the level of water activity three days after baking. This behavior may be pertaining to ability of *Lepidium sativum* seed gum to prevent cracking of dough surface and protect moisture during baking and storage. Razavizadegan Jahromi *et al*. (2012) found that using oil on the dough surfaces had an unpleasant effect on moisture barrier property, since they tend to crack upon the handling or during the temperature changes. Cracking of dough surface lead to exiting of moisture and consequently, reduction in water activity. Hahn *et al*. (2001) indicated that using oil and fat as a coating can acts as a physical barrier, which indirectly impairs the water activity. Sahraiyan *et al*. (2013) reported that, using *Lepidium sativum* seed gum in composite bread formula due to creating thick surface and Slight shrinkage might prevent the reduction of product's moisture and water activity.

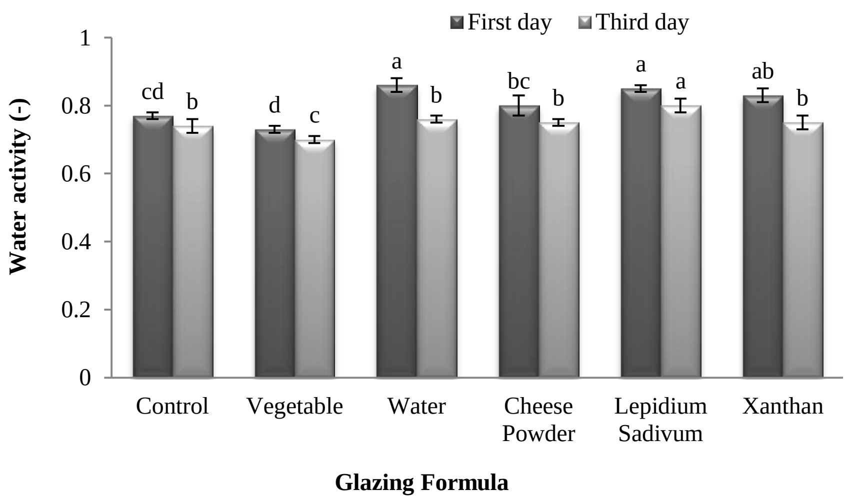

Fig. 1. Effect of different glazing formulas on water activity after storage for 1 and 3 days at 5 °C of gluten-free bread,
* Different letters show the statistically significant differences (P<0.05).

Moisture content

Different glazes had the significant (P<0.05) effect on the moisture content of gluten-free bread (Table 2). The Moisture content of the control sample was 22.96±1.13%. After glazing, the moisture content has differed in the range of 20.42-28.71 and 18.04-26.67 at first and third days of storage. The Moisture content of all samples was significantly higher than control except vegetable oil and cheese powder. The vegetable oil treated samples were as same as control at first day. The moisture of both treatments was more than cheese powder. At the third day, control and cheese powder treated samples had the lowest moisture. Whey protein (β-lactoglobuiin) is most important in the formation of gel in 75 °C (Invensys, 2002) and to improve the quality of glaze. Cheese powder had the lowest β-lactoglobuiin. So, it isn't capable to protect the moisture of sample because of low quality gel formation. Averbach (1992) reported that oil and fats as coating surface tend to crack upon the handling or during the temperature changing and have some disadvantages on the moisture barrier. Due to cracking the crust of sample, a lot of water exits from the vegetable oil-treated samples. *Lepidium sativum* seed gum had the highest moisture at first and third days. Also, there were no significant differences (P<0.05) between water and xanthan in moisture content on the first day but xanthan is better than water three days after baking because of xanthan treated samples had higher moisture than water treated samples after 3 days storage. This improvement in moisture content by hydrocolloids is attributed to water retention ability of this polymer which is as the result of their hydrophilic nature (Bárcenas & Rosell, 2006). Mohammadi, Sadeghnia, Azizi, Neyestani, & Mortazavian (2014) investigated the effect of xanthan gum and carboxymethyl cellulose (CMC) on quality parameters of gluten-free bread, based on rice and corn starch. The bread containing xanthan showed the highest moisture content, so using xanthan gum was more effective in decreasing hardness, in both fresh and stored bread. Naji-Tabasi & Mohebbi (2015) reported xanthan and *Lepidium sativum* seed gum were hydrated in cold water and produced a viscose solution. This gel had proper texture characteristics to link with water and keep it during baking and storage.

Table 2. Effect of different glazes on moisture, specific volume and porosity of gluten-free bread

Treatments	Moisture (%)		Specific volume (cm^3/g)	Porosity (%)
	First day	Third day		
Control	22.96±1.13^b	18.23±0.32^d	1.90±0.3^c	36.3±1.1^c
Vegetable oil	22.48±0.87^b	19.97±1.01^c	1.89±0.1^c	37.1±0.7^c
Water	26.93±0.93^a	24.91±0.79^b	2.45±0.4^b	41.0±0.4^b
Cheese powder	20.42±1.22^c	18.04±0.53^d	1.90±0.3^c	38.4±0.9^{bc}
Lepidium sativum	28.71±1.14^a	26.97±1.07^a	3.40±0.2^a	45.3±0.4^a
Xanthan	26.68±0.39^a	25.33±0.57^b	2.97±0.5^b	43.7±1.2^a

Different letters show the statistically significant differences (P<0.05).

Specific volume and porosity

The results of specific volume and porosity analysis of samples are presented in Table (2). The Binary images of treatments were shown in Fig. (2). Results indicated that specific volume was enhanced by water, xanthan and *Lepidium sativum* gum. The highest porosity of gluten-free bread (binary images showed the most proportion of bright to dark points) was related to *Lepidium sativum* treatment. These increasing behaviors may be pertaining to the ability of *Lepidium sativum* gum to permit dough expansion during the baking process. The hydrocolloids give stability to interface upper surface which conferees additional strength to the gas cells through baking. Consequently, the gas losses will be reduced and in turn, bread volume will improve (Bárcenas & Rosell, 2006). Generally, Lonergan (1999) reported that the glaze helps to keep the outer surface of the dough malleable without the addition of water, thereby delaying the setting of the outer dough surface, while not affecting the amount of water absorbed by the outer dough surface. Naji-Tabasi & Mohebbi (2015) studied the effect of *Lepidium sativum* (cress seed) gum and xanthan on gluten-free bread. The results exhibited that hydrocolloids, by foaming thick layer, influenced the stability of gas cells and caused more regular pores (increasing specific volume and porosity) in gluten- free bread which was more noticeable in bread containing cress seed gum. Demirkesen *et al*. (2014) studied the effect of hydrocolloids and hydrocolloids blend on gluten-free bread. The highest number of pores and lowest average area of pores were obtained from gluten-free bread prepared with the addition of xanthan, CMC, xanthan-guar gum, xanthan-locust bean gum and hydroxypropyl methylcellulose (HPMC), which is associated texture of these crumbs. So the use of hydrocolloids especially *Lepidium sativum* gum represents the most widespread approach used to glaze in manufacture of gluten free bread.

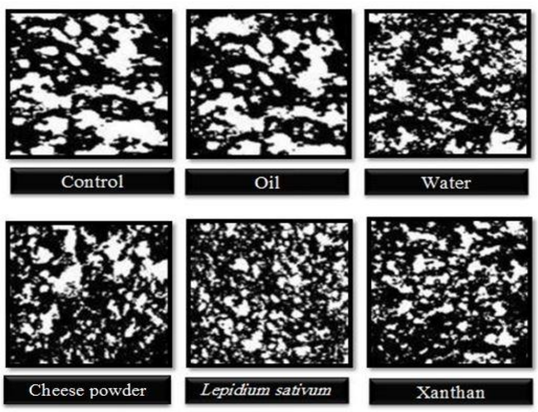

Fig. 2. Effect of different glazing formulas on binary images of gluten-free bread

Texture

The results showed significant differences in crumb firmness of samples ($P<0.05$), which varied between 1.59±0.17 and 3.13±0.1 N (Fig. 3). The outcomes indicated that firmness reduced with using water, xanthan and *Lepidium sativum* seed gum. Among all treatments, *Lepidium sativum* seed gum formula had the lowest and cheese powder formula had the highest firmness. The improving effect of precipitated whey protein on softness, yellowness (b* value) and sensory quality of lavash bread has been reported by Jooyandeh (2009). The adverse effect of whey protein concentrate (WPC) (over 5% level) on the quality characteristics of parotta (UFB) especially softness has been found by (Indrani, Prabhasankar, Rajiv, & Rao (2007). These researchers reported an unpleasant increment in surface thickness of WPC-treated samples which increased crumb firmness. On the other hand, vegetable oil treated sample did not show the significant difference compared to the control. The anti-staling effect of water, xanthan and *Lepidium sativum* seed gum may be related to their ability to retain the water on the top of dough surface. Mariotti, Pagani, & Lucisano (2013) studied the influence of HPMC on the bread making properties of some commercial gluten-free bread. The results showed the presence of HPMC proved useful in reducing diffusion and loss of water from crumb and crust, resulting in a softer gluten-free crumb and slower staling kinetics during storage. Hydrocolloids consist the number of water- soluble polysaccharides with varied chemical structures providing a wide range of fictional properties such as increasing specific volume and porosity and decreasing crumb hardness (Li & Nie, 2016).

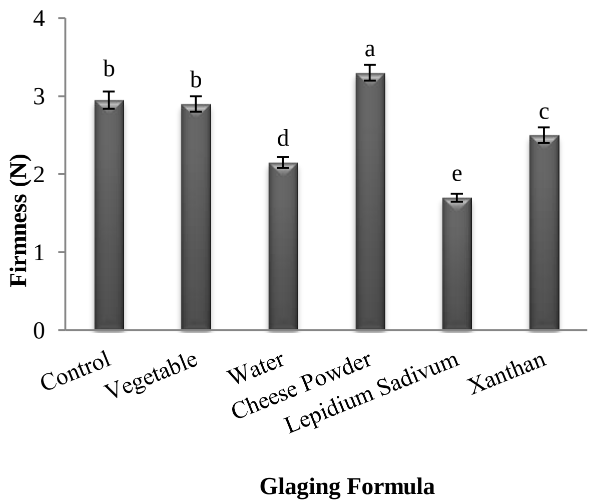

Fig. 3. Effect of different glazing formulas on firmness of gluten-free bread, different letters show the statistically significant differences ($P<0.05$)

Sensory analysis

Outcomes indicated *Lepidium sativum* seed gum treated samples had the highest upper surface and overall quality score (Table 3). Based on the present result, it might be conveyed that the produced surface in the presence of *Lepidium sativum* seed gum, might express higher moisture content and as a result higher brightness of the product was achieved. In this regard, Purlis & Salvadori (2009) reported that the moisture maintenance ability during the cooking process, might lead to the production of the smooth surface, as a result of it the light reflex of the products' surface increases and the brightness of the produced product increases. Furthermore, the achieved results presented that the general acceptance is in the middle of moisture content and water activity, indicating the positive effect of these two parameters on the general acceptance of final products.

Table 3. Effect of different glazes on sensory properties of gluten-free bread

Treatments	Properties		
	Upper surface	Odor and taste*	Overall quality
Control	5.2±0.20[c]	6.4±1.01[a]	5.4±0.26[c]
Vegetable oil	5.5±0.37[c]	5.9±1.16[a]	5.4±0.32[c]
Water	6.2±0.90[b]	6.5±1.41[a]	5.9±0.14[c]
Cheese powder	5.1±0.30[c]	7.1±0.74[a]	5.7±0.30[c]
Lepidium sativum	7.8±0.24[a]	7.3±1.25[a]	7.8±0.92[a]
Xanthan	6.5±0.76[b]	7.0±0.69[a]	6.9±0.28[b]

Values are the average of three replicates samples; all scores were from 0 to 9, with 9 being the highest value.
*$P<0.05$, not statistically significant.

Conclusions

The quality properties of different glazing such as water, vegetable oil, cheese powder, xanthan and a native hydrocolloid (*Lepidium sativum* seed gum) on gluten-free bread were evaluated. Some glazing treatments probably provided the layer of the moisture barrier on the surface of the dough and restricted migration of water from crumb to crust, therefore increasing the specific volume, porosity and moisture while decreasing firmness of gluten-free bread. Finally, outcomes indicated *Lepidium sativum* seed gum (a novel and local hydrocolloid) is the most effective than the traditional glazes to improve gluten-free bread quality and quantity. Due to the results of this project, the glazes have better effects on sensory and technological properties of part baked gluten-free bread. Then, it is recommended to use glazes in these products.

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توسعهٔ کاربرد پوشش خوراکی جدید حاوی صمغ شاهی و مقایسهٔ اثرات آن با رومال‌های سنتی نان بدون گلوتن بر پایهٔ آرد سورگوم

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چکیده

رومال‌ها جهت بهبود بافت و ویژگی‌های ظاهری نان استفاده می‌شوند. در این پژوهش اثرات رومال‌های سنتی (آب، روغن، پودر پنیر و صمغ زانتان) و رومال حاوی صمغ شاهی بر ویژگی‌های فیزیکوشیمیایی و خصوصیات حسی نان بدون گلوتن مقایسه شدند. بدین‌منظور حجم مخصوص، تخلخل، فعالیت آبی، رطوبت، سفتی بافت و ویژگی‌های حسی نان بررسی گردید. نتایج نشان داد، نمونه‌های حاوی پودر پنیر و روغن کمترین میزان رطوبت و نمونه‌های حاوی صمغ شاهی و زانتان بیشترین حجم مخصوص و تخلخل را داشتند. همچنین نتایج حاکی از آن بود نمونه‌های تیمارشده با رومال آب و صمغ شاهی دارای کمترین میزان بیاتی و سفتی بافت بودند. این در حالی بود که تمام رومال‌های استفاده‌شده در این پژوهش اثر معنی‌داری ($P>۰/۰۵$) بر بو و مزهٔ نمونه‌های تولیدی نداشتند. درنهایت باید گفت، صمغ شاهی به‌عنوان یک رومال جدید عملکرد بهتری در مقایسه با صمغ زانتان داشت و از رومال حاوی این صمغ می‌توان جهت بهبود سطح نو ویژگی‌های کیفی و ظاهری نان بدون گلوتن استفاده نمود.

واژه‌های کلیدی: تخلخل، رومال، صمغ شاهی، نان بدون گوتن