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The Effect of the Addition of Pumpkin Flour on the Rheological, Nutritional, Quality, and Sensory Properties of Bread

Ibrahim Hoxha[1], Besiana Hoxha[1*], Gafur Xhabiri[2], Nexhdet Shala[1], Adem Dreshaj[3], Namik Durmishi[2]

[1] Faculty of Agribusiness, University of "Haxhi Zeka", Rr. KLA. Peja 30000, Kosovo

[2] Faculty of Food Technology And Nutrition, University of Tetova, Street Ilinden Bb 1200, Tetovo 1220, North Macedonia

[3] Faculty of Tourism Management, Hotel and Environment, University of "Haxhi Zeka", Peja, Rr. KLA. Peja, Postal Code 30000, Kosovo

* Corresponding author's e-mail: besiana.hoxha@student.unhz.eu

ABSTRACT

Bread in Kosovo and beyond is still the most consumed food product, but the increase in consumer awareness of healthy foods has stimulated interest in the addition of various ingredients to improve its nutritional value and sensory properties. This study aimed to identify the ideal percentage of adding pumpkin flour through its influence on the rheological, nutritional, qualitative, and sensory properties of bread. Breads were produced with different amounts of pumpkin flour (control, 5%, 10%, 15%, and 25%). The results of the rheological properties with the Brabender farinograph and extensograph devices showed that the pumpkin flour pulp had an impact on the delay in dough formation, thus affecting the increase in water absorption, development time, stability, resistance, and energy of the dough. The falling number was very high for all types of bread over 350 seconds, and there were no significant differences between them ($p < 0.05$). The content of nutrients in the bread, such as fat, cellulose, and ash, increased along with the content of pumpkin flour, while the protein content decreased. Also, the content of iron, magnesium, potassium, and calcium increased along with pumpkin flour addition, while the content of zinc and manganese decreased. The bread with 5% pumpkin flour had the best specific volume, while the control bread and the bread with 5% pumpkin flour had better acidity. The bread with 5% pumpkin flour and control bread had better sensory properties, but even the breads with 10% pumpkin flour had good sensory properties. Therefore, using less than 10% pumpkin flour is suggested in the production of bread without compromising the quality or sensory properties of the bread.

Keywords: pumpkin flour, rheological properties, nutrition values, minerals, sensory properties, bread.

INTRODUCTION

Of all bakery products, bread in Kosovo and around the world is still the most consumable. Bread has always been one of the most recognized sensory and textural ready-to-eat food products, as well as a competitively low (1977) cost, high caloric and carbohydrate content, and poor other nutrients, which made it a source of poor health (Chandan, 2011). Therefore, nowadays, the emphasis is on healthy bread with a low glycemic index, more protein, dietary fiber, and resistant starch (Păucean & Man, 2014). Among the important vegetable crops in Kosovo is pumpkin (*Cucurbita maxima* L), which is mainly used as jam, in the production of pies, and in animal feed, but not in the production of bread. Of the total area planted with vegetables of 17.886 ha in 2018, pumpkins had a participation rate of 13%, which satisfies the needs of 98% (MBPHR, 2019), (Mostoviak et al., 2023). The chemical composition of pumpkins varies from one cultivar or species to another. According to some authors, (Bhat & Bhat, 2013); Kim et al., 2012); See et al., 2007)) pumpkin pulp composition varied between 75.8% and 91.33% moisture, 0.2% and 2.7% crude protein, 0.47% and 2.1% crude ash, as well as 3.1% and 13% carbohydrate content. According to Wahyono et al. (2018), pumpkin is a food that is high in dietary fiber, notably pectin, functional compounds, vitamins like A, B6, K, C, and E, as well as minerals like K, Mg, P, Se, and Fe (Korkhova et al., 2023). High dietary fiber consumption lowers blood glucose levels, controls serum insulin levels, and enhances glucose tolerance (Quanhong et al., 2005), and it offers a defense against conditions such as colon cancer, diabetes, constipation, and cardiovascular disease (Anderson et al., 1994). Pumpkin's yellow or orange hue is a result of its high levels of beta-carotene (Namana et al., 2023). According to Bhaskarachary et al. (2008), eating the foods high in beta-carotene helps prevent cancer, skin ailments, and eye disorders (Benedich, 1989). Pumpkin can be processed into flour, which has a longer shelf life, so because of its highly desirable flavor, sweetness, and deep yellow-orange color, it has been reported to be used to supplement cereal flour in food products. In turn, Ptitchkina et al. (1998) noted that adding pumpkin flour boosted the volume and organoleptic properties of the bread prepared. Additionally, to enhance the nutritional, physical, and sensory properties of bakery products, Lee et al. (2002) and Shih et al. (2007) reported on the use of pumpkin flour as a supplement to cereal flour (Abdulazeem et al., 2023). The objective of this study was to assess how adding various amounts of pumpkin pulp flour affected the rheological, nutritional, qualitative, and sensory characteristics of bread.

MATERIALS AND METHODS

Materials

For the production of bread, T 500 Finnesa flour was used, which had the following composition: moisture 13.4%, protein 11.43%, moist gluten 26.4%, and ash 0.55%, while for the enrichment of wheat flour for the production of bread with high nutritional values, the local pumpkin mill, the so-called walnut pumpkin, was used. The pumpkin was taken from the market, and after the peel and seeds were removed, the pulp was cut into small pieces and ground in a grinder, dried at 50°C for about 10 hours, and then ground in a laboratory mill by Yucebas Machinery-Izmir, Turkey. Pumpkin flour had the following composition: moisture 14.6%, protein 9.63%, fat 2.49%, cellulose 2.07%, and ash 3.07%. In order to increase the nutritional values, wheat flour was replaced with pumpkin flour and 5%, 10%, 15%, and 25%.

Then, the bread production process was carried out, where for the production of bread, 1 kg of flour was first weighed (a mixture of wheat flour and pumpkin flour); at the beginning, water was added to the flour according to the water absorption capabilities in the chronograph; then salt in the amount of 1.5%; and yeast in the amount of 1.5% (Vasylyshyn et al., 2023) Dough mixing was done using a two-speed spiral mixer, model SM-Yucebas Turkey for up to 15 minutes, depending on the mix. To obtain the massive 500-gram bread, 570 grams of dough was measured, which was fermented in an ALS-Zita Belgrade type fermenter at a temperature of 30°C, for a duration of 90 minutes, while baking was carried out in the ALS-Zita laboratory oven at a temperature of 225°C for a duration of approximately 20–25 minutes (Kliachenko et al., 2023).

Methods

Moisture, protein, lipid, and ash content of wheat flour, pumpkin flour, and manufactured bread were determined according to AOAC (2005) methods. Moisture determination was performed using the standard method by drying at 105°C for 4 hours. The ash content was determined by the standard burning method in the Northerm furnace at 900°C for 2 hours. Protein content (% N x 6.25) was determined by using the Kjedahl method. A crude fate test was carried out based on the Soxhlet Extraction Method. The determination of cellulose was based on the decomposition of organic matter other than cellulose with an acid solution (acetic acid-nitric acid) and weighing the filtered and dried cellulose (Xhabiri & Sinani, 2011). Free Acidity was determined by using the titrimetric method (Kaluerski & Filipović, 1998).

The determination of the rheological properties of the dough with Brabender equipment was performed using a farinograph in accordance with ISO 5530-1:2003 as well as an extensograph in accordance with ISO 5530-2:2012 (Hoxha et al., 2020). To determine the activity of α amylase, the Falling Number method was used in accordance with ISO 3093:2009. A panel of 12 experienced assessors examined the sensory properties of bread, including volume, external appearance, crumb appearance, aroma, and taste of the crust and crumb. Each of the bread attributes was given a score between 1 and 5, and the total points were calculated by multiplying the result by the coefficient of relevance for each attribute. According to Kaluerski & Filipovic (1998), the specific volume (cm^3/g) of bread was defined as the product of its volume and mass, where the mass was calculated two hours after baking and chilling and the volume was calculated using a procedure for removing millet grains. The determination of mineral substances such as Zn, Mn, Fe, Cu, P, K, Mg, Ca, and Na was carried out in the laboratory of the Institute of Agriculture, Peja, Republic of Kosovo. Using the MP-AES technique (Microwave Plasma Atomic Emission Spectroscopy, model 4200 Agilent Technologies, CA, US), according to (Kastrati et al., 2022).

Statistical analysis

The obtained data were statistically analyzed using the SPSS 16 program (SPSS Inc., Chicago, IL, USA), through One-way ANOVA and Post-hoc (Duncan test), with a level of significance of $p<0.05$.

RESULTS AND DISCUSSION

Rheological properties of dough

From a practical standpoint, it is crucial to fully comprehend the rheological behavior of flour dough since it directly impacts the baking performance of flour (Amjid et al., 2013). The rheological properties of dough obtained by mixing pumpkin flour with wheat flour are presented in Table 1. (Dryha et al., 2023). The results of Farinograph Brabendet analysis showed that the water absorption (WA) of dough increased as the pumpkin flour content increased (5–25%). Increased water absorption has also been reported by (Wongsagonsup et al., 2015) in their study. Dough development time (DDT) was significantly higher than the control dough (1.8±0.10 minutes), which is influenced by the much slower absorption of water by the fibers than wheat flour, which delays the development of the gluten network (Xhabiri et al., 2023). Dough stability (S) had significant differences for $p<0.05$, and it increased along with pumpkin flour content and was highest in the dough with 25% pumpkin flour at 9.7±0.26 minutes. The degree of softening (DS) decreased or improved, but was lowest in the dough with 10% pumpkin flour with 30±1.00FU. (Ahmed et al., 2013) reported similar results in their study.

The results of the Brabender Extensograph analysis showed that the extensibility (EX) generally decreased with increasing pumpkin flour content; similar results were also obtained by Seleem & Omran (2014) in their study. The maximum resistance to extensibility (MR) with increasing pumpkin flour content increased significantly and was twice as high as the control dough in the dough with 25% pumpkin flour with 1638±7.94 EU (Xie et al. 2022). The results of the R/E ratio increased many times with the addition of pumpkin flour, which will directly affect the quality of the bread. Dough energy represents the area under the extensograph curve, which increased along with pumpkin flour content (Laghlimi et al., 2022).

The results from the falling number analysis showed that there were no significant differences for $p<0.05$, respectively, and all the types of dough had a falling number higher than 350

Table 1. Rheological properties of dough

Mixtures	Brabender Farinograph				Brabender Extensograph				Failing number
	WA (%)	DDT (min)	S (min)	DS (FU)	EX (mm)	MR (EU)	R/E	E (cm^2)	(s)
Control	52.6±0.40^a	1.8±0.10^a	2.6±0.26^a	91±2.64^d	112±3.61^c	526±4.00^a	4.7±0.17^a	80±2.64^a	369±4.36^a
5%	54.3±0.44^b	1.9±0.17^a	8.7±0.17^b	84±2.00^c	86±3.46^b	882±5.56^b	10.2±0.36^b	95±2.64^b	355±2.65^a
10%	55.0±0.53^b	6.4±0.26^d	10.2±0.36^d	30±1.00^a	87±2.65^b	956±5.19^d	11.0±0.35^c	105±3.61^c	371±2.00^a
15%	56.3±0.44^c	5.5±0.30^c	9.3±0.35^c	50±2.64^b	70±2.00^a	942±4.85^c	13.4±0.46^d	86±4.36^a	356±2.64^a
25%	58.0±0.56^d	2.7±0.26^b	9.7±0.26^c	49±3.00^b	73±3.46^a	1638±7.94^e	22.3±0.36^e	144±4.36^d	353±3.61^a

Note: Brabender parameters: Farinograph: WA – water absorption, DDT– dough development time, S – dough stability, DS – degree of softening; extesograph – EX (extensibility), MR – max. resistance to extension, R/E – ration resistance/ extensibility, E – energy; failing number.

seconds, which indicates that the activity of α-amylase is very small and the bread produced will be crumbly and of improper volume (Xhabiri & Sinani, 2011). In contrast, good-quality flour should have a falling number between 200 and 250 seconds (Dromantienė et al., 2013).

Nutritional value of bread

The nutritional compositions of bread samples are dependent on the content of different levels of pumpkin flour (Table 1). Moisture content increased along with pumpkin flour content but was highest in the bread with 10% pumpkin flour at 34.39±0.34% (Table 2). Protein content was highest in the bread with 5% pumpkin flour, then decreased with increasing pumpkin flour content, and was lowest in the bread with 25% pumpkin flour. Similar results were also reported by Păucean & Man (2014), See et al. (2007), and Baht & Baht (2013). However, as observed from Table 2, the results show that the addition of pumpkin flour significantly increases the fat, cellulose, and ash content of the bread samples. Giotto et al. (2020) had similar results in their study. The data presented in Table 3 shows the content of some minerals in the bread fortified with pumpkin flour. The results revealed that there was a marked increase in minerals in the bread produced. The content of iron increased as the content of pumpkin flour increased, and there were significant differences between them for $p<0.05$. Also, the content of potassium, magnesium, and calcium increased along with the increase in the content of pumpkin flour. El-Soukkary (2000) had similar results in his study. The majority of the loaves of bread made with pumpkin flour had lower phosphorus contents than control bread, with the exception of the 10% pumpkin flour bread, which had the highest content (1805.2±0.40 mg/kg). The copper content was also higher in the 10% pumpkin flour bread and lower in the bread made from other mixes. However, the zinc and manganese content of all bread generally decreased with increasing pumpkin flour content.

Qualitative properties of bread

Figure 1 displays the specific volumes of the loaves. As can be seen, adding 5% more pumpkin flour resulted in a greater specific volume of 5.66±25 cm^3/g, but other loaves with higher pumpkin flour contents had a shorter specific volume. Lower gluten level, according to Hsu et al. (2004), results in a drop in flour strength and gas retention, which lowers bread volume and bread characteristics. Similarly, to this, Wahyono et al. (2016) showed that a greater quantity of Jerusalem artichoke powder led to a decrease in the specific volume of bread. Similar outcomes were obtained from See et al. (2007) study utilizing pumpkin flour at 5, 10, and 15%. The acidity of the control bread and the bread with 5% pumpkin flour was lower and between them were significant for $p<0.05$, while with the increase in the content of pumpkin flour, it increased and was higher in the bread with 25% pumpkin flour with 5.5 ±0.17 °SH Figure 1. Similar results were also reported by Păucean & Man (2014).

Table 2. Nutritional values of bread

Mixtures	Moisture (%)	Protein (%)	Fat (%)	Cellulose (%)	Ash (%)
Control	26.74±0.29^{a}	9.05±0.12^{bc}	1.12±0.05^{a}	1.03±0.04^{a}	1.31±0.04^{a}
5%	28.86±0.42^{b}	9.21±0.13^{c}	1.33±0.07^{b}	1.38±0.08^{b}	1.82±0.05^{b}
10%	34.39±0.34^{d}	9.14±0.06^{bc}	1.52±0.05^{c}	1.65±0.06^{b}	2.33±0.03^{c}
15%	33.62±0.43^{c}	8.97±0.07^{b}	1.76±0.06^{d}	1.94±0.07^{c}	2.78±0.07^{d}
25%	34.15±0.32^{cd}	8.71±0.10^{a}	2.08±0.04^{e}	2.55±0.09^{d}	3.79±0.05^{e}

Table 3. The mineral content of bread

Mixtures	Zn (mg/kg)	Mn (mg/kg)	Fe (mg/kg)	Cu (mg/kg)	P (mg/kg)	K (mg/kg)	Mg (mg/kg)	Ca (mg/kg)	Na (mg/kg)
Control	7.73±0.08^{d}	5.60±0.05^{c}	22.0±0.03^{a}	4.69±0.01^{d}	1715.2±0.53^{d}	1897.3±0.46^{a}	270.6±0.45^{a}	237.6±0.36^{a}	5246.7±0.85^{e}
5%	7.14±0.09^{c}	5.07±0.04^{b}	23.5±0.26^{b}	3.19±0.03^{c}	1705.6±0.62^{c}	3177.0±0.70^{b}	291.2±0.43^{b}	505.1±0.45^{c}	4790.9±0.62^{d}
10%	6.54±0.06^{b}	4.61±0.06^{a}	33.7±0.17^{c}	11.7±0.02^{e}	1805.2±0.40^{e}	3622.5±0.87^{c}	319.2±0.35^{c}	416.1±0.56^{b}	4072.5±0.96^{a}
15%	5.45±0.04^{a}	4.64±0.03^{a}	50.9±0.10^{d}	2.55±0.01^{a}	1570.9±0.26^{a}	4219.0±0.50^{d}	333.8±0.26^{d}	663.0±0.17^{d}	4084.8±0.75^{b}
25%	5.51±0.05^{a}	4.58±0.02^{a}	52.6±0.20^{e}	2.63±0.02^{b}	1619.7±0.44^{b}	5439.9±0.52^{e}	385.3±0.30^{e}	845.0±0.40^{e}	4327.7±0.79^{c}

Sensory properties of bread

Figure 2 presents the bread produced with the addition of pumpkin flour, while Table 4 shows the obtained results. The sensory properties data presented in Table 4 showed that the control bread and the bread with 5% pumpkin flour were preferred, had the highest score for all sensory properties, and gained more total points Figure 3 and Table 2. Respectively, the control bread had the best crust and crumb appearance and flavor, while the bread with 5% pumpkin flour had the

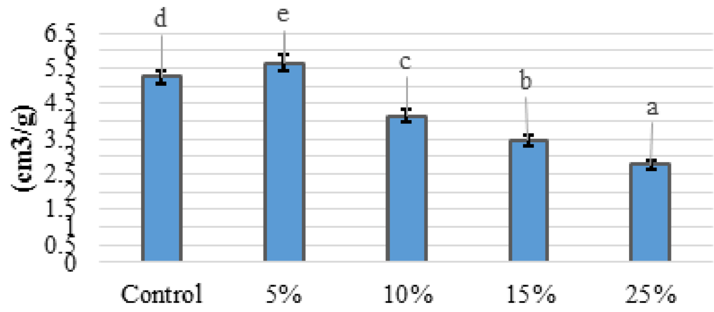

Figure 1. The specific volume of bread

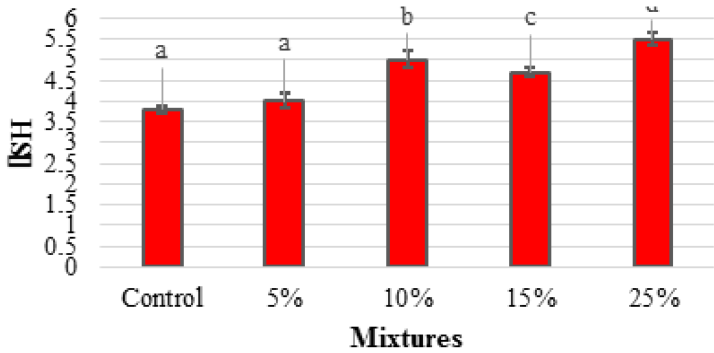

Figure 2. Acidity of bread

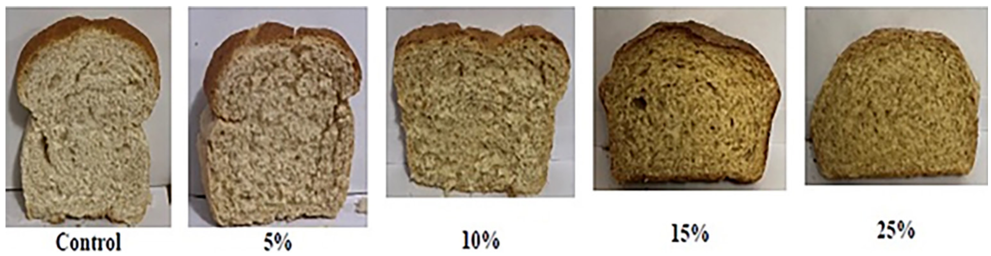

Figure 3. View of the cross-section of the crumb of bread

Table 4. Sensory qualities of bread

Mixtures	Volume	Exterior appearance	Appearance of the crumb	Aroma of the crust and crumb	Taste of the crust and crumb	Total point
	k=4	k=3	k=5	k=3	k=5	
Control	4.58±0.67^{bc}	4.50±0.67^{c}	4.33±0.77^{b}	4.75±0.45^{c}	4.42±0.52^{c}	89.82
5%	4.83±0.39^{c}	4.25±0.75^{bc}	4.42±0.79^{b}	4.16±0.72^{b}	4.66±0.65^{bc}	89.95
10%	4.33±0.88^{abc}	3.92±0.99^{bc}	4.08±0.90^{b}	4.00±0.43^{b}	4.25±0.86^{bc}	82.37
15%	4.08±0.79^{ab}	3.66±0.65^{ab}	3.33±0.77^{a}	3.42±0.79^{a}	3.83±0.57^{b}	73.36
25%	3.75±0.86^{a}	3.08±0.66^{a}	2.92±0.79^{a}	3.00±0.73^{a}	3.25±0.75^{a}	64.09

Note: *k* – coefficient of importance.

best crust and crumb volume, crumb appearance, and taste. In turn, in the other bread, as the content of pumpkin flour increased, the sensory properties decreased, but the bread with 10% pumpkin flour also had good sensory properties with 82.37 total points, while the bread with 15% and 25% pumpkin flour had much poorer qualities, where the bread with 25% had only 64.09 total points. Similar results in their study were also reported by Dabash et al. (2017) and Kampuse et al. (2015).

CONCLUSIONS

The quality criteria of bread changed when pumpkin flour was added at various concentrations (5–25%). Rheological properties with Brabender equipment such as water absorption, dough development, stability, resistance, and dough energy increased along with pumpkin flour content, while extensibility decreased. The falling number was higher than normal for all types of bread over 350 seconds, and there were no significant differences between them ($p<0.05$). The addition of pumpkin flour increased the content of fat, cellulose, and ash and decreased protein; it also increased the content of iron, magnesium, potassium, and calcium while reducing the content of zinc and manganese. The specific volume of bread made with 5% pumpkin flour was greater but decreased with the addition of more pumpkin flour, whereas the acidity of the bread was the same as that of the control bread and decreased when more pumpkin flour was added. The bread with 5% pumpkin flour had better sensory properties than the control bread, which also had better total scores, and breads with 10% had good sensory properties. Therefore, without compromising the quality or texture of the bread, it is suggested to use less than 10% pumpkin flour while baking bread.

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