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Research Article

Effect of Xylanase and Pentosanase Enzymes on Dough Rheological Properties and Quality of Baguette Bread

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The wheat flour baguette bread is one of the most important foods throughout the world. Therefore, improving the quality of this type of white bread has always been of interest. In this study, the effect of xylanase and pentosanase enzymes on the rheological properties of dough and baguette bread characteristics was investigated. Adding xylanase and/or pentosanase had led to improve rheological properties of the dough. Using 0.2 gr pentosanase in 100 g flour significantly strengthened the gluten network of the dough. Also, this treatment had the lowest extensibility and the highest resistance ratio number. The treatment containing 0.6 g xylanase and 0.1 g pentosanase in 100 g flour had a higher moisture content on the first, third, and fifth days of storage time. Regarding the color of the crust of the produced bread, it was found that the addition of both enzymes at higher levels, especially in enzyme mixtures, decreased the brightness of the bread crust. Due to the organoleptic features of breads, adding xylanase and pentosanase enzymes could improve the volume and crumb texture of the bread, but no significant difference was observed in baking uniformity, physical shape, taste, and odor of bread crumbs. In conclusion, the findings in this study indicated that the type of enzymes added and enzyme levels affected dough rheology, bread properties, and quality of the baguette bread significantly.

1. Introduction

Bread is one of the oldest foods for many people in the world and it provides most of the energy, minerals, and B vitamins for the body daily [1]. A baguette bread belongs to the group of volume breads. This product is obtained mainly from wheat flour, water, yeast, oil, improver, and salt. The dough of these breads is processed using yeast and the optimal rest time in the fermentation of bread and the evaporation of gases from the dough lead to an increase in the volume of the dough [2].

Due to the poor quality, short shelf life, and staleness of this type of bread, the waste of various types of baguette breads is mainly high; therefore, the production of these kinds of bread in good quality with a long shelf life is a challenge from the standpoint of consumers' acceptance. A quite complex molecular structure change involves multiple mechanisms that occur in baguette bread during storage, which leads to a firming and staling phenomenon [3]. Recently, one of the most common methods in breadmaking for improving dough rheological properties, preserving freshness, reducing the rate of staling, increasing consumer acceptance, and shelf life of bread is adding enzymes because they are safe and do not have any negative effect on humans. Several studies have investigated the improvement of dough and bread characteristics using enzymes [3–8].

As stated by Altinel and Ünal [4], hemicellulase enzymes have the ability to improve the handling characteristics of dough and bread quality. Among hemicellulases, xylanases and pentosanases are the two key enzymes responsible for the hydrolysis of the major components of hemicellulose, xylans, and pentosans [9]. Xylanase enzymes have been

widely used in breadmaking processes since the 1970s [10]. Xylanase is reported to release free water, decreasing the amount of water that must be added to the dough. The effect of xylanases on dough and bread properties is due to the hydrolysis of the xylan backbones of water-insoluble arabinoxylans, which leads to the release of water-soluble arabinoxylans [7]. The water-soluble arabinoxylans could stabilize gas cells and enhance dough viscosity [6]. The yield of this action is to provide a flexible dough with easier handling, which leads to a larger loaf volume and improved crumb structure [11]. Higher proof height has been reported in xylanase-supplemented dough due to more complete gluten hydration resulting from the transfer of water from pentose molecules to protein [12]. Alaunyte et al. [13] investigated the improvement of the quality of teff breads (a type of local bread) using various combinations of xylanase, lipase, amylase, and glucose oxidase enzymes. The teff bread was prepared in their study by replacing buckwheat flour with teff flour at different levels using sourdough and regular dough. They studied some physical, textural, and sensory properties of the final product. The teff bread prepared by enzymes was improved in terms of bread strength, bread crumb volume, and flavor.

Pentosanases, which are used in the production of baking products, are prepared from different species of *Aspergillus*. Pentosanases break down pentosan into smaller molecules, making the dough softer, in other words, reducing the dough viscosity. On the other hand, if the activity of pentosanases is high, the water absorption of the dough reduces and the dough becomes loose. Steffolani et al. [14] investigated the effects of glucose oxidase, transglutaminase, and pentosanase on wheat protein quality. They stated that pentosanases increased the amount of water-soluble pentosane. Also, in some samples, there was a tendency to increase free sulfhydryl groups. In addition, pentosanases increased the isopropanol-soluble protein, indicating that reducing the amount of pentosan increased the spatial insulation of insoluble pentosan. By using pentosanases, a softer dough and a higher specific volume of bread was achieved.

The aim of this study was to study the effect of addition of xylanase, pentosanase, and the combination of them into the dough. The farinographic and extensographic properties of dough were investigated. Also, the effect of the prepared dough on the quality characteristics and organoleptic properties of baguette bread was assessed in this research.

2. Materials and Methods

2.1. Materials. Commercial type wheat flour, with the parameters of moisture = 13.67% (w/w, wet basis), ash = 0.68% (w/w, wet basis), protein = 11.26%, Zeleny number = 20 mm, falling number = 450 s, dry gluten = 9.23%, and wet gluten = 27.50% (w/w, wet basis), was purchased from Behnan company (Qazvin, Iran). Instant active dry yeast was supplied from the Fariman company (Mashhad, Iran). The xyn and pn enzymes were provided by DSM company, Netherlands. All other chemicals used in this study were obtained from Merck (Darmstadt, Germany).

Table 1: Composition of the enzymatic treatments of a baguette bread formulated with different levels of xylanase and pentosanase enzymes.

Treatment	Enzyme concentration
X_3	0.3 g xylanase/100 g flour
X_6	0.6 g xylanase/100 g flour
P_1	0.1 g pentosanase/100 g flour
P_2	0.2 g pentosanase/100 g flour
X_3P_1	(0.3 g xylanase + 0.1 g pentosanase)/100 g flour
X_3P_2	(0.3 g xylanase + 0.2 g pentosanase)/100 g flour
X_6P_1	(0.6 g xylanase + 0.1 g pentosanase)/100 g flour
X_6P_2	(0.6 g xylanase + 0.2 g pentosanase)/100 g flour

2.2. Preparation of Dough and Breadmaking Procedure. The ingredients of the control dough as percentage by weight based on the flour consumption were as follows: flour 100%, water 65%, yeast 2%, sugar 1.5%, and salt 0.5%, and the enzymatic treatments are listed in Table 1. The direct method was used to prepare the dough. In this method, flour and all the ingredients were poured into a laboratory mixer (Dierks and Sohne, Maschinenfabrik, Osnabruck, Germany) and the dough was kneaded at 100 rpm for 7 min. The two leavening steps were performed using a proofing cabinet at 30°C and 75–80% relative humidity for 5 and 15 min, respectively. Then, the dough was turned into 100 g pieces, hand-rounded, molded, and proofed for 45 min at 35°C. Baking of the bread was carried out for 20 min at 180°C in a baking oven with a steam injection system [4].

2.3. Farinograph and Extensograph Analysis of the Dough. Dough rheology analyses were carried out using farinograph (Brabender, Mod. PL Nr. 810105, Duisburg, Germany) and extensograph (Brabender, Mod. PL Nr. 860000, Duisburg, Germany) measurements. Farinograph and extensograph tests were performed on selected samples Z_3, P_2, Z_3P_1, and Z_6P_1 (see Table 1) in triplicate.

The farinograph demonstrates characteristics and durability of the dough against mixing and tension stresses and clarifies technological characteristics of the dough. The farinograph test is used for property assessment of the dough such as water absorption, resistance, degree of softening, development time, and stability. The operation of the device is such that the force resulting from the dough resistance is applied to the blades of the mixer, which is rotating at a constant speed, and its curve is recorded.

An extensograph device was used to assess the ability of dough extension due to the force of tearing, resistance to extension, the ratio of these two parameters against each other, and fermentation effects on these parameters. The assessments were carried out using AACC methods No. 54-21 and 54-10 [15]. 22 pieces of 150 g of the dough were prepared in the form of a tube and placed in the special chambers of the device and fermentation was performed under controlled conditions of temperature and relative humidity. After 45, 90, and 135 minutes, graphs of samples were drawn.

Table 2: Farinographic properties of the dough samples.

Treatment[A]	Water absorption (%)	Development time (min)	Arrival time (min)	Leaving time (min)	Stability (min)	Degree of softening after 10 min (BU)	Degree of softening after 20 min (BU)	Farinograph quality number
Control	61.20[a]	3.75[a]	1.50[a]	5.50[a]	7.00[a]	60[a]	100[a]	52[a]
X_3	62.20[a]	3.75[a]	1.75[a]	5.25[a]	7.00[a]	65[b]	110[b]	51[a]
P_2	61.20[a]	3.75[a]	1.50[a]	6.00[a]	7.50[a]	60[a]	100[a]	51[a]
X_3P_1	61.80[a]	3.25[a]	1.50[a]	5.75[a]	7.25[a]	60[a]	120[c]	49[a]
X_6P_1	62.00[a]	4.00[a]	1.50[a]	5.75[a]	7.00[a]	60[a]	120[c]	49[a]

[A]For treatment descriptions, see Table 1. Data are expressed as mean values. Values in the columns followed by different lowercase letters are significantly different ($P < 0.05$).

2.4. Moisture Content of the Bread. The moisture content of bread samples was determined according to AOAC [16]. The purpose was to study the changes in moisture content and the amount of loss during the bread storage days.

2.5. Color Measurement of the Bread. The color of bread crust and the crumb was measured by Chroma Meter CR-400 (Konica Minolta Co. Ltd., Osaka, Japan) in three replications according to AACC method [15] No. 14.22.02. L^* (lightness), $+a^*$ (redness), $-a^*$ (greenness), $+b^*$ (yellowness), and $-b^*$ (blueness) were read using a D65 light source.

2.6. Hardness Evaluation of the Bread. Crumb hardness of bread samples was analyzed by Instron (Testo-metric, Japan) in the first, third, and fifth days of storage time according to AACC [15] No. 74-09.

2.7. Organoleptic Properties of the Bread. In order to evaluate the organoleptic characteristics of the bread samples, the analysis of the bread was performed using a sensory method according to AACC standard [15] No. A50-33. External characteristics, such as bread volume, crust color, physical shape, crust fracture, and baking uniformity, and internal properties, such as crumb color, taste, odor, bread texture, chewability, and crumb porosity, were measured [17]. The sensory assessment was evaluated by 10 experienced panelists. The maximum score for texture color, odor, chewability, crumb porosity, and bread volume was 10; for bread texture and the taste, it was 15; for physical shape, crust fracture, and baking uniformity, it was 3; for the color of the crust, it was 8; and the minimum score for all properties was 0.

Evaluation of staling feature of bread samples was done according to AACC [15] No. 74-30. The staleness of all samples was assessed after 1, 3, and 5 days of the storage period in a suitable package at room temperature. The assessors were asked to rank the bread samples in the ranks of 1 to 6 in terms of staleness so that the freshest bread is given the rank of 6 and the stalest bread is given the rank of 1, and giving the same ranks was avoided.

2.8. Statistical Analyses. Data analysis was carried out using analysis of variance and comparison of the mean of data with Duncan's test at a probability of 5%. All tests were carried out three times and analyzed using SPSS Software v.20 (IBM Analytics, USA). The mean values were compared using Tukey HSD Post Hoc Test ($P < 0.05$). Kruskal–Wallis test and Mann–Whitney post hoc test were used to evaluate the results of sensory evaluation and the Friedman test was used to evaluate the quality of produced bread samples.

3. Results and Discussion

3.1. Dough Rheology Analysis

3.1.1. Farinographic Properties of Dough. The farinographic properties of selected dough samples are presented in Table 2. The amount of water absorption is an important factor in terms of bread quality and also from the economic view; it predicts increase in the distribution of dough materials, hydration, and the development of the gluten protein network. Increasing water absorption leads to the increased shelf life of the final product and a relative reduction in moisture lost during cooking [18]. Based on the results of Table 2, the water absorption of the treatments and control was not significantly different from each other. One study of whole wheat dough reported that a blend of hemicellulases consisting mainly of endo-xylanase did not produce any significant change in the farinographic properties of whole wheat dough [5]. The highest water absorption was for treatment X_3 and the lowest water absorption was for treatment P_2, which indicates a greater effect of xylanase on increasing water absorption than that of pentosanase. To confirm this result, in the combined treatments containing xylanase and pentosanase, with increasing the amount of xylanase, water absorption also increased. Pentosans can indirectly influence gluten formation by competing for water and pentosanase can reduce the water-binding capacity of pentosans [8].

The process of dough swelling can be found during dough development time [19]. Reducing the dough development period causes the unsuitable formation of dough due to the weakness of the gluten network, which has a negative effect on bread volume [20]. Based on the results, there was no significant difference in the dough development period among the treatments and control, but the minimum and maximum development times were observed in treatments X_3P_1 and X_6P_1, respectively. It has been reported that increasing the amount of glucose oxidase led to increase in dough development duration [14].

Table 3: Extensographic properties of the dough samples at 45, 90, and 135 min resting time periods.

Treatment[A]	Maximum resistance (BU)			Resistance to extension (BU)			Extensibility (mm)			Resistance ratio			Dough energy (cm^2)		
	45 min	90 min	135 min	45 min	90 min	135 min	45 min	90 min	135 min	45 min	90 min	135 min	45 min	90 min	135 min
Control	135^{b}	155^{b}	175^{d}	120^{c}	140^{b}	160^{c}	175^{a}	175^{a}	151^{a}	0.70^{c}	0.80^{b}	1.06^{c}	34^{b}	37^{b}	38^{ab}
X_3	110^{a}	120^{a}	130^{a}	90^{b}	90^{a}	95^{a}	184^{b}	197^{b}	203^{d}	0.50^{b}	0.46^{a}	0.46^{a}	29^{a}	30^{a}	35^{a}
P_2	145^{c}	170^{c}	170^{d}	130^{d}	150^{c}	160^{c}	176^{a}	176^{a}	165^{b}	0.73^{c}	0.83^{b}	0.96^{c}	35^{b}	42^{c}	40^{b}
X_3P_1	100^{a}	125^{a}	150^{c}	80^{a}	95^{a}	115^{b}	204^{c}	190^{b}	195^{c}	0.40^{a}	0.50^{a}	0.83^{b}	30^{a}	31^{a}	37^{ab}
X_6P_1	100^{a}	120^{a}	140^{b}	80^{a}	90^{a}	110^{b}	201^{c}	196^{b}	195^{c}	0.40^{a}	0.40^{a}	0.56^{a}	29^{a}	31^{a}	38^{ab}

[A]For treatment descriptions, see Table 1. Data are expressed as mean values. Values in the columns followed by different lowercase letters are significantly different ($P < 0.05$).

The results of the arrival and leaving times showed no significant difference between treatment and control. Similarly, Altinel and Ünal [4] reported that glucose oxidase did not significantly affect the farinographic properties of whole wheat or white flour dough. The dough stability indicates the strength of the flour [21]. From the results in Table 2, no significant difference was observed in dough stability of treatment and control, but the highest stability time was related to the treatment P_2. Weak and strong flour shows low and high farinograph quality numbers, respectively [14]. Evaluating farinograph quality numbers showed no significant difference among treatments. Giannone et al. [22] found that α-amylase lipase did not significantly affect dough development period or dough stability, which is in agreement with the present study.

The highest degree of softening of the dough indicates the least mechanical resistance of the flour. The results of this study showed that treatment X_3 had the highest degree of softening after 10 minutes; treatments X_3P_1 and X_6P_1 had the highest degree of softening after 20 minutes among other treatments. As stated previously, xylanase causes the softening of wheat flour dough because xylanase can break down soluble pentosans [23]. Colakoglu and Özkaya [24] studied the effects of two lipases on the farinographic properties of dough. They reported that lipase had a hardening effect on the dough, as suggested by a decrease in the softening degree and increase in dough hardness.

3.2. Extensographic Properties of Dough. The extensograph gives information about the viscoelastic characteristics of the dough. The extensographic properties (at 45, 90, and 135 min) of dough samples are presented in Table 3. The amount of maximum resistance and resistance to extension of all treatments, except treatment P_2, was lower than the control sample. This finding is in agreement with the study of Diler et al. [25], who stated that using amyloglucosidase declined the dough's elastic properties. Also, it is reported that the addition of glucose oxidase and endo-xylanase decreased the resistance to the extension of whole wheat dough [4, 5]. This was attributed to the dough weakening effect of hydrogen peroxide, which is produced during the reaction catalyzed by glucose oxidase. In our study, all treatments containing xylanase had the ability to decrease resistance to the extension of the dough. As reported previously, the effect of xylanase on the softening of wheat flour dough can be due to the breaking down of soluble pentosans [26].

Table 4: Moisture content of baguette bread samples on the first, third, and fifth days of storage time.

Treatment[A]	First day	Third day	Fifth day
Control	24^{a}	24^{bc}	23.75^{c}
X_3	24^{a}	22^{a}	20.75^{c}
X_6	28.5^{c}	27^{cd}	25^{d}
P_1	25.5^{b}	25^{b}	22^{b}
P_2	29.5^{c}	28.5^{e}	28^{d}
X_3P_1	28.5^{c}	28^{de}	27.5^{d}
X_3P_2	26^{b}	25^{b}	24.5^{c}
X_6P_1	31^{d}	35.5^{f}	30^{e}
X_6P_2	23^{a}	21.5^{a}	20^{a}

[A] For treatment descriptions, see Table 1. Data are expressed as mean values. Values in the columns followed by different lowercase letters are significantly different ($P < 0.05$).

Extensibility indicates the degree of elasticity of the dough against the force applied to the dough. Based on Table 3, the extensibility of all treatments increased in comparison to the control sample. In fact, using starch and nonstarch hydrolyzing enzymes leads to the release of free water and changes the soluble fraction of the dough. So, gluten extensibility increases due to the redistribution of water from pentosans to gluten [27]. In contrast, Vukić et al. [28] investigated the effect of glucose oxidase on dough rheology and reported a decrease in the extensibility of wheat flour dough compared with control. As confirmed by Steffolani et al. [14], using the high glucose oxidase level caused to reducing dough extensibility because of more covalent crosslinking between proteins, importing S–S disulfide, and dityrosine bonds into the gluten network.

As reported in Table 3, the highest resistance ratio belonged to the control sample and treatment P_2. The larger resistance ratio indicates a stronger flour and dough. Dough energy expresses the amount of energy expended to knead the dough and eventually tear it. Based on our results, the highest amount of dough energy was observed in the control sample and treatment P_2. In confirmation of these results, Steffolani et al. [14], in their study regarding the effect of the addition of glucose oxidase, transglutaminase, and pentosanase enzymes on the dough properties, stated that the addition of pentosanase has increased the energy of the dough. Conversely, in the current study, the addition of xylanase significantly reduced the dough energy. Similarly, it is reported that glucose oxidase can decrease the energy required for handling the dough during bread production

Table 5: Hardness and staling feature of baguette bread samples on the first, third, and fifth days of storage time.

Treatment[A]	Hardness (N)			Staling feature		
	First day	Third day	Fifth day	First day	Third day	Fifth day
Control	8.41^{e}	9.60^{c}	10.04^{c}	6.0^{d}	3.8^{ab}	2.0^{abc}
X_3	6.35^{d}	7.20^{b}	7.65^{a}	6.0^{d}	3.2^{ab}	1.8^{ab}
X_6	6.50^{d}	7.40^{b}	9.51^{b}	6.0^{d}	5.0^{d}	2.6^{bc}
P_1	6.60^{d}	7.20^{b}	7.55^{a}	5.6^{cd}	2.4^{a}	1.6^{ab}
P_2	6.55^{d}	6.65^{a}	12.30^{d}	5.0^{bcd}	3.4^{abc}	1.6^{ab}
X_3P_1	10.60^{f}	11.10^{d}	14.20^{e}	3.8^{a}	2.8^{a}	1.2^{a}
X_3P_2	3.79^{a}	10.85^{d}	12.72^{d}	2.5^{bcd}	4.2^{cd}	3.0^{c}
X_6P_1	4.70^{b}	9.68^{c}	10.54^{c}	4.4^{ab}	3.4^{abc}	2.0^{abc}
X_6P_2	5.73^{c}	13.27^{e}	14.90^{e}	4.8^{ab}	3.6^{bc}	2.0^{abc}

[A]For treatment descriptions, see Table 1. Data are expressed as mean values. Values in the columns followed by different lowercase letters are significantly different ($P < 0.05$).

[5]. Also, Ognean et al. [29] reported that xylanase induced a small decrease of dough energy in white flour dough.

In general, there are positive or negative effects on the extensographic properties of dough depending on the type of flour, enzyme specificity, and dosage of the applied enzyme [29].

3.3. Bread Characteristics

3.3.1. Moisture Content. The moisture content of bread samples on the first, third, and fifth days of storage time is demonstrated in Table 4. Due to the results, the highest and lowest moisture content of samples during these days were related to treatments X_6P_1 and X_6P_2, respectively (maybe due to the synergistic effect of the two enzymes). In the treatments containing pentosanase alone, the moisture content was higher and in the treatments containing xylanase alone, the moisture content was lower. This finding is in agreement with the findings of Shah et al. [27] who stated that the moisture content of wheat breads was decreased by adding xylanase. In contrast, Silva et al. [30] found that intermediate levels of xylanase combined with higher levels of oxidizing agents generally increased the moisture content of whole wheat breads. Ghoshal et al. [31] similarly observed that xylanase increased the moisture content. Pentosanase can increase the solubility of the protein, which indicates that the size of pentosans reduction could lead to reducing the spatial barrier of insoluble pentosans [14]. This description can be the reason for the increased moisture content of bread samples containing pentosanase. Jaekel et al. [32] reported that adding xylanase levels of 4, 8, and 12 g/100 kg flour did not significantly change the bread moisture content. Also, it is stated that cellulase did not significantly alter the final moisture content of whole wheat bread [4].

3.4. Hardness and Staling Feature. The hardness and staling feature of bread samples during storage time is shown in Table 5. Water can act as a softener in bread, and therefore reducing moisture increases the hydrogen bonding between starch filaments and the formation of bonds between protein and starch, which in turn increases hardness [30]. The crumb moisture content is one of the most important factors in the hardness of bread. In addition, duration, quality of fermentation, and baking conditions affect the hardness and staling of bread [27]. Based on the results, adding 0.3 g xylanase and 0.1 g pentosanase to the 100 g flour decreased the hardness of treatments X_3 and P_1 on day five of storage in comparison to control and other treatments. Similarly, Driss et al. [12] and Ghoshal et al. [31] observed that xylanase decreased the hardness of fresh and stored bread. Also, Kim and Yoo [3] reported that α-amylase and endo-xylanase at a 100-ppm level decreased bread hardness by 63.4% and 56.9%, respectively. They stated that combined α-amylase and endo-xylanase delayed bread hardening after the fifth day of storage duration.

Table 6: The crust and crumb color of baguette bread samples.

Treatment[A]	Crust color			Crumb color		
	L^*	a^*	b^*	L^*	a^*	b^*
Control	54.95^{e}	15.32^{f}	34.86^{e}	76.56^{b}	0.47^{d}	16.28^{f}
X_3	59.03^{g}	17.75^{g}	38.29^{f}	78.65^{c}	0.68^{d}	19.24^{g}
X_6	46.18^{a}	-1.69^{b}	20.77^{c}	83.17^{d}	-2.50^{ab}	0.62^{e}
P_1	57.61^{f}	17.61^{g}	38.47^{f}	68.02^{a}	1.59^{e}	20.02^{h}
P_2	51.36^{c}	0.31^{c}	14.92^{a}	88.28^{f}	-1.43^{c}	-2.83^{b}
X_3P_1	35.50^{d}	-2.98^{a}	14.45^{a}	86.59^{e}	-2.24^{ab}	-1.48^{c}
X_3P_2	46.34^{a}	3.20^{e}	16.75^{b}	87.74^{f}	-2.44^{ab}	-3.99^{a}
X_6P_1	42.28^{b}	-1.38^{b}	13.95^{a}	88.09^{f}	-2.72^{a}	-1.32^{c}
X_6P_2	49.84^{b}	1.61^{d}	22.25^{d}	86.55^{e}	-2.03^{b}	-5.58^{d}

[A]For treatment descriptions, see Table 1. Data are expressed as mean values. Values in the columns followed by different lowercase letters are significantly different ($P < 0.05$).

The molecular structure changes, which are quite complex and responsible for the staling phenomenon, occur in bread during storage time [3]. The water loss during the baking process has a negative effect on the freshness of bread which leads to earlier staling [33]. As shown in Table 5, treatment X_6 had the lowest staling rate in comparison with control and other treatments. The anti-staling influence of xylanase on the bread containing wheat flour was also reported previously [3], which is in agreement with this study. It is reported that in a blend of refined flour and whole wheat flour, α-amylase improved the gas retention capacity of the dough and decreased bread hardness and staling rate [6]. They stated that the decrease in hardness and staling achieved by α-amylase is due to the increase in low

Table 7: External and internal characteristics of baguette bread samples.

Treatment[A]	External characteristics					Internal characteristics					
	Bread volume	Crust color	Physical shape	Crust fracture	Baking uniformity	Crumb color	Taste	Odor	Crumb texture	Chewability	Crumb porosity
Control	6.4^{a}	6.4^{a}	2.4^{ab}	2.0^{ab}	2.6^{ab}	9.0^{b}	13.6^{a}	9.1^{b}	8.5^{bc}	8.9^{cd}	8.5^{bc}
X_3	6.4^{a}	7.4^{b}	2.4^{ab}	2.2^{ab}	2.6^{ab}	7.6^{a}	13.2^{a}	7.8^{a}	13.2^{ab}	8.1^{ab}	7.5^{a}
X_6	8.6^{ab}	8.0^{c}	3.0^{b}	2.9^{c}	3.0^{b}	10.0^{c}	13.8^{a}	10.0^{b}	15.0^{d}	9.4^{d}	9.6^{d}
P_1	7.4^{ab}	7.8^{bc}	2.4^{ab}	2.4^{ab}	2.6^{ab}	7.5^{a}	12.3^{a}	7.8^{a}	12.8^{a}	7.4^{a}	7.7^{ab}
P_2	8.8^{bc}	8.2^{c}	3.0^{b}	2.9^{c}	3.0^{b}	10.0^{c}	13.4^{a}	9.6^{b}	14.2^{cd}	8.6^{bcd}	9.0^{cd}
X_3P_1	9.4^{c}	8.0^{c}	3.0^{b}	2.8^{c}	3.0^{b}	10.0^{c}	12.8^{a}	9.4^{b}	13.8^{bc}	9.2^{d}	8.6^{bc}
X_3P_2	7.2^{ab}	6.6^{ab}	1.8^{a}	1.8^{a}	1.9^{a}	10.0^{c}	12.6^{a}	9.4^{b}	14.2^{cd}	9.2^{d}	9.6^{d}
X_6P_1	7.5^{ab}	6.9^{ab}	1.7^{a}	1.7^{a}	2.0^{a}	10.0^{c}	11.8^{a}	9.4^{b}	14.0^{bc}	9.0^{d}	9.0^{cd}
X_6P_2	8.6^{bc}	7.3^{b}	2.4^{ab}	2.5^{ab}	2.4^{ab}	9.8^{c}	11.8^{a}	9.2^{b}	13.8^{bc}	9.0^{d}	9.0^{cd}

[A]For treatment descriptions, see Table 1. Data are expressed as mean values. Values in the columns followed by different lowercase letters are significantly different ($P < 0.05$).

molecular weight saccharides. Furthermore, these saccharides interfere with starch-protein interactions in the aging bread, which decreases hardness.

3.5. Color of Bread. The color of the bread crust is one of the main quality factors influencing consumer preference. Generally, a baguette bread's crust is characterized as light brown in color [3]. The results from the color of crust and crumb bread sample measurements are shown in Table 6. Treatments X_3 and X_6 had the highest and lowest L^* value in the bread crust, respectively. In a previous study, it is reported that adding xylanase to the wheat flour caused to lower the amount of L^* value because of the Maillard reaction in the presence of sugar [7]. Treatments X_3 and P_1 had the highest a^* and b^* values; in contrast, treatments X_3P_1 and X_6P_1 had the lowest a^* and b^* values in the bread samples crust. In general, regardless of the type of the enzyme, the lower the amount of enzyme, the less likely it is to break down into simpler sugars, resulting in less readiness to participate in the Maillard reaction, which is the main cause of the crust color, and hence resulting in a lighter crust [34]. It can be concluded that the addition of enzymes in higher amounts simultaneously enhances each other's effect, decreases the L^* value of the bread crust, and also reduces the color spectrum of a^* and b^* values. Similarly, Kim and Yoo [3] used combined α-amylase and endo-xylanase in bread and their results showed low L^* values and led to a much darker crust color.

Based on the results in Table 6, treatments P_2, X_3P_2, X_6P_1, and P_1 had the highest and lowest L^* value in the bread crumb, respectively. In general, most treatments had lighter bread crumbs than the control sample. This could be due to the fact that brown-colored products of Maillard reactions become observable at temperatures around 105–115°C but the temperature of bread crumb rarely rises above 100°C [35]. Treatments P_1 and X_6 had the highest and lowest b^* value of bread crumbs. Treatment X_3 and control samples had the lowest a^* value of bread crumbs in comparison with other treatments.

3.6. Organoleptic Characteristics of Bread

3.6.1. External Properties. Bread volume is one of the most important factors in baguette bread acceptance. Decreased bread volume occurs due to the reduction of dough extensibility and dilution of the gluten network and also the interactions of nongluten proteins with other flour compounds, which reduce the storage capacity of the gas in the dough [36]. The organoleptic external properties of bread samples are presented in Table 7. The bread volume increased in all treatments, except treatment X_3, in comparison to the control sample. Increased bread volume by xylanase addition has been demonstrated by several studies [5, 12, 31, 32, 37]. The addition of xylanase decreases the water absorption of the flour, leading to better gluten hydration and network formation and hence higher dough rise during the fermentation and larger bread volume [31]. Altinel and Ünal [5] suggested that increasing bread volume is due to the conversion of water-unextractable arabinoxylan into water-extractable arabinoxylan, which improves the gas retention capacity in the dough. Jaekel et al. [32] observed an increase in bread volume as the xylanase dose was increased from 0 to 8 g/100 kg flour, then decreased to 12 g/100 kg flour. At the highest addition level, the dough had the largest proof volume but collapsed during baking. Therefore, optimization of the enzyme usage level is important.

All treatments in this study could improve the crust color of bread in comparison to the control sample. Xylanase and pentosanase enzymes can release fermentable sugars that participate in the Maillard reaction and affect the color of the bread crust. Also, the increase in the crust color can be attributed to the increase of compounds that can be caramelized in the bread crust. Whole wheat breads prepared with xylanase received higher scores in all sensory attributes evaluated by Driss et al. [12], which is in agreement with our results. As shown in Table 7, no significant difference was observed between the control sample and other treatments in terms of physical shape and baking uniformity.

Regarding crust fracture, no significant difference was observed between the control sample and treatments X_6P_1

and X_3P_2. Other treatments achieved higher scores in comparison to the control sample. Bread cracking can occur because of the formation of gas caused by excessive fermentation in the gluten network. In fact, the dough wall cracks and tears due to the high pressure of the gases, and ultimately the gases, which have been produced by yeast's activity, come out of the dough mass [38].

3.7. Internal Properties. The organoleptic internal properties of bread samples are shown in Table 7. In relation to the crumb color of the bread, the highest score belonged to the treatments containing higher amounts of xylanase/pentosanase or the treatments containing the combination of these two enzymes, which scored significantly higher than the control sample. Since the Maillard reaction did not interfere with the coloring of the bread crumb, and the compaction of the crumb leads to turbidity, it is possible that the porosity and volume of the bread prevented their high turbidity. Changes in the bread color can happen because of the changes in the amount of water, protein changes, starch gelatinization, and free water in different baking steps [39].

According to Table 7, no significant difference was observed between the control sample and other treatments in terms of taste. Also, there was no significant difference in the odor of bread crumbs among the treatments containing higher amounts of xylanase/pentosanase or the treatments containing the combination of these two enzymes and the control sample.

Water retention in the crumb could improve the textural properties in bread because it can prevent its redistribution, retrograde starch, and the formation of starch and gluten bonds. Similarly, Ghoshal et al. [31] reported significant improvements to the organoleptic properties (texture, aroma, taste, and color) of the whole wheat bread when prepared with xylanase. These attributes were rated higher than those of the control for the bread when it was fresh and after 7 days of storage, indicating that xylanase can help provide a more sensorily acceptable product over the bread's shelf life. Also, Kumar and Satyanarayana [37] reported an improved crumb structure for the xylanase-supplemented bread.

Regarding chewability and crumb porosity, higher amounts of xylanase/pentosanase or the use of these two enzymes together have led to more cavities and granulation of bread crumbs; and in these treatments, large and non-uniform cavities were observed lower than other treatments. Produced carbon dioxide during the fermentation causes the porosity of dough texture which leads to producing a spongy bread [40]. As claimed by a recent review article [41], transglutaminase can improve the sensory and textural characteristics of the bread. Also, the improvement is even greater when both transglutaminase and α-amylase are added together.

4. Conclusions

The aim of this study was to consider the effect of the addition of xylanase and pentosanase, at different levels, on the rheological properties of dough and baguette bread characteristics. The obtained results clearly indicated that adding xylanase and pentosanase into the flour had no significant influence on the farinographic properties of the dough but improved the extensographic properties. The data from this study showed that the hardness of bread samples increased with increase in staling over time. According to the results of the bread crust color, the addition of enzymes in lower amounts had led to brightness enhancement. All treatments could improve the volume and crumb texture of bread samples. No significant difference was observed in physical shape, baking uniformity, taste, and odor of bread crumbs by adding the enzymes. Generally, the findings of the present study confirmed that the type and dosage of added enzymes play an important role in breadmaking. Further research is needed to investigate regarding use of each of the applied enzymes along with other enzymes, such as transglutaminase, in the breadmaking industry. Also, the influence of adding these enzymes into the dough along with other improvers, such as ascorbic acid or emulsifiers, could be studied in the future.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding the publication of this paper.

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