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THE EFFECT OF DIFFERENT MALT FLOURS ON RHEOLOGICAL PROPERTIES OF DOUGH

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ABSTRACT
The present work explored the effect of malt flours obtained from different grains (wheat, barley, rye, triticale, millet, maize, rice, oat) on rheology, fermentation and pasting properties of wheat dough. Malt flour and commercial enzyme added to bread flour decreased peak viscosity and peak temperature values measured in Amylograph. Wheat, rye and oat malt flours provided the best result, respectively, in terms of farinogram properties of flour samples such as water absorption, development time, dough stability, degree of softening and mixing tolerance index. In general, the addition of malt flour increased the extensibility of the dough, while lowering the dough resistance and dough energy. Oats, rice and corn malt positively affected the fermentation properties of the dough such as gas holding power, maximum dough height and gas escape point. It is possible to say that wheat malt gave the best results in terms of pressure, extensibility and energy values obtained by dough inflation analysis. When all the data obtained from the study were taken into consideration, it was seen that the use of malt flour as the enzyme source gave better results compared to the commercial enzyme in terms of dough rheological properties. It has been concluded that wheat malt gives the best results in terms of all dough properties.
Keywords: Malt flour, dough rheology, D/R dough inflation system, fermentation properties

FARKLI MALT UNLARININ HAMURUN REOLOJİK ÖZELLİKLERİ ÜZERİNE ETKİSİ

ÖZ
Bu çalışmada, farklı tahıllardan (buğday, arpa, çavdar, tritikale, darı, mısır, pirinç, yulaf) elde edilen malt unlarının hamurun reolojik, fermantasyon ve çirişlenme özellikleri üzerindeki etkisi araştırılmıştır. Ekmeklik una eklenen malt unu ve ticari enzim, Amilograf cihazında ölçülen pik viskozite ve sıcaklık değerlerini düşürmüştür. Un örneklerinin su absorpsiyon, gelişme süresi, hamur stabilitesi, yumuşama derecesi ve yoğurma tolerans indeksi gibi farinogram özellikleri açısından sırasıyla buğday, çavdar ve yulaf maltı en iyi sonucu vermiştir. Genel olarak, malt unu ilavesi hamurun uzayabilirliğini arttırırken, hamur direncini ve hamur enerjisini düşürmüştür. Yulaf, pirinç ve mısır

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maltı, hamurun gaz tutma gücü, maksimum hamur yüksekliği ve gaz kaçış noktası gibi fermantasyon özelliklerini olumlu yönde etkilemiştir. Hamur şişirme analizi ile elde edilen basınç, uzayabilirlik ve enerji değerleri açısından en iyi sonuçları buğday maltının verdiğini söylemek mümkündür. Çalışmadan elde edilen tüm veriler dikkate alındığında enzim kaynağı olarak malt unu kullanımının hamur reolojik özellikleri açısından ticari enzime göre daha iyi sonuçlar verdiği görülmüştür. Tüm hamur özellikleri açısından buğday maltının en iyi sonuçları verdiği sonucuna varılmıştır.
Anahtar kelimeler: Malt unu, hamur reolojisi, D/R hamur şişirme sistemi, fermantasyon özellikleri

INTRODUCTION

It is of great importance that the flour used in bread making has a certain level of amylolytic (especially alpha amylase) activity. It is known that the amylolytic activity is low in the wheat grown in Turkey, as wheat cultivation is common in arid areas where there is not much rainfall (Bilgiçli and Soylu, 2016). There is no legal objection to adding enzymatic additive to flour. For this reason, the addition of enzymes to bread flours becomes obligatory in a sense, since the amylolytic activity is not at a sufficient level in the wheat used in bread making. Although bacterial, fungal and cereal-derived enzymes are used as amylolytic enzymes, cereal-derived enzymatic additives and especially malt flour, which has some superior properties, are widely used (Elgün and Ertugay 2002; Hrušková et al., 2018).

The germination of grains, which involves a number of physiological and metabolic processes, is one of the important and critical stages in the plant's life cycle, as it determines the development and yield of the crop. Since the antinutrients decrease and the amount of digestible nutrients increases, the nutritional value of the grains increases during the germination process (Aguilar et al., 2019). In the germination process, the first metabolic activities start in the embryo, the scutellum and epithelial layers secrete hydrolytic enzymes such as protease and amylase. As germination progresses, cell walls melt, proteins and starch break down and become water-soluble, and these flow into the embryo as a nutrient and energy source. Morphological changes in grain occur as rootlet and leaflet elongation and endosperm melting. Germinated grains are rich in vitamins, minerals and secondary metabolites due to the activation of metabolic enzymes and the synthesis of metabolites occurring in the embryo. For use an enzymatic additive in bakery products, cereal grains that are germinated to a certain extent under controlled conditions are used to produce enzyme-active malt flour (Traoré et al., 2004; Gujjaiah and Kumari, 2013). In the baking industry flours with low enzyme content have a negative impacts on the properties of the final product (Zakupszki et al., 2018). Since the germination process significantly increases the α-amylase activity of the grain (Nkhata et al., 2018), enzyme-active malt flour produced from germinated and properly dried cereal grains is widely used in flours with low amylolytic enzyme activity.

Since malt flours are rich in maltose, minerals, soluble proteins, amylolytic and proteolytic enzymes and flavorings, they accelerate gas formation in the dough by promoting yeast activity and contribute to the flavor and aroma of the baked product (Hrušková et al., 2018). The addition of malt flour causes significant changes in the rheological properties of the dough. The use of malt flour changes dough consistency and water absorption during mixing in Farinograph, decreases tolerance to excessive kneading by increasing dough stickiness. Furthermore, the addition of enzyme-active malt flour decreases gelatinization initial temperature and maximum peak point in Amylograph, and increases dough extensibility by decreasing dough elasticity in Extensograph or Alveograph. These changes in dough rheological properties significantly affect the final product properties (Codină and Leahu, 2009; Boz et al., 2010).

In a study (Nechita et al., 2009) in which malt flour (0.1-0.25%) was added to strong wheat flour, it was reported that added malt flour accelerated gluten development as it developed proteolytic activity of dough, and also improved bread texture and crust color. Hugo et al. (2000) investigated the effect of different levels of malt flours obtained by subjecting malt obtained from germinated sorghum to different heat treatments on the quality of wheat pan bread. It was stated that the use of sorghum in the form of heat-treated malt flour obtained by germinated and then applying wet heat, especially boiling, gives better results compared to other methods.

In the study conducted by Veluppillai et al. (2010) in which the effect of flour obtained from germinated rice at different durations on bread quality was investigated, it was stated that malt flour obtained from rice germinated for 3 days gave the best results in terms of the physical and nutritional quality of bread. In another study (Makinen and Arendt, 2012), the effect of using different levels (0.5% to 5%) of malt flour obtained from oat, barley and wheat on dough and bread characteristics was investigated. In the study, it was stated that all malt flours increased the bread volume, and barley and wheat malts at levels above 2.5% increased the stickiness of bread more than oat malt. In addition, it was stated that oat malt gave better results than wheat and barley malt in terms of both dough and bread properties due to its high lipolytic activity.

Optimum enzyme activity in bread flour is important for overall product quality. Cereal malts provide regulation of amylolytic activity (Elgün and Ertugay, 2002) and they also increase the quality and nutritional value of bread and enrich the bread aroma (Boz, 2008). Barley and wheat are widely used in malt flour production. In this study, enzyme-active malt flour was obtained from rye, triticale, millet, corn, rice and oat in addition to wheat and barley and it was aimed to determine the effects of these malt flours on the rheological properties of dough.

MATERIALS AND METHODS

Materials

A commercial bread wheat flour, without additives, used for dough preparation was supplied from Birsan Milling Factory (Erzurum, Turkey). It contained 12.5% moisture and 12.1% dry matter protein. Commercially available wheat (Doğu 88), barley (Olgun), rye (Aslım-95), triticale (Ümranhanım), millet (White millet), corn (ADA 313), paddy (Osmancık- 97), and oat (Ankara-76) were used in the production of malt flour. A commercial enzyme (α-amylase from *Bacillus* sp.; Sigma) was used as enzymatic additive.

Malt flour preparation and addition levels

The cleaned grains were washed and kept in water at 20°C for 24 hours, and after removing the excess water, they were allowed to germinate in the container at room temperature (20°C), 70% relative humidity and darkness conditions. Samples were hydrated every 8-10 h and scrambled to prevent matting. The grains that sprout up to 1 cm, were dried at 40 °C (up to 14% moisture content). The dried malts was milled in a combined mill (Yücebaş Makine Analytical Devices Industry, İzmir, Turkey) and sieved to pass a 0.25 mm screen. Sieved malt flours were stored at 5 °C until use. In order to reduce the falling number value of wheat flour (539 seconds) to the optimum value (274±3 seconds); the wheat, barley, rye, triticale, millet, corn, oats, and paddy malt and commercial enzyme were added to the wheat flour at the rates of 0.88, 0.57, 1.067, 0.598, 1.455, 1.356, 1.902, 1.705, and 0.0115%, respectively.

Flour and dough analysis

Moisture content of flour samples was determined according to AACC method 44-15A, and amylolytic enzyme activity was determined according to AACC method 56-81 using the Falling Number device (Perten FN 1800, Perten Instruments, Springfield, IL) (AACC, 2000).

Dough rheological properties during mixing

Farinograph (Farinograph-E, Brabender GmbH & Co., Duisburg, Germany) was used to evaluate dough mixing properties according to the ICC (1992) Method No: 115/1. The Farinograph water absorption (%) of flour, development time, stability, mixing tolerance index (MTI) and degree of softening values were determined.

Pasting properties

The pasting properties of the flour samples were determined by using amylograph (Brabender, Duisburg, Germany) (Rojas et al., 1999). The suspension (80 g flour/350 ml water) was heated from 30 °C to 92 °C at a rate of 1.5 °C/minute, after being kept at this temperature for 20 minutes, it was cooled from 92 °C to 50 °C at the same rate. The peak viscosity (BU, Brabender Unit), and peak and initial gelatinization temperatures were calculated from the obtained curve (amylogram).

Instrumental dough extensibility

Uniaxial extension tests were performed using the texture analyzer TAXT.Plus (Stable Micro System, Surrey, England) equipped with SMS/Kieffer dough and gluten extensibility rig at 3.30 mm/s test speed, 75 mm distance, and 1 g trigger force. The dough sample was shaped into thin rolls, then been formed into 5 cm long pieces with a trapezoidal cross section (3 mm × 5 cm × 4 cm). After resting in the mold for 40 min at 30 °C, extensographic assay was conducted and the maximum resistance (g), dough extensibility (mm) and extension area (g·s) were determined.

Rheological properties of dough during fermentation

The rheological properties of dough during fermentation were measured by Texture Analyzer (model TA-XTplus, Stable Micro System, England) and 50 mm aluminium probe. The dough samples were prepared in the Farinograph mixer using 300 g flour, 4.5 g salt and 3% yeast and, mixing time to reach 500 BU consistency determined by Farinograph studies. Water was added according to farinograph absorption, i.e. to 500 BU. After mixing, the dough samples were allowed to rest for 30 min before being analysed to the Texture Analyzer. A cylindrical container of 7 cm diameter was positioned in the water bath so that it could not move. 100 g of kneaded dough was weighed. Both the dough and the cylindrical bowl were thinly covered with paraffin so that the dough made in rounds did not stick to the chamber during analysis. A 600 g weight was put on the dough mass placed in the cylindrical bowl, and the probe was in contact with this weight during analysis. The ambient temperature was kept constant at 35 °C with a water bath during the analysis. Measurements were performed at the following conditions: Pre-test speed: 1 mm/s; test speed: 0.50 mm/s; post-test speed: 10 mm/s; duration: 45 min; trigger force: 1 g; and load cell: 5 kg. The results were expressed as the values of maximum dough development height (Hmax, mm), gas retention (min.mm) and gas escape height at which gas starts to escape from the dough (mm) (Fig.1).

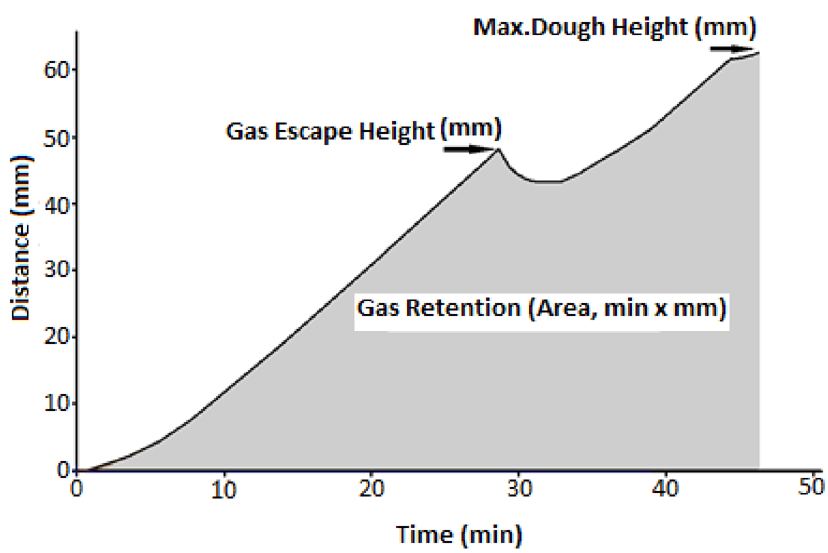

Figure 1. A sample dough gas retention capacity curve (SMS Model TA-XTplus, Stable Micro System, U.K.)

Dough inflation measurement

Dough inflation test of dough samples were determined by the D/R dough inflation system mounted on TA.XT Plus Texture Analyzer (Dobraszczyk, 1997). Doughs for the dough inflation test were first prepared in a farinograph, using 300 g flour, 2% salt and water (according to farinograph water absorption) addition and mixed to peak time. Then dough was rolled to a thickness of 8 mm by using roller mechanism. 55 mm circular pieces were cut from these sheets by using cookie cutter. Then circular pieces were pressed for 30 sec. The five discs were compressed in turn, then stacked up in holders to prevent moisture loss and rested for 30 min at 25±5 °C and tested at texture analyser in five replicates under the following conditions: test speed 1602 cm^3/minute, volume: 20.000 m^3, trigger volume 20.000 mm^3. The following parameters were obtained: bi-axial extensibility, L (mm); tenacity, P (mm) and deformation energy, W (kj) at bubble failure.

Statistical analysis

The experiments were carried out in duplicate and the analysis were performed in triplicate. ANOVA and Duncan's multiple range tests significance was carried out to all data in order to determine differences between means (*P<0.05*) using SPSS (Version 16.0.1, IBM SPSS Statistics for Windows, IBM Corp., Armonk, NY, USA).

RESULTS AND DISCUSSION

Pasting properties of the flour samples

The falling number value of the wheat (control) flour (539 s) was reduced to the ideal FN value (274±3 s) by adding the enzyme-active malt flours and commercial enzyme. Addition levels of these additives were determined as 0.88, 0.57, 1.067, 0.598, 1.455, 1.356, 1.902, 1.705, 0.0115% for wheat, barley, rye, triticale, millet, maize, oats, paddy malt and commercial enzyme (amylolytic), respectively. In this way, the pasting properties of the flour samples which are the wheat flours mixed with malt flours and enzyme were determined by Amylograph device and Duncan multiple range test results of the mean values of peak viscosity, peak temperature and initial gelatinization temperature derived from amylograms are given in Table 1.

Table 1. Effect of malt flours addition on pasting properties of flour [(1)]

Flour Samples	Enzyme Source	Peak Viscosity (BU)	Peak Temperature (°C)	Initial Gelatinization Temperature (°C)
Control	-	957.50a	80.25a	61.25abc
	Wheat M.	262.50g	71.25d	61.25abc
	Barley M.	312.50f	72.50bcd	60.50bc
	Rye M.	322.50e	72.50bcd	61.50ab
	Triticale M.	305.00f	71.50cd	61.75a
Control +	Millet M.	417.50c	73.50b	61.25abc
	Corn M.	407.50d	73.25b	61.75a
	Oat M.	517.50b	72.75bc	61.50ab
	Paddy M.	402.50d	72.50bcd	61.75a
	C.E.	322.50e	73.25b	60.25c
	P	**	**	*

[(1)] Means with different letters in each column were significantly different (**P* < 0.05 and ***P* < 0.01).
P indicates level of significance, BU: Brabender Unit, M: Malt, C.E: Commercial Enzyme.

As it can be seen in Table 1, while the highest peak temperature and viscosity values were determined in the control flour, the lowest values were found in wheat malt added flour. It was observed that the usage of malt flours and enzyme reduced these values. It was also observed that the peak temperature value of the flour samples added with barley, rye and paddy malt was statistically the same. While the triticale, corn and paddy malt added flour samples had the highest initial gelatinization temperature (61.75 °C), the lowest value (60.25 °C) was determined in the commercial enzyme added flour sample. The initial gelatinization temperature values of the control flour and wheat, and millet malt added flours were statistically not different (*P* > 0.05).

By heating the flour-water suspensions in the amylograph, starch gelatinization occurs as a result of thermal effect at a certain temperature, and the viscosity of the suspension increases. While the starch gel breaks down due to the effect of the amylase enzymes present in the flour, both the pasting properties of the starch and the activity level of the amylase enzymes can be determined from the obtained curve (amylogram). In bread flours, the peak viscosity value is required to be between 350-500 BU (Elgün et al., 2011). It is seen that the enzyme activity in bread flours can be brought to the desired peak viscosity value with the appropriate use of malt flours obtained from different grains used in the study.

Dough mixing properties

Duncan multiple range test results of the mean of water absorption, development time, stability, mixing tolerance index and degree of softening values of the flour samples were given in Table 2. The water absorption of the flour samples varied between 61.2 % (flour containing wheat malt) and 58.95 % (flour containing barley malt). Water absorption, which is an important quality criterion in bread making, is desired to be high as far as possible (Aydoğan et al., 2012; Şahin et al., 2013). While the development time of the flour samples containing oat (5.55 min) and wheat malt (4.25 min) showed quite high values, it varied between 1.35 and 2.55 minute in other flour samples. The long development time is proportional to the gluten quality (Köten, 2005; Aydoğan et al., 2012), and it also shows that the dough strength is high (Şahin et al., 2013). The short development time negatively affects bread volume and pore structure (Aydoğan et al., 2012).

Table 2. Effect of malt flours addition on farinograph indices of dough (1)

Flour Samples	Enzyme Source	Water absorption (%)	Development time (min)	Stability (min)	Degree of Softening (BU)	Mixing Tolerance Index (BU)
Control	-	59.40e	2.45c	9.45c	68.50f	18.50f
	Wheat M.	61.20a	4.25b	10.45b	68.50f	10.50h
	Barley M.	58.95f	2.55c	7.15f	87.50b	41.50a
	Rye M.	59.95cd	2.25d	11.15a	50.50h	8.50ı
	Triticale M.	59.65de	2.45c	8.55d	61.50g	14.50g
Control +	Millet M.	60.10bc	1.35e	5.65h	85.5c	26.50d
	Corn M.	60.15bc	2.25d	6.55g	76.50e	34.50c
	Oat M.	59.90cd	5.55a	8.15e	118.50a	39.50b
	Paddy M.	60.35b	2.25d	8.55d	68.50f	15.50g
	C.E.	60.05bc	2.15d	8.15e	78.50d	24.50e
	P	**	**	**	**	**

(1) Means with different letters in each column were significantly different (***P* < 0.01).
P indicates level of significance, BU: Brabender Unit, M: Malt, C.E: Commercial Enzyme.

While the highest stability value was obtained in the flour sample containing rye malt, the lowest value was determined in the flour sample containing millet malt. As expected, the degree of softening and the mixing tolerance index values were generally low in flour samples which have high stability value. High-quality bread flour is defined by high dough stability (Köten, 2005) and low degree of softening (Aydoğan et al., 2012). Since the dough will soften quickly and lose its consistency, the dough fermentation time should be kept short in the flours which have a high degree of softening value and the dough should be processed in a short time (Elgün et al., 2011). The mixing tolerance index, which is preferred to be low for bread making, is the difference in BUs between the top of the curve and the top of the curve measured 5 min after the peak is reached (D'Appolonia, 1984). Considering the farinograph properties such as dough stability and mixing tolerance index, wheat and rye malt gave the best results.

Dough development and gaseous release characteristics

As it can be seen in Table 3, while the highest gas retention capacity was determined in the dough contain paddy and oat malt, the lowest gas retention capacity was determined in the dough contain millet malt and commercial enzyme. For the gas retention capacity parameter, there was no statistically significant difference among the control dough and wheat, barley, rye, triticale and corn malt added dough. The corn malt flour added dough had the highest the maximum dough height value (77.16 mm), while the dough added with commercial enzyme had the lowest (62.08 mm). Although there was no statistically significant difference between the values, wheat, barley, rye, triticale and oat malt added dough had lower the maximum dough height values compared to control flour dough. The earliest gas escape was observed in the rye malt added dough, while the latest gas escape was found in the oat malt added dough. No gas escape occurred until the end of the test period in the dough with added corn and rice malt and commercial enzyme. The final product quality is significantly affected by fermentation properties of the dough such as gas retention capacity, maximum dough height and gas escape height. Particularly, it has been reported that there is a positive correlation between bread specific volume and maximum dough height value (Huang et al., 2008). Malt flours are widely used to improve the rheological properties of dough and to form substrate for yeasts in a fermentation environment. It is stated that the addition of malt flour to bread flours affects the dough viscosity and gas production capacity, and improves the volume, colour and textural properties of the bread (Boz, 2008). When all fermentation properties of dough such as gas retention capacity, maximum dough height and gas escape height are considered together, it is seen that the use of the corn, oat and paddy malt gave the best results.

Table 3. Effect of malt flours addition on fermentation properties of dough (1)

Flour Samples	Enzyme Source	Gas Retention Capacity (mm.min)	Maximum Dough Height (mm)	Gas Escape Height (mm)
Control	-	1543.00ab	72.71ab	43.53b
	Wheat M.	1481.30ab	68.50ab	50.17a
	Barley M.	1502.30ab	71.01ab	50.13a
	Rye M.	1437.70ab	65.00ab	43.36b
	Triticale M.	1450.80ab	66.60ab	48.80ab
Control +	Millet M.	1384.80b	63.88b	50.60a
	Corn M.	1513.20ab	77.16a	N.E.
	Oat M.	1601.50a	70.47ab	52.95a
	Paddy M.	1602.80a	76.78a	N.E.
	C.E.	1364.10b	62.08b	N.E.
	P	*	*	**

(1) Means with different letters in each column were significantly different (*$P < 0.05$ and **$P < 0.01$).
P indicates level of significance, M: Malt, C.E: Commercial Enzyme, N.E.: No Escape.

Large deformation dough rheology by SMS/Kieffer Rig

While there was no statistically significant difference between the extensibility values of dough made from control flour and barley malt added flour, it was observed that the other enzyme additives increased the extensibility of dough (Table 4). The corn malt added dough had the highest extensibility value (48.03 mm), and there was no statistically significant difference between corn malt and oat malt added dough. The lowest extensibility value (29.67 mm) was found in the dough containing barley malt. It has been observed that the addition of different grain malts (except barley malt) to wheat flour generally results in an increase in the dough extensibility. Boz (2008) stated that the addition of malt flour to wheat flour increased the dough extensibility, while decreasing the maximum resistance and dough energy values.

Table 4. Effect of malt flours on the extensibility, maximum resistance and energy values of dough (1)

Flour Samples	Enzyme Source	Extensibility (mm)	Maximum Resistance (g)	Energy (g.s)
Control	-	29.70f	56.66a	365.30ab
	Wheat M.	34.48de	40.41d	318.70de
	Barley M.	29.67f	48.63b	329.20cde
	Rye M.	37.81c	36.17e	337.53cd
	Triticale M.	36.79cd	44.75c	375.50a
Control +	Millet M.	42.35b	30.54g	309.21ef
	Corn M.	48.03a	30.29g	350.84bc
	Oat M.	46.87a	29.31g	344.28bc
	Paddy M.	34.03e	40.10d	337.24cd
	C.E.	36.66cd	32.52f	293.92f
	P	**	**	**

(1) Means with different letters in each column were significantly different (**$P < 0.01$).
P indicates level of significance, M: Malt, C.E: Commercial Enzyme.

As it can be seen in Table 4, the maximum dough resistance decreased in the dough added with all malt flours and commercial enzyme compared to the control. While the control flour had the highest maximum dough resistance value (56.66 g), the oat malt added dough had the lowest value (29.31 g). No statistically difference was observed in the dough containing corn, oat and millet malt flours in terms of maximum resistance value. Malt flour is used in bakery products, especially to increase the amylolytic activity of flours. However, since malt flours contain proteolytic enzymes as well as amylolytic enzymes (Bilgiçli and Türker, 2004), the addition of malt flour also reduced dough resistance by affecting gluten strength.

It has been determined that, except for triticale malt, the addition malt flour to wheat flour reduced the dough energy. The highest dough energy value (375,5 g.s) was belonged to the dough added with triticale malt, and the lowest value (293.92 g.s) was belonged to the dough added with commercial enzyme. Energy is the indicator of the strength and machinability degree of the dough against processing. The high energy value indicates that the gas holding capacity and fermentation tolerance of the dough is high. It is stated that the volume of breads made from the dough which has high energy value is also high (Elgün et al., 2011). It was also stated that the high energy value of dough is closely related to the gluten content and protein quality of flour (Köten, 2005), and the dough had low energy value should be processed in a short time (Elgün et al., 2011).

D/R dough inflation test results

The peak height (P, mm) also referred to as the maximum pressure or tenacity indicated the resistance that the dough offered to deformation and it is connected with the tensile strength or stability that the dough exhibited during the proofing stage of bread making (Ibrahim et al., 2021). It has been determined that the dough containing wheat malt flour had the highest P value (368.86 mm), it was followed by triticale (331.78 mm) and paddy (312.5 mm) malt flours (Table 5). However, the oat malt addition resulted the lowest P value (107.58 mm). The extensibility value (L) which is the indicator of the inflation rate and elasticity of the dough was found to be 31.88 mm (the highest) and 14.1 mm (the lowest) for the control and the paddy malt added dough, respectively. However, extensibility (L) and deformation energy (W) values for the dough containing oat malt flour could not be detected. It was determined that the extensibility value of all dough samples containing enzymatic additive decreased compared to the control dough. The deformation energy value (W), which corresponds to the work to inflate the dough sample and is an indicator of the strength of the flour, was found to be the highest (1598 kj) in the dough wheat malt flour and the lowest (997.6 kj) in the dough rye malt flour. There was no statistically significant difference was determined among the W values of control dough, barley and corn malt added dough. It is reported that P and W values determined by dough inflation test are positively correlated with bread volume and texture, and negatively correlated with bread crumb hardness; however, it is stated that the L value is negatively correlated with bread texture, and positively correlated with bread internal hardness (Dikici et al., 2006).

Table 5. Effect of malt flours addition on dough inflation test values [(1)]

Flour Samples	Enzyme Source	P (mm)	L (mm)	W (kJ)
Control	-	246.30d	31.88a	1437.2b
	Wheat M.	368.86a	19.93cd	1598.0a
	Barley M.	220.81de	27.23ab	1447.3b
	Rye M.	299.94bc	15.06d	997.6f
	Triticale M.	331.78ab	19.90cd	1309.6cd
Control +	Millet M.	148.48f	22.35bc	1207.0de
	Corn M.	160.59ef	21.22c	1441.2b
	Oat M.	107.58f	-	-
	Paddy M.	312.50ab	14.10d	1118.8e
	C.E.	135.79f	27.36ab	1413.2bc
	P	**	**	**

[(1)] Means with different letters in each column were significantly different (** $P < 0.01$).
P indicates level of significance, M: Malt, C.E: Commercial Enzyme.

Conclusion

Malt flours and commercial enzyme addition significantly affected all the properties of the dough made from wheat flour. While the peak viscosity and peak temperature values measured by Amylograph were decreased with malt flour and commercial enzyme addition to wheat flour, the highest decrease was observed in wheat malt added flour. The initial gelatinization temperatures of the flour samples were almost the same. It was observed that the water absorption value and the degree of softening were increased with the addition of malt flour (except barley, and rye and triticale malts respectively) compared to the control. The wheat and rye malt additions gave the best results especially in terms of the stability and mixing tolerance index values of dough. The oat, paddy and corn malts gave the best results of the gas retention capacity, maximum dough height and gas escape values. Generally, the addition of malt flour increased the extensibility of the dough, while decreased the maximum resistance and energy values. It can be said that the wheat malt gave the best results in terms of pressure, extension and energy values obtained by dough inflation test. According to the data obtained from this study, it was concluded that the use of malt flour as an enzyme source gave better results than the commercial enzyme in terms of dough rheological properties. It can be easily said that the use of wheat malt had a positive effect on all quality properties of the dough.

CONFLICT OF INTEREST

The article authors declare that there is no conflict of interest between them.

AUTHOR CONTRIBUTIONS

The authors declare that they have contributed equally to the article.

ETHICAL APPROVAL

Ethical approval is not required for this research.

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