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Research Article/Araştırma Makalesi

The influence of Barley (*Hordeum vulgare* L.) flour substitution to wheat flour on the color and sensory quality characteristics of Şanlıurfa Lavaş bread

Buğday ununa arpa (Hordeum vulgare L.) unu ikamesinin Şanlıurfa Lavaş ekmeğinin renk ve duyusal kalite özelliklerine etkisi

Mehmet Ali ELÇİ[1], Ahmet Sabri ÜNSAL[2], Mehmet KÖTEN[3], Ali YILDIRIM[4*]

[1,2,4]Harran University, Engineering Faculty, Food Engineering Department, Şanlıurfa, Türkiye
[3]Kilis 7 Aralık University, Yusuf Şerefoğlu Health Sciences Faculty, Nutrition and Dietetics Department, Kilis, Türkiye

[1]https://orcid.org/0000-0001-6138-9054; [2]https://orcid.org/0000-0002-8012-3208, [3]https://orcid.org/0000-0002-8232-8610; [4]https://orcid.org/0000-0001-7226-1902

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Address for Correspondence:
Ali YILDIRIM
e-mail:
ayildirim@harran.edu.tr

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ABSTRACT

In response to the rapidly increasing global population, the depletion of food resources has intensified research efforts aimed at improving yield and quality in agricultural production. Given these limited resources, there is a growing need to utilize crops from the agricultural production pattern more extensively for human consumption. Although barley is predominantly used as animal feed both globally and in Türkiye, interest in its use for human nutrition has been growing due to the reasons mentioned above. In addition, decreased physical activity and a refined, low-dietary fiber diet, have contributed to various health issues. As a result, consumers have become more conscious and have increasingly preferred foods rich in nutrients and dietary fiber. In the study, barley flour was substituted with wheat flour and used in the production of Lavaş bread at the rates of 0, 20, 40, 60, 80 and 100%. Şanlıurfa Lavaş bread is a flat bread type distinctive originating from Şanlıurfa. It is characterized by its dough formulation, which typically incorporates a higher water content and reduces yeast compared to traditional pide dough. Following fermentation, the dough surface is flattened, subsequently moistened with a flour-water slurry, and then baked. In the study, L*, a* and b* color values of all bread samples ranged from 73.20 to 83.51, 1.49 to 2.90 and 13.63 to 16.39, respectively. It was found that as the amount of barley flour added to bread flour increased, the L* value decreased, while the a* and b* values increased. Barley flour added up to 40% instead of wheat flour and Lavash breads made from mixtures of these flours were highly rated in all sensory properties, while it was found that the surface property and shape were adversely affected by 80% or more barley flour substitution and color by 100% barley flour substitution. Although samples were low scored with barley flour greater than 40% substitution, all other properties were found to be within acceptable limits.

Key Words: Lavaş, sensory, bread, quality, barley flour

ÖZ

Dünyada hızla artan nüfusla birlikte gıda kaynaklarının daralması, tarımsal üretimde verimliliği ve kaliteyi artırmaya yönelik çalışmaları da hızlandırmıştır. Bu sınırlı kaynaklar göz önüne alındığında, tarımsal üretim modelindeki ürünlerin insan tüketimi için daha yaygın bir şekilde kullanılmasına yönelik artan bir ihtiyaç vardır. Arpa dünyada ve Türkiye'de ağırlıklı olarak hayvan yemi olarak kullanılmasına rağmen yukarıda

belirtilen nedenlerden dolayı insan beslenmesinde kullanımına olan ilgi artmaktadır. Ayrıca, azalan fiziksel aktivite ve rafine edilmiş besinsel lif içeriği düşük gıdaların beslenmede kullanılması, çeşitli hastalıkları da beraberinde getirmiştir. Sonuç olarak tüketiciler daha bilinçli hale gelmiş ve besin değeri ve diyet lifi açısından zengin gıdaları giderek daha fazla tercih etmeye başlamıştır. Yapılan çalışmada arpa unu, buğday unuyla %0, 20, 40, 60, 80 ve %100 oranlarında ikame edilerek Lavaş ekmeği üretiminde kullanılmıştır. Şanlıurfa Lavaş ekmeği Şanlıurfa'ya özgü bir yassı ekmek türüdür. Geleneksel pide hamuruna kıyasla genellikle daha yüksek su içeriği ve azaltılmış maya içeren hamur formülasyonu ile karakterize edilir. Fermantasyondan sonra hamur yüzeyi düzleştirilir, daha sonra un-su bulamacı ile nemlendirilir ve sonra pişirilir. Çalışmada, tüm ekmek örneklerinin L*, a* ve b* renk değerleri sırasıyla 73.20 ile 83.51, 1.49 ile 2.90 ve 13.63 ile 16.39 arasında değiştiği tespit edilmiştir. Ekmek ununa eklenen arpa unu miktarı arttıkça L* değerinin azaldığı, a* ve b* değerlerinin ise arttığı belirlenmiştir. Buğday unu yerine %40'a kadar arpa unu eklenmiş ve bu unların karışımlarından yapılan Lavaş ekmekleri tüm duyusal özelliklerde yüksek puan alırken, yüzey özelliği ve şeklin %80 veya daha fazla arpa unu ikamesiyle ve rengin %100 arpa unu ikamesiyle olumsuz etkilendiği tespit edilmiştir. Arpa ununda %40'tan fazla ikame oranına sahip örneklerde düşük puan alınmasına rağmen, diğer tüm özelliklerin kabul edilebilir sınırlar içerisinde olduğu görülmüştür.

Anahtar Kelimeler: Lavaş, duyusal, ekmek, kalite, arpa unu

Introduction

Barley (*Hordeum vulgare* L.) is among the earliest domesticated crops and has evolved into a significant cereal grain. It is grown across various countries and regions that experience temperate climates during the summer, as well as in some temperate and subtropical areas during the winter. Initially, barley was likely used for human consumption. However, as wheat gained prominence in human diets, barley transitioned to play a crucial role in animal feed production and became a key crop for malt production (Sharma & Gujral, 2010).

Barley is a significant food due to its high content of β-glucan, a soluble fiber known to reduce coronary heart disease risk, lower blood cholesterol, stabilize blood sugar levels, prevent obesity, and support gastrointestinal health (AbuMweis et al., 2010; Behall et al., 2004; Cavallero et al., 2002). Research also shows that barley delays staling and extends bread shelf life. Barley has been used as a healthy food for thousands of years. Barley was probably first consumed by humans, although it has since changed to be used mostly for feed, malt, and brewing. Only around 2% of the barley harvest is now used for human consumption, with the remaining two-thirds going toward feed and the remaining one-third going toward malting (Baik & Ullrich, 2008).

The practice of baking flatbread from a blend of cereal and pulse flour has recently gained popularity worldwide. A diet incorporating a combination of pulses and cereals offers significant nutritional benefits, particularly in protein content, due to an enhanced amino acid profile. Pulses are characterized by elevated levels of lysine, which effectively complements the proteins found in cereals, known for their high sulfur-containing amino acids and tryptophan. Furthermore, enriching flatbread with pulse flours or additional cereals increases their fiber and mineral content, thereby enhancing their overall nutritional value. (Borsuk et al., 2012; Yıldırım et al., 2018; Dankwa et al., 2021). Newman & McGuire (1985) found that substituting 10-40% barley flour for wheat flour decreased in bread volume from 4.6 mL/g to 3.9 mL/g, and external appearance or shape deteriorated. Barley-wheat flour blends (25:75, 50:50, 75:25) showed reduced crust color and loaf volume as barley content increased. Breads with 10% barley flour show detectable barley flavor and aroma. Lavaş bread is a kind of flat bread which is widely consumed in Türkiye. It is prepared from wheat flour, salt, water, and compressed yeast + baking soda by 1.5 h fermentation. (Yıldız & Bilgiçli, 2012).

Food acceptance is influenced by the interplay of sensory characteristics, contextual factors, familiarity with sensory experiences, and the nutritional content of the item. Research on food labelling shows that the same product can receive varying evaluations depending on the information provided regarding its sensory attributes,

presence of organically grown ingredients, or dietary fiber (Newman & Newman, 2006; Kihlberg et al., 2005). Long baking times and low temperatures reportedly result in dry, firm crumbs in flatbreads. Conversely, baking at high temperatures for shorter durations improves crust characteristics and consumer preference (Imm et al., 2012; Mollakhalili-Meybodi et al., 2023). Knuckles et al. (1997) produced high-fiber bread by substituting 5%, 20%, and 40% barley flour into wheat flour. Bread with 20% β-glucan-enriched barley flour showed no quality issues and were deemed healthier due to increased fiber and reduced calories per serving. Başman & Köksel (1999) reported that substituting up to 40% barley flour in Bazlama bread reduced sensory attributes like color, texture, flavor, and aroma but supported acceptable overall quality. The preference for barley products has significantly decreased when the sensory quality of items made from barley is compared to those made from wheat or rice (Newman & Newman, 2006). Başman & Köksal (2001) found that adding barley flour and wheat bran to Yufka (flat bread) similarly slightly reduced sensory attributes, though all samples remained acceptable. Dhingra & Jood (2001) studied bread made with soy and barley flour blends with increasing substitutions elevated protein, total lysine, dietary fiber, and β-glucan content while supporting sensory and nutritional acceptability. Cereal-derived β-glucans, particularly abundant in barley and oats (2-10% in barley), are linked to health benefits (Knuckles et al., 1997). Ereifej et al. (2006) noted that Baladi bread with 15-30% barley flour was acceptable to consumers but had a harder texture, darker color, and irregular shape. Sharma and Gujral (2013) reported that Chapati bread with barley flour (28-84%) and β-glucan (1.5-4.5%) delayed staling, but reduced baking loss, baking time, and loaf size. Preliminary sensory evaluations indicated a favorable acceptance of the formulations containing 40–60% barley flour, with the primary concerns pertained to the taste of the bread (del Carmen Robles-Ramírez et al., 2020).

Meeting consumer demand for healthy foods requires new products to support acceptable sensory attributes like taste and aroma, surface color, texture, mouthfeel, appearance, and overall acceptability. The rapid population growth in Şanlıurfa, the affordability of bread, and the widespread consumption of open breads like Lavaş bread in the region motivated this study. We investigated the sensory quality characteristics of Lavaş bread made by substituting wheat flour with barley flour at varying ratios. This article focuses on the sensory quality outcomes.

Materials and Methods

Materials

TARM 92 barley variety with 1000 grain weight, hectoliter weight and moisture content of 38.95 g, 66.50 kg/hL and 13.90 % respectively used in this study was obtained from the wheat market in Kızıltepe district of Mardin province of Türkiye. The milling of the barley was carried out according to AACC method no 26-50 (AACC, 2010) by a laboratory type 4-roller mill (DC-4057, MAXI-C model, Bastak company, Türkiye). Milled barley was sifted by sieves with silk no 8 (180 micron), 15GG (1400 micron), 32GG (600 micron) and 70GG (236 micron), respectively to obtain flour with 68% yield extraction (13.80% moisture, 2.20% ash and 13.79% protein). All other ingredients such as wheat flour (13.20% moisture, 0.79% ash and 11.10% protein) (İmsa, Adıyaman, Türkiye), pressed fresh yeast (Pakmaya, İzmit, Türkiye) and salt (Billur, Izmir, Türkiye) was obtained from a local market in Şanlıurfa and city water supply was used as water.

Experimental design and bread production

Six Lavaş bread recipes were prepared, using 0 (A), 20 (B), 40 (C), 60 (D), 80 (E) and 100% (w/w) (F) replacement levels of bread wheat flour by barley flour. The sample A (100% wheat flour) was used as a control Lavaş bread. The experimental design of the study is given in Table

1. Bread samples were produced according to the Lavaş bread production method reported by Köten & Ünsal (2007) as shown in Figure 1. Bread production was carried out in a local bakery that produced Lavaş bread, Şanlıurfa-Türkiye.

Table 1. Amounts of ingredients used for Lavaş breads dough formulations

Ingredients	Lavaş Bread types					
	A	B	C	D	E	F
Wheat flour (g)	350.00	280.00	210.00	140.00	70.00	-
Barley flour (g)	-	70.00	140.00	210.00	280.00	350.00
Salt (g)	3.50	3.50	3.50	3.50	3.50	3.50
Yeast (g)	5.25	5.25	5.25	5.25	5.25	5.25
Water (mL)	225.00	225.00	225.00	225.00	225.00	225.00

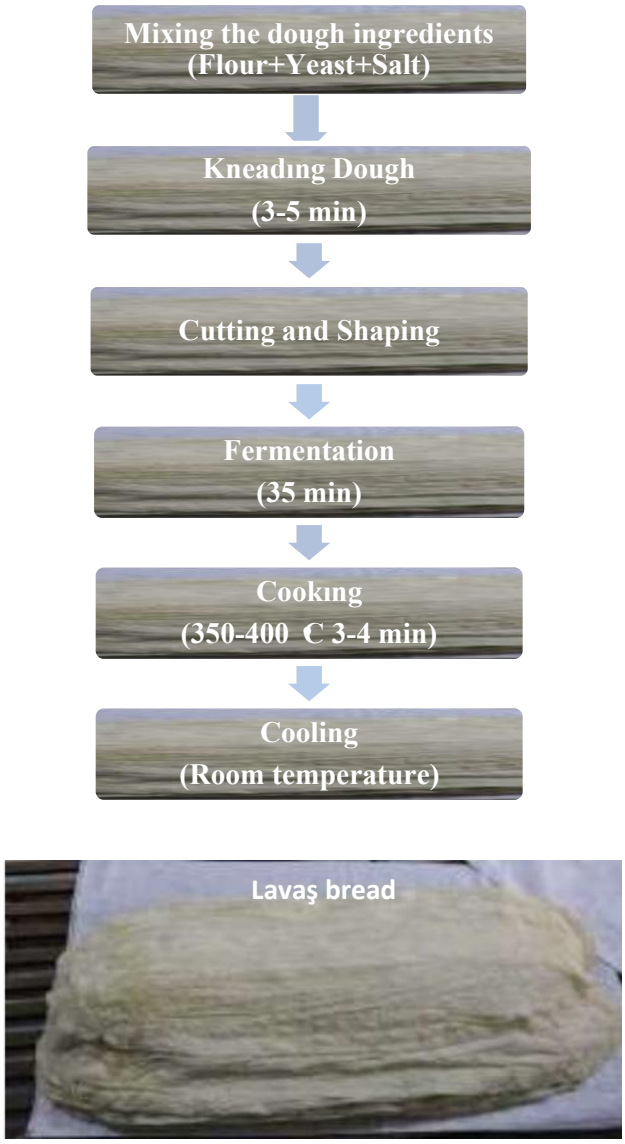

Figure 1. Flowchart of Lavaş bread making stages (Köten & Ünsal, 2007).

1000-kernel and hectoliter weight analysis

The thousand-kernel weight was assessed following the method outlined by Williams et al. (1983). Hectoliter weight was measured using a shopper chondrometer fitted with a 250 mL cylinder, and the results were expressed in kg/hL (TS EN ISO 7971-2, 2009).

Moisture, ash and protein content analysis

The moisture content (standard no 110) and ash content (standard no 114) of the samples were determined using the ICC standard method (ICC, 2002). The protein content was analysed employing the Dumas method with a Leco FP-528 model instrument (Wiles et al., 1998).

Instrumental color (L, a* and b*) determination*

The color values of the samples were determined by measuring the L* (100=white and 0=black), a* (+ red and - green), and b* (+ yellow and - blue) parameters utilizing Hunter Lab Color Flex (Model No. 45/0, USA) with illuminant D65 as reference. After the breads were cut into thin slices, dried (Figure 2) and ground, color measurements were made according to AACC Method 14-22 (AACC, 2010). The means were found using three samples.

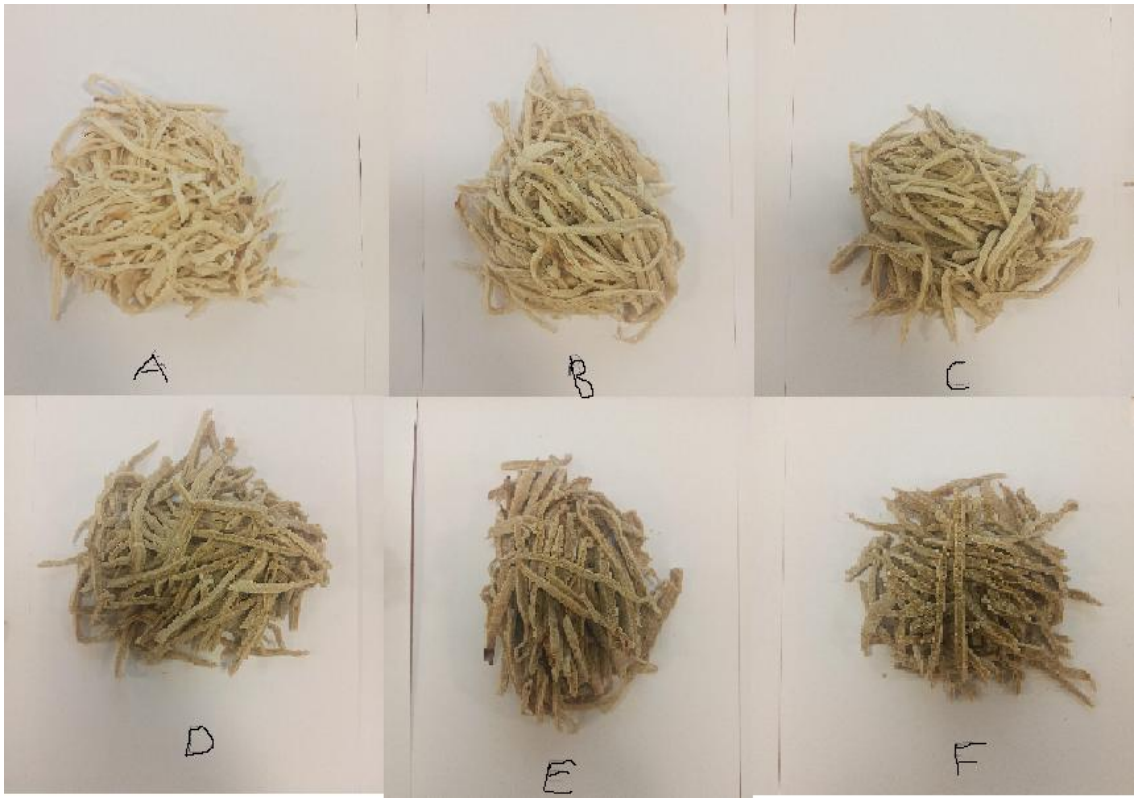

Figure 2. Slices of bread that were dried and ready for grinding

Sensory analysis

Sensory evaluation of Lavaş breads was carried out by 13 untrained panelists (8 men and 5 women, aged between 25 and 60 years) who habitually consume bread consisting of academic staff at Harran University, Faculty of Engineering, Department of Food Engineering. While the use of untrained panelists is acceptable for this type of study, it is acknowledged that this may present a limitation in the depth of sensory discrimination compared to trained panels, a factor considered during the interpretation of the results. The different formulations were evaluated by overall acceptability using a ten-point hedonic scale. The Lavaş bread samples were evaluated in terms of their softness, surface characteristics, shape, surface color, ability to roll and fold or foldability, mouthfeel, flavor and aroma, and overall acceptability properties after 1 h production. The form used in sensory evaluation is given in Table 2.

Table 2. Lavaş bread sensory evaluation form

			SAMPLES					
LAVASH BREAD PROPERTİES		**SCORE***	A	B	C	D	E	F
Appearance Characteristics	**Shape and Symmetry** (Higher scores reflect well-formed, evenly shaped, and symmetrical appearance)	1-10						
	Crust Color (Higher scores indicate lighter/whiter coloration)	1-10						
Textural Properties	**Surface Characteristics** (Scored based on the uniformity of fold lines, and minimal roughness or mottled texture)	1-10						
	Bread Softness (Higher scores indicate softer texture, lower scores reflect increased firmness)	1-10						
	Rollability and Foldability (Low scores indicating brittleness/cracking during folding and high scores indicating optimal softness and pliability without breakage)	1-10						
Taste and Aroma	**Taste ve Aroma** (Scored on a scale from undesirable to highly acceptable/characteristic flavor/aroma)	1-10						
	Mouthfeel (Scored on a scale reflecting increasing ease of chewability and swallowability, positively stimulating saliva secretion)	1-10						
Overall Acceptability	**Overall Acceptability** (scored on a scale from least acceptable to most acceptable, considering all sensory attributes collectively)	1-10						

poor, 3-4: Poor, 5-6: Fair, 7-8: Good, 9-10: Excellent.

Statistical analysis

JMP13 package program was used for the evaluation of data. All experiments were conducted with two replications, and the primary factor investigated was the barley flour substitution rate. LSD test was applied for multiple comparisons of means analyzed by one-way ANOVA at P≤ 0.05 significance level. LSD test was applied for multiple comparisons of means analyzed by one-way ANOVA at P≤ 0.05 significance level."

Results and Discussions

Instrumental color (L, a* and b*) values of Lavaş Breads*

The color of bread plays a crucial role in both its consumption and production. The L* (lightness), a* (red-green) and b* (yellow-blue) of Lavaş bread containing different levels of barley flour are shown in Table 3. The control Lavaş bread had the highest L* value (83.51) and differed significantly from all samples containing barley flour, while the lowest L* value (73.20) was found 100% barley flour added to Lavaş bread. It has been observed that as the amount of barley flour added to wheat flour increases, the L* value of Lavaş bread decreases. A decrease in L* value indicates a decrease in brightness. This conclusion is consistent with the findings of many researchers (Newman and McGuire, 1985; Hatcher et al., 2005; Ereifej et al., 2006; Alu'datt et al., 2014; Sharma and Gujral, 2014; Ünsal et al. 2016; Al-Ansi et al., 2022).

The lowest a* value was obtained from the A sample with 1.49, the highest a* value was obtained from the F sample with 2.90, the lowest b* value was obtained from the B sample with 13.63 and the highest b* value was obtained from the F sample with 16.39. This result showed that the Lavaş bread obtained with the addition of barley flour gave a more red and yellowish color. In a study examining the effect of different levels of wheat, corn, rice and oat bran on Turkish flat

bread (pita), it was found that the L* values of the pita samples supported by bran were lower and the a* and b* values were higher (Anıl, 2012). The values related to the a* and b* values obtained are within the value ranges obtained from the study conducted by Başman & Köksel (2001), Anıl (2012), Alu'datt et al. (2014) and AlAnsi et al. (2022).

Table 3. Change in L*, a* and b* color values of Lavaş breads

Lavaş Bread		L*	a*	b*
A	**(Control)**	83.51±0.25^{a}	1.49±0.42^{c}	13.96±0.33^{c}
	B	80.73±0.34^{b}	1.61±0.56^{c}	13.63±0.29^{c}
	C	78.04±0.18^{c}	2.00±0.13^{b}	15.00±0.23^{b}
	D	75.29±0.43^{d}	2.01±0.27^{b}	14.90±0.32^{b}
	E	75.10±0.55^{d}	2.76±0.38^{a}	15.97±0.36^{a}
	F	73.20±0.21^{e}	2.90±0.52^{a}	16.39±0.26^{a}

Mean values ±SD with different letters are significantly different at P≤ 0.05.

Sensory profile of Lavaş bread samples

The illustrations of different Lavaş breads produced were given in Figure 3. The change of the sensory properties of lavaş breads was shown in Figures 4-11. The addition of barley flour to wheat flour had a significant impact (P≤ 0.05) on the sensory attributes of Lavash breads (Figures 3-11). In a study conducted by Erbil and İncekara Çeper (2023), the sensory properties of Lavash breads produced by adding chickpea, lentil, oat, buckwheat, chia and flaxseed flour to wheat flour in different formulations were examined, and it was determined that positive results were obtained in terms of taste and aroma, and their appearance and textural properties could vary from good to bad depending on the formulations prepared.

Softness

As shown in Figure 4, the softness decreased as the addition of barley flour to the wheat flour increased. There were significant differences (P≤0.05) between Lavaş bread samples in terms of softness. The Lavaş bread made from 100% wheat flour (A) had the highest score with value of 8.69, while the Lavaş bread made from 100% barley flour (F) had the lowest value at 5.69. This outcome aligns with the conclusions drawn by other researchers (Ereifej et al., 2006; Holtekjølen et al., 2008; Rødbotten et al., 2015; Wani et al., 2016; Mansoor et al., 2021).

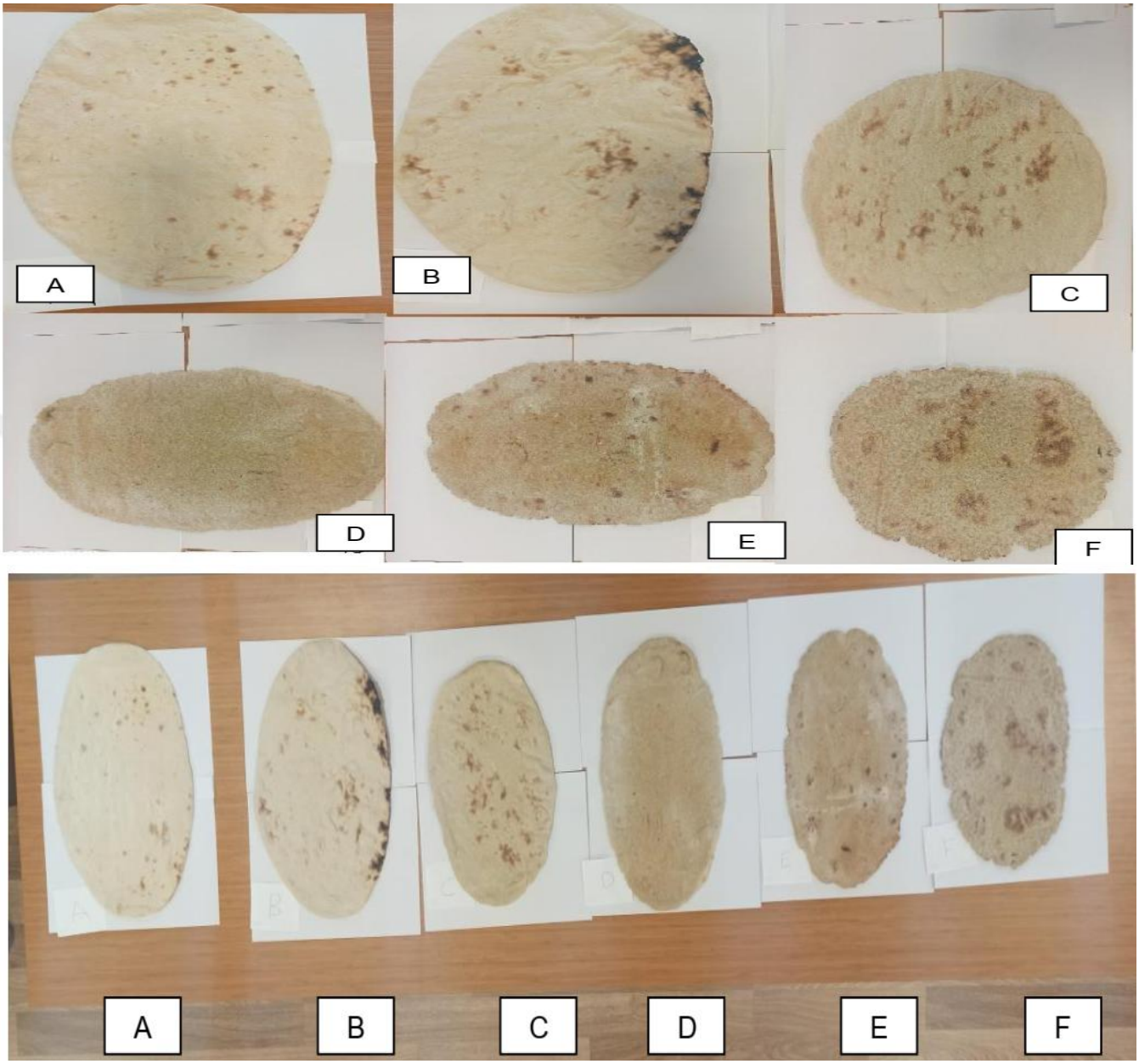

Figure 3. Illustrations of Lavaş breads produced using barley and wheat flour

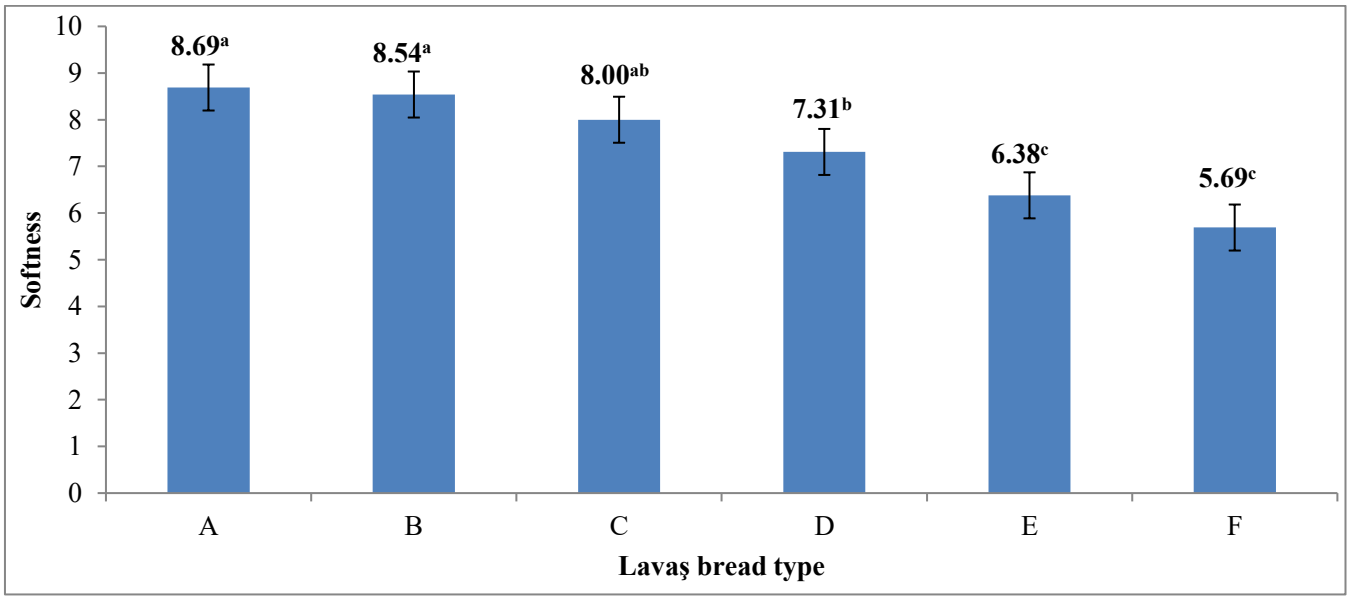

Figure 4. Mean scores of softness attribute for selected Lavaş breads (Values with different letters are significantly different at P≤ 0.05)

Surface characteristics

According to Figure 5, the bread made from 100% wheat flour received the highest score for surface characteristics, with a value of 8.53, while the lowest scores were obtained from Samples F and E, with values of 4.15 and 4.61, respectively, both of which were below average. In both samples, the homogeneity of the folds was disrupted, surface roughness increased, and a spotted structure became clearer (Figure 3). The negative effect of barley flour addition on surface properties has also been reported by other researchers (Newman & Mcguire, 1985; Ereifej et al., 2006; Holtekjølen et al., 2008; Sharma & Gujral, 2014; Rødbotten et al., 2015; Wani et al., 2016; Mansoor et al., 2021).

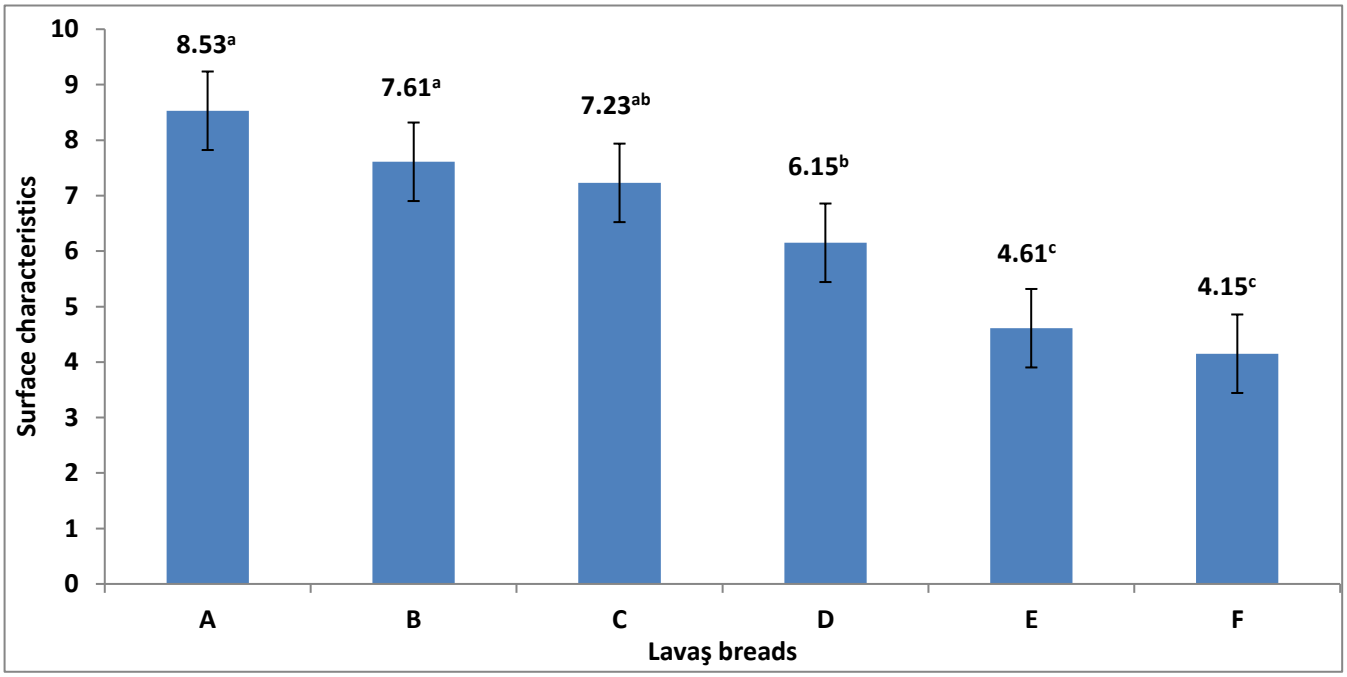

Figure 5. Mean scores of surface characteristics attribute for selected Lavaş breads. (Values with different letters are significantly different at P≤ 0.05)

Shape

Figure 6 shows that the highest score for shape was obtained by Sample A, made from 100% wheat flour, with a value of 9.00, while samples E and F received the lowest scores, 4.84 and 3.92, respectively. There was a significant difference (P ≤0.05) between control bread and others as the barley flour addition increased. As the addition of barley flour addition increased, the symmetry of bread was lost, and an irregular, jagged structure formed along the outer edges (Figure 3 and 6). Similar findings have been reported in the studies of other researchers (Newman & Mcguire, 1985; Ereifej et al., 2006; Holtekjølen et al., 2008; Rødbotten et al., 2015; Wani et al., 2016; Mansoor et al., 2021).

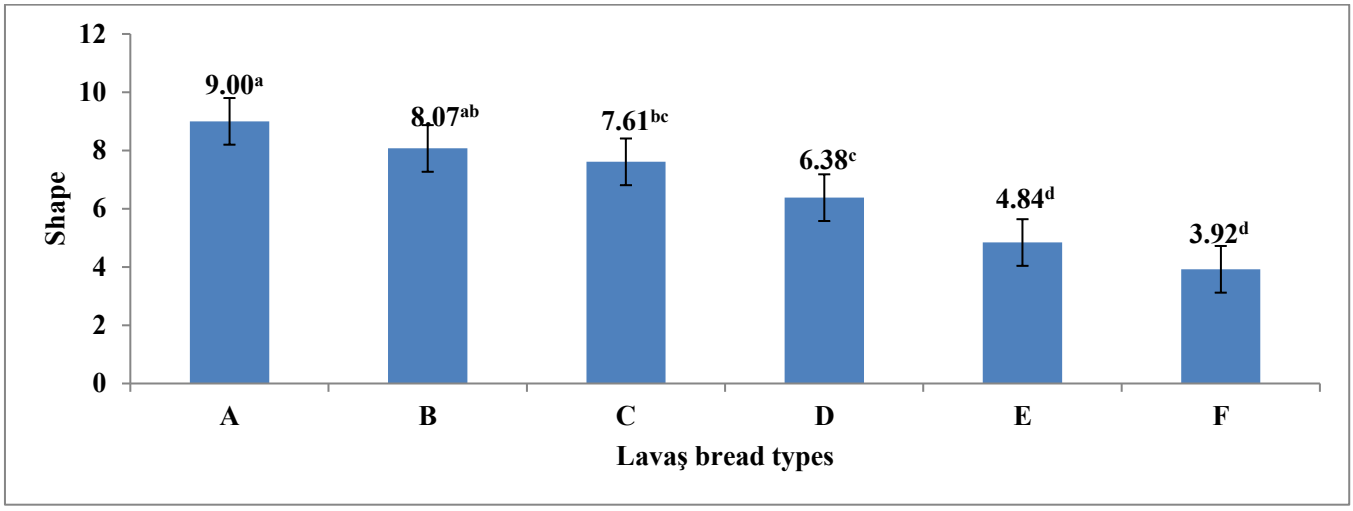

Figure 6. Mean scores of shape attribute for selected Lavaş breads (Values with different letters are significantly different at P≤ 0.05)

Surface color

In Figures 3 and 7, it is seen that the whiteness decreases, and the color darkens as the bread moves from being made with 100% bread wheat flour to 100% barley flour. The highest color value, 8.76, was obtained from sample A, while the lowest color value, 4.84, was obtained from sample F. Although low color values within the same statistical group were also obtained from samples D and E, with values of 5.84 and 5.69, respectively, only sample F, with a value of 4.84, remained below the average. It has been found in the studies of many researchers that the addition of barley flour accelerates the formation of melanoid and causes darkening in color (Hatcher et al., 2005; Ereifej et al., 2006; Holtekjølen et al., 2008; Sharma & Gujral, 2014; Rødbotten et al., 2015; Wani et al., 2016; Mansoor et al., 2021).

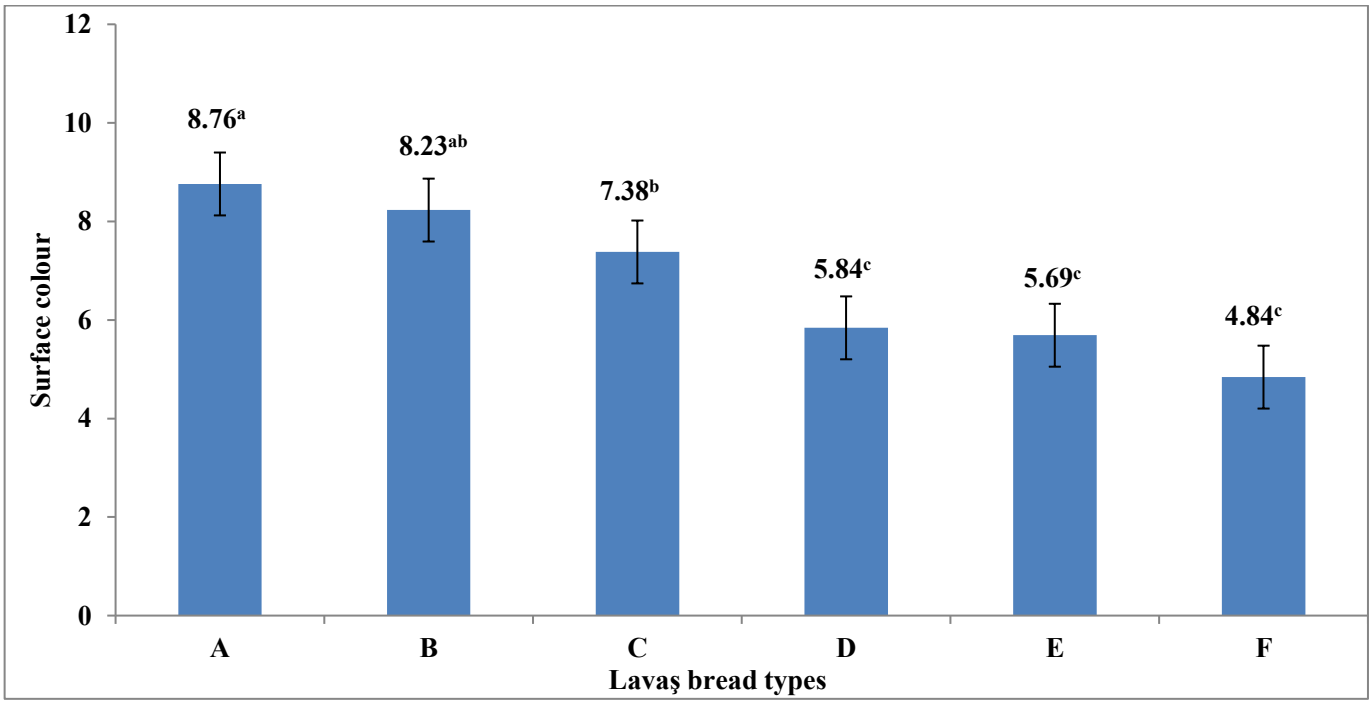

Figure 7. Mean scores of surface color attribute for selected Lavaş breads (Values with different letters are significantly different at P≤ 0.05)

Ability to roll and fold or foldability

In flat bread types such as Lavaş bread to roll and foldability, and a soft structure provide great convenience for holding and consuming food without it spilling. Ideally, flatbread should maintain its integrity during folding or rolling,

without cracking or breaking. Cracks or breaks during folding reduce the bread's functionality and are considered undesirable. Evaluating this property after one day of storage also provides insight into the staling behavior of the bread. As shown in Figure 8, samples A and B showed the highest scores of 9.31 and 9.23, respectively, and were highly favored by the panelists. Although samples E and F received the lowest scores with 6.62 and 6.31, respectively, they were still rated above average. Other researchers have also reported that the addition of barley flour negatively affected the rollability of tortillas, pita bread, and flat breads (Holtekjølen et al., 2008; Malcolmson et al., 2014; Rødbotten et al., 2015; Wani et al., 2016; Özer, 2019; Mansoor et al., 2021).

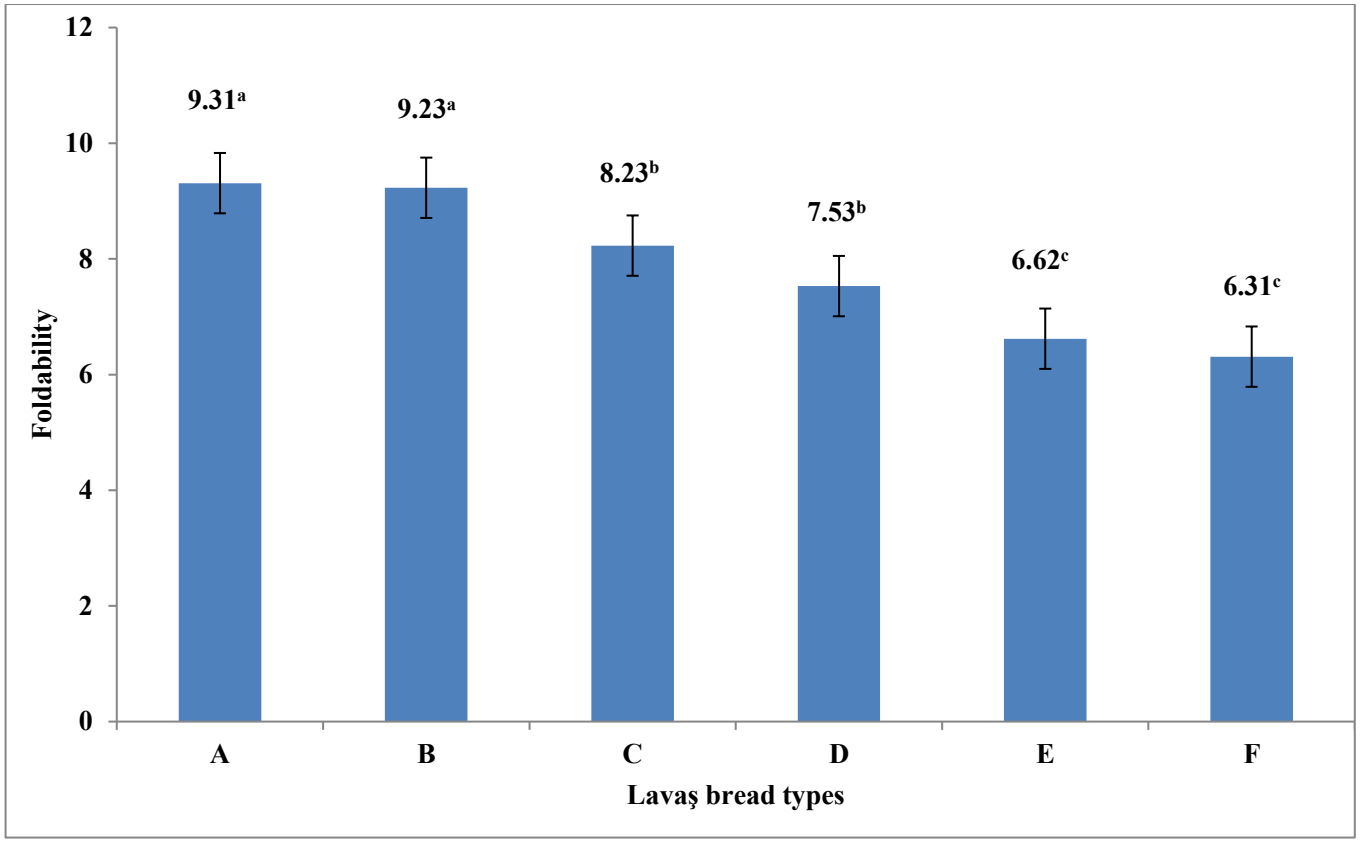

Figure 8. Mean scores of foldability attribute for selected Lavaş breads (Values with different letters are significantly different at P≤ 0.05)

Taste and aroma

In Figure 9, sample A, made from 100% wheat flour, received the highest score for taste and aroma with a value of 8.92, while samples E and F received the lowest scores, 6.92 and 6.53, respectively. Although, Başman & Köksel, (1999) and Başman & Köksel (2001) reported that increasing the amount of barley flour negatively affected taste and aroma. Newman & McGuire (1985) and Newman et al. (1990) noted that while taste and aroma decreased with increasing barley flour content, they stayed within acceptable limits. In present study, a decrease in taste and aroma was seen with the increase in barley flour; however, even the lowest scores were rated above average and were not found to be displeasing by the panelists. A similar decrease in taste and aroma scores of flat breads with the increase in barley flour addition was also obtained by the study of Holtekjølen et al. (2008), Kahlon & Chiu (2012), Rødbotten et al. (2015), Wani et al. (2016) and Mansoor et al. (2021).

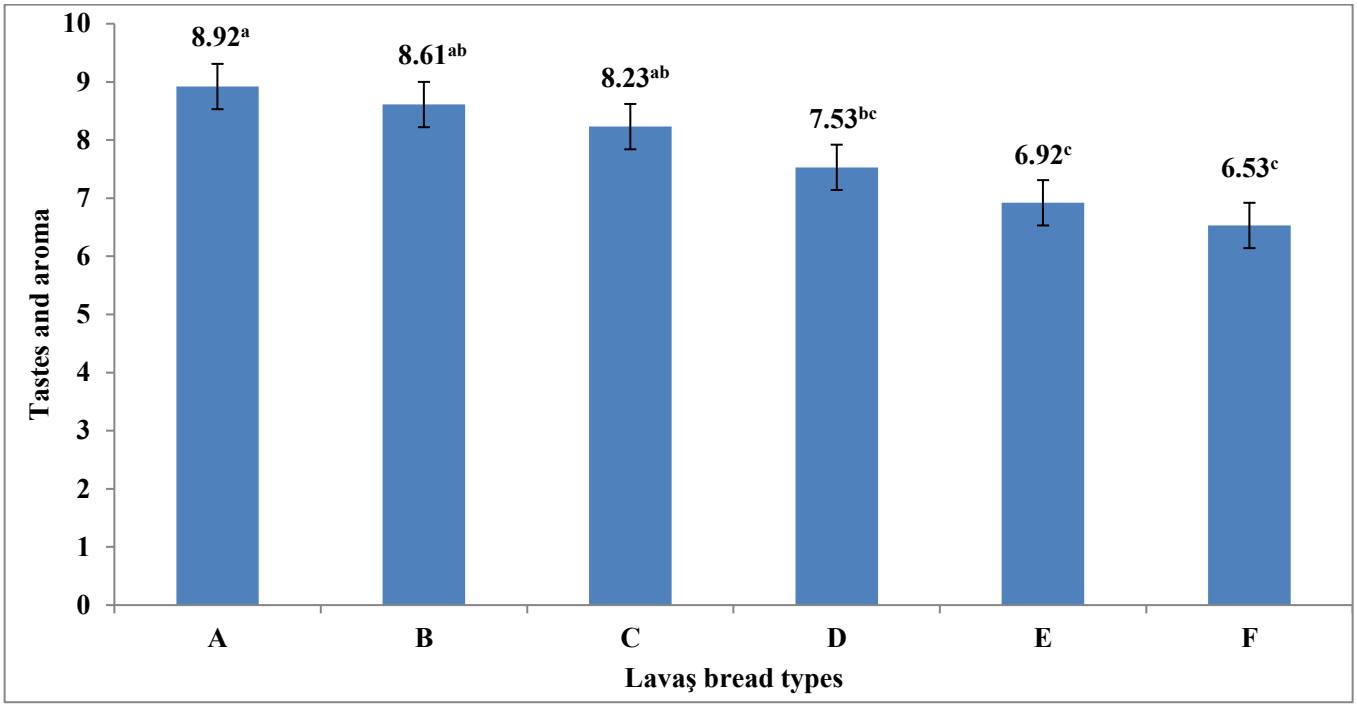

Figure 9. Mean scores of tastes and aroma attribute for selected Lavaş breads. (Values with different letters are significantly different at P≤ 0.05)

Mouthfeel

Figure 10 shows that mouthfeel, an indicator of salivation, chewability, and ease of swallowing, received above-average scores across all bread samples. The highest score of 8.30 was obtained from the bread made with 100% wheat flour, while the lowest score, 6.46, was obtained from the bread made with 80% barley flour. Similar results of mouthfeel of barley fortified breads were reported by Holtekjølen et al. (2008). Knuckles et al. (1997) also found no significant issues in the eating quality of bread enriched with 20% β-glucan from barley flour. Kahlon & Chiu (2012), Wani et al. (2016) and Mansoor et al. (2021) were reported similar results of mouthfeel scores of bakery foods fortified with different flours.

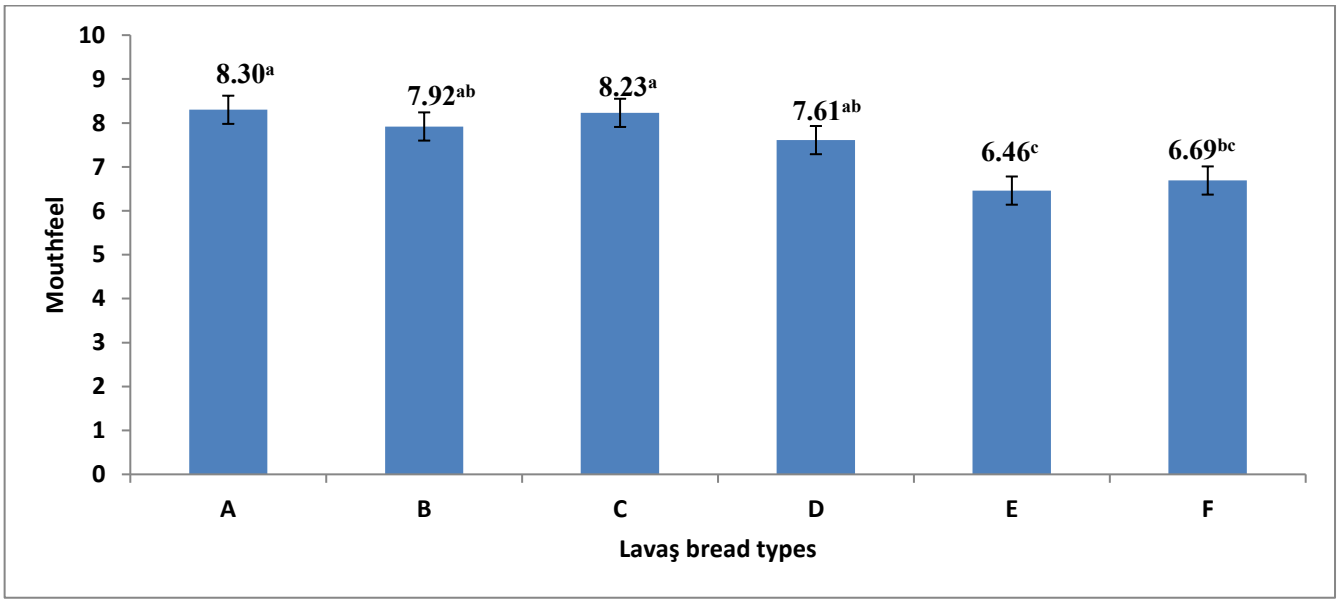

Figure 10. Mean scores of mouthfeel attribute for selected Lavaş breads. (Values with different letters are significantly different at P≤ 0.05)

Overall acceptability

As shown in Figure 11, all bread samples received acceptable 5 or higher scores in terms of overall sensory characteristics. The highest values were obtained from Samples A (100% wheat flour) and B (20% barley flour), with scores of 8.92 and 8.15, respectively, while the lowest score of 5.77 was obtained from Sample F. Lavaş breads containing barley flour at 0 and 20% were not significantly different (P≥0.05) for overall acceptability attribute while there were significant differences (P ≤0.05) between all other incorporated barley flour breads in terms of overall acceptability. The overall acceptability quality of bread produced with barley flour was found to be within acceptable limits, which aligns with the findings of other researchers (Başman & Köksel, 1999; Başman & Köksel, 2001; Dhingra & Jood, 2001; Holtekjølen et al., 2008; Anil, 2012; Kahlon & Chiu, 2012; Rødbotten et al., 2015; Alu'datt et al., 2014; Wani et al., 2016; Mansoor et al., 2021; Al-Ansi et al., 2022).

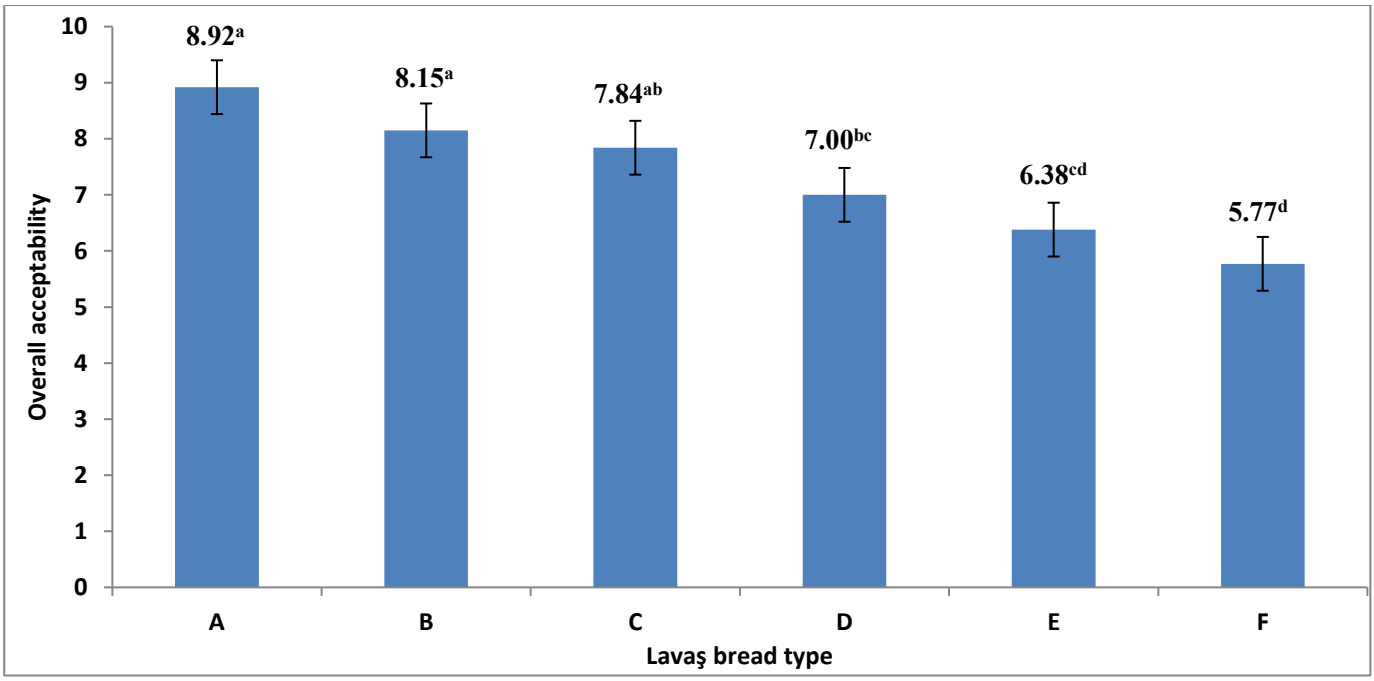

Figure 11. Mean scores of overall acceptability attribute for selected Lavaş breads. (Values with different letters are significantly different at P≤ 0.05)

Conclusions

According to the color values obtained, as the amount of barley flour added increased, the L* value decreased, while the a* and b* values increased. According to the sensory evaluation results, samples having up to 40% barley flour were highly rated in all sensory attributes. Samples prepared with 60% barley flour were moderately appreciated in terms of surface characteristics, shape, and color, while other attributes were rated as good. Surface characteristics and shape properties were negatively affected by the addition of 80% or more barley flour, while color was negatively affected by 100% barley flour. However, softness, foldability, taste and aroma, mouthfeel, and overall acceptability characteristics were rated above average even in samples with 80% or more barley flour. Barley's high β-glucan content, diet fiber and the other functional properties can contribute to meeting growing consumer demand for healthy-bakery products. Bread is a staple food in many countries and is at the forefront of efforts to enrich foods nutritionally. This study shows that adding barley flour to wheat flour does not significantly affect the sensory quality of the bread, providing a science-based foundation for healthy nutrition. This study may serve as a reference for future research in this area.

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Conflict of interest

The authors declare that they have no conflict of interest

Author contributions

The authors declare that they contributed equally to the article.

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