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Chemical Composition in Barley (*Hordeum vulgare* L.) as Affected by Hectoliter Weight

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Abstract: This research was carried out to determine the effect of different hectoliter weights on some chemical properties of barley under laboratory conditions in 4 replications. In this study, barley having 4 different hectoliters weight (55, 60, 65 and 70 kg hl^{-1}) was used and crude protein, crude fiber, crude oil, crude ash and starch content were examined. The datas obtained were subjected to variance analysis according to the randomized plot design. According to the analysis of variance, the hectoliter weight had a statistically significant effect on all characters at the level of 1%. According to the results, crude protein ranged 9.83-12.18%, crude fiber 4.14-6.26%, crude oil 1.43-1.51%, crude ash 2.40-2.98% and starch 47.63-53.17% and as the hectoliter weight increased, the crude protein and crude fiber and crude ash content decreased, while the crude oil and starch content increased.

Key Words: Barley, Chemical property, Crude protein, Starch

Hektolitre Ağırlığının Arpa (*Hordeum vulgare* L.)' da Kimyasal Bileşime Etkisi

Öz: Bu araştırma farklı hektolitre ağırlıklarının arpada bazı kimyasal özelliklere etkisini belirlemek amacıyla laboratuvar koşullarında 4 tekerrürlü olarak yürütülmüştür. 4 farklı hektolitre ağırlığına (55, 60, 65 ve 70 kg/hl) sahip arpanın kullanıldığı bu araştırmada ham protein, ham selüloz, ham yağ, ham kül ve nişasta oranları incelenmiş olup, sonuçlar tesadüf parselleri deneme desenine göre varyans analizine tabi tutulmuştur. Yapılan varyans analizine göre, hektolitre ağırlığı incelenen tüm karakterler üzerine istatistiki olarak %1 düzeyinde önemli etki yapmıştır. Elde edilen sonuçlara göre, ham protein oranı %9.83-12.18, ham selüloz oranı%4.14-6.26, ham yağ oranı %1.43-1.51, ham kül oranı %2.40-2.98 ve nişasta oranı %47.63-53.17 arasında değişmiş olup, hektolitre ağırlığı arttıkça ham protein, ham selüloz ve ham kül oranı azalırken, ham yağ ve nişasta oranı artmıştır.

Anahtar Kelimeler: Arpa, Ham protein, Kimyasal özellik, Nişasta

1. Introduction

Barley (*Hordeum vulgare* L.), belongs *Poaceae* family, is one of the oldest cultivated plants. It ranks 2nd after wheat in Turkey in terms of harvested area and production while it ranks 4th in world cereal production after wheat, paddy and corn.

Today, the large majority of barley produced is used in animal nutrition. So, in Turkey, 90% of the barley produced is used in animal nutrition while the other part is used the malting industry (Sirat and Bahar, 2020). It has an important place in animal nutrition since it contains protein rich in lysine, especially with its low cellulose and high starch content (Dyulgerova et al., 2017). Besides, a small part of it is used as human food, except for North Africa and Asian countries where it is used as staple food. Recently, determination of high digestible fiber and β-glucan content and health effects increased the importance of barley as food (Baik & Ullrich, 2008; Sterna et al., 2015).

Generally, barley contains 8.2-14.5% crude protein, 4-6% crude fiber, 3-4% crude oil, 2-3% crude ash, 56-67% starch and 2.5-5.5% β-glucan (Aydoğan et al. 2017; Holopainen-Mantila, 2015) and this chemical composition creates the quality of barley. Hectoliter weight is the expression of 100 liters of barley in kg. Genetics, environmental factors, agricultural practices and their interaction, fullness, homogeneity, hull rate and endosperm structure of grain have an effect on the hectoliter weight (Andersson et al., 1999; İmamoğlu & Yılmaz, 2012; Öztürk et al., 2001). In addition, hectoliter weight is affected by the purity of grain and the grain moisture content and it decreases when the amount of foreign matter and grain moisture increases (Şehitoğlu, 2007). Hectoliter weight of barley has been considered in many studies, since it is an important physical property of barley (Aydoğan et al., 2017; Kendal & Doğan, 2014; Kızılgeçti et al., 2019; Oral et al., 2017; Öztürk et al., 2017; Sirat & Sezer, 2005). So, the purpose of this study to determine the effect of hectoliter weight, which is an important quality parameter in barley, on these values.

2. Material and Method

This study, conducted to determine the effect of different hectoliter weights on some chemical properties of barley, was carried out according to randomized plot design with 4 replications at quality control laboratory of Manav Feed and Flour Industry and Trade Inc., located in Canakkale-Biga in Turkey. Mixed barleys with different hectoliter weights (55, 60, 65 and 70 kg hl^{-1}) supplied by the company from different suppliers were used as the material. In order to prevent the negative effect of low purity on hectoliter, barleys were sieved in 3 mm and hectoliter weight was determined at 100% purity by using a hectoliter measuring device. The barleys with different hectoliter weights used in this study are shown in figure 1.

Figure 1. Barley with different hectoliter weights used in the study
Şekil 1. *Araştırmada kullanılan farklı hektolitre ağırlığına sahip arpalar*

Dry matter of samples was determined by using Precisa XM 60 brand moisture analyzer and these values changed between 89.00-89.59%. Then, crude protein, crude fiber, crude fat, crude ash and starch content were examined on this determined dry matter. Crude protein content (%) was determined according to the Kjeldahl method. This method is based on calculating the crude protein content by multiplying the amount of nitrogen in the sample (0.50 gr) with 6.25 (Kutlu 2008). Crude fiber (%) was determined according to the Weende method.

In this method, samples firstly were boiled with 1.25% H2SO4 and 28% KOH for 1 hour and filtered. The residue was incinerated in a muffle furnace at 550°C for 1 h, after washing with 1% H2SO4, 1% NaOH and acetone, after (Kutlu 2008). Crude fat (%) was extracted with petroleum ether (boiling range of 40−60°C) by using Soxhlet extraction method. Crude ash (%) was determined by incineration in a muffle furnace at 550°C for 4 h (Kutlu, 2008). Starch content (%) was determined by the Ewers polarimetric method, which based on the optical activity of starch (Farcaş et al., 2013). In this method, 2.5 g of sample was boiled with 1.128% 50 ml HCl solution in a water bath for 15 minutes and after adding 5 ml of Carez I and Carez II solutions, it was completed to 100 ml with distilled water and filtered. The optical refraction of this filtrate was determined by polarimeter and the starch content was calculated with the formula [(Optical refraction x 2000) / 181.5]. Variance analysis of data was performed according to the randomized plot design and the significance control of the means was made by LSD test.

3. Results and Discussion

Variance analysis results regarding the effect of hectoliter weight on examined properties (crude protein, crude fiber, crude fat, crude ash and starch content) in barley are given in table 1. As seen from table 1, the effect of hectoliter weight on the properties examined was statistically significant at the level of 1%.

The average values and significance groups of the examined properties depending on the hectoliter are given in table 2.

Table 1. Analysis of variance regarding the effect of hectoliter weight on some chemical compositions in barley
Çizelge 1. *Hektolitre ağırlığının arpada bazı kimyasal özellikler üzerine etkisine ilişkin varyans analizi*

Sources of Variation	Degrees of Freedom	*Mean of Squares*				
		Crude Protein (%)	Crude Fiber (%)	Crude fat (%)	Crude Ash (%)	Starch (%)
Hectoliter Weight	3	482.105**	120.911**	8.596**	28.533**	10019.413**
Error	12	0.005	0.031	0.001	0.002	0.644
General	15	96.425	24.207	1.720	5.708	2004.398
Coefficient Variation (%)		0.666	3.207	1.835	1.464	1.605

Table 2. Average values and significance groups of the examined properties
Çizelge 2. *İncelenen özelliklere ilişkin ortalama değerler ve önem grupları*

	Crude Protein (%)	Crude Fiber (%)	Crude Fat (%)	Crude Ash (%)	Starch (%)
Hectoliter Weight 55	12.18^{A}	6.26^{A}	1.43^{B}	2.98^{A}	47.63^{C}
Hectoliter Weight 60	11.48^{B}	5.74^{B}	1.44^{B}	2.73^{B}	47.66^{BC}
Hectoliter Weight 65	10.27^{C}	5.14^{C}	1.48^{AB}	2.53^{C}	51.51^{A}
Hectoliter Weight 70	9.83^{D}	4.74^{D}	1.51^{A}	2.40^{D}	53.17^{A}
$LSD_{(0.01)}$	0.157	0.379	0.058	0.084	1.733

As seen from table 2, crude protein content at different hectoliter weights varied between 9.83-12.18%. As the hectoliter weight increased, the crude protein content decreased and the highest and lowest crude protein values were determined at 55 kg hl^{-1} and 70 kg hl^{-1}, respectively. Crude protein contents obtained from this study are between 9.34-11.16%, reported by Budaklı et al. (2005) and 9.40-11.30% reported by Öztürk et al. (2001), These findings are consistent with the values of 11.70-15.10% presented by İmamoglu and Yilmaz (2012), 10.90-13.10% recorded by Sirat and Sezer (2005) and 13.4% reported by Aydoğan et al. (2017). Oral et al. (2017) reported higher values (14.00-17.20%) than the values obtained from this study. As seen, crude protein content in barley has shown wide variations in many studies. It has been determined that crude protein content changes under the influence of many factors such as: genotype (Öztürk et al., 2001), environmental conditions and agricultural practices; (Kendal & Doğan, 2014), the number of rows in spike (Kendal & Doğan, 2014), the fullness of the grain (Griffey et al., 2010) and mutation applications to seeds (Akgün et al., 2019). Besides, the protein content in barley is mostly in the aleuron layer of the grain (Evers & Millar, 2002). The decrease in the crude proein content depending on the increase in hectoliter weight can be explained by this situation. In barley grain, 75% of the endosperm weight consists of the starchy endosperm and the rest is aleuron layer (Holopainen-Mantina, 2015). So, as the grain fullness increases, the part of starchy endosperm will increase proportionally, and the crude protein content will decrease depending on the aleuron part.

Crude fiber, which is a polysaccharide consisting of lignin, cellulose and hemicellulose, is an important quality criterion in barley. Considering that most of the barley produced is used as animal feed, it is desired that the crude fiber content is low in feed barley not the quality of the feed is to be affected negatively. In current study, a negative relationship was determined between the hectoliter weight and crude fiber content. So, the crude fiber content decreased, as the hectoliter weight increased (Table 2). In a research carried out by (Aydoğan et al., 2017), it has been determined that the crude fiber content in barley is affected by environmental conditions and varies between 5.90-7.30%. In another study, it was determined that the crude fiber content of barley changed between 5.15-6.10%, affected by the genotype and environmental factors (Aydoğan et al., 2011). Crude fiber content (4.74-6.26%) obtained from the current study is similar to the results of these researchers. The decrease in the crude fiber content depending on increasing hectoliter weight can be explained by the decrease in the hull content. In other words, as the grain fullness increases, the crude fiber content decreases depending on the decrease in the hull content. Bell et al. (1983) and Karaduman (2006)'s findings confirm this situation.

Crude oil content of barley in different hectoliter weights varied between 1.43-1.51% and three groups were formed statistically in averages. While the highest crude oil content was determined in a weight of 70 kg hl^{-1}, there was no significant difference in crude oil content in increasing hectoliter (55, 60 and 65 kg hl^{-1}). Studies have reported that the crude oil content of barley is low (Moreu, 2009; Osman et al., 2000,). Fedak and De La Roche (1977) reported in their study on 21 different barley lines that the crude oil content varied between 2.5-3.1%, while Madazimov et al. (1976) reported crude oil values ranged 1.67-2.30%. In another study, Alijošius, et al. (2016) reported that the crude oil content in barley varied between 1.09-2.00%. As seen, the crude oil content of barley varies depending on many factors. In this study, the increase in the crude oil values due to the increasing hectoliter can be related to the crude oil content of barley flour.

Crude ash values varied between 2.40-2.98% at different hectoliter weights and the crude ash content decreased as the hectoliter weight increased (Table 2). This situation can be related to the ratios of endosperm and aleuron layers in the grain. Indeed, Evers and Millar (2002) reported that the aleuron part of the grain contains protein, oil and mineral substances. Therefore, the ratio of endosperm in the grain will increase depending on increasing hectoliter weight and the ratio of aleuron will decrease. As a result, the crude ash content will decrease. This situation was reported by Dyulgerova et al. (2017), who reported a negative relationship between hectoliter weight and crude ash content.

Starch content is the most important property of barley in quality. Since the amount of beer to be obtained from barley depends largely on the content of starch it has, it is desirable that the hectoliter weight especially in malting barley is more than 66 kg (Atlı et al., 1989). In this study, starch content varied between 47.63% and 53.17% in different hectoliter weights and starch content was also increased depending on the increase in hectoliter weight. This situation is associated with an increase in the endosperm ratio due to grain fullness. This positive relationship between hectoliter weight and starch content also reported by Kaur et al. (2016), Dyulgerova et al. (2017) and Sirat and Bahar (2020). Different starch values were reported in other studies examining the starch content in barley. Baik and Ulrich (2008), Imamoğlu and Yilmaz (2012), Sterna et al. (2015) were detected 65-68%, 58.2-63.5%, 62.2-64%, respectively.

The starch content obtained from current study was lower than these values reported by these researchers. Thus, starch content is one of the quantitative characters that can change under the influence of many factors.

4. Conclusion

As a result, it was determined that the chemical properties of barley were significantly affected by the hectoliter weight. Positive and negative relationships were found between the examined chemical properties and the hectoliter weight. An increase in hectoliter weight led to a significant decrease in crude protein, crude fiber, and crude ash content, while starch content showed a significant increase. In addition, it was observed that the traits examined were also influenced by each other. As the crude protein content increased, the starch content decreased and as the crude fiber content decreased, the starch content increased. These results are also supported by the findings obtained from other studies. This study is important in being a guide when barley is used as a source of protein or starch.

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