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Effects of the *1RS.1BL* Wheat-Rye Translocationon Kernel and Bran Content of Bread Wheat (*Triticum aestivum* L.)

1RS.1BL Çavdar Translokasyonunun Ekmeklik Buğdayda (*Triticum aestivum* L.) Tane ve Kepek İçeriğine Etkileri

Nevzat AYDIN[1], Bedrettin DEMİR[2], Abdulvahit SAYASLAN[3], Özge DOĞANAY ERBAŞ KÖSE[4], Tuğba GÜLEÇ[5], Cemal ŞERMET[6], Erdinç SAVAŞLI[7], Mesut Ersin SÖNMEZ[8], Mehmet KOYUNCU[9], Zeki MUT[10]

[1]Karamanoğlu Mehmetbey University, Faculty of Engineering, Department of Bioengineering, Karaman
• **nevzataydin@gmail.com** • ORCID > 0000-0003-3251-6880

[2]Karamanoğlu Mehmetbey University, Vocational School of Tecnical Sciences, Department of Chemistry and Chemical Processing Technologies, Karaman
• **bedrdemir@gmail.com** • ORCID > 0000-0002-8892-2282

[3]Karamanoğlu Mehmetbey University, Faculty of Engineering, Department of FoodScience, Karaman
• **sayaslan@kmu.edu.tr** • ORCID > 0000-0001-7161-1552

[4]Bilecik Şeyh Edebali University, Faculty of Agriculture and Natural Science, Department of Field Crops, Bilecik
• **ozgedoganay.erbas@bilecik.edu.tr** • ORCID > 0000-0003-0429-3325

[5]Karamanoğlu Mehmetbey University, Vocational School of Tecnical Sciences, Department of Plant and Animal Production, Karaman
• **tuba.eserkaya@gmail.com** • ORCID > 0000-0002-1755-1082

[6]Black Sea Agricultural Research Institute, Samsun
• **cemalsermet@gmail.com** • ORCID > 0000-0002-3428-6022

[7]Transitional Zone Agricultural Research Institute, Eskişehir
• **esavasli2626@gmail.com** • ORCID > 0000-0001-5326-4710

[8]Karamanoğlu Mehmetbey University, Faculty of Engineering, Department of Bioengineering, Karaman
• **mesutersinsonmez@kmu.edu.tr** • ORCID > 0000-0002-0966-9216

[9]Karamanoğlu Mehmetbey University, Faculty of Engineering, Department of FoodScience, Karaman
• **mkoyuncu@kmu.edu.tr** • ORCID > 0000-0002-7704-9529

[10]Bilecik Şeyh Edebali University, Faculty of Agriculture and Natural Science, Department of Field Crops, Bilecik
• **zeki.mut@bilecik.edu.tr** • ORCID > 0000-0002-1465-3630

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Sorumlu Yazar/Corresponding Author: Tuğba GÜLEÇ

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EFFECTS OF THE *1RS.1BL* WHEAT-RYE TRANSLOCATIONON KERNEL AND BRAN CONTENT OF BREAD WHEAT (*Triticum aestivum* L.)

ABSTRACT

In this study, the effects of rye translocation on some quality properties and mineral content of whole wheat kernel and bran were investigated.The plant material consisted of 147 recombinant inbred lines (RILs) and five control cultivars, including the parent. The genotypes were grown in Turkey at two different locations for two consecutive years. In the study, lines with and without rye translocation were determined by SDS-PAGE and PCR analysis, and the glutenin subunits of the lines at *Glu-A1, Glu-B1, Glu-A3* and *Glu-B3* loci were also analyzed. The protein, starch, fat, ash, dry matter, acid detergent insoluble fiber (ADF), neutral detergent insoluble fiber (NDF), potassium (K), phosphorus (P) and magnesium (Mg) contents of kernels and bran of the RILs were determined. Statistically significant differences were found between the genotypes in terms of all the examined characteristics except the amount of dry matter. The RILs carrying translocation 1RS.1BLhad a higher average ADF, NDF, protein content, ash content, K, Mg, and P contents of kernels, as well as a higher average ADF, NDF, ash, and K bran contents than the RILs without thetranslocation. The bran of the RILs without thetranslocationhad higher values in terms of fat, starch, and phosphorus content. The results indicate that wheat- rye translocation*1RS.1BL* has a significant effect on both whole wheat kernel and bran content, and can be used to enrich the content of wheat bran.

Keywords: Rye Translocation, Grain, Location, Quality.

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1RS.1BL ÇAVDAR TRANSLOKASYONUNUN EKMEKLİK BUĞDAYDA (*Triticum aestivum* L.) TANE VE KEPEK İÇERİĞİNE ETKİLERİ

ÖZ

Bu çalışmada *1RS.1BL* çavdar translokasyonunun tam buğday tanesi ve kepeğin bazı kalite özelliklerine ve mineral içeriğine etkisi araştırılmıştır. Bitki materyali 147 rekombinant kendilenmiş hat (RIL›ler) ve ebeveyn dahil beş kontrol çeşidinden oluşmuştur. Genotipler Türkiye'de iki yıl üst üste iki farklı yerde olmak üzere toplam dört çevrede yetiştirilmiştir. Çalışmada önce *1RS.1BL* çavdar translokasyonu olan ve olmayan hatlar SDS-PAGE ve PZR analizi ile belirlenerek hatların *Glu-A1, Glu-B1, Glu-A3* ve *Glu-B3* lokuslarındaki glutenin alt birimleri analiz edilmiştir.

Daha sonra RIL'lerin tane ve kepeklerinin protein, nişasta, yağ, kül, kuru madde, asit deterjanda çözünmeyen lif (ADF), nötr deterjanda çözünmeyen lif (NDF), potasyum (K), fosfor (P) ve magnezyum (Mg) içerikleri belirlenmiştir. Kuru madde miktarı dışında incelenen tüm özellikler açısından genotipler arasında istatistiksel olarak önemli farklılıklar bulunmuştur. *1RS.1BL* çavdar translokasyonu taşıyan hatların tanelerinde ortalama ADF, NDF, protein içeriği, kül oranı, K, Mg ve P içerikleri çavdar translokasyonu taşımayan hatlardan daha yüksektir. Çavdar translokasyonu taşıyan hatların kepekleri ise ortalama ADF, NDF, kül ve potasyum içeriği bakımından daha yüksek değerlere sahip iken, çavdar translokasyonu taşımayan hatların kepekleri yağ, nişasta ve fosfor içeriği bakımından daha yüksek değerlere sahip olmuştur. Sonuçlar, *1RS.1BL* çavdar translokasyonunun hem tam buğday tanesi hem de kepek içeriği üzerinde önemli bir etkiye sahip olduğunu ve buğday kepeği içeriğini zenginleştirmek için kullanılabileceğini göstermektedir.

Anahtar Kelimeler: Çavdar Translokasyonu, Buğday Tanesi, Lokasyon, Kalite.

1. INTRODUCTION

Wheat is the most widely cultivated and produced cereal in Turkey and many other countries. It is a crucial raw material for various products, particularly for making bread, which is a staple food for many people, especially in developing countries. In Turkey, bread alone accounts for 56% of daily calorie and 50% of daily protein consumption needs, and the average daily bread consumption per person is approximately 400 grams (TUIK, 2014; TPMA, 2021). Wheat is primarily used in the flour industry. Before using wholemeal flour, industrialists must consider its properties and how they will affect the final product's quality. Since bread quality is closely related to the flour's chemical composition, it is necessary to know the amount of moisture, ash, protein, starch, fat, crude fiber, and free acidity values in the flour (Lasztity, 1996).

Bran, a by-product consisting of wheat husks and other wheat particles separated from the flour during the sifting of flour after the milling stage of wheat, is used in the feeding ruminant animals. Ruminant animals can digest this product at around 70-75%. Wheat bran contains higher amounts of crude protein, fat, cellulose, and ash than the kernel of wheat (Prueckler et al., 2014). Ruminants can utilize the protein, energy, and highly digestible cell wall fractions of wheat bran extremely well. Therefore, it is used instead of some of the other grains or protein sources in the rations (Zhao et al., 2011). In addition to food groups such as carbohydrates, fats, and proteins, animal organisms also require mineral substances (Bailey, 2001). Wheat bran is a valuable feed ingredient as it contains a higher concentration of mineral substances than the kernel.

Structural carbohydrates found in roughage are divided into two groups: neutral detergent insoluble fiber (NDF), which includes cellulose, hemicellulose, and lignin, and acid detergent insoluble fiber (ADF), which includes cellulose and hemicellulose. The amount of NDF and ADF that ruminants consume with their ration, according to their physiological status, affects the degree of feed digestibility and the resulting benefits (Mertens, 1987; Van Soest et al., 1991; Moon et al., 2002; Zhao et al., 2011; Tekce and Gül, 2014).

The major protein in wheat is gluten, composed of gliadins and glutenins. Gluten accounts for 78-85% of the proteins in wheat (Vetter, 1984; Marconi et al., 2000). Gluten proteins in wheat are categorized into High Molecular Weight (HMW) and Low Molecular Weight (LMW) types (Hsia and Anderson, 2001). HMW glutenin subunits, which are controlled by three gene loci, have been identified as *Glu-1A*, *Glu-1B*, and *Glu-1D*, and are located on the long arms of group 1 chromosomes (1AL, 1BL, and 1DL) (Payne et al., 1987). The LMW subunits are encoded by the *Glu-A3, Glu-B3*, and *Glu-D3* loci, located on the short arms of chromosomes 1A, 1B, and 1D, respectively (Jackson et al., 1983). The*Glu-A3* locus has six different alleles (*a, b, c, d, e, f*), the *Glu-B3* locus has nine (*a, b, c, d, e, f, g, h, i*), and the *Glu-D3* locus has five (*a, b, c, d, e*) different alleles. It is known that alleles in the *Glu-B3* locus, which is one of the LMW glutenin subunits, have an effect on improving dough quality and *Glu-A1* HMW subunits affect the rheological properties of dough (Vetter, 1984; Payne et al., 1987; Marconi et al., 2000; Hsia and Anderson, 2001).

Rye introgressions are used in wheat breeding to improve agronomic performance, disease resistance, and adaptation to environment (Graybosch, 2001; Ehdaie et al., 2003; Kim and Johnson, 2004; Hoffman, 2008; Sharma et al., 2009; Güleç et al., 2021). Of several wheat-rye translocations used in wheat breeding, translocation*1RS.1BL*has been shown in numerous studies to increase the agronomic performance but has a negative effect on wheat quality (Graybosch, 2001; Moiraghi et al., 2013). The low quality of wheat genotypes carrying rye translocations is due to the absence of LMW glutenin subunits at the *Glu-B3* locus and the presence of secalin proteins transferred from rye (Zeller and Hsam, 1984). However, the this translocation may not only affect the bread-making quality but also animal nutrition, so it is important to determine the chemical contents of both the kernel and bran. In recent years, interest in whole wheat flour and wholemeal bread has increased worldwide, and the importance of bran in animal nutrition has been further understood. This study investigates the effects of HMW-LMW glutenin subunits and *the 1RS.1BL* translocationon some quality parameters and the mineral contents of wheat kernel and bran in trials conducted in four different environments.

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2. MATERIALS AND METHODS

2.1 Plant Material

In this research, we used 147 recombinant inbred lines (RILs) obtained by hybridizing cultivars Tosunbey × Tahirova2000, along with five control wheat cultivars. All accessions had white grains. The parents are known to have significant differences in quality characteristics. Tahirova2000 variety has higher potential in terms of grain yield. However, the Tahirova2000 variety exhibited good cold tolerance. Cv. Tosunbey carries HMW glutenin subunits 1, 17+18, 5+10 and *Glu-A3b, Glu-B3b, Glu-D3b* LMW glutenin subunits. Cv. Tahirova2000 carries HMW glutening subunits 2*, 7+9, 5+10 HMW and *Glu-A3e* (null), *Glu-B3j* (null), *Glu-D3b* LMW glutenin subunits. Control cultivars were Tosunbey, Tahirova2000, Adana99, Nevzatbey and Altay2000. Tahirova2000 has the *Glu-B3j* subunit, indicating a *1RS.1BL* translocation.

2.2. Trial Locations

Trials were conducted in Samsun/Bafra (41°34′N-35°54′E) and Eskişehir (39°39′31″N-31°2′13″E) locations in Turkey during 2012-2013 and 2013-2014 growing seasons. Samsun/Bafra is known for its high yield potential and ample precipitation, while Eskişehir represents the Middle Passage Zone of Turkey with relatively low precipitation rates. The experiments were sown using a plot planting seeder (Wintersteiger) and harvested with a plot combine harvester (Hege 80). The plot size was 6.47 m x 1.2 m at sowing, 5 m x 1.2 m during the growing season, and 4 m x 1.2 m at harvest. An edge effect of 50 cm was taken from both sides of the parcels. The sowing frequency was adjusted to 400-450 seeds per square meter. 15 kg/decare of N were used in Samsun, and 10 kg/decare of N in Eskişehir. P fertilization was done at 6 kg/decare. In Eskisehir, irrigation was done once (35-40 mm) in the summer of 2013 and 2014 and the total precipitation was 332.8 mm and 316.7 mm in the two years, respectively. In Bafra/Samsun the total precipitation during the wheat growing seasons was 416.2 mm and 283.3 mm in 2012-13 and 2013-14, respectively, The average temperatures during the wheat growing seasons were 14.4°C and 13.3°C in Bafra/Samsun location in 2012-13 and 2013-14, respectively, and 10.7°C and 10.5°C in Eskisehir. The trials were generally successful with no significant damage observed.

2.3. Quality Analysis

Wheat samples were ground using a standard laboratory mill (Brabender Quadrumat Jr.; AACC Method 26-50). The debranning process was carried out with a Loyka ESM-200 sieve shaker using a 415 µm sieve at 150 rpm for 1 minute.

Protein contents of whole wheat flours were determined using the flour module of the Perten Inframatic 9500 device (Perten Instruments, Sweden) and expressed as a percentage at 14% moisture content (Koyuncu, 2009). Damaged starch contents of wheat flours were measured using an amperometric damaged starch measuring device (Chopin – SLMWtic) following the the International Cereal Science and Technology Association (ICC, 2011) protocol ICC Method 172. Damaged starch values were read at 14% moisture content. The ash content of wheat flours was determined by using the flour module of the Perten Inframatic 9500 device (Perten Instruments, Sweden) and expressed as the amount in dry matter (Koyuncu, 2009).

The ADF, NDF, potassium, phosphorus, and magnesium contents of bran samples were determined using IC-1035FE and IC-0912FE calibrations in the Foss XDS NIR device.

2.4. Molecular Analysis

The SDS-PAGE was used to determine the HMW and LMW glutenin subunits of the RILs (Masci et al., 2000; Gianibelli et al., 2001). Wheat genotypes with the*1RS.1BL* translocation lack wheat LMW glutenin subunits as the short arm of chromosome 1B is missing. Instead, rye-specific secalin bands appear on the gel. The absence of *Glu-B3* and the presence of secalins were taken as identificators of the *1RS.1BL* translocation (Zeller and Hsam, 1984).

DNA isolation from seed was performed using the ZR Plant/Seed DNA miniPrep™ Kit. The presence of the*Glu-B3b* allele was detected using primers as as specified by Wang et al. (2009). The total volume of the PCR reaction solution was 20 µL. To this solution, 1X PCR buffer (50 mM KCl, 10 mM Tris-HCl, pH 9.0, 0.1% Triton X-100), 0.1 mM dNTPs, 1.5 mM $MgCl_2$, 1.0 U Taq polymerase, 10 pmol DNA primer, and 50 ng DNA sample were added. The reaction underwent initial denaturation at 94 °C for 5 minutes, followed by denaturation at 94 °C for 45 seconds, annealing at 56-61 °C for 45 seconds, elongation at 72 °C for 90 seconds, and final extension at 72 °C for 8 minutes. PCR products were run on a 2% (w/v) agarose gel at 130-150 volts for 1.5 hours to verify primer amplification. The gel was then imaged using the BioRad gel imaging system.

2.5. Evaluation of Data and Statistical Analysis

The variance analysis of the collected data was conducted using the JMP 10 statistical program, following the partial lattice trial design (JMP, 2010).

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3. RESULTS AND DISCUSSION

3.1. SDS-PAGE Results

The population of RILs screened here showed 16 different combinations of HMW and LMW glutenin subunits, ranging from two to 16 lines with a given combination. Cv. Tahirova2000 carried HMW glutenin subunits 2*, 7+9 and 5+10, and *GluA3e, GluB3j, GluD3b*alleles of LMW glutenins while cv. Tosunbey caries HMW glutenin subunits 1, 17+18, 5+10, and *GluA3b, GluB3b, GluD3b* alleles of LMW glutenins (Fig.1). Among 147 RILs analyzed, 60 included rye translocations, while 87 did not.

3.2. PCR Results

In PCR using the *Glu-B3b* primers, a band of 1570 bp in size was observed. It was determined that 60 of the lines included rye translocation, and 87 of them did not contain rye translocation (Fig. 2).

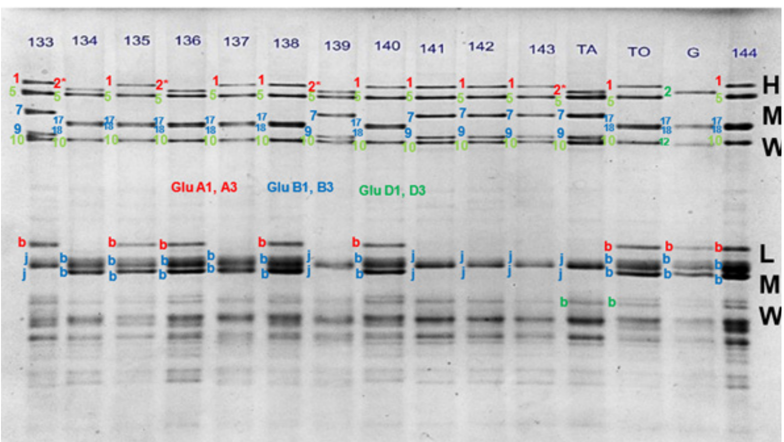

Figure 1. SDS-PAGE photograph showing bands for HMW and LMW glutenin subunits in some lines

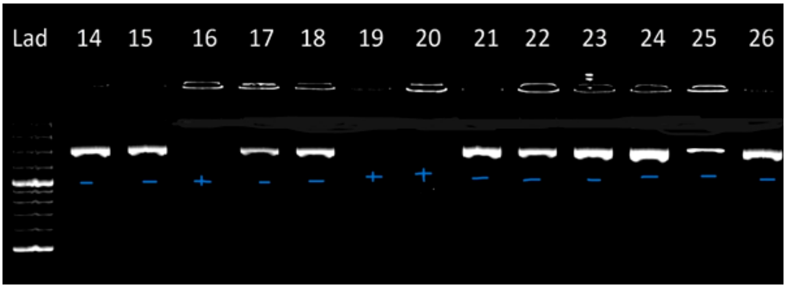

Figure 2. Gel photograph of lines scanned with *Glu-B3b* primer (-: *not containing 1BL.1RS, +: containing 1BL.1RS)*

3.3. Quality Analysis Results of Kernel and Bran

Statistically significant differences were found at a 1% level between years and locations in terms of all characteristics examined in the kernel and bran samples of the genotypes, except for the dry matter ratio (Table 1). The kernel protein content of RILs ranged from 11.2% to 15.0%, the starch content from 63.8% to 68.7%, the fat content from 0.91% to 1.54%, and the dry matter content from 89.5% to 89.9%. In the bran, the protein content ranged from 15.0% to 17.8%, the starch content from 17.9% to 28.8%, the fat content from 3.63% to 5.32%, and the dry matter content from 88.3% to 89.3% (Table 1).

The ADF content ranged from 2.46% to 3.74%, NDF content from 14.8% to 17.0%, K content from 0.357 to 0.497, Mg content from 0.123% to 0.159%, and P content from 0.371 to 0.409. In the bran, ADF content ranged from 8.79% to 13.1%, NDF content from 26.8% to 31.6%, K content from 0.897 to 1.076, Mg content from 0.249 to 0.299, and P content from 0.552 to 0.637 (Table 1).

The ADF, NDF, K, Mg, and P contents in the kernel and bran were higher in the first year, starch and fat contents were higher in the second year (Table 2). Dry matter content was found to be higher in the first year in the kernel and in the second year in the bran. Protein, starch, dry matter, NDF, K, Mg, and P contents in the kernel were found to be higher in the Samsun location. Starch, ash, fat, and ADF contents were higher in Eskisehir. Protein, dry matter, ADF, NDF, K, Mg, and P contents in the bran were higher in the Samsun.

Table 1. The mean values and ranges of the quality traits of the genotypes in the combined data of the years and locations

Traits		**Mean (%)**	**Range (%)**	**CV %**	**SD**
PC	Kernel	12.7	11.2-15.0	9.62	1.22
	Bran	16.3	15.0-17.8	6.99	1.14
SC	Kernel	67.0	63.8-68.7	2.22	1.49
	Bran	23.5	17.9-28.8	11.9	2.79
FC	Kernel	1.25	0.91-1.54	16.0	0.20
	Bran	4.61	3.63-5.32	5.03	0.23
AC	Kernel	1.34	1.16-1.52	10.4	0.14
	Bran	5.25	4.58-5.62	4.95	0.26
DM	Kernel	89.7	89.5-89.9	0.38	0.34
	Bran	88.8	88.3-89.3	0.96	0.85
ADF	Kernel	3.05	2.46-3.74	18.0	0.55
	Bran	11.3	8.79-13.1	8.76	0.99
NDF	Kernel	15.7	14.8-17.0	4.39	0.69
	Bran	29.2	26.8-31.6	3.39	0.99
K	Kernel	0.420	0.357-0.497	10.5	0.044
	Bran	0.983	0.897-1.076	6.92	0.068
Mg	Kernel	0.137	0.123-0.159	8.03	0.011
	Bran	0.281	0.249-0.299	4.98	0.014
P	Kernel	0.387	0.371-0.409	3.88	0.015
	Bran	0.601	0.552-0.637	3.99	0.024

PC: Protein content, SC: Starch content, FC: Fat content, AC: Ash content, DM: Dry matter, ADF: Acid detergent fiber, NDF: Neutral detergent fiber, K: Potassium, Mg: Magnesium,P: Phosphorus CV: Coefficient of variation

Table 3 shows the ratios of protein, starch, fat, ash, and dry matter in grain and bran for the *Glu-A1, Glu-B1, Glu-A3,* and *Glu-B3* loci. At the *Glu-A1* locus, the starch and dry matter ratios were higher in the kernel, while the bran had higher protein, fat, and ash ratios. The fat ratio was higher in the bran of the genotypes carrying the 7+9 subunit (*Glu-B1* locus). The difference between the protein, starch, fat, ash, and dry matter ratios in the kernel and bran of genotypes was significant for the *Glu-B3* locus (Table 3). Specifically, for the *Glu-B3* locus, the ratio of starch and dry matter (DM) was higher in the kernel, while the protein, fat, and ash ratios were higher in the bran. Additionally, genotypes carrying the *j* subunit (i.e., the rye translocation) had higher protein and ash ratios than those carrying the *b* subunit (i.e., without the rye translocation), while the starch and fat ratios were lower in genotypes with rye translocation.

Table 2. Mean values of investigated traits for locations and years (%)

Traits		Years		Locations	
		2012-2013	2013- 2014	Samsun	Eskişehir
PC	Kernel	13.7	11.6	13.2	12.1
	Bran	16.6	15.9	17.1	15.4
SC	Kernel	66.2	67.8	67.2	66.8
	Bran	22.1	24.9	22.7	24.3
FC	Kernel	1.20	1.29	1.20	1.29
	Bran	4.45	4.77	4.48	4.73
AC	Kernel	1.41	1.27	1.32	1.36
	Bran	5.30	5.20	5.23	5.27
DM	Kernel	89.5	89.8	89.8	89.6
	Bran	89.4	88.2	89.6	88.0
ADF	Kernel	3.25	2.84	2.86	3.23
	Bran	12.1	10.5	11.6	10.9
NDF	Kernel	16.2	15.2	16.0	15.4
	Bran	29.8	28.6	29.3	29.1
K	Kernel	0.434	0.405	0.441	0.398
	Bran	1.015	0.959	1.008	0.959
Mg	Kernel	0.141	0.132	0.141	0.132
	Bran	0.292	0.269	0.291	0.270
P	Kernel	0.393	0.382	0.392	0.383
	Bran	0.616	0.587	0.615	0.587

PC: Protein content, SC: Starch content, FC: Fat content, AC: Ash content, DM: Dry matter, ADF: Acid detergent fiber, NDF: Neutral detergent fiber, K: Potassium, Mg: Magnesium, P: Phosphorus

Table 3 shows the ratios of ADF, NDF, and mineral matter (K, Mg, P) in the kernel and bran for the *Glu-A1, Glu-B1, Glu-A3*, and *Glu-B3* loci in the genotypes analyzed in the study. The bran within the four loci had higher ADF, NDF, and mineral substance ratios. ADF, NDF, K, and Mg ratios were higher in both kernels and brans with rye translocation at the *Glu-B3* locus compared to kernels and brans without rye translocation. The P ratio was higher in bran without rye translocation.

Table 3. Mean values of HMW and LMW loci in kernel and bran for the investigated properties

Locus	Subunit	Line Number	Protein		Starch		Fat		Ash		DM	
			Kernel	Bran	Kernel	Bran	Kernel	Bran	Kernel	Bran	Kernel	Bran
Glu-A1	1	68	12.7	16.2	66.9	23.8	1.27	4.61	1.35	5.25	89.7	88.8
	2*	79	12.8	16.4	66.9	23.2	1.24	4.66	1.34	5.28	89.7	88.9
Glu-B1	7+9	60	12.7	16.3	67.0 a	23.6	1.27	4.67 a	1.34	5.27	89.7	88.8
	17+18	87	12.8	16.3	66.7 b	23.4	1.24	4.59 b	1.35	5.25	89.7	88.8
Glu-A3	*b*	73	12.9	16.4	66.8	23.6	1.26	4.64	1.34	5.26	89.7	88.8
	e	74	12.7	16.2	67.0	23.4	1.25	4.63	1.35	5.26	89.7	88.8
Glu-B3	*b* *(-1BL.1RS)*	87	12.6 b	16.3	67.4 a	24.0a	1.30 a	4.73 a	1.31 b	5.24	89.7	88.8
	j *(+1BL.1RS)*	60	13.0 a	16.3	66.4 b	22.9b	1.20 b	4.53 b	1.38 a	5.28	89.7	88.8

Table 3 continue

Locus	Subunit	Line Number	ADF		NDF		K		Mg		P	
			Kernel	Bran	Kernel	Bran	Kernel	Bran	Kernel	Bran	Kernel	Bran
Glu-A1	1	68	3.12 a	11.3	15.7	29.2	0.423	0.972	0.138	0.280	0.390	0.599 b
	2*	79	2.97 b	11.3	15.7	29.2	0.422	0.986	0.138	0.283	0.388	0.605 a
Glu-B1	7+9	60	3.05	11.3	15.6	29.1	0.420	0.976	0.137	0.281	0.388	0.601
	17+18	87	3.03	11.3	15.8	29.3	0.425	0.982	0.139	0.282	0.390	0.603
Glu-A3	*b*	73	3.08	11.2	15.8	29.2	0.427	0.971b	0.139 a	0.282	0.391 a	0.601
	e	74	3.01	11.3	15.6	29.3	0.418	0.987 a	0.137 b	0.281	0.387 b	0.603
Glu-B3	*b* *(-1BL.1RS)*	87	3.03b	11.2b	15.5 b	28.9 b	0.412b	0.970 b	0.136 b	0.281	0.387 b	0.604
	j *(+1BL.1RS)*	60	3.05a	11.5a	15.9 a	29.6a	0.433a	0.988 a	0.140 a	0.281	0.391 a	0.599

Tables 4 and 5 present the results of the quality analysis of the *Glu-A1, Glu-B1, Glu-A3,* and *Glu-B3* loci, as well as their combinations in kernel and bran. When examining the effect of loci alone on the kernel, it is observed that the *Glu-B3* locus increases the protein, starch, fat, ash, NDF, K, and Mg ratios in the grain compared to other loci (Table 4). When examining the effect of the triple combination of loci in the kernel, the *Glu-B1 x Glu-A3 x Glu-B3* combination has a significant effect on protein, starch, Mg and P ratios.

When examining the effect of individual loci on the bran, it is observed that the*Glu-B3* locus increases the ratios of starch, fat, ash, ADF, NDF, and K (Table 5). The combinations of *Glu-A1 x Glu-B1*and *Glu-A1 x Glu-B3*increases the ratios of fat, ash, and ADF in the bran. These data suggest that the effects of individual loci and their combinations on quality and mineral matter in bran and kernel may vary.

Table 4. Quality analysis results of HMW and LMW loci and combinations in kernel

Source	df	PC	SC	FC	AC	ADF	NDF	K	Mg	P	DM
					MS						
Glu-A1 (A1)	1	0.492	0.075	0.090	0.0005	2.92**	0.328	0.0003	0.000003	0.0003	0.135
Glu-B1 (B1)	1	0.548	14.4*	0.147	0.039	0.059	2.37	0.002	0.0004	0.0005	0.043
Glu-A3 (A3)	1	5.04	4.03	0.022	0.003	0.618	2.02	0.009	0.0008*	0.002**	0.367
Glu-B3 (B3)	1	17.9*	142.2**	1.28**	0.630**	0.033	18.1**	0.056**	0.002**	0.002**	0.115
A1× B1	1	5.47	0.870	0.193	0.045	0.070	0.001	0.004	0.0004	0.001	0.084
A1× A3	1	4.31	7.06	0.007	0.008	0.002	0.874	0.003	0.0006	0.001*	0.049
A1× B3	1	3.40	0.072	0.163	0.020	0.025	0.030	0.005	0.00009	0.001	0.060
B1× A3	1	0.008	0.019	0.206*	0.063	1.01	0.993	0.006	0.00006	0.0004	0.002
B1× B3	1	0.466	0.117	0.036	0.018	0.005	0.441	0.0003	0.00004	0.0003	0.110
A3× B3	1	1.35	0.159	0.045	0.048	0.792	0.143	0.008	0.0001	0.0005	0.004
A1× B1× A3	1	2.07	0.036	0.111	0.0005	0.229	0.624	0.004	0.0004	0.0008	0.009
A1× B1× B3	1	0.067	0.489	0.041	0.013	0.323	0.308	0.00001	0.000001	0.0003	0.077
A1× A3× B3	1	5.46	0.848	0.008	0.00002	0.053	0.206	0.002	0.0005	0.0008	0.032
B1× A3× B3	1	15.9*	14.0*	0.029	0.002	0.032	0.488	0.004	0.001**	0.002**	0.465*
A1× B1× A3× B3	1	9.16	10.4	0.121	0.032	0.0002	1.40	0.006	0.001**	0.002*	0.101
Error	1160	2.99	3.15	0.053	0.028	0.405	0.829	0.003	0.0002	0.0003	0.118

** P <0.05, ** P <0.01 level of significance, PC: Protein content, SC: Starch content, FC: Fat content, AC: Ash content, DM: Dry matter, ADF: Acid detergent fiber, NDF: Neutral detergent fiber, K: Potassium, Mg: Magnesium,P: Phosphorus, df: degrees of freedom

As it generally contains more protein than the kernel, Wheat bran is an important feed source, especially for ruminants (Ünal, 2002; Balandran-Quintana et al., 2015). It was found that the lines analyzed in the study had higher protein in their bran compared to their kernels. Protein ratio in both bran and kernel was found to be higher in 2012-2013 compared to 2013-2014 years. Similarly, the average protein content of the lines was higher in Samsun than Eskişehir. Mut et al. (2017) reported that the contents of protein, ash, fat, starch, ADF, and NDF in the kernel vary depending on genotypes and years. Hossain et al. (2013) has shown that in wheat bran, dry matter, ash, and calcium contents vary depending on the location (environment), while ash, protein, fat, and calcium contents vary depending on the genotypes. Stated studies support the results of this study.

Table 5. Quality analysis results of HMW and LMW loci and combinations in bran

Source	df	PC	SC	FC	AC	ADF	NDF	K	Mg	P	DM
						MS					
Glu-A1 (A1)	1	5.31	43.4	0.268	0.161	0.009	0.096	0.022	0.001	0.005*	1.20
Glu-B1 (B1)	1	0.546	7.60	0.832*	0.027	0.026	6.14	0.004	0.00009	0.0003	0.166
Glu-A3 (A3)	1	5.16	6.02	0.015	0.001	3.15	0.708	0.030*	0.00004	0.0004	0.004
Glu-B3 (B3)	1	0.891	149.3**	5.14**	0.248	12.2*	56.7**	0.039*	0.0000007	0.003	0.002
A1× B1	1	0.065	21.6	1.34**	1.17**	11.4*	0.676	0.003	0.0003	0.0006	0.018
A1× A3	1	1.59	1.27	0.085	0.016	0.055	0.012	0.003	0.0008	0.001	0.379
A1× B3	1	0.002	26.2	0.927**	0.610**	9.62*	2.03	0.004	0.0004	0.0007	0.210
B1× A3	1	1.65	0.418	0.040	0.015	1.64	1.34	0.0002	0.00002	0.0000006	0.001
B1× B3	1	0.282	19.9	0.472	0.026	1.15	1.29	0.026*	0.00009	0.0004	0.062
A3× B3	1	0.070	1.59	0.209	0.114	0.865	0.022	0.0001	0.00001	0.0001	0.377
A1× B1× A3	1	1.19	1.41	0.010	0.0000006	2.76	0.525	0.0007	0.00002	0.0006	0.029
A1× B1× B3	1	0.047	8.16	0.183	0.107	0.001	0.933	0.0003	0.00002	0.00007	0.021
A1× A3× B3	1	1.15	8.65	0.0002	0.146	0.014	1.21	0.00006	0.00006	0.0003	0.292
B1× A3× B3	1	6.91	7.38	1.13**	0.164	4.24	1.92	0.004	0.003*	0.002	0.527
A1× B1× A3× B3	1	4.38	2.31	0.194	0.068	0.115	1.36	0.011	0.0008	0.0005	0.355
Error	1160	2.23	12.9	0.134	0.084	1.94	1.70	0.007	0.0005	0.001	1.60

** P <0.05, ** P <0.01 level of significance, PC: Protein content, SC: Starch content, FC: Fat content, AC: Ash content, DM: Dry matter, ADF: Acid detergent fiber, NDF: Neutral detergent fiber, K: Potassium, Mg: Magnesium, P: Phosphorus,

It is desirable to have appropriate amounts of ADF in the ration according to the age of the animal. These amounts increase with the age of the animal and vary between 19-25% (Khafipour et al., 2009; Tekce and Gül, 2014). In the study, the ADF content of the kernels used varied between 2.46% and 3.74%, while in the bran, it varied between 8.79% and 13.1%.

Ruminants cannot produce enough saliva when the NDF ratio is between 16-25%. Optimum efficiency can be achieved when the NDF ratio is between 25-32%. When the NDF ratio exceeds 32%, feed intake is limited by rumen capacity (Campbell et al., 1992; Khafipour et al., 2009; Tekce and Gül, 2014). In this study, the NDF ratio in the kernel (15.7%) was lower than the optimum level, while the NDF values in the bran were higher (29.2%) and at the optimum level. This indicates that bran is more valuable in animal nutrition.

In animal nutrition, the P ratio should be at least 0.3-0.5%, the magnesium ratio should be a minimum of 0.35%, and the potassium ratio should be 0.70% in the total ration (McDowell, 1992; Harris et al., 1994). The study found high ratios of P (0.6%) and K (0.98%) in bran. Although the Mg ratio is low, it is still higher in bran than in the kernel (Table 1). This study shows that wheat bran is a more valuable animal feed in terms of mineral content.

4. CONCLUSION

The study examined some quality characteristics such as ADF, NDF, dry matter, protein content, ash, fat, and starch ratios, as well as K, Mg, and P ratios in both whole kernel and bran, and attempted to associate those with the presence/absence of the *1RS.1BL* wheat-rye translocation, and specific allelic variation at several gluten loci. In the kernels, there was no effect of the *1RS.1BL*translocation on ADF and DM; all other tested parameters were signicantly affected by its presence. The average ADF, NDF, protein content, ash content, K, Mg, and P contents in the kernels of RILs carrying the translocation were higher than in those without it. The kernels of RILs without the translocationhad higher fat and starch content. In the bran, there was no statistically significant effects of the translocation on dry matter, protein, and Mg content. On the other hand, The bran of RILs carrying the translocation had higher ADF, NDF, ash and K contents, while those without it had higher fat, starch, and P content. This demonstrates that the wheat-rye translocation *1RS.1BL*has significant effects on the properties of both wheat kernel and bran. Lines with the translocation may be better for the production of whole wheat bread with higher protein and mineral content. The bran of such genotypes may be more advantageous in animal nutrition.

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Conflict of Interest

The authors declare that there is no conflict of interest.

Ethics

This study does not require ethics committee approval.

Author Contribution Rates

Design of Study: NA(%40), AS(%20), CM(%20) ES(%20)

Data Acquisition: BD(%20), ÖDEK(%20), MES(%15) MK(%15) CM(%15) ES(%15)

Data Analysis: NA(%55), AS(%15), TG(%15), ZM(%15)

Writing Up: TG(%50), NA(%25), ZM(%25)

Submission and Revision: TG(%85), ZM(%15)

REFERENCES

Bailey, E., 2001. Mineral supplements for beef cattle. University of Missouri Extension 1-14.

Balandrán-Quintana, R.R., Mercado-Ruiz, J.N., Mendoza-Wilson, A.M., 2015. Wheat bran proteins: a review of their uses and potential. Food Reviews International, 31(3), 279-293.

Campbell, C.P., Marshall, S.A., Mandell, I.B., Wilton W.J., 1992. Effects of source of dietary neutral detergent fiber on chewing behavior in beef cattle fed pelleted concentrates with or without supplemental roughage. Journal Animal Science, 70: 894-903. https://doi.org/10.3168/jds.S0022-0302(89)79360-7.

Ehdaie, B., Whitkus, R.W., Waines, J.G., 2003. Root biomass, water use efficiency, and performance of wheat–rye translocations of chromosomes 1 and 2 in spring bread wheat 'Pavon'. Crop Science, 43(2): 710-717. https://doi.org/10.2135/cropsci2003.7100.

FAO, 2011a. Quality assurance for animal feed analysis laboratories. http://www.fao.org/ag/againfo/home/documents/Network-control.pdf (Accessed 27 Oct 2022).

FAO, 2011b. Nutritional requirements of dairy cattle. http://www.merckmanuals.com/vet/management_and_nutrition/nutritional_requirements_of_dairy_cattle.html (Accessed 27 Oct 2022).

Gianibelli, M.C., Larroque, O.R., MacRitchie, F., Wrigley, C.W., 2001. Biochemical, genetic, and mol. characterization of wheat endosperm proteins. Cereal Chemistry, 78(6): 635-646. https://doi.org/10.1094/CCHEM.2001.78.6.635.

Graybosch, R.A., 2001. Uneasy Unions: Quality Effects of Rye Chromatin Transfers to Wheat. Journal of Cereal Science,33: 3-16. https://doi.org/10.1006/jcrs.2000.0336.

Güleç, T., Sönmez, M.E., Demir, B., Sabancı, K., Aydın, N., 2022. Effect of vernalization (Vrn) genes on root angles of bread wheat lines carrying rye translocation. Cereal Research Commucation, 50: 367-378.https://doi.org/10.1007/s42976-021-00188-4.

Harris, B., Adams, A.L., Van Horn, H.H., 1994. Mineral Needs of Dairy Cattle. University of Florida Florida Cooperative Extension Service Circular, pp. 468.

Hoffmann, B., 2008. Alteration of drought tolerance of winter wheat caused by translocation of rye chromosome segment 1RS. Cereal Research Commucation, 36: 269-278. https://doi.org/10.1556/CRC.36.2008.2.7.

Hossain, K., Ulven, C., Glover, K., Ghavami, F., Simsek, S., Alamri, M.S., Kumar, A., Mergoum, M., 2013. Interdependence of cultivar and environment on fiber composition in wheat bran. Journal Crop Science, 7(4): 525-531. https://pubmed.ncbi.nlm.nih.gov/30147755/.

Hsia, C.C., Anderson, O.D., 2001. Isolation and characterization of wheat - genes. Theoretical and Applied Genetics, 103: 37-44. https://doi.org/10.1007/s00122-001-0552-2.

ICC, 2011. ICC Standard Methods. International Association for Cereal Science and Technology (ICC), Vienna, Austria.

Jackson, E.A., Holt, L.M., Payne, P.I., 1983. Characterisation of highmolecular weight gliadin and low-molecular weight glutenin subunits of wheat endosperm by two-dimensional electrophoresis and chromosomal localisation of their controlling genes. Theoretical and Applied Genetics,66: 29-37. https://doi.org/10.1007/BF00281844.

JMP, 2010. JMP User Guide, Release 10, SAS Institute Inc., Cary, NC, USA, ISBN 978-1-59994-408-1.

Khafipour, E., Li, S., Plaizier, J.C., Krause, D.O., 2009. Rumen microbiome composition determined using two nutritional models of subacute ruminal acidosis. Appl Environ Microb, 75: 7115–7124. https://doi.org/10.1128/AEM.00739-09.

Kim, W., Johnson, J.W., Baenziger, P.S., Lukaszewski, A.J., Gaines, C.S., 2004. Agronomic effect of wheat-rye translocation carrying rye chromatin (1R) from different sources. Crop Science, 44: 1254-58. https://doi.org/10.2135/cropsci2004.1254.

Koyuncu, M., 2009. Yerel Durum Buğday Çeşitlerinin Makarnalık Kalitelerini Etkileyen Önemli Parametreler Bakımından Taranması (Yüksek Lisans Tezi). Gaziosmanpaşa Üniversitesi Fen Bilimleri Enstitüsü Gıda-Mühendisliği Anabilim Dalı, Tokat.

Lasztity, R., 1996. The Chemistry of Cereal Proteins. CRC Press, USA, pp. 328.

Marconi, E., Graziano, M., and Cubadda, R., 2000. Composition and utilization barley pearling by-products for making functional pastas. Cereal Chemistry, 77(2): 133-139. https://doi.org/10.1094/CCHEM.2000.77.2.133.

Masci, S., Dovidio, R., Lafianda, D., Kasarda, D.A., 2000. 1B-Coded low molecular weight glutenin subunit associated with quality in durum wheats shows strong similarity to a subunit present in some bread wheat cultivars. Theoretical and Applied Genetics,100(3): 396-400. https://doi.org/10.1007/s001220050052.

McDowell, L.R., 1992. Minerals in animal and human nutrition; ISBN: 0- 12-483369-1 Academic Press, Inc. New York, USA.

Mertens, D.R., 1987. Predicting intake and digestibility using mathematical models of ruminal function. Journal Animal Science, 64:1548 1558. https://doi.org/10.2527/jas1987.6451548x.

Moiraghi, M., Vanzetti, L., Pflüger, L., Helguera, M., Pérez, G.T., 2013. Effect of high molecular weight glutenins and rye translocations on soft wheat flour cookie quality. Journal of Cereal Science, 58:424-430. https://doi.org/10.1016/j.jcs.2013.08.007.

Moon, Y.H., Lee, S.C., Lee, S.S., 2002. Chewing activities of selected roughages and concentrates by dair steers. Asian-Aust Journal Animal Science, 15: 968-973.

Mut, Z., Erbaş, Ö.D., Akay, H., 2017. Determination grain yield and quality characteristics of some bread wheat (*Triticum aestivum*) varieties. Anatol Journal Agricalture Science, 32: 85-95.

Payne, P.I., Nightingale, M.A., Krattiger, A.F., Holt, L.M., 1987. The relationship between HMW glutenin composition and the bread-making quality of british grown wheat varieties. Journal of Science of Agriculture,40:51-65. https://doi.org/10.1002/jsfa.2740400108.

Prueckler, M., Siebenhandl-Ehn, S., Apprich, S., Hoeltinger, S., Haas, C., Schmid, E., Kneifel, W., 2014. Wheat bran-based biorefinery 1: Composition of wheat bran and strategies of functionalization. LWT-Food Science Technol, 56(2):211-221. https://doi.org/10.1016/j.lwt.2013.12.004.

Sharma, S., Bhat, P.R., Ehdaie, B., Close, T.J., Lukaszewski, A.J., Waines, J.G., 2009. Integrated genetic map and genetic analysis of a region associated with root traits on the short arm of rye chromosome 1 in bread wheat. Theoretical and Applied Genetics, 119: 783–793. https://doi.org/10.1007/s00122-009-1088-0.

Tekçe, E., Gül, M., 2014. Ruminant Beslemede NDF ve ADF'nin Önemi. Veterinary Sciences and Practices, 9(1): 63-73. Doi.10.17094/avbd.34439.

TPMA, 2023. Turkish Pasta Manufacturers Association. http://www.makarna.org.tr/d/makarna-sektoru/makarna-tuketimi/42/ html (Accessed 23 Feb 2023).

TUIK, 2014. Turkish statistical instutite. https://arastirma.tarimorman.gov.tr html (Accessed 15 Feb 2023).

Ünal, S., 2002. Importance of wheat quality and methods in wheat quality determination. Proceedings of the Cereal Products Technology Congress and Exhibition, October. pp. 25-37.

Van Soest, P.J., Robertson, J.B., Lewis, B.A., 1991. Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. Journal Dairy Science, 74: 3583-3597. https://doi.org/10.3168/jds.S0022-0302(91)78551-2.

Wang, R., Hai, L., Zhang, X.Y., You, G.X., Yan, C.S., Xiao, S.H., 2009. QTL mapping for grain filling rate and yield-related traits in RILs of the Chinese winter wheat population Heshangmai x Yu8679. Theoretical and Applied Genetics, 118: 313-325. https://doi.org/10.1007/s00122-008-0901-5.

Zeller, F.J., Hsam, S.L.K., 1984. Broadening the genetic variability of cultivated wheat by utilizing rye chromatin. Proc 6th Int Wheat Genetic Symp, Kyoto, Japan, pp. 161-173.

Zhao, X.H., Zhang, T., Xu, M., Yao, J.H., 2011. Effects of physically effective fiber on chewing activity, ruminal fermentation and digestibility goats. Journal Animal Science, 89: 501-509. https://doi.org/10.3168/jds.S0022-0302(06)72086-0.