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GRAIN - BRAN QUALITY PARAMETERS AND AGRONOMIC TRAITS OF BREAD WHEAT CULTIVARS

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ABSTRACT

Wheat (*Triticum avestivum* L.) is used as an important source of essential nutrients for both humans and animals. Whole wheat flour and bran has a unique nutritional composition due to the amount of proteins, mineral content and B complex vitamins content and dietary fiber content. The aim of this study was to determine the grain yield and quality parameters of 36 wheat cultivars and the nutritional properties of the bran obtained from these cultivars. The study was carried out in Bilecik ecological conditions in 2019-2020 and 2020- 2021. In addition to the grain yield and yield components of the cultivars, many quality traits were determined both in whole grain and bran. According to the average over two years, grain yields of wheat cultivars ranged from 3.1 to 8.1 t ha^{-1}. Significant differences were observed between the cultivars in terms of the chemical composition of the bran and the whole grain of wheat. Protein ratio from whole grains and bran ranged from 12.7 to 14.7% and 15.9 to 18.8%, respectively. It is expected that the data obtained in this study will be reported in the literature, evaluated in terms of product quality and taken into account in breeding programs.

Keywords: Bran, cultivar, grain yield, protein, *Triticum avestivum* L.

INTRODUCTION

Cereals, which are in the *Poaceae* family are considered important low-fat staple foods in most diet patterns, and for many populations they also important providers of carbohydrate, dietary fiber, minerals, protein and water- and fat-soluble vitamins (Seal et al., 2021). Cereal grains are the most important renewable resource for human food and animal feed. Wheat (*Triticum* spp.) which is among the cereals is a crop that is a staple source of nutrients for around 40% of the world's population (Cai et al., 2014). Wheat has been among the first cereal crops to be farmed for millennia because it is of strategic importance in many countries due to its wide adaptation limit, ease of production, transportation, storage and processing, as well as its ability to be bread (Mut et al., 2017). Wheat is the primary grain used in the preparation of bread, noodles, tortillas, and many other staple foods.

In order to increase the wheat yield above today's level, high yielding varieties suitable for ecological conditions should be determined and presented to the producers. Yield and quality are affected by the climate and soil characteristics of the region where the cultivars are grown, and these criteria are taken into account when choosing the cultivar (Mut et al., 2017). The concept of quality in wheat, which varies greatly in line with the demands of the producer, industry and consumer, is formed under the influence of many factors. Quality is the expression of a product's suitability for different uses. Whole wheat grain is an excellent source of protein, carbohydrate, dietary fiber, minerals, vitamins, and bioactive phytochemicals, such as antioxidant compounds (Marion and Sournier, 2020).

The whole grain is surrounded by a series of layers formed mostly by the walls of dead cells; the set of all these surrounding layers is called the bran in the argot of milling (Balandran-Quintana et al., 2015). For the production of whole grain wheat flour, bran is ground along with endosperm. This flour presents many challenges to food manufacturers as it has negative effects on the processing, storage and sensory acceptance of their food (Seal et al., 2021).

The composition of wheat varies among genotypes, environments and their interactions, classes of wheat, and parts of a wheat grain (Poudel and Bhatta, 2017). A wheat grain is divided into three main parts: the bran (14.5%), endosperm (83%), and germ (2.5%) (Hossain et al., 2013). Wheat bran is a by-product of the milling of wheat grain. It has a unique nutritional composition due to the amount and quality of proteins, mineral content, B complex vitamin content and dietary fiber content. Despite these traits, the consumption of bran by humans is very low and the great majority of the bran generated is used for livestock feed (Hauze et al., 2013). Moreover, a small portion of the bran produced is used as an ingredient in the formulation of fiber-rich foods, mainly baked goods and cereals (Pruckler et al., 2014). Use of wheat bran as dietary fiber helps in the prevention of various gastric and digestive ailments, obesity, cardiovascular disease, some cancers, hypertension, gallbladder diseases, hypercholesterolemia, type 2 diabetes and hemorrhoid (Francois et al., 2010; Zhu et al., 2013). Since the 2000s, consumers have become more aware of and interested in breads made with different types and qualities of grains, including the bran of other grains like wheat and oat bran, as well as whole kernel flours (Kadan et al., 2001; Wang et al., 2003).

The aim of this study was to determine the grain yield and quality parameters of 36 wheat cultivars and the nutritional properties of the bran obtained from these cultivars.

MATERIALS AND METHODS

Plant material and location

Thirty-six registered wheat varieties were used in the study, which were obtained from Sakarya Maize Research Institute (Momtchil, Beskopru, Acar, Altug, Alada, Nusrat, Adalı, Halis), Trakya Agricultural Research Institute (Bereket, Aldane, Atilla-12, Selimiye, Pehlivan, Kate-1, Gelibolu, Prostor, Saraybosna, Tekirdag, Saban, Kopru, Yuksel), and Eskisehir Zone Agricultural Research Institute (Bezostaja-1, Gerek-79, Harmankaya-99, Altay-2000, Sonmez-2001, Izgi-2001, Soyer, Mufitbey, Nacibey, ES-26, Mesut, Sultan 95, Alpu 2001, Yunus, Reis).

Field trials were conducted at the Agricultural Research and Application Center of the Faculty of Agriculture and Natural Sciences, Bilecik Seyh Edebali University, Turkey, during the 2019-2020 and 2020-2021 cropping seasons. Table 1 shows the location, climate, and soil attributes of the experimental sites. Climate data were obtained from the Turkish State Meteorological Service in the period (Anonymous, 2022). Thirty-six genotypes were tested using 6x6 alpha lattice designs with three replications. Each genotype was sowed in eight rows of 6 meters length with 20 cm row spacing. The sowing density was 550 seeds per m^2. Sowing dates were set for 10 November 2019 and 16 November 2020, respectively. Plots were fertilized with 60 kg ha^{-1} N and 60 kg ha^{-1} P_2O_5 (di-ammonium phosphate) during sowing. In addition, top-dressing was administered at 60 kg ha^{-1} N the urea tillering stage. For weed management, a herbicide (Tribenuran-Metil (DF)%75) was used during the tillering stage. On July 18 in the first year and July 23 in the second year, samples from all plots were hand-picked close to the ground with a sickle.

Table 1 Location, soil and climate traits of testing years

	Years	2019-2020	2020-2021
Field area traits	Latitude (N)	30° 10'	30° 10'
	Longitude (E)	40° 11'	40° 11'
	Altitude (m)	500	500
Soil Traits	Soil type	clay loam	clay loam
	Organic matter (%)	2.26	2.24
	Salinity (%)	0.78	0.77
	pH	7.82	7.88
Climate traits	Mean temperature (˚C)	11.6	11.6
	Total rainfall (mm)	482.6	436.1
	Relative humidity (%)	66.8	66.4

Grain yield, physical and chemical analyses

The grains from each plot were weighed and the results were converted to grain yield (GY) ton per hectare after the harvest and threshing. Plant height (PH) was measured from the soil surface to the ear end for each genotype which was selected ten plants randomly, after that was calculated mean. Test weight (TW) was determined by using the 55-10 Approved Methods (AACC, 2020). Determining of thousand grain weight (TGW), wheat seeds was counted by a seed counting device and calculated by weighing of 1000 seeds (Chopin Technologies-Numigral).

For chemical analyses, dry seeds from each genotype were ground with a hammer mill a 0.5 mm screen for ash, protein, fat, starch, ADF, NDF and minerals. Zeleny sedimentation and wet gluten analyzes were performed on the flour. The samples were stored for later analyses at +4 ˚C and samples were analysed within three months after harvest in both years. Also, all determinations were conducted in duplicate. Ash content was determined by burning the samples in an oven at 550 °C and then weighing, according to AACC International Methods of 08-01.01 (AACC, 2020). Protein contents were determined according to AACC International Methods of 46-30.01 (AACC, 2020). The starch contents of samples were determined with the aid of enzymatic test kit (Megazyme International, Bray, Ireland) according to AACC Approved Method of 76-13.01 (AACC, 2020) and fat content was determined according to Soxhlet method of Welch (1977). Zeleny sedimentation and wet gluten were determined according to AACC International Methods of AACC 56-60.01 and AACC 38-12.02, respectively (AACC, 2020). The ADF and NDF content (Van Soest et al., 1991) were determined by using an ANKOM 220 Fiber Analyser. The K, Ca and Mg contents were determined by Atomic Absorption Spectroscopy (Kacar, 1994), and the P content was determined by the “Olsen” method (Olsen and Sommers 1982). All of these analysis results were expressed as the mean on a dry weight basis.

Wheat samples were ground in a standard laboratory mill (Brabender Quadrumat Jr. type; 4-roll 3-pass) (AACC Method 26-50). The debranning (bran separation) process was carried out using by a Loyka ESM-200 sieve shaker with a 415 µm sieve at 150 rpm. Bran samples were analysed on the Foss XDS NIR instrument using calibrations IC-1035FE and IC-0912FE.

Statistical analysis

For statistical analysis, all data of two years (2019-2020 and 2020-2021) were combined and data are expressed as the mean. The properties examined in the study were analysed by SAS (1998) software according to the 6×6 Alpha Lattice Design (Patterson and Williams, 1976; Kumar et al., 2020). The mean comparison among cultivars was obtained by using the Tukey test. The means were shown in colours to make it easy to see of the differences among cultivars in tables.

RESULTS AND DISCUSSION

The descriptive data (mean, standard deviation (SD), minimum, maximum, coefficient of variation (CV) of the investigated traits of seed and bran are reported in Table 2. The mean data of the investigated traits of wheat seed are reported in Tables 3 and 4 while wheat brans are reported in Table 5. In these tables, the average value of two years of combined data is given. The effects of cultivars, years and their interactions on all investigated traits of both grain and bran were highly significant.

Table 2 The mean values and ranges of traits examined in flour and bran of 36 genotypes in the combined data of the years

Traits	Abbreviation	Mean	SD	Minimum	Maximum	CV
Whole Grain						
Plant height (cm)	PH	98.2	9.5	74.5	115.8	13.2
Spike length (cm)	SL (SH)	10.6	1.2	8.2	13.8	12.8
Number of spikelets per spike (no)	SS	19.3	1.3	16.3	22.1	8.7
Number of grains per spike (seed)	NS	39.9	8.1	25.7	53.9	21.6
Grain yield (ton ha^{-1})	GY	5.9	11.7	3.5	8.1	24.1
Thousand grain weight (g)	TKW	42.5	4.7	28.4	50.9	11.4
Test weight (kg)	TW	78.8	0.8	77.5	81.1	10.9
Wet gluten (%)	WG	29.0	2.6	24.2	35.2	14.0
Sedimentation value (ml)	SV	29.8	2.2	25.8	33.5	14.4
Ash content (%)	AC	1.8	0.2	1.5	2.2	16.1
Protein content (%)	PC	13.5	0.5	12.7	14.7	6.8
Starch content (%)	SC	61.7	1.4	59.1	66.3	4.6
Fat content (%)	FC	1.7	0.2	1.2	2.1	13.3
Acid detergent fiber (%)	ADF	4.1	0.6	2.9	5.2	12.3
Neutral detergent fiber (%)	NDF	16.1	1.0	13.8	20.6	9.4
Potassium (g kg^{-1})	K	7.8	0.5	6.7	8.6	10.2
Phosphorus (g kg^{-1})	P	3.6	0.3	2.8	4.2	15.2
Magnesium (g kg^{-1})	Mg	1.5	0.1	1.1	2.1	16.5
Bran						
Bran ash content (%)	BAC	6.3	0.3	5.7	6.8	9.3
Bran fat content (%)	BFC	3.7	0.4	2.8	4.3	16.0
Bran protein content (%)	BPC	17.1	0.8	15.9	18.8	7.7
Bran starch content (%)	BSC	23.7	2.2	19.2	28.4	14.0
Bran acid detergent fiber (%)	BADF	10.3	1.6	7.1	15.0	9.3
Bran neutral detergent fiber (%)	BNDF	35.6	2.0	30.6	38.5	8.2
Bran potassium (g kg^{-1})	BK	12.2	0.8	10.7	14.1	11.6
Bran phosphorus (g kg^{-1})	BP	6.3	0.1	5.8	6.6	5.1
Bran magnesium (g kg^{-1})	BMg	2.9	0.09	2.7	3.1	7.1

SD: standard deviation, CV: coefficient of variation

The plant height, spike length, number of spikelets per spike and number of grains per spike of wheat cultivars ranged from 74.5 (Yunus) to 115.8 cm (Izgi-2001), 8.2 (Gerek-79) to 13.8 cm (Adali), 16.3 (Gerek-79) to 22.1 number (Adali) and 25.7 (Mufitbey) to 53.9 seed (Adali), respectively (Table 2 and Table 3). All of these features examined in the first year were higher than in the second year in the cultivars (except for the number of spikelets per spike) (Fig. 1). There were significant differences in these traits, demonstrating that a large genetic variation between the cultivars. Plant height is one of the most stressed morphological parameters in cereals, along with yield, yield components, and quality traits. Wheat plant height varies according to cultivar genetic composition, climate and soil conditions, and agricultural practices (Mut et al., 2017).

According to Albayrak et al. (2020), wheat varieties with long plant heights may be good for dry conditions, infertile locations, and places where straw is used for animal nutrition, but short types may be more suitable for fertile soils. Spike length is a criterion that has a direct impact on wheat grain yield and should be considered with the number of spikelets per spike and the number of grains per spike (Albayrak et al., 2022).

Table 3 Two-year average values of grain yield and quality characteristics of wheat cultivars

Cultivars	PH	SL	SS	NS	GY	TGW	TW	WG	SV
Momtchil	106.0^{a-e}	10.5^{h-m}	20.2^{a-f}	34.1^{j-n}	5.7^{i-l}	49.0^{ab}	78.9^{c-g}	28.8^{d-i}	28.5^{a-d}
Beskopru	101.4^{b-g}	12.1^{bcd}	20.9^{a-d}	48.9^{a-e}	4.8^{no}	39.5^{j-n}	78.5^{d-g}	31.3^{a-e}	31.2^{a-d}
Acar	108.4^{a-d}	10.0^{k-n}	17.9^{h-l}	32.4^{l-p}	5.3^{k-n}	41.8^{g-k}	78.3^{f-k}	24.2^{j}	28.8^{a-d}
Altug	98.0^{c-h}	10.3^{i-n}	18.6^{f-k}	43.6^{c-h}	5.9^{f-k}	34.9^{o}	78.3^{f-k}	28.6^{d-i}	28.1^{a-d}
Alada	100.7^{b-g}	11.3^{d-i}	20.2^{a-g}	36.9^{h-l}	7.4^{bcd}	38.9^{k-n}	78.8^{c-h}	27.7^{e-j}	27.8^{bcd}
Nusrat	91.0^{g-j}	11.1^{d-k}	18.9^{d-k}	43.1^{d-h}	6.9^{de}	45.1^{c-e}	81.1^{a}	34.0^{ab}	32.3^{abc}
Adali	107.3^{a-e}	13.8^{a}	21.1^{ab}	53.9^{a}	8.0^{ab}	42.2^{e-j}	79.3^{b-f}	25.9^{hij}	26.2^{d}
Halis	104.9^{a-f}	11.3^{d-i}	17.7^{h-l}	50.7^{ab}	7.0^{c-e}	41.3^{g-l}	79.5^{bcd}	26.8^{g-j}	30.4^{a-d}
Bezostaja-1	97.0^{d-h}	11.3^{d-i}	19.6^{b-i}	32.8^{k-o}	4.7^{no}	49.2^{ab}	78.4^{e-k}	31.8^{a-d}	33.4^{a}
Gerek-79	101.3^{b-g}	8.5^{pq}	16.3^{l}	27.4^{nop}	4.6^{no}	40.2^{i-m}	79.5^{b-e}	29.3^{d-i}	29.8^{a-d}
Harmankaya-99	102.3^{b-g}	11.6^{c-g}	20.4^{a-f}	42.8^{d-i}	4.4^{op}	41.0^{h-l}	77.7^{ijk}	27.4^{e-j}	27.6^{bcd}
Altay-2000	98.0^{c-h}	10.2^{i-n}	18.9^{d-k}	39.8^{f-j}	6.4^{efg}	44.8^{def}	79.4^{b-e}	35.2^{a}	33.5^{a}
Sonmez-2001	113.0^{ab}	12.5^{bc}	19.0^{c-k}	47.1^{a-e}	6.4^{e-h}	45.5^{cd}	78.7^{d-j}	29.9^{c-h}	32.3^{abc}
Izgi-2001	115.8^{a}	10.6^{g-m}	18.7^{e-k}	39.5^{f-k}	5.1^{lmn}	41.5^{g-k}	78.5^{d-k}	33.7^{abc}	31.0^{a-d}
Soyer-02	98.0^{c-h}	13.0^{ab}	19.7^{b-h}	44.4^{b-g}	4.8^{no}	41.4^{g-k}	79.6^{bcd}	29.8^{c-h}	28.7^{a-d}
Mufitbey	110.8^{abc}	10.1^{j-n}	19.4^{b-j}	25.7^{p}	3.5^{q}	44.8^{def}	79.9^{bc}	29.0^{d-i}	27.0^{cd}
Nacibey	106.5^{a-e}	11.0^{e-k}	19.5^{b-i}	34.8^{j-m}	6.4^{e-i}	38.4^{lmn}	78.7^{d-j}	30.3^{b-g}	32.2^{abc}
ES-26	95.0^{e-i}	10.8^{f-l}	19.1^{c-k}	30.8^{l-p}	5.0^{mno}	39.5^{j-n}	78.8^{c-i}	31.2^{a-f}	30.7^{a-d}
Mesut	102.8^{a-g}	11.1^{d-j}	20.8^{a-e}	45.0^{b-f}	7.8^{ab}	50.6^{ab}	78.0^{g-k}	27.3^{e-j}	29.8^{a-d}
Sultan 95	91.0^{g-j}	12.1^{b-e}	21.1^{abc}	49.7^{a-d}	6.4^{efg}	40.2^{i-m}	80.1^{ab}	31.1^{b-f}	30.8^{a-d}
Alpu 2001	101.7^{b-g}	11.8^{c-f}	21.8^{a}	48.9^{a-e}	6.0^{f-k}	41.9^{f-j}	79.5^{bcd}	31.3^{a-e}	30.0^{a-d}
Yunus	74.5^{k}	10.8^{f-l}	22.1^{a}	50.9^{ab}	8.1^{a}	50.0^{ab}	78.8^{c-j}	25.2^{ij}	26.6^{d}
Bereket	91.7^{g-j}	9.3^{nop}	18.5^{f-k}	47.4^{a-e}	7.5^{a-d}	37.7^{mno}	77.7^{jk}	26.9^{g-j}	27.7^{bcd}
Aldane	94.3^{e-i}	9.8^{l-o}	17.3^{kl}	34.7^{j-m}	5.8^{g-l}	44.2^{d-g}	79.3^{b-f}	33.6^{abc}	32.6^{abc}
Atilla-12	91.8^{f-i}	10.3^{i-n}	19.2^{b-k}	45.2^{b-f}	6.1^{f-j}	41.1^{h-l}	78.6^{d-j}	28.9^{d-i}	28.0^{a-d}
Selimiye	97.1^{d-h}	9.8^{l-o}	18.7^{e-k}	30.7^{l-p}	6.9^{de}	47.9^{bc}	78.7^{d-j}	29.0^{d-i}	29.5^{a-d}
Pehlivan	109.0^{a-d}	10.1^{j-n}	19.2^{b-k}	28.3^{m-p}	5.7^{h-l}	42.5^{e-i}	78.5^{d-k}	27.7^{e-j}	30.7^{a-d}
Kate-1	101.0^{b-g}	9.6^{m-p}	17.5^{i-l}	28.8^{m-p}	4.7^{no}	36.8^{no}	77.5^{k}	26.9^{g-j}	28.2^{a-d}
Gelibolu	83.7^{ijk}	9.8^{l-o}	18.4^{f-l}	50.2^{abc}	7.6^{abc}	45.1^{cde}	78.7^{d-j}	28.5^{d-i}	28.4^{a-d}
Prostor	96.5^{d-i}	8.2^{q}	17.4^{j-l}	36.1^{i-l}	5.9^{f-k}	41.6^{g-k}	77.8^{g-k}	26.8^{g-j}	33.0^{ab}
Saraybosna	78.6^{jk}	8.5^{pq}	19.0^{c-k}	36.0^{i-l}	3.8^{pq}	28.4^{p}	77.8^{g-k}	28.0^{d-j}	32.8^{ab}
Tekirdag	86.3^{h-k}	8.8^{opq}	18.1^{g-l}	26.8^{op}	5.5^{j-m}	37.0^{no}	77.7^{h-k}	26.2^{g-j}	25.8^{d}
Saban	91.4^{g-j}	10.0^{k-n}	19.6^{b-i}	42.4^{e-i}	6.6^{efg}	42.9^{d-i}	77.8^{g-k}	26.7^{g-j}	28.1^{a-d}
Kopru	89.9^{g-j}	9.7^{l-o}	19.6^{b-h}	46.1^{b-f}	5.8^{g-k}	47.9^{bc}	79.4^{b-e}	28.9^{d-i}	29.9^{a-d}
Yuksel	86.6^{h-k}	10.4^{h-n}	19.1^{b-k}	44.5^{b-f}	4.8^{no}	43.2^{d-h}	79.2^{b-f}	27.2^{f-j}	29.6^{a-d}
Reis	110.3^{abc}	11.5^{c-h}	19.6^{b-h}	37.5^{g-l}	7.0^{cde}	50.9^{a}	80.3^{ab}	28.5^{d-i}	32.5^{bc}

All of these traits are yield components that have a direct impact on grain yield. As reported by Chaudhary et al. (2018), wheat cultivars' plant height, spike length, number of spikelets per spike, and number of grains per spike ranged from 71.5-140.0 cm, 7.4-13.2 cm, 17.0-23.6 number, and 36.3-82.0 seed, respectively. Xhulaj et al. (2019) reported that wheat cultivars' plant height, spike length, number of spikelets per spike, and number of grains per spike ranged from 82.9-180.3 cm, 6.4-17.8 cm, 10.6-26.6 number, and 12.8-71.0 seed, respectively.

Grain yield has the most complex heredity of any agronomic parameter, making genetic advances in this area difficult. To determine a genotype's yield potential, it should be tested at more than one location with various climate and soil conditions or for more than one year (Ceseviien et al., 2009). Grain yields of examined wheat cultivars ranged from 3.5 (Mufitbey) to 8.1 (Yunus) t ha-1 on average over two years (Table 3). When the average quantity of precipitation in the vegetative season was lower (436.1 mm) (Table 1), grain yield was lower in 2020-2021 (5.3 t ha^{-1}) (Fig.1). Previous research indicates that grain yield wheat varies depending on the variety utilized, the ecological structure of the location, and the cultural procedures used (Mut et al., 2017; Kondi'c-pika et al., 2019; Albayrak et al., 2022). In this experiment, the observed variations in the grain yields and yield components of the cultivars were assumed to be due to differences in rainfall rather than to variation in average temperatures. Total rainfall was higher in the first year (482.6 mm) than the second year (436.1 mm). Grain yield and yield components were affected by the experimental year's weather conditions, but the genotype of the variety had an impact on the variation as well.

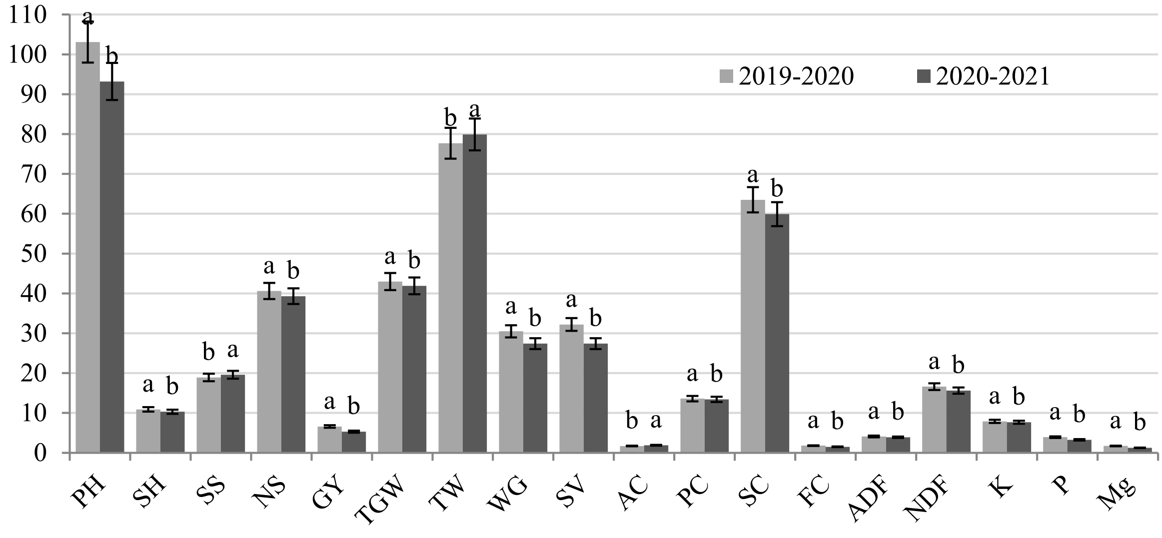

Figure 1 Mean values and standard deviation for grain yield and quality traits of wheat cultivars in 2019-2020 and 2020-2021. Bars not accompanied by the same letter are significantly different at $P < 0.05$, using Tukey HSD test (PH= plant height (cm), SH=SL= spike length (cm), SS =number of spikelets per spike (no), NS= number of grains per spike (seed), GY = grain yield (t ha^{-1}), TGW= thousand-grain weight (g), TW= Test Weight (kg hL^{-1}), WG= wet gluten (%), SV=Zeleny sedimentation value (ml), AC = ash content (%), PC = protein content (%), SC = starch content (%), FC = fat content (%), ADF = acid detergent fiber (%), NDF = neutral detergent fiber (%), K = potassium (g kg^{-1}), P = phosphorus (g kg^{-1}), Mg = magnesium (g kg^{-1})

According to combined variance analysis, the thousand-grain weight and test weights of the cultivars ranged from 28.4 (Saraybosna) to 50.9 g (Reis) and 77.5 (Kate-1) to 81.1 kg (Nusrat), respectively (Table 3). The first year had a greater thousand-grain weight, while the second year had a higher test weight (Fig. 1). In the wheat industry, thousand grain weight and test weight are essential quality factors that determine flour yield. The thousand-grain weight is considered as a good measure in estimating the amount of flour in wheat, since the endosperm is higher than the small grained ones in large and dense grains in wheat (Mut et al., 2007). Genetic structure and environmental factors influence the thousand grain weight, which impacts grain yield and quality. Different researchers found in their investigations on bread wheat genotypes that thousand-grain weights varied according to genetic, farming methods, and environmental variables (Kara and Akman, 2008; Mut et al., 2017; El Refaey et al., 2022; Osekita et al., 2022). Although test weight is an important quality factor, it is also a key criterion in determining variety quality. Test weight changes according to factors such as genotypic performance, environmental conditions, agricultural techniques, illnesses, and pests. Furthermore, biotic and abiotic factors that cause the wheat grain to remain tiny influence the test weight (Yuce et al., 2022). Furthermore, while environmental factors such as precipitation and temperature during the growing season influence test weight, structural characteristics of the grain such as grain filling, length of vegetation period, grain size and shape, abdominal cavity, and wrinkling also influence it (Aguirre et al., 2002).

The average wet gluten and Zeleny sedimentation values of wheat cultivars ranged from 24.2 (Acar) to 35.2% (Altay-2000) and from 25.8 (Tekirdag) to 33.5 ml (Altay-2000), respectively (Tables 3 and 4). The wet gluten and Zeleny sedimentation values were higher in the first year (Fig. 1). In bread flour, gluten proteins are important components in terms of dough swelling and elasticity (Egesel et al., 2009). Gluten proteins, which form a mesh-like structure during the kneading of the dough, ensure that the carbon dioxide formed by the yeast is retained and the dough swells; therefore, the amount of gluten is one of the most important features in determining the flour quality. In the evaluation of wet gluten amount results, ≤ 20% (low), 20-27% (moderate), 28-35% (good) and > 35% (high) criteria are used (Ozen and Akman, 2015). One of the important tests determining gluten quality is sedimentation value (Zeleny et al., 1960). It is desired that the sedimentation value is high in bread wheat quality because, as the Zeleny sedimentation value increases, the bread volume also increases. In the evaluation of sedimentation amount results, ≤ 15 (very bad), 16-21 (poor), 22-27 (moderate), 28-33 (good) and > 33 (very good) parameters are used (Sanal et al., 2009). It has been reported that the wet gluten content and sedimentation value of quality bread wheat flour should be above 28% and 25%, respectively

(Mutlu and Tas, 2020). Different researchers have reported that the sedimentation and the wet gluten values differ according to the cultivars in their studies (Karaduman et al., 2021).

On the other hand, the amount of ash, protein, starch, fat, ADF, NDF and mineral contents were determined in both wheat whole grain flours and bran in the study. The means of ash, protein, starch, fat, ADF and NDF content of whole wheat grain were 1.8% (range: 1.5-2.2 %), 13.5% (range: 12.7-14.7%), 61.7% (range: 59.1-66.3%), 1.7 % (range: 1.2-2.1%), 4.1 % (range: 2.9-5.2%) and 16.1% (range: 13.8-20.6%), respectively. The K, P and Mg contents of whole wheat grains ranged from 6.7 (Bereket) to 8.6 (Gerek-79) g kg^{-1}, 2.8 (Bereket) to 4.2 (Kopru) g kg^{-1} and 1.1 (Bereket) to 2.1 (Reis) g kg^{-1}, respectively (Table 2 and Table 4). All of these traits examined in the first year (except for ash content) were higher than in the second year in the cultivars (Fig. 1).

Table 4 Average values of grain quality traits of wheat cultivars over two years

Cultivars	AC	PC	SC	FC	ADF	NDF	K	P	Mg
Momtchil	1.8^{a-d}	13.8^{abc}	60.0^{c-f}	1.8^{a-f}	4.7^{a-d}	17.3^{b}	8.2^{a-f}	3.9^{abc}	1.8^{abc}
Beskopru	1.9^{a-d}	13.8^{abc}	62.7^{b-f}	1.6^{g-l}	4.2^{a-g}	15.8^{bcd}	8.0^{a-i}	3.7^{a-f}	1.5^{b-i}
Acar	1.7^{bcd}	12.8^{bc}	62.9^{a-e}	1.7^{d-k}	5.0^{ab}	16.1^{bcd}	8.3^{abc}	3.8^{a-e}	1.4^{c-i}
Altug	1.9^{a-d}	13.2^{abc}	61.7^{b-f}	1.8^{b-h}	3.6^{e-j}	15.4^{cde}	8.1^{a-h}	3.7^{a-f}	1.5^{b-i}
Alada	1.6^{cd}	13.0^{bc}	62.3^{b-f}	1.8^{a-f}	3.8^{d-j}	15.2^{de}	7.2^{h-k}	3.5^{b-g}	1.4^{c-i}
Nusrat	1.9^{a-d}	14.1^{abc}	62.2^{b-f}	1.8^{b-i}	3.5^{g-j}	13.8^{e}	8.2^{a-f}	3.5^{b-g}	1.3^{e-k}
Adali	1.6^{cd}	12.7^{c}	63.3^{abc}	1.6^{e-k}	4.1^{b-h}	15.7^{bcd}	7.3^{e-k}	3.4^{c-g}	1.4^{c-i}
Halis	2.0^{abc}	13.1^{bc}	61.8^{b-f}	1.9^{a-e}	4.4^{a-f}	15.8^{bcd}	7.4^{c-k}	3.5^{b-g}	1.3^{e-k}
Bezostaja-1	1.8^{a-d}	14.7^{a}	59.5^{ef}	1.4^{klm}	3.7^{e-j}	16.9^{bcd}	8.1^{a-h}	4.0^{ab}	1.9^{ab}
Gerek-79	1.9^{a-d}	13.6^{abc}	60.7^{b-f}	1.3^{lm}	3.8^{d-j}	16.7^{bcd}	8.6^{a}	3.5^{b-g}	1.4^{c-i}
Harmankaya-99	1.8^{a-d}	13.0^{bc}	62.5^{b-f}	2.0^{ab}	4.9^{abc}	16.4^{bcd}	7.6^{b-j}	3.4^{c-g}	1.4^{c-i}
Altay-2000	1.8^{bcd}	14.0^{abc}	61.6^{b-f}	1.2^{m}	3.9^{d-j}	15.3^{de}	7.6^{b-j}	3.3^{d-g}	1.2^{ijk}
Sonmez-2001	1.7^{bcd}	14.2^{ab}	60.7^{b-f}	1.5^{j-m}	3.2^{hij}	15.7^{bcd}	7.7^{a-j}	3.5^{b-g}	1.6^{b-h}
Izgi-2001	1.6^{cd}	14.2^{ab}	61.4^{b-f}	1.6^{g-l}	3.4^{g-j}	15.8^{bcd}	7.8^{a-i}	3.5^{b-g}	1.6^{b-h}
Soyer-02	1.6^{bcd}	12.7^{c}	63.3^{abc}	1.5^{i-l}	4.5^{a-f}	15.6^{bcd}	7.2^{f-k}	3.4^{c-g}	1.3^{e-k}
Mufitbey	1.8^{bcd}	13.5^{abc}	60.6^{b-f}	1.6^{e-k}	3.5^{f-j}	15.8^{bcd}	8.2^{a-d}	3.6^{a-g}	1.5^{b-i}
Nacibey	1.8^{a-d}	13.7^{abc}	61.1^{b-f}	1.7^{b-i}	4.1^{b-i}	16.2^{bcd}	7.9^{a-i}	3.5^{b-g}	1.4^{c-i}
ES-26	1.9^{a-d}	14.0^{abc}	59.6^{ef}	1.6^{f-l}	4.0^{c-i}	16.1^{bcd}	8.4^{ab}	3.6^{a-g}	1.5^{b-i}
Mesut	1.6^{cd}	13.5^{abc}	61.6^{b-f}	1.6^{d-k}	3.8^{d-j}	16.1^{bcd}	7.5^{b-k}	3.6^{a-g}	1.6^{b-h}
Sultan 95	1.9^{a-d}	13.8^{abc}	61.7^{b-f}	1.7^{c-j}	3.6^{e-j}	16.5^{bcd}	7.1^{i-k}	3.1^{gh}	1.3^{e-k}
Alpu 2001	2.0^{abc}	13.7^{abc}	59.1^{f}	1.7^{d-k}	4.4^{a-g}	16.6^{bcd}	7.4^{d-k}	3.2^{fgh}	1.3^{e-k}
Yunus	1.8^{a-d}	13.1^{bc}	61.7^{b-f}	1.6^{d-k}	5.2^{a}	17.1^{bc}	7.7^{a-j}	3.8^{a-d}	1.6^{b-h}
Bereket	1.6^{cd}	12.8^{bc}	63.9^{ab}	1.6^{f-l}	4.2^{a-g}	15.1^{de}	6.6^{k}	2.8^{h}	1.1^{k}
Aldane	1.5^{d}	14.1^{abc}	63.0^{a-e}	1.2^{m}	3.1^{ij}	15.7^{bcd}	7.5^{b-k}	3.5^{b-g}	1.5^{b-i}
Atilla-12	1.9^{a-d}	13.1^{abc}	61.6^{b-f}	1.8^{b-g}	4.3^{a-g}	16.0^{bcd}	8.1^{a-h}	3.6^{a-g}	1.4^{c-i}
Selimiye	1.6^{cd}	13.4^{abc}	62.2^{b-f}	1.6^{g-l}	2.9^{j}	15.6^{b-e}	7.4^{c-k}	3.4^{c-g}	1.4^{c-i}
Pehlivan	1.7^{bcd}	14.1^{abc}	59.7^{def}	1.6^{g-l}	3.8^{d-j}	16.3^{bcd}	8.1^{a-h}	3.6^{a-g}	1.6^{b-h}
Kate-1	1.9^{a-d}	13.1^{bc}	59.6^{ef}	1.9^{a-d}	4.3^{a-g}	16.7^{bcd}	8.1^{a-h}	3.8^{a-e}	1.7^{bcd}
Gelibolu	1.7^{bcd}	13.3^{abc}	63.2^{a-d}	1.9^{a-d}	4.2^{b-g}	15.5^{cde}	7.1^{h-k}	3.6^{a-g}	1.4^{c-i}
Prostor	1.6^{d}	13.5^{abc}	62.7^{b-e}	1.8^{b-i}	4.2^{a-g}	15.3^{de}	7.2^{g-k}	3.3^{d-g}	1.3^{e-k}
Saraybosna	2.0^{abc}	13.7^{abc}	61.2^{b-f}	1.8^{b-i}	5.0^{abc}	16.9^{bcd}	8.2^{a-f}	4.0^{ab}	1.6^{b-h}
Tekirdag	1.7^{bcd}	12.8^{bc}	61.5^{b-f}	1.4^{klm}	4.0^{c-i}	15.7^{bcd}	6.8^{jk}	3.1^{gh}	1.2^{jk}
Saban	1.9^{a-d}	13.1^{bc}	61.2^{b-f}	2.1^{a}	3.8^{d-j}	15.9^{bcd}	7.3^{d-k}	3.4^{c-g}	1.3^{e-k}
Kopru	2.2^{a}	13.9^{abc}	61.1^{b-f}	1.8^{b-i}	4.7^{a-d}	16.6^{bcd}	8.6^{a}	4.2^{a}	1.7^{bcd}
Yuksel	1.9^{a-d}	13.4^{abc}	61.5^{b-f}	2.0^{abc}	4.6^{a-e}	15.8^{bcd}	8.2^{a-f}	3.6^{a-g}	1.4^{c-i}
Reis	1.6^{cd}	14.2^{ab}	66.3^{a}	1.5^{h-l}	4.7^{a-d}	20.6^{a}	8.0^{a-i}	3.6^{a-g}	2.1^{a}

Whole wheat flour has a rough appearance and contains the endosperm of the wheat kernel, germ, and bran. Wheat is essential for the health of people due to its large number of diet contents and nutritional value. Carbohydrates (78%), protein (14%), fat (2%), minerals (2.5%), and vitamins make up the whole wheat (Topping, 2007). Whole-grain flours and whole-grain foods made from them are actively promoted as part of a healthy, sustainable diet profile based on the need for higher intakes of plant-based dietary fiber-containing foods and lower consumption of higher fat meat and animal products (Seal et al., 2021). Whole-grain flours are more nutrient-dense than refined (white) flours because they retain the bran and germ fractions of the grain that are separated from the starchy endosperm during the manufacture of refined flours. The bran and germ contribute a range of nutrients including minerals, vitamins, phytochemicals and dietary fiber, so any food made with whole grain will be richer in these nutrients and phytochemicals (Zhu and Sang, 2017).

When the bran content is evaluated the means of ash, fat, protein, starch, ADF and NDF content were determinate as 6.3% (range: 5.7-6.8 %), 3.7% (range: 2.8-4.3%), 17.1% (range: 15.9-18.8%), 23% (range: 19.2-28.4%), 10.3% (range: 7.1-15.0%) and 35.6% (range: 30.6-38.5%), respectively. The K, P and Mg contents of wheat bran ranged from 10.7 (Altug) to 14.1 (ES-26) g kg-1, 5.8 (Reis) to 6.6 (ES-26) g kg-1 and 2.7 (Nusrat) to 3.1 (ES-26) g kg-1, respectively (Table 2 and 5). All of these traits examined in the first year (except for fat and protein content) were higher than in the second year in the cultivars (Fig. 2). Significant differences in the chemical composition of wheat bran were observed between cultivars and years.

Table 5 Average values of quality traits in bran of wheat cultivars over two years

Cultivars	BAC	BFC	BPC	BSC	BADF	BNDF	BK	BP	BMg
Momtchil	6.8^{ab}	4.0^{a-d}	16.9^{c-k}	21.7^{o-r}	11.2^{d-g}	35.6^{d-j}	12.3^{e-i}	6.5^{ab}	3.1^{ab}
Beskopru	6.6^{a-e}	3.3^{g-j}	16.1^{ijk}	20.9^{p-s}	11.0^{efg}	38.1^{ab}	14.0^{ab}	6.4^{abc}	2.9^{abc}
Acar	6.6^{a-d}	3.7^{d-h}	17.5^{a-h}	26.2^{bc}	8.9^{lmn}	33.0^{klm}	12.4^{d-i}	6.3^{a-f}	2.8^{abc}
Altug	5.7^{l}	4.1^{abc}	17.5^{b-h}	24.1^{f-l}	9.8^{h-l}	30.6^{n}	10.7^{o}	5.9^{klm}	2.7^{bc}
Alada	6.3^{c-k}	4.2^{ab}	16.3^{h-k}	25.3^{b-f}	10.2^{g-k}	36.0^{b-j}	11.5^{h-o}	6.1^{f-l}	2.8^{abc}
Nusrat	5.9^{jkl}	4.0^{a-e}	17.2^{c-j}	28.4^{a}	9.6^{i-m}	30.6^{mn}	10.9^{no}	6.0^{i-m}	2.6^{c}
Adali	6.5^{a-g}	4.0^{a-d}	16.4^{g-k}	22.3^{m-p}	11.2^{d-g}	36.0^{b-j}	12.1^{f-k}	6.3^{a-f}	2.9^{abc}
Halis	6.5^{a-h}	3.7^{c-g}	16.1^{ijk}	23.2^{i-n}	11.4^{c-f}	36.7^{a-g}	13.2^{a-d}	6.5^{ab}	2.9^{abc}
Bezostaja-1	6.3^{a-j}	4.0^{a-e}	18.0^{a-e}	24.4^{d-k}	8.7^{lmn}	34.7^{g-l}	11.2^{l-o}	6.3^{a-f}	2.9^{abc}
Gerek-79	6.5^{a-h}	2.8^{k}	18.8^{a}	23.9^{f-l}	9.4^{j-m}	36.4^{a-h}	12.9^{c-f}	6.3^{a-f}	2.9^{abc}
Harmankaya-99	6.4^{a-i}	4.0^{a-e}	17.1^{c-k}	23.7^{g-m}	10.3^{f-j}	36.7^{a-g}	12.4^{d-h}	6.2^{b-j}	2.9^{abc}
Altay-2000	6.0^{h-l}	3.3^{hij}	18.7^{ab}	27.9^{a}	7.1^{p}	33.7^{jkl}	11.5^{i-o}	6.2^{b-j}	2.7^{bc}
Sonmez-2001	6.3^{b-j}	3.8^{c-f}	16.8^{d-k}	23.0^{k-o}	10.9^{efg}	37.0^{a-g}	12.5^{c-g}	6.3^{a-f}	2.9^{abc}
Izgi-2001	6.2^{d-k}	3.7^{c-g}	17.0^{c-k}	24.9^{b-h}	8.1^{nop}	34.1^{h-l}	11.4^{j-o}	6.2^{b-j}	2.8^{abc}
Soyer-02	6.1^{g-l}	3.7^{d-h}	18.2^{abc}	26.3^{b}	7.5^{op}	32.4^{lmn}	11.4^{j-o}	6.5^{ab}	2.9^{abc}
Mufitbey	6.1^{e-k}	4.1^{abc}	16.1^{ijk}	20.5^{rst}	10.2^{f-j}	36.6^{a-g}	12.0^{g-l}	6.0^{i-l}	2.9^{abc}
Nacibey	6.5^{a-i}	3.6^{e-h}	16.0^{jk}	22.1^{n-q}	13.2^{b}	38.5^{a}	13.3^{abc}	6.3^{a-f}	3.0^{ab}
ES-26	6.7^{ab}	3.2^{ijk}	18.1^{a-d}	21.1^{pqr}	10.8^{e-h}	37.5^{a-e}	14.1^{a}	6.6^{a}	3.2^{a}
Mesut	6.5^{a-f}	3.0^{jk}	16.6^{f-k}	23.7^{g-m}	12.2^{bcd}	37.5^{a-e}	12.9^{c-f}	6.4^{abc}	2.9^{abc}
Sultan 95	6.1^{d-k}	3.3^{hij}	16.4^{g-k}	24.6^{d-j}	10.9^{e-h}	37.6^{a-d}	12.0^{g-k}	6.1^{f-l}	2.8^{abc}
Alpu 2001	6.0^{h-l}	3.4^{g-j}	16.8^{e-k}	24.6^{d-j}	11.0^{efg}	35.7^{c-j}	11.0^{mno}	5.9^{lm}	2.7^{bc}
Yunus	6.5^{a-h}	3.5^{f-i}	16.8^{e-k}	22.8^{l-o}	12.5^{bc}	38.3^{ab}	13.2^{abc}	6.5^{ab}	2.9^{abc}
Bereket	6.3^{c-k}	3.9^{b-e}	16.1^{ijk}	23.1^{j-o}	10.5^{f-i}	36.3^{a-i}	12.1^{f-k}	6.3^{a-f}	2.8^{abc}
Aldane	6.3^{c-k}	3.7^{c-g}	17.8^{a-f}	24.1^{f-l}	8.6^{lmn}	34.6^{g-l}	11.7^{g-n}	6.3^{a-f}	2.8^{abc}
Atilla-12	5.9^{jkl}	4.3^{ab}	15.9^{k}	23.5^{h-n}	11.7^{cde}	34.8^{g-l}	11.3^{k-o}	6.1^{f-l}	2.9^{abc}
Selimiye	6.8^{a}	3.8^{a-f}	16.9^{d-k}	19.2^{t}	11.9^{cde}	38.3^{ab}	12.3^{f-j}	6.4^{abc}	3.0^{ab}
Pehlivan	6.5^{a-e}	3.4^{f-i}	17.3^{c-i}	19.5st	11.7^{cde}	38.1^{abc}	12.2^{f-j}	6.2^{b-j}	2.9^{abc}
Kate-1	6.2^{c-k}	4.1^{abc}	17.6^{a-g}	24.5^{d-j}	8.4^{mno}	34.1^{h-l}	12.0^{g-k}	6.3^{a-f}	2.8^{abc}
Gelibolu	6.2^{d-k}	4.2^{ab}	16.9^{c-k}	24.2^{e-l}	9.0^{k-n}	34.7^{g-l}	12.0^{g-k}	6.2^{b-j}	2.8^{abc}
Prostor	6.3^{c-k}	3.5^{f-i}	17.5^{b-h}	25.7^{b-e}	9.1^{k-n}	34.2^{h-l}	11.9^{g-m}	6.1^{f-l}	2.7^{bc}
Saraybosna	6.1^{e-k}	3.6^{e-h}	16.9^{d-k}	21.1^{pqr}	11.3^{d-g}	36.5^{a-h}	11.7^{g-n}	6.1^{f-l}	2.8^{abc}
Tekirdag	6.1^{f-l}	4.3^{a}	16.7^{f-k}	24.7^{c-i}	8.8^{lmn}	35.2^{e-k}	11.9^{g-m}	6.4^{abc}	2.8^{abc}
Saban	6.5^{a-i}	4.0^{a-e}	16.9^{d-k}	20.6^{q-t}	11.2^{d-g}	37.4^{a-f}	12.5^{c-g}	6.3^{a-f}	3.0^{ab}
Kopru	6.0^{i-l}	4.0^{a-d}	17.2^{c-j}	25.7^{bcd}	9.7^{h-l}	35.0^{f-k}	13.2^{b-e}	6.5^{ab}	2.9^{abc}
Yuksel	5.9^{kl}	4.1^{abc}	16.8^{d-k}	25.2^{b-g}	9.3^{j-m}	34.8^{g-l}	12.2^{f-j}	6.2^{b-j}	2.8^{abc}
Reis	6.6^{abc}	3.0^{jk}	18.0^{a-e}	26.2^{bc}	15.0^{a}	33.9^{i-l}	12.2^{f-j}	5.7^{m}	3.0^{ab}

Wheat bran is a by-product of milling that has a high nutrient content. Bran makes up roughly 14.5% of the weight of the kernel (Uauy et al., 2006). Bran can be present in whole wheat flour and can also be purchased individually. However, it is not broadly consumed by humans but is used for animal feed. Wheat bran contains more than 15% high-quality proteins, but most of them are enclosed within a matrix of cell wall polysaccharides and, so they are poorly digested (Balandrán-Quintana et al., 2015). According to nutritional point of view, the wheat bran is highly rich in different nutrients like fiber, vitamin B6, thiamine, folate and vitamin E, sterols, and antioxidants including bioactive compounds like alkyl resorcinol, ferulic acid, flavonoids, carotenoids, and lignans, which are also known as phytochemicals (Budhwar et al., 2020; Deroover et al., 2020). For these reasons, the use of wheat bran for human consumption has gradually increased. Due to its cheap and easy availability, high nutritional content and being a natural component of wheat, it is consumed without hesitation by consumers. In addition, studies on the possibilities of using resources that are released as a by-product in the food industry, which are generally considered animal feed and have low economic added value and contain significant fiber, in human nutrition have gained importance. It is also an important by-product recommended for lowering cholesterol, preventing heart diseases, and certain types of cancer (Javed et al., 2012). Moreover, wheat bran is an important feed source, especially for the nutrition of ruminant animals, because it contains more protein than the kernel. In animal nutrition, the K ratio should be 0.70% in the total ration, the P ratio should be at least 0.3 to 0.5% and the Mg ratio should be a minimum of 0.35% (McDowell, 1992; Harris et al., 1994). The study found high ratios of P (0.6%) and K (0.98%) in bran. Mineral matter is still higher in bran than in the kernel (Table 1). This study shows that wheat bran is a valuable animal feed in terms of mineral content. In a study conducted on wheat bran, it was found that the protein content ranged between 9.6% and 18.6%, the ash ratio between 3.9% and 8.10%, and the starch content between 9.1% and 38.9% (Curti et al., 2013).

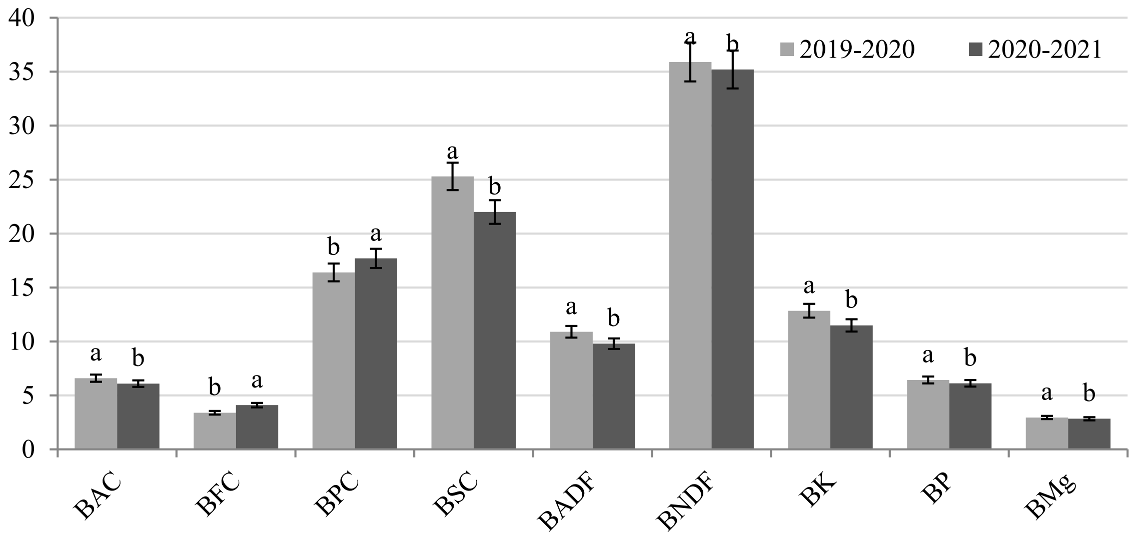

Figure 2. Mean values and standard deviation for quality traits in bran of wheat cultivars in 2019-2020 and 2020-2021. Bars not accompanied by the same letter are significantly different at $P < 0.05$, using Tukey HSD test (BAC = ash content (%), BFC = fat content (%), BPC = protein content (%), BSC = starch content (%), BADF = acid detergent fiber (%), BNDF = neutral detergent fiber (%), BK = potassium (g kg^{-1}), BP = phosphorus (g kg^{-1}), BMg = magnesium (g kg^{-1})

CONCLUSION

Wheat is the most important food component around the globe. It is commonly used in its refined form, excluding the Bran. In recent years, with the increased awareness of consumers, the interest in products that use cereal bran and whole grain flour (especially wheat) has increased. Turkey, being an agricultural country, produces tons of wheat each year. Each year millions and tons of bran are produced as a by-product of the wheat milling industry. Wheat bran from wheat-milling industries in our country can serve as a potential nutritious and cheap raw material for the fermentation industry, feed and food. In the study, Yunus, Elibolu, Bereket, Mesut and Adali varieties were determined as the varieties with the highest grain yield. Moreover, significant differences were observed between the cultivars in terms of the chemical composition of the bran and the grain of wheat. Protein from whole grains and bran varied between 12.7 and 14.7% and 2.8 and 4.3%, respectively. It is expected that the data obtained in this study will be reported in the literature, evaluated in terms of product quality and taken into account in breeding programs.

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