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Some chemical and technological properties of Turkish triticale (*Triticosecale* Wittm.) genotypes

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Abstract

Triticale was developed by man-crossing to combine the grain yield and quality of wheat and the durability of rye. The bread-making quality of triticale is inferior to wheat. Although it is mainly used as feeding animal, the potential of bread-making quality of Turkish triticale genotypes has not been fully investigated. This study was conducted to determine bread-making qualities of seven Turkish triticale genotypes in a randomized block design with 3 replicates over a two-year trial in Biga, Turkey. Significant differences were determined among the triticale genotypes for the traits studied including grain moisture, protein content, gluten, gluten index, Zeleny sedimentation, modified sedimentation, falling number and ash. According to mean values over two years, the mean values of the genotypes ranged from 10.8 to 12.1% for grain moisture, 9.8 to 12.0% for protein, 22.3 to 26.7% for gluten, 61.3 to 69.2% for gluten index, 14.2 to 22.2 ml for Zeleny sedimentation, 17.8 to 28.2 ml for modified sedimentation, 161.5 to 267.3 s for falling number and 0.59 to 0.64% for ash. The results revealed that the triticale genotypes had inferior parameters for bread-making quality, and they could be used in blends with bread wheat.

Keywords: Bread-making quality, Falling number, Gluten, Gluten index, Protein content

1. Introduction

Triticale is an inter-generic crossing of wheat and rye. The main aim of the crossing is to merge the characteristics of both parental cereals; the grain yield and quality of wheat with the resistance to pathogens and pests and the environmental tolerance of rye. Cereal scientists and breeders have been trying to combine the yield, quality and uniformity properties of wheat, which is unique among other cereals in bread making, with the vigor and hardiness of rye for many years. As a result of triticale improvement programs conducted worldwide, many triticale varieties have been developed and registered, producing high grain yield in marginal fields. Stable tetraploid, hexaploid and octoploid triticale varieties have been bred from crossing wheat and rye; from crossing two triticale varieties; and crossing from a triticale with a wheat or rye variety (D. SALMON & al. [1]).

Cereals which provide the major source of energy, protein, and minerals are of great importance for human consumption for bread-based diets in countries including Turkey. The consumption of triticale depends on its highly variable chemical composition and is more similar to wheat than rye. However triticale contains high dietary fiber which is anti-nutritional, it is mainly used as feeding livestocks as grain, silage, forage etc. It is not used in bread-making industry on a large scale because it has low gluten content and inferior rheological properties. Triticale is generally soft-textured and the baking of crackers, cakes, biscuits, and cookies requires soft flour. Some triticale varieties have high α-amylase activity (J. LAFFERTY, T. LELLEY, [2]). The superior lysine content of triticale, which is the limiting amino acid in cereals, provides a better source of protein with good biological value. Nowadays, it can also be used in the brewing industry (GLATTHAR & al. [3]).

Due to the higher competitiveness of industrial crops across the cereals and the low-income of the farmers obtained from the cereals, their cultivation area has drastically decreased in Turkey as well as in Biga in the last decades. The area sown with cereals was 18 087 000 ha in 2001, while it was 15 692 000 ha in 2011 in Turkey. The area cultivated with wheat was 9.350.000 ha in 2001, while it was decreased to 8 096 000 ha in 2011 in Turkey. Triticale could be a new plant material to be cultivated by the farmers in the region as well as in Turkey, and its cultivation area, production and yield were 29 783 ha, 103 797 tons and 349 kg da^{-1} respectively in 2011 in the country (ANONYMOUS, [4]). In 2012, the area sown with triticale was 1 097 ha with a production of 4 118 tons and with a yield of 375 kg da^{-1} in Çanakkale province (ANONYMOUS, [5]). Some big and small dams as well as the channels and the canals have been constructed for irrigation in Biga, resulted a decrease in bread-wheat planting area in the region. Since our daily diets depend mainly upon the cereal, cultivation of cereals over infertile and unproductive soils and fields is needed. Triticale, as an alternative crop, may be grown in these conditions. Herewith the miller's requirements and baker's expectations as well as the consumer's expectations using different flour mixture of wheat with triticale have to be satisfied.

The objectives of this study were to examine the grain quality characteristics of seven Turkish triticale genotypes grown in Biga in the northwest Turkey, and to determine the potential of bread-making properties.

2. Materials and Methods

The data were collected from a two-year trial in which seven triticale genotypes were grown in Aşağı Demirci in Biga, in the northwest part of Turkey. Among them, the genotypes Alperbey, Melez 2001, Mikham 2002 and Tatlıcak 97 were obtained from Bahri Dağdaş International Agricultural Research Institute (Konya); Karma 2000 and Presto from Trakya Agricultural Research Institute (Edirne), and Egeyıldızı from Ege Agricultural Research Institute (İzmir). Of those genotypes, Egeyıldızı is spring genotype; the others are winter and facultative genotypes. The field experiments were conducted in a randomized block design with three replications in the growing seasons of 2010-2011 and 2011-2012. The experimental soil was clay loam with a pH of 6,7. Its characteristics were presented in Table 1 (ANONYMOUS, [6]).The field trials were sown at a rate of 500 seeds m^{-2}. Each plot consisted of 6 rows, 6 m long, with rows 20 cm apart. All plots were fertilized at the sowing time with 30 kg ha^{-1} N, 50 kg ha^{-1} P_2O_5, and in the beginning of stem elongation with 30 kg ha^{-1} N. Sowings were performed on 25 November 2010 for the first year and 22 November 2011 for the second year by hand. Recommended herbicide (2,4-D) was applied to control the broad-leaved weeds before the beginning of stem elongation of the plant materials. The crops were hand harvested in the first week of July for both years.

The experimental grain quality analyses in triplicate were carried out at the laboratory of Kaptanlar Un AŞ in Biga. Moisture content was determined by drying grain samples at 105 °C. Kjeldahl analysis was used to determine the protein contents of the genotypes. The gluten, gluten index, Zeleny sedimentation and falling number were performed by the standard methods of the International Cereal Chemistry (ICC, [7]). Flour milling was performed in a Chopin mill (Moulin Cd Type), using the grains previously tempered. The gluten and gluten index of the flour were performed according to the ICC standards (No. 137, 155 and 158) using a Glutomatic 2200 instrument. Falling number was done following the ICC standard No. 107. Zeleny sedimentation test (ICC standard method No.116) and modified sedimentation (A. ELGÜN & al. [8]) were taken. Ash content was determined by ICC method 104.

The statistical analyses of the measured parameters were carried out using the software package program (SAS, [9]), and the Tukey test was used to determine the significances of differences. Least significant differences (LSD) among the mean values were evaluated at the level of 5%.

Table 1: Soil properties of the experimental field

Properties	Values
pH	6.7
Saturation (%)	59.0
EC (mmhos cm^{-1})	480.0
Total Lime (%)	0.4
Organic Matter (%)	4.0
Available P (kg da^{-1})	43.0
Available K (kg da^{-1})	176.0

3. Results and Discussion

Mean values of the first and second growing seasons of the grain quality parameters evaluated were shown in Table 2. The differences between the two years were significant for all the traits studied except for grain moisture. Data describing the properties of the grain quality for seven triticale genotypes were presented in Table 3.

Table 2: Mean values of the first year and second year*

Years	M (%)	P (%)	GL (%)	GI (%)	S (ml)	MS (ml)	FN (s)	A (%)
1st year	11.6	9.42 b	23.8 b	78.8 a	16.7 b	19.7 b	254.9 a	0.62 a
2nd year	11.5	11.81 a	26.3 a	51.3 b	20.0 a	24.1 a	162.5 b	0.61 b
$LSD_{0.05}$	0.131	0.133	0.453	1.273	0.767	0.606	3.498	0.008

* Means followed by the same letter in one column are not significantly different.

M: Grain moisture, P: Protein, G: Gluten, GI: Gluten index, S: Zeleny Sedimentation, MS: Modified sedimentation, FN: Falling number and A: Ash.

Moisture Content

The mean values of the moisture contents of the genotypes were 11.6% for the first year and 11.5% for the second year, and the differences by years were not significant (Table 2). The differences among the genotypes were significant, ranging from 12.1% (Egeyıldızı) to 10.8% (Tatlıcak97) (Table 3). Moisture content of the grains is important in term of storage and trade (A. ELGÜN & al. [8]). High grain moisture may cause higher microbial activity and lower dry matter meaning lower crop price for growers and unsuitable conditions for the storage.

Protein Content

As far as the protein contents of the genotypes were considered, they were ranged from 9.8% to 12.0% (Table 3). Mean protein content was higher in the second year (11.81%) than in the first year (9.42%). The differences between the years were significant (Table 2). O. EREKUL, W. KÖHN, [10] investigated four triticale varieties in two locations, and found that the crude protein contents ranged from 10.9 % to 17.0%. L.J. MACRI & al. [11] found protein contents of the triticales from 9.3 % to 12.9 %. In another study, the protein content of

12 triticale cultivars varied from 9.7-14.5% with an average of 11.8 % (M. TOHVER & al. [12]). Flour characteristics such as gluten, water absorption, loaf volume are highly correlated with protein content (Y. POMERANZ [13]). A strong relationship exists between protein content and bread-making quality in cereals, and bread wheat has the superior properties among the other cereals. In this study, the findings on the protein content were in agreement with above studies.

Table 3: Means of grain quality properties of seven triticale genotypes over two years*

Genotypes	M (%)	P (%)	G (%)	GI (%)	S (ml)	MS (ml)	FN (s)	A (%)
Mikham2002	12.0 a	10.5 b	26.7 a	61.3 c	21.8 ab	28.2 a	267.3 a	0.61 cd
Alperbey	11.8 ab	9.9 c	23.4 c	64.2 bc	19.7 b	22.2 b	258.2 a	0.59 d
Presto	11.5 b	9.8 c	24.9 b	65.0 bc	14.2 d	18.5 d	161.5 e	0.61abc
Egeyıldızı	12.1 a	9.9 c	22.3 c	69.2 a	16.3 cd	17.8 d	172.8 d	0.64 a
Melez2001	10.9 c	10.4 b	25.5 ab	64.0 bc	16.8 c	19.3 cd	211.3 c	0.63 ab
Karma2000	11.5 b	11.8 a	26.2 ab	65.7 ab	17.3 c	20.5 cb	167.7de	0.63abc
Tatlıcak97	10.8 c	12.0 a	26.4 a	66.0 ab	22.2 a	26.5 a	222.0 b	0.61bcd
Mean	11.53	10.62	25.0	65.1	18.3	21.8	208.7	0.62
CV (%)	1.78	1.97	2.85	3.08	6.59	4.37	2.64	0.02
$LSD_{0.05}$	0.378	0.387	1.315	3.694	2.226	1.760	10.156	0.025

* Means followed by the same letter in one column are not significantly different.

M: Grain moisture, P: Protein, G: Gluten, GI: Gluten index, S: Zeleny Sedimentation, MS: Modified sedimentation, FN: Falling number and A: Ash.

Gluten and Gluten Index

The gluten content were significantly different from year to year, and it was higher in the second year (26.3%) than in the first year (23.8%) (Table 2). The lowest gluten contents were determined from the genotypes Alperbey (23.4%) and Egeyıldızı (22.3%) while genotypes Mikham2002 and Tatlıcak97 had the highest gluten contents (26.7% and 26.4% respectively) (Table 3). A. ELGÜN & al. [8] reported that the gluten content generally shows a positive correlation with the amount of nitrogenous matter and determines protein quality rather than protein quantity. M. TOHVER & al. [12] also reported undetectable or very low gluten content in triticale cultivars tested.

The results of this study showed significant differences for the gluten index among the genotypes tested and the average gluten indexes were determined as 78.8% and 51.3% in the first and second year, respectively (Table 2). Egeyıldızı with a value of 69.2% gave the highest gluten index, while Mikham2002 with a value of 61.3% gave the lowest (Table 3). Although mean protein and gluten contents of genotypes were lower in the first year, a higher value of average gluten index was obtained from the first year, suggesting that gluten strength and gluten quality of genotypes have been affected by the environment of the first year. Previous studies indicated that gluten index provides information about the level of gluten strength and weakness which were determined by gluten quality and quantity in a given genotype (A. ELGÜN & al. [8]; O. EREKUL, W. KÖHN [10]; P. MARTINEK & al. [14]). It is also used for many other purposes for cereal trade such as variety selection, in milling industry, in bread making and bakery (A. ELGÜN & al. [8]). O. EREKUL, W. KÖHN, [10] determined very large gluten index differences among triticale varieties, ranging from 36.8% to 84.5%. They reported a higher average gluten index value for wheat (84%) than triticale (60%). A four-year research results conducted by P. MARTINEK & al. [14] showed that gluten indexes of the triticale cultivars were ranged from 55% to 77% and were strongly influenced by the environment and crop years. The lower gluten index of flour was mostly related to poor gluten content and gluten index values of wheat were optimum when it ranged from 60% to 90% (A. ELGÜN & al. [8]). Gluten index of triticale was positively influenced by weather conditions and soil quality (O. EREKUL, W. KÖHN [10]).

Zeleny Sedimentation

The Zeleny sedimentation values were lower in the first year (16.7%) than the second year (20.0%) (Table 2). The average sedimentation value was the highest in Tatlıcak97 (22.2 ml), while it was the lowest value in Presto (14.2 ml), and the differences among the genotypes were found to be significant (Table 3). The sedimentation value is the measurement of the swelling of gluten protein (L. ZELENY, [15]; O. EREKUL, W. KÖHN, [10]). The lower sedimentation values compared to bread wheat variety were related to their lower gluten protein content reported by L.J. MACRI & al. [11] who found out that the sedimentation values of four triticales varied from 25 cm^3 to 40 cm^3. O. EREKUL, W. KÖHN, [10] determined the sedimentations of four triticale varieties grown in two locations ranged from 12 ml to 28 ml. P. MARTINEK & al. [14] observed that the average Zeleny value of wheat checks and triticale Presto were 31 ml and 23 ml respectively. In another study conducted by M. TOHVER & al. [12], the sedimentation values of triticale cultivars varied from 10.5 ml to 21.0 ml and they stated that the triticale flour must be baked on blends of wheat flour, as the falling number and Zeleny sedimentation value were low.

Modified Sedimentation

With respect to the modified sedimentation values, as a measurement of insects damages such as *Eurygaster* spp. and *Aelia* spp., Mikham2002 (28.2 ml) had the highest value, whereas Egeyıldızı (17.8 ml) had the lowest value (Table 3), showing significantly lower in the first year (19.7 ml) than in the second year (24.1 ml) (Table 2). The differences among the genotypes were significant. The modified sedimentation must be higher than the sedimentation if there is no insect damage in the grains (A. ELGÜN & al. [8]; Ş. TAYYAR [16]). In this study, the modified sedimentation values had higher values than those of the sedimentation values which indicated no insect damages.

Falling Number

Significant falling numbers differences were determined among the genotypes. The falling number values ranged from 267.3 s (Mikham2002) to 161.5 s (Presto) and the mean value was determined as 208.7 s (Table 3). The falling number influences the dough properties and bread-making characteristics, and the high α-amylase activities in flours of triticale resulted in low falling number worsening bread-making quality (P. MARTINEK & al. [14]; C.M. MCGOVERIN & al. [17]). The falling numbers of winter triticale varieties were very low (mostly below 100 s) indicating very high α-amylase activity (O. EREKUL, W. KÖHN [10]). P. MARTINEK & al. [14] stated that triticale had a low falling number ranged from 62 s to 70 s while wheat had an average of 301 s. European triticale varieties showed high α-amylase activities producing low falling number (P. MARTINEK & al. [14]) suggesting that those varieties showed a strong genetic property of filling stages under cold and humid environmental conditions (C.M. MCGOVERIN & al. [17]). On the other hand, it was reported that falling numbers must vary between 220 s and 250 s, and below 120 s are regarded as poor for the satisfactory baking performance (P. MARTINEK & al. [14]). The results of this study revealed that only Tatlıcak97 genotype showed a required value of falling number whereas Mikham2002 and Alperbey genotypes were over 250 s. Falling number is also important to determine viscoelastic properties of dough, proper gas production during fermentation and loaf shape. The mean values of falling number for wheat ranged from 200 s to 250 s. It was indicated that falling number 300 s and over 300 s produced low amylase activities with low bread volume and dry crust while falling number 150 s and below 150 s provided a high amylase activities with sticky crust (A. ELGÜN & al. [8]). Low and high falling numbers of triticale flours had soft dough and stable dough, respectively (M. TOHVER & al. [12]).

Ash

The ash values of the genotypes between 0.64% (Egeyıldızı) to 0.59% (Alperbey) were ascertained, and the differences among the genotypes were significant (Table 3). Mean values of the first year were significantly higher than those of the second year (Table 2). L.J. MACRI & al. [11] indicated that the ash contents of four triticale varieties were between 0.41% and 0.57%. Y. COŞKUNER, E. KARABABA [18] determined that the ash value of variety Tatlıcak97 was 4.9 g/kg. In another study, average ash values of the triticale cultivars varied from 0.45% to 0.50% (J. PETR [19]).Ash values of wheat flour, used as a criterion for determining the flours types, are of great importance for bread making quality. It is highly influenced by variety, climate, soil and growing conditions. Drought is one of the factors that causes a decrease in ash value (A. ELGÜN & al. [8]).

The uses of triticale are mainly determined by its chemical composition, and the quality of triticale is a complex mechanism of physical and chemical characteristics. Both genotype and environment significantly affect the bread making properties of triticale. The results of this experiment confirm that very large differences were obtained among the genotypes. Karma2000 and Tatlıcak97 genotypes gave rise to higher protein content than other genotypes. The highest gluten percentages were obtained from Mikham2002 and Tatlıcak97, and the highest gluten index was from Egeyıldızı. Mikham2002 had the highest falling number, while Presto had the lowest value. The protein content, the gluten percentage, the gluten index, the Zeleny sedimentation and the falling number of bread wheat flour is required to be 10-12%, 20% and above, 60-90%, 25-36 ml and 200-250 s, respectively (A. ELGÜN & al. [8]). As far as the protein content, the gluten and the gluten index values of the genotypes were considered, they were suitable for bread-making, but the Zeleny sedimentation values of all genotypes were classified as low (poor) (below 25 ml). The Zeleny sedimentation value gives us an opinion about the amount and quality of protein, and it is positively correlated with baking tests (A. ELGÜN & al. [8]). As for falling numbers of the genotypes, Melez2001 and Tatlıcak97 gave rise to desired values, according to A. ELGÜN & al. [8].

The interest in triticale production has steadily grown over the world including Germany, Poland, Canada, China, Australia and Mexico (C.M. MCGOVERIN & al. [17]). The bread making qualities of triticale have been intensively investigated, whereas limited studies are available in Turkey. Triticale is primarily used for animal feeding and the unsuitable nature of triticale in baking and bread-making industry has largely been acknowledged (L.J. MACRI & al. [11]; C.M. MCGOVERIN & al. [17]; K. LORENZ [20]; M. TOHVER & al. [21]). Despite initial investigations on triticale started in 1940s in Turkey (M.A. FURAN & al. [22]), it is not presently grown on a large scale in Turkey, and the potential of triticale has remained largely unrealized. However some investigations were carried out about the cultivation and agronomical properties of Turkish triticale varieties (M.A. FURAN & al. [22]; İ. DEMİR & al. [23]; İ. AKGÜN & al. [24]), little has acknowledged on their bread-making characteristics. Annual bread wheat production has drastically decreased in the region over the last decades as a result of the increase in the irrigatable agricultural lands and the increase in the cultivation of industrial crops. Triticale ought to be cultivated to satisfy annual cereal production in marginal areas.

4. Conclusions

The results of this study revealed that Turkish triticale genotypes evaluated were not suitable for bread-making. Their bread-making quality would be improved by blending with wheat flour. The applicability of triticale in bread-making is influenced by the level of triticale in blends, and the mixing and baking properties of the blends will have to be investigated. They can possibly be used in soft-textured products such as biscuits, crackers and cookies. Future studies on Turkish triticale genotypes should focus on rheological and other technological properties as well as baking tests characteristics of triticale.

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