Araştırma Makalesi / Research Article

Comparison of Protein Characteristics of Some Wheat Varieties Harvested in Turkey

Seda YALÇIN[1*], Besim MADEN[2]

[1]*Afyon Kocatepe University, Afyon Vocational School, Food Processing Department, 03200, Afyon, Turkey*
[2]*Afyon Kocatepe University, Afyon Vocational School, Food Processing Department, 03200, Afyon, Turkey*

Corresponding author e-mail: syalcin@aku.edu.tr　　ORCID: https://orcid.org/0000-0001-9741-0919
b.maden@hotmail.com ORCID: https://orcid.org/0000-0003-4973-1958

Keywords
Wheat;
Gluten;
α-amylase;
Sedimentation;
Alveograph

Abstract

Physical and rheological characteristics activity of five wheat varieties, harvested in Turkey, having different origins including Tosunbey (Turkey) Adana-99 (Turkey) Negev (Israel), Esperia (Italy) and Bezostaya-1 (Russia) were investigated in this study. For this purpose, L*, a* and b* color values, thousand grain weight of wheat samples, protein content, gluten index value, zeleny sedimentation value, alveograph properties and falling number value of flours milled from these samples were analyzed. Bezostaya-1, Esperia and Negev wheat samples showed lower brightness and yellowness and higher redness compared to Tosunbey Adana-99 wheat samples. Among wheat samples, Esperia had the highest thousand grain weight. Adana-99 wheat flour had the higher gluten index value, zeleny sedimentation value and α-amylase activity compared to other wheat flours. Alveograph properties showed that tenacity (P) strength (W) and elasticity (Ie) of Adana-99 wheat flour were higher than those of other wheat flours. α-amylase activity of Bezostaya-1 wheat flour was lower than that of other wheat flours. As a consequence, Adana-99 wheat flour had the best protein quality and high α-amylase activity.

Türkiye'de Hasat Edilen Bazı Buğday Çeşitlerinin Protein Özelliklerinin Karşılaştırılması

Anahtar kelimeler
Buğday;
Gluten;
α-amilaz;
Sedimantasyon;
Alveograf

Öz

Bu çalışmada, Tosunbey (Turkey), Adana-99 (Turkey), Negev (İsrail), Esperia (İtalya) ve Bezostaya-1 (Rusya) gibi farklı menşeili Türkiye'de hasat edilen 5 buğday çeşitinin fiziksel ve reolojik özelliklei incelenmiştir. Bu amaçla, bu örneklerden öğütülen unların L*, a* ve b* renk değerleri, bin tane ağırlığı, protein içeriği, gluten index değeri, zeleny sedimantasyon değeri, alveograf özellikleri ve düşme sayısı analiz edilmiştir. Bezostaya-1, Esperia ve Negev buğday çeşitleri, Tosunbey ve Adana-99 çeşitlerine kıyasla düşük parlaklık ve sarılık ve yüksek kırmızılık göstermiştir. Buğday örnekleri arasında, Esperia en yüksek bin tane ağırlığı değerini vermiştir. Adana-99 buğday unu, diğer buğday unlarına kıyasla yüksek gluten indeks değeri, zeleny sedimantasyon değeri ve α-amilaz aktivitesi göstermiştir. Alveograf özelliklerine göre, Adana-99 buğday unun yapışkanlık (P), stabilite (W) ve elastikiyet (Ie) değerleri diğer unlardan yüksek bulunmuştur. Bejostaja-1 buğday ununun α-amilaz aktivitesi diğer unlarınkinden düşüktür. Sonuç olarak, Adana-99 buğday unu en iyi protein kalitesi ve en yüksek α-amilaz aktivitesini göstermiştir.

1.Introduction

Wheat quality is determined by the protein quantity and quality, degree of damaged starch and amylase content. The analysis of wheat quality is carried out by common methods such as protein content, falling number and zeleny sedimentation value. These parameters affect qualities of mill, flour and product (Hruskova et al., 2004). Protein is an important wheat component due to affecting product quality (Sissons 2008). The polypeptide composition of protein (ratio of glutenin and gliadin) is determined by genotype of wheat (Vazquez et al., 1996). The glutenin (polymeric protein) is responsible for the dough elasticity, while the gliadin (monomeric protein) has influence on extensibility. So the ratio of glutenin to gliadin is related to balance of dough strength and extensibility (Wrigley 2006). Gupta et al. (1993) reported that HMW (high molecular weight) glutenin subunits affected maximum resistance and extensibility of dough, while LMW (low molecular weight) glutenin subunits affected only extensibility. Sewry et al. (1992) proposed that wheat varieties related with good rheological properties could have allelic subunits 1 or 2* on the Glu-A1 locus, 17 + 18 or 7 + 8 on the Glu-B1 locus, and 5 + 10 Glu-D1 locus, while 2 + 12 subunits were related to poor rheological properties. Katyal et al. (2016) reported that protein content and zeleny sedimentation value of flours milled from Indian wheat varieties ranged from 8.89% to 12.77% and from 27.8 mL to 51.0 mL, respectively. It was observed that protein content of wheat flours showed a good correlation with zeleny sedimentation value (R=0.739). Zaidel et al. (2009) reported that correlations between gluten quantity and gluten quality of strong wheat flour and weak wheat flour were 0.60<R<0.80 and 0.30<R<0.50, respectively. It was demonstrated that this indicates the increase in gluten quality with increasing of gluten quantity. Ktenioudaki et al. (Ktenioudaki, 2010) found that Canadian blend (mix of at least three wheat varieties) had the highest protein content (13.4%), while Irish wheat varieties (Cordiale and Raffles) and Greek wheat varieties (Tzeneroso and Tzemele) had lowest protein content (9.5%, 8.7% and 8.6%, 8.2%, respectively). Singh et al. (2011) reported that protein content of Indian wheat varieties ranged from 8.26% to 12.85%. Aalami et al. (2007) investigated the physical properties of six Indian durum wheat and physicochemical properties and rheological properties of semolina samples milled from these wheat varieties and found that relations between semolina characteristics (protein content, mixograph, farinographs) were strong. Kibar (2015) reported that zeleny sedimentation value and dry gluten content of wheat varieties (cv. Bezostaja and Lancer) increased with storage until two months and then decreased, while falling number value increased with storage (180 days). Sanchez-Garcia et al. (2015) investigated the protein properties of wheat varieties cultivated in Spain during the 20. century and analyzed rheological properties of 16 wheat varieties from 4 fields by using alveographs test. It was reported that strength (W) and tenacity (P) values of samples increased at relative rates of 1.38% y^{-1} and 0.99% y^{-1} from the year of 1930 to the year of 2000, respectively, while extensibility (L) decreased by -0.46% y^{-1} and the equilibrium (P/L) increased at 1.45% y^{-1}. It was also reported that protein content of the samples decreased by -0.21% y^{-1} at relative rates. It was demonstrated that local wheat varieties are very tall and less productive than modern wheat varieties. Migliorini et al. (2016) investigated the quality characteristics of seven old wheat varieties (Sieve, Verna, Gentil rosso, Andrielo, Gambo di ferro, Frassineto, Abbondanza), four modern varieties (Bolero, Blasco, Arabia, Bologna) and two wheat variety mixtures for two years (2011 and 2012) harvested from three organic farms in Italy. It was reported that agronomic characteristics of wheat samples affected by years and locations. It was found that the highest yielding wheat varieties were Bologna, Abbondanza, Arabia and two wheat variety mixtures. According to the authors, strength (W) ranged from 230 in the year of 2011 for Andrielo to 38 in the year of 2012 for Gambo di ferro. It was demonstrated that gluten index value of wheat samples was affected by the year. Savas and Basman (2016) investigated the effect of infrared drying on bulgur quality produced from four wheat varieties (Mirzabey, Altın, Bayraktar and İkizce) and reported that the protein contents of Mirzabey, Altın, Bayraktar and İkizce were 12.81%, 13.44%, 12.49% and 14.29%, respectively and qualities of bulgur samples produced with infrared drying were higher than that of bulgur samples produced with other methods.

The aim of this study is to evaluate the differences in gluten properties and α-amylase activity of five wheat varieties, harvested in Turkey, having three origins (Turkey, Italy, Russia).

2. Material and Method

2.1 Material

Five wheat varieties, harvested in Turkey, were obtained from Tınaztepe Flour Factory (Afyon, Turkey). These wheat samples are Tosunbey (Polatlı), Adana-99 (Adana), Negev (Aydın), Esperia (Konya) and Bezostaya-1 (Eskişehir).

2. 2. Color values

L*, a* and b* color values of wheat varieties were determined by using X-rite Ci6x portable spectrophotometer (USA).

2.3. Thousand grain weight

Thousand grain weight of five wheat varieties was determined according to the AACC method 55-31 (2000).

2.4. Protein content

Protein content (Nx5.70, dry weight) of the flours milled from wheat samples was determined according to the AACC method 46-10 (2000).

2.5. Gluten index value

Gluten index value of the flours milled from different wheat varieties was analyzed according to AACC Method 38-10 (2000)

2.6. Zeleny sedimentation value

Zeleny sedimentation value of the wheat flours was determined according to ICC method 116/1(1994).

2.7. Falling number value

Falling number value was determined to estimate α-amylase activity of wheat flours according to ICC 117/1 method(1968).

2.8. Alveograph properties

Alveograph test was performed using an Alveolink NG (Chopin Technologies, France) according to standard method 54-30A (2000). Alveograph characteristics were tenacity (P), extensibility (L), strength (W), equilibrium (P/L), extensibility index (G) and elasticity (Ie).

2.9. Statistical analysis

Results of samples were statistically evaluated by SPSS one way ANOVA procedure. Duncan test was performed to compare the mean values ($P<0.05$).

3. Results

3.1. Grain characteristics

Wheat varieties tested in this study were Tosunbey, Adana-99, Negev, Esperia and Bezostaya-1. Tosunbey and Adana-99 wheat samples are hard and have white color. Negev wheat sample is semi-hard and has red color. Esperia and Bezostaya-1 wheat samples are hard and have red color. The origin of Tosunbey and Adana-99 wheat samples is Turkey, while that of Negev wheat sample is Israel, that of Esperia wheat sample is Italy and that of Bezostaya-1 wheat sample is Russia. Negev, Esperia and Bezostaya-1 wheat samples were registered in Turkey at the year of 2007, 2011 and 1970, respectively. L*, a* and b* color values of wheat varieties are given in Table 1. L*, a* and b* color values of wheat samples ranged from to, respectively. L* is brightness, a* is redness and b* is yellowness. Tosunbey wheat sample showed highest L* color value (61.76), while Bezostaya-1 wheat sample showed the lowest (55.34). Bezostaya-1 and Esperia wheat samples showed higher a* color values and Tosunbey and Adana-99 wheat samples showed the lower. Negev wheat sample showed highest b* color value and Tosunbey and Adana-99 wheat samples showed the lower.

Thousand grain weight value of five wheat varieties is given in Table 1. Thousand grain weight can be used to determine the potential flour yield for wheat grain and quality factor by the milling industry (Kibar 2015). Thousand grain weight of wheat samples ranged from 32.83 g to 43.57 g. Esperia wheat sample had the highest thousand grain weight among all wheat samples. Thousand grain weight of Tosunbey wheat sample was not statistically different from that of Bezostaya-1 wheat sample. Thousand grain weight of Adana-99 wheat sample was statistically similar to that of Negev wheat sample. It was concluded that Esperia wheat sample had high flour yield.

3.2. Protein content of wheat flours

Protein content of wheat flours is given in Table 2. Protein content of flours milled from five wheat varieties ranged from 10.8 % (Tosunbey) to 13.6% (Bezostaya-1). Protein contents of these wheat flours are similar to that of flours) milled from nine

wheat varieties grown in USA (9.3%-11.9%) reported by Adeyeye et al. (2013).

3.3.Gluten index value of wheat flours

Gluten index value of wheat flours is given in Table 2. Gluten index value of wheat flours ranged from 81.86 (Tosunbey) to 98.50 (Adana-99). Gluten index values of Adana-99, Negev and Esperia wheat flours were significantly higher compared to that of Tosunbey and Bezostaya-1 wheat flours. Significantly lower gluten index value was obtained by Tosunbey wheat flour than that of Bezostaya-1 wheat flour. Gluten index value is related with the polydisperse polymer quantity in developed gluten (Adeyeye et al., 2013). Optimum gluten index value is between 65 and 80. Gluten index value below 65 indicates weak gluten, gluten index value above 80 indicates strong gluten (Migliorini et al., 2016). All wheat samples had strong gluten due to having gluten index value above 80. Gluten index values of five wheat samples were higher than that of Italian wheat samples reported by Migliorini et al. (2016). According to Migliorini et al. (2016), gluten index value was correlated with strength and elasticity of gluten protein and gluten index value of wheat samples, cultivated in Italy, ranged from 57.0 to 80.3 and affected by the harvested year. It was found that the gluten index value of Italian wheat samples harvested in 2012 was higher than that of Italian wheat samples harvested in 2011.

3.4.Zeleny sedimentation value of wheat flours

Zeleny sedimentation value of wheat flours was given in Table 2. Zeleny sedimentation value of wheat samples ranged from 25.5 mL (Tosunbey) to 65.0 mL (Adana-99). Zeleny sedimentation value of Negev wheat sample was not significantly different from that of Esperia wheat sample. Significantly higher zeleny sedimentation value was obtained by Bezostaya-1 wheat sample than that of Tosunbey wheat sample. High correlation was found between gluten index value and zeleny sedimentation value of wheat samples (R=0.8863).
These values are similar to results of Indian wheat samples (36 mL-56 mL) reported by Kaur et al. (2013). It was concluded that Adana-99 wheat sample had high gluten quality due to having high zeleny sedimentation value. The results of present study are also corresponding with the results of Adeyeye et al (2013). Adeyeye et al. (2013) reported that sedimentation values of wheat

varieties ranged from 27.5 mL (Wakeland) to 69.0 mL (Durum Rolette).

3.5.Falling number value of wheat flours

Falling number value of five wheat samples is given in Table 2. Falling number value of wheat flours ranged from 268.0 sec (Adana-99) to 466.5 sec (Bezostaya-1). If falling number value of flour is above 300 sec, the flour has low α-amylase activity. This result indicates that Adana-99 wheat sample had suitable α-amylase activity, while other wheat samples had low α-amylase activity.

3.6.Alveograph properties of wheat flours

Alveograph properties (P, L, W, P/L, G, Ie) of five wheat samples are given in Table 3. Alveograph characteristics (P, L, W, P/L, G, Ie) measure ability of flour to stretch. Tenacity (P, height of the curve) indicates dough resistance to extension. Extensibility (L, length of the curve) is an indicator of the handling characteristic of dough. Strength (W, area under the curve) is energy absorbed by the dough when being streched. Equilibrium (P/L, curve configuration ratio) gives information about the elastic resistance and extensibility balance of dough. Extensibility index (G) indicates dough extensibility. Elasticity (Ie) indicates dough elasticity. Tenacity (P) of wheat flours ranged from 101.0 mm (Bezostaya-1) to 183.0 mm (Adana-99). Adana-99 wheat sample had higher dough resistance to extension than other wheat samples. Tenacity of Bezostaya-1 wheat sample was not significantly different from that of Tosunbey wheat sample and that of Negev wheat sample. The extensibility (L) of wheat flours ranged from 50 mm (Tosunbey) to 138 mm (Esperia). Tosunbey dough sample was less extensible compared to other wheat dough samples. Extensibility of Adana-99 wheat sample was not significantly different from that of Negev wheat sample and that of Bezostaya-1 wheat sample. Strength (W) of wheat flours ranged from 173.5 x 10^{-4} J (Tosunbey) to 726.0 x 10^{-4}J (Adana-99). Strength of Negev wheat sample was not significantly different from that of Bezostaya-1 wheat sample. Equilibrium (P/L) of wheat samples ranged from 0.80 (Negev) to 2.03 (Tosunbey). Equilibrium of Adana-99 wheat sample was significantly lower than that of Tosunbey wheat sample. According to Qualia [23], when P/L (ratio of tenacity, which is 1.1 x height of the curve, to length of curve) is more than 1.5, wheat sample has good gluten quality. Tosunbey and Adana-99

wheat samples had the equilibrium above 1.5, while Negev, Esperia and Bezostaya-1 wheat samples had the equilibrium below 1.5. Equilibrium of Tosunbey wheat sample was significantly higher than that of Adana-99 wheat sample, indicating a less extensible dough. There were not significant differences between the equilibrium of Negev, Esperia and Bezostaya-1 wheat samples. Extensibility index (G) of wheat flours ranged from 15.70 mm (Tosunbey) to 26.15 mm (Esperia). Elasticity (Ie) of wheat flours ranged from 37.9% (Tosunbey) to 66.8% (Adana-99). Elasticity of Adana-99 dough sample was higher than that of other wheat dough samples. Negev wheat sample had statistically similar elasticity to Bezostaya-1 wheat sample. The rheological properties of Adana-99 wheat sample, having high dough strength, were strong, whereas those of Tosunbey wheat sample, having low dough strength, were

poor. Gluten index value is highly correlated with extensibility (R=0.8698), strength (R=0.7997), extensibility index (R=0.8760) and elasticity (R=0.7758). Zeleny sedimentation value is also correlated with tenacity, strength and elasticity (R=0.8959, 0.9776, 0.9622, respectively). These correlations show that gluten index value, zeleny sedimentation value and alveograph properties express gluten quantity and gluten quality. Similar values were observed by Koksel et al. (2009). Koksel et al. (2009) reported that P, G, W and P/L alveograph values of 16 wheat flours were 54-196 mm, 8.9-23.1 mm, 55-286 x 10^{-4} J and 0.5-5.6, respectively. Koksel et al. (2009) found significant correlations between some mixolab parameters (stability, C2) and zeleny sedimentation and alveograph W values and also between other mixolab parameters (C3, C4, C5) and alveograph G and P/L values.

Table 1. L*, a* and b* color values and thousand grain weight of the five wheat varieties

Samples	L*	a*	b*	Thousand grain weight (g)
Tosunbey	61.76 a	11.71 b	30.40 b	32.14 b
Adana-99	58.71 b	13.17 a	31.44 b	35.66 ab
Negev	51.51 d	13.63 a	26.87 b	39.14 ab
Esperia	49.03 d	13.81 a	26.65 a	43.57 a
Bezostaya-1	55.34 c	13.76 a	26.95 a	32.83 b

Mean values in the same row are significantly different (p<0.05).

Table 2. Quality characteristics of the flours milled from the five wheat varieties

Samples	Protein (%)	Gluten index	Zeleny sedimentation (ml)	Falling number (sec)
Tosunbey	10.8 d	81.86 c	25.5 d	363.5 c
Adana-99	11.3 c	98.50 a	65.0 a	268.0 e
Negev	11.1 cd	97.00 a	44.5 b	331.5 d
Esperia	12.2 b	94.85 a	44.0 b	420.5 b
Bezostaya-1	13.6 a	88.47 b	36.5 c	466.5 a

Mean values in the same row are significantly different (p<0.05).

Table 3. Alveograph properties of the flours milled from the five wheat varieties

Samples	P (mm)	L (mm)	W(x10^{-4}J)	P/L (index)	G (mm)	Ie (%)
Tosunbey	101.5 c	50.0 d	173.5 d	2.03 a	15.70 d	37.9 d
Adana-99	183.0 a	112.0 bc	726.0 a	1.64 b	23.55 bc	66.8 a
Negev	106.5 bc	133.0 ab	339.5 c	0.80 c	25.65 ab	45.3 c
Esperia	115.0 b	138.0 a	428.5 b	0.84 c	26.15 a	52.5 b
Bezostaya-1	101.0 c	103.0 c	273.5 c	0.98 c	22.60 c	44.5 c

Mean values in the same row are significantly different (p<0.05).
P, tenaciy; L, extensibility; P/L, equilibrium; W, strength; G, extensibility index; Ie, elasticity.

4. Discussion and Conclusion

In this study, L*, a* and b* color values and thousand grain weight of five wheat varieties (Tosunbey, Adana-99, Negev, Esperia, Bezostaya-1) and protein content, gluten index value, zeleny sedimentation value and alveograph properties and falling number value of flours milled from these wheat samples were evaluated. Tosunbey wheat sample showed brighter color compared to other wheat samples. Esperia showed greater redness due to having more a* color value. Adana-99 showed more yellowness. Esperia wheat sample had the highest thousand grain weight which indicates high flour yield, while Tosunbey wheat sample had the lowest thousand grain weight. Protein content of Bezostaya-1 wheat sample was higher than that of other wheat samples. Adana-99 wheat sample had higher gluten index value and zeleny sedimentation value compared to other wheat samples. Tosunbey wheat sample had lower protein content, gluten index value and zeleny sedimentation value than other wheat samples. Falling number value of Bezostaya-1 wheat sample was the highest, while that of Adana-99 wheat sample was the lowest among that of all wheat samples. This result indicates that Bezostaya-1 wheat sample had low α-amylase activity and Adana-99 wheat sample had high α-amylase activity. Alveograph characteristics measure the ability of flour to stretch, expand and can determine the total effect of resistance to stretching and extensibility (Adeyeye et al. 2013). According to alveograph results, Adana-99 wheat sample had high tenacity, strength and elasticity, Esperia wheat sample had high extensibility and Tosunbey wheat sample had high equilibrium. Result of alveograph indicated that the degree of resistance by the dough to a deformation stress of Adana-99 was higher than those of other wheat samples. Highest strength could lead to good increase in bread volume. The results showed that Adana-99 wheat sample had high gluten quality due to having high gluten index value, zeleny sedimentation value, tenacity and strength, elasticity. These characteristics indicated that Adana-99 posseses a strong type of flour dough, while Tosunbey posseses a weak type of flour dough. Correlation coefficients (R) between tenacity and strength, extensibility and equilibrium, tenacity and elasticity, extensibility and extensibility index, strength and elasticity, equilibrium and extensibility index are 0.9490, -

0.8551, 0.9358, 0.9976, 0.9949 and -0.8526, respectively.

References

AACC International 2000. Approved Methods of the American Association of Cereal Chemists, tenth ed. American Association of Cereal Chemistry, St. Paul.

Aalami, M., Leelavathi, K., Rao, U.J.S.P. 2007. Physicochemical and biochemical characteristics of Indian durum wheat varieties: Relationship to semolina milling and spaghetti making quality. *Food Chemistry,* **102**, 993-1005.

Adeyeye, J.A., Singh, B.O., Doboblaise, E.P. 2013. Evaluation of triticale and wheat grains for cookie-baking characteristics. *actaSATECH 5(1),* 38-47.

Edwards. NM, Gianibelli ML, McCaig, T.N., Clarke, J.M., Ames, N.P., Larroque, D.R., Dexter, J.E. 2007. Relationships between dough strength, polymeric protein quantity and composition for diverse durum wheat genotypes. *Journal of Cereal Science, 45, 140-149.*

Gupta, R.B., Khan, K., Macritchie, F. 1993. Biochemical basis of flour properties in bread wheats. 1. Effects of variation in the quantity and size distribution of polymeric protein. *Journal of Cereal Science,* **18(1),** 23-41.

Hruskova, M., Skodova, V., Blazek, J. 2004. Wheat sedimentation values and falling number. *Czech Journal of Food Science*, **22**, 51-57.

ICC 1968. International Association for Cereal Science and Technology. Standard method number 117/1.

ICC 1994. International Association for Cereal Science and Technology. Standard method number 116/1

Ilker. E., Altunbaş, M., Tosun, M. 2009. Selection for test weight and kernel weight in high yielding wheat using a safety-first index. *Turkish Journal of Agriculture and Forestry, 33,* 37-45.

Katyal, M., Virdi, A.S., Kaur, A., Singh, N., Kaur, S., Ahlawat, A.K., Singh, A.M. 2016. Diversity in quality traits amongst Indian wheat varieties I: Flour and protein characteristics. *Food Chemistry,* **194***,* 337-34.

Kaur, A., Singh, N., Ahlawat, A.K., Kaur, S., Singh, A.M., Chauhan, H., Singh, G.P. 2013. Diversity in grain, flour, dough and gluten properties amongst Indian wheat cultivars varying in high molecular weight subunits (HMW-GS). *Food Research International*, **53***,* 63-72.

Kibar, H., 2015. Influence of storage conditions on the quality properties of wheat varieties. *Journal of Stored Products.* Research, **62***,* 8-15.

Koksel, H., Kahraman, K., Sanal, T., Sivri Ozay, D., Dubat, A. 2009. Potential utilization of mixolab for quality evaluation of bread wheat genotypes. *Cereal Chemistry,* **86(5),** 522-526

Ktenioudaki, A., Butler, F., Gallagher, E. 2010. Rheological properties and baking quality of wheat varieties from various geographical regions. *Journal of Cereal Science,* **51,** 402-408.

Migliorini, P., Spagnolo, S., Torri, L., Arnoulet. M., Lazzerinic, G., Ceccarelli, S. 2016. Agronomic and quality characteristics of old, modern and mixture wheat varieties and landraces for organic bread chain in diverse environments of northern Italy. *European Journal of Agronomy,* **79,** 131-141.

Qualia, G.B. 1988. Other durum wheat products. In: Durum chemistry and Technology, *AACC International, St. Paul,* MN, 263-282.

Sanchez-Garcia, M., Álvaro, F., Peremarti, A., Martín-Sánchez, J.A., Royo, C. 2015. Changes in bread-making quality attributes of bread wheat varieties cultivated in Spain during the 20th century. *European Journal of Agronomy,* **63***,* 79-88.

Savas, K., Basman, A. 2016. Infrared drying: Apromising technique for bugur production. *Journal of Cereal Science***,** **68***,* 31-37.

Shewry, P.I., Halford, N.G., Tatham, A.S. 1992. High molecular weight subunits of wheat glutenin. *Journal of Cereal Science,* **15***,* 105-120.

Singh S, Singh N, MacRitchie F (2011) Relationship of polymeric proteins with pasting, gel dynamic- and dough empirical-rheology in different Indian wheat varieties. *Food Hydrocolloid,* **25***,* 19-24.

Sissons, M. 2008. Role of durum wheat composition on the quality of pasta and bread. Global Scie Books. 90.

Vazquez, J.F., Ruiz, M., Nieto-Taladriz, M.T., Albuquerque, M.M. 1996. Effects on gluten strength of low M_r glutenin subunits coded by alleles at Glu-A3 and Glu-B3 loci in durum wheat. *Journal of Cereal Science,* **24,** 125-130.

Wrigley, C., Bekes, F., Bushuk, W. 2006. Gliadin and Glutenin: The unique balance of wheat quality (1st Edn), AACC Inter, MN, 3-32.

Zaidel, A.D.N., Chin, N.L., Yusof, Y.A., Abd Rahman, R. 2009. Analysis and correlation studies on gluten quantity and quality during production, *Journal of Applied Science,* **9(9),** 1686-1694.