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Assessment of Quality of Durum Wheat Breeding Material by Means of Mixograph Parameters

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Abstract

This study was conducted with twenty durum wheat (*Triticum durum* L.) genotypes (Lines 16, cultivars 4) under rainfed conditions in 2012-2013 growing season in Konya location. Physical, chemical and rheological analyzes of trial material were made. TKW (Thousand Kernel Weight g), PRT (Protein content %), SDS (Sodium dodecyl sulfate sedimentation ml), CLR (Yellowness (b value)), MMT (Mixograph mixing time min), MPH (Mixograph mixing peak height %); MRS (Mixograph right peak slope min/%), MPW (Mixograph mixing peak weight %), MBE (Mixograph bandwith energy Nm) and MTE (Mixograph total energy Nm) were investigated. In this study, it was obtained that the significant and positive relationships between SDS sedimentation and MMT ($p<0.01$), MPH ($p<0.05$), MPW ($p<0.05$) MPE ($p<0.05$) MTE ($p<0.05$) were significant. According to the analyses results lines 18 and 1, Eminbey variety has high quality. The Mixograph analysis is most useful and pratical test to predict the end use quality of durum wheat in a breeding program.

Keywords: Durum wheat, quality, mixograph, SDS sedimentation, protein

Makarnalık Buğday Islah Materyalinin Miksograf Parametreleri ile Değerlendirilmesi

Öz

Bu çalışma 20 makarnalık buğday (*Triticum durum* L.) genotipi ile (16 hat, 4 çeşit) 2012-2013 yetiştirme döneminde kuru şartlarda Konya lokasyonunda yürütülmüştür. Deneme materyalinde fiziksel, kimyasal ve reolojik analizler yapılmıştır. TKW (Bin tane ağırlığı g), PRT (Protein miktarı %), SDS (Sodyum dodesil sülfat sedimantasyon ml), Renk (CLR, b sarı renk değeri), MMT (Miksograf gelişme süresi dk), MPH (Miksograf pik yüksekliği %), MRS (Miksograf sağ pik eğimi dk/%), MPW (Miksograf pik genişliği %), MBE (Miksograf bant alanı Nm), MTE (Miksograf toplam alan Nm) incelenmiştir. Bu çalışmada SDS sedimantasyon ve MMT ($p<0.01$), MPH ($p<0.05$), MPW ($p<0.05$) MPE ($p<0.05$) MTE ($p<0.05$) değerleri arasında pozitif ve önemli korelasyon bulunmuştur. Analiz sonuçlarına göre 18 ve 1 numaralı hat ile Eminbey çesidinin yüksek kaliteye sahip olduğu belirlenmiştir. Makarnalık buğday ıslah programlarında son ürün kalitesinin tahmininde Miksograf analizi çok kullanışlı ve pratik bir testtir.

Anahtar Kelimeler: Makarnalık buğday, kalite, miksograf, SDS sedimantasyon, protein

Introduction

Durum wheat is used predominantly for pasta and couscous but the use of durum wheat in flat and specialty breads is also common in Mediterranean countries, the Middle East, and North Africa (Boggini et al. 1995; Boyacioglu and Dappolonia, 1994). Most durum wheat cultivar development programs focus on improving pasta-making quality, but strategies to improve the bread-making quality may also be worthwhile because such cultivars could be used either alone for bread production or in blends with bread wheat flour (Boggini et al. 1995).

The main objective of wheat breeding programmes is in terms of yield for producers to develop stable and high-quality varieties. Wheat trade and industry is very important for quality of wheat. Color, grain protein concentration and gluten strength are important traits that influence end-use quality of durum wheat. Color, protein content, and gluten strength are evaluated throughout genotype development from early generation lines to released cultivar.

Many quality characteristics are important for the utilization of durum wheat, particularly protein content, yellow pigment, semolina yield, rheological properties and pasta making properties. These characteristics usually are influenced by cultivar and interactions of cultivar and environment (Lukow and McVetty, 1991; Peterson et al. 1992).

In the pasta and bread-making industries, wheat quality is commonly determined by evaluating its performance in food processing and by determining the cooking/baking quality characteristics of the end product. This practice uses large amounts of raw material (semolina and flour) and is time-consuming. Alternatively, the industry has adopted dough rheological methods as less time- consuming means of predicting pasta-cooking and bread-making qualities. Dough rheological methods (using the Mixograph, the Farinograph, and the Alveograph, among others) used to measure the viscoelastic properties (strength and extensibility) of the gluten protein correlate well with the firmness and springiness of cooked pasta and with the loaf volume and crumb structure of bread (Pena, 2000).

The various mixograph parameters have been found to be reliable predictors of durum wheat quality (Kovacs et al. 1993). Mixograph parameters have been considered very useful in selecting good quality wheat lines in hard wheat breeding programmes because they are significantly affected by the genetic effects (Ram and Mishra, 2010). The mixograph is widely used to measure mixing properties of flours with more less samples and in less time (Hoseney and Finney, 1974). Most rheological and sensory tests used in industry to assess durum wheat quality are not suitable to screen hundreds of experimental breeding lines at the segregating and the early-advanced stages, due to the limited amount of testing sample and short testing time. The mixograph test quickly analyzes small quantities of flour for dough gluten strength. Wheat breeders use mixograph results to screen early generation lines for dough gluten strength.

The objectives of this research were to compare several fundamental rheological measurements (Mixograph) developed for durum wheat for their ability and to select wheat genotypes.

Material and Methods

Twenty durum wheat genotypes were grown according to randomized block design under rainfed conditions in 2012-2013 growing season in Konya location. The experiment was a randomized complete block design with 4 replications. Whole meal and refined flour samples were obtained with a Perten 3100 mill (0.5 mm sieve) and with a Brabender Jr. mill (70 GG sieve) Wheat samples were analyzed two replication. Protein content of the flour was measured using a Leco FP 528 analyzer (Leco Inc, St Joseph, MI) AOAC 992.23 (Anonymous, 2009). SDS sedimentation were determined AACC 56-70, (Anonymous, 2002). Flour of color (Yellowness) values b measured with (Hunterlab mini scan XEplus).

Mixograph properties were determined according to AACC approved methods 54-40A (Anonymous, 2002). 35-g mixograph (National Mfg. Co.Lincoln, NE) was used to evaluate the mixing properties of flour samples. The six main characteristics of a mixogram; MMT: Mixograph mixing time (min). MPH: Mixograph mixing peak height (Nm). MRS: Mixograph right peak slope (min/Nm). MPW: Mixograph mixing peak

weight (Nm) MBE: Mixograph bandwith energy (Nm), MTE: Mixograph total energy (Nm) were used as the quality parameters.

Result and Discussion

Physical and chemical properties of durum wheat

Mean of studied traits were given in Table 1. With good quality durum wheat, the kernels are large, amber in color, translucent in appearance, with kernel size as the best indicator of potential semolina yield. The lowest thousand kernel weight 29.80 g, the highest 39.60 g, average 35.68 g were determined in this study. Line 6 and Line 2 showed highest and lowest value for thousand kernel weight .Thousand kernel weight consists of very small and very large units would not be desirable. In this research, line 2 is set too low.

Grain protein concentration and gluten strength greatly affect the mechanical strength of dried pasta and the quality of cooked pasta. The lowest protein content 11.86%, the highest 15.30%, average 13.54% were determined in this study (Table 1). Protein content is important quality trait for using durum wheat. Protein is highly desirable in durum wheat by pasta industrialists. Protein content is often used as a rapid estimate of wheat quality. The unique dough forming properties of wheat flour are primarily due to its protein constituents, especially the gluten proteins. Protein content is more informative with regard to protein quality if the variety is known (Bagci, 1998).

Table 1. Quality characteristics of durum wheat materials

GNT	TKW	PRT	SDS	CLR	MMT	MPH	MRS	MPW	MBE	MTE
Line1	33.80	13.99	26.5	22.45	2.20	82.65	16.28	10.35	128.94	409.22
Line 2	29.80	14.24	12.50	23.31	1.63	62.46	29.44	2.64	65.79	251.39
Line 3	35.20	14.97	21.00	19.88	2.27	64.31	15.57	3.29	81.77	307.24
Line 4	34.80	13.26	19.00	20.70	2.12	63.45	10.89	4.07	114.73	314.66
KZ	34.40	13.09	12.00	23.96	1.53	63.40	29.03	2.30	61.66	246.63
Line 6	39.60	12.47	20.00	22.67	1.97	69.64	25.01	3.77	82.17	309.74
Line 7	34.80	11.87	16.00	25.67	1.93	66.02	24.35	3.24	72.73	282.51
Line 8	34.00	14.36	18.00	21.90	2.27	65.36	14.36	3.35	74.05	316.30
Line 9	35.80	14.00	13.50	23.46	2.20	63.17	19.29	3.35	83.00	283.57
Ç-1	36.80	12.33	16.50	23.90	2.13	53.98	11.68	4.83	91.30	269.60
Line 11	39.60	11.87	22.50	24.92	3.05	72.02	13.32	12.19	160.88	363.71
Line 12	36.20	14.84	19.50	21.04	1.93	62.21	20.88	2.55	73.14	274.35
Line 13	39.40	13.51	16.00	22.61	1.63	69.83	32.48	3.05	69.87	297.05
Line 14	36.20	14.52	16.50	23.41	2.16	71.20	18.65	3.52	93.72	334.91
EM	32.80	13.38	23.50	23.71	3.23	74.66	12.96	8.68	171.96	327.63
Line 16	35.40	15.30	23.00	24.18	5.85	55.80	19.09	2.46	55.22	256.53
Line 17	34.80	13.97	13.00	22.15	1.41	55.32	19.23	1.78	46.63	231.80
Line 18	34.80	12.64	31.00	20.64	3.24	75.70	20.40	25.15	252.68	371.28
Line 19	38.80	12.39	17.00	21.00	2.21	69.37	16.68	7.06	113.52	329.84
KN	36.60	13.94	16.50	23.08	1.68	65.59	26.52	3.02	63.67	278.20
Mean	35.68	13.54	18.68	22.73	2.33	66.31	19.81	5.53	97.87	302.81

GNT: Genotypes, TKW: Thousand kernel weight (g), PRT: Protein content (%), SDS: Sodium dodecyl sulfate sedimentation (ml), CLR: Yellowness (b Value), MMT: Mixograph mixing time (min), MPH: Mixograph mixing peak height (%), MRS: Mixograph right peak slope (min/%), MPW: Mixograph mixing peak Weight (%), MBE: Mixograph bandwith energy (Nm), MTE: Mixograph total energy (Nm).
KZ: Kızıltan, Ç-1: Çeşit 1252, EM: Eminbey KN: Kunduru 1149

Average SDS sedimentation value was 18.67 ml, the lowest SDS sedimentation value was 12 ml, the highest SDS sedimentation value was 31 ml (Table 1). The SDS-sedimentation test remained the best single small-scale test to screen for gluten strength and consequently for pasta-cooking and bread-making quality in durum wheat (Pena, 2000). The sedimentation value was found to be a good predictor of the viscoelasticity of cooked pasta (Kovacs et al., 1995). SDS Sedimentation value is an effective parameter in predicting reological properties of durum wheat genotypes in breeding programmes

Content of yellow pigment in semolina is another important parameter determining the pasta making potential of semolina samples. Semolina should be yellow in color and should be as free from specks as possible, especially when used for pasta. The lowest color (yellowness) b value was 19.88, the highest b value was 25.67, average b value was 22.73.

Reological properties of durum wheat

The Mixograph is a precision instrument for determining wheat and flour quality, measuring and recording the resistance of dough to mixing (Şahin et al., 2011). In these research reological properties was determined by mixograph. Gluten strength and gluten extensibility influence both pasta-making and bread-making qualities of durum wheat. Most rheological and sensory tests used in industry to assess durum wheat quality are not suitable to screen hundreds of experimental breeding lines at the segregating and the early-advanced stages, due to the limited amount of testing sample and short testing time. Several small-scale parameters used to screen germplasm at early breeding stages are strongly associated with rheological quality and with pasta cooking quality attributes (Pena, 2000).

The lowest mixograph mixing time (min) (MMT) value 1.41 min., the highest value 5.85 min., average value 2.33 min. were determined. Mixograph mixing peak height (%) (MPH) value ranged from 53.98% to 82.65% . Mixograph right peak slope (min/%) (MRS) values lowest 32.48 min/%, highest 10.89 min/%, average 19.81 min/% were determined. Mixograph mixing peak weight (%) (MPW) values lowest 1.78%, highest 25.15%, average 5.53% were determined. Mixograph bandwith energy (Nm), (MBE) values lowest 46.63 Nm., highest 252.68 Nm., average 97.87 Nm. were determined. Mixograph total energy (Nm) (MTE) values lowest 231.80 Nm., highest 409.22 Nm., average 302.81 Nm were determined (Table 1).

Table 2. Correlation coefficients between quantitative and qualitative in durum wheat parameters

	MMT	**MPH**	**MRS**	**MPW**	**MBE**	**MTE**	**TKW**	**PRT**	**SDS**
MPH	-0.0213								
MRS	0.3339	0.0228							
MPW	0.2926	0.604**	0.2424						
MBE	0.2907	0.648**	0.3862	0.9487**					
MTE	0.1576	0.878**	0.4114	0.700**	0.745**				
TKW	-0.0049	0.0762	-0.0085	0.0270	0.0060	0.1777			
PRT	0.1996	-0.2396	-0.0445	-0.3961	-0.4121	-0.2438	-0.3899		
SDS	0.581**	0.580**	0.4031	0.780**	0.772**	0.739**	0.0470	-0.0504	
Color(b)	0.1635	-0.0938	-0.2017	-0.1909	-0.1909	-0.2176	0.0046	-0.3136	-0.2718

**Significant at $p < 0.01$, *significant at $p < 0.05$, NS = not significant.
TKW: Thousand kernel weight (g), PRT: Protein content (%), SDS: Sodium dodecyl sulfate sedimentation (ml), CLR: Yellowness (b Value), MMT: Mixograph mixing time (min). MPH: Mixograph mixing Peak Height (%). MRS: Mixograph right peak slope (min/%). MPW: Mixograph mixing peak Weight (%). MBE: Mixograph bandwith energy (Nm), MTE: Mixograph total energy (Nm).

In this study the mixograph data demonstrate a wide variation in dough mixing characteristics among the genotypes (Table 1). Generally, mixing characteristics of a cultivar can be classified by mixograms on the basis of (MMT), (MPW), (MPH), (MRS), (MBE) (MTE). The development time of a wheat flour is genetically controlled mainly by its protein content and glutenin fraction of protein (MacRitchie, 1992; Khatkar et al., 1996). Protein quality and quantity affect the mixing properties of wheat flours.

Matsuo et al. (1982), their study with 30 durum wheat genotypes means protein content 14.40%, Mixograph mixing time as 1.61 min were determined. According to Pena (2000) sedimentation test to screen for gluten viscoelastic properties was clearly manifested. The presence of mixographic parameters in all three predicting equations indicates that this instrument is also of great value in screening for gluten strength-related parameters.

Conclusions

The mixograph has been used to help predicting functional dough mixing properties of durum wheat genotypes in durum wheat breeding programs. In this study, it was obtained that the relationships between SDS sedimentation; MMT ($p<0.01$), MPH ($p<0.05$), MPW ($p<0.05$), MPE ($p<0.05$), MTE ($p<0.05$) were significant and positive (Table 2). According to the analyses results lines 18 and 1, Eminbey variety is high quality varieties. Mixograph useful in identifying lines with superior gluten strength and spaghetti making quality (Joppa et al., 1983; Josephides et al., 1987).

Both the mixograph and SDS sedimentation test reliably identify strong gluten cultivars because neither are markedly affected by environment induced changes in protein content (Quick and Donnely, 1980; Matsuo et al., 1982).

To predict cooking quality of durum wheat pasta at the early stages of a breeding program, rheological properties are among the most useful parameters to assess or measure. Mixograph analysis results quickly because it is useful in breeding programs. The results of this study indicate that there is potential to identify quality of durum wheat genotypes by mixograph.

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