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End-use Quality of Bulgarian Durum Wheat

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Abstract

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A review of the quality of winter durum wheat, grown in Bulgaria during the past 20 years was made. The primary quality parameters associated with wheat milling performance, gluten strength, semolina colour, pasta mixing parameters, pasta colour and pasta cooking properties were examined. The position of Bulgarian durum wheat according to contemporary industrial requirements for durum wheat quality was clarified. Usually Bulgarian winter durum wheat has large grain with high-test weight and vitreousness, which is a prerequisite for its good milling performance. Durum wheat meets the requirements for protein accumulation in favourable conditions. The decline of protein content for the past several years is a problem, as protein content requirement is part of the sales agreements on durum wheat. The older Bulgarian varieties registered in 1980s possess gliadin band 42 and have weak gluten and low cooking potential. Since 1998 new generation durum of γ-45 electrophoretic type with stronger gluten and improved pasta-making quality has been bred. All registered durum wheat varieties in Bulgaria have lower yellow pigment levels and inferior pasta colour by the standards of today. The breeding varieties supported for registration in the 2003-2004 period have improved wheat, semolina and pasta yellowness. So the development of genetically improved varieties with higher technological suitability for pasta industry remains main quality priority in the Bulgarian durum-breeding program.

Key words: durum wheat, crops, grain, semolina, pasta, quality parameters
Abbreviations: AWB-Australian Wheat Board; CGC-Canadian Grain Commission; CWC-California Wheat Commission; FN- Falling Number; NDWC-North Dakota Wheat Commission; PSI-particle size index

Introduction

Durum is the best wheat for pasta products due to its excellent amber colour and superior cooking quality. Pasta is delicious and healthy food. As a ready source of protein and complex carbohydrates, it has become one of Western society's staple foods. Modern food science has revealed that pasta is rich in minerals such as iron, phosphorus and essential B vitamins (Thiamine, Niacin and Riboflavin). Now it is also fortified with folic acid, which is important for the early development of infants

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in the womb. Durum products are a key part of stable diet in Mediterranean countries (Pasta professional, 2004).

The basic quality criteria valid today, include a high yield of highly refined semolina; high protein and yellow pigment content, strong gluten and good pasta cooking quality, and are to remain valid for the foreseeable future (Dexter and Marchylo, 2000).

Durum wheat is a traditional crop in Bulgaria. Its growing dates back to the times of the Thracians, before the foundation of the First Bulgarian Kingdom. It is a winter - type durum and is cultivated mainly in the southern part of the country although there are favourable conditions in the northern part also. Research work on selection of durum wheat in the country dates back from the twenties of the past century. It is carried out in the Institute of Durum Wheat and Cotton near Chirpan (Popov et al., 1985). The first short-stemmed durum varieties with very good lodging resistance was released in the 1980s. They are Zagorka (1980), Chirpan (1981) and Gergana (1984). In the 1990s new durum wheat varieties Progress (1990), Desislava (1997), Neptune 2 (1998), Saturn 1(1998) and Vashod (1998) have been developed. With the creation of new generation durum varieties Neptune 2 and Saturn 1 with stronger gluten and improved pasta making quality and better market acceptance in the Dobrudza Agricultural Institute in General Toshevo an important stage in durum wheat breeding in Bulgaria began.

The purpose of this paper is to make a review of the functional quality of Bulgarian durum wheat grown during the last two decades. The most important quality characteristics of wheat, semolina and pasta were determined.

Material and Methods

Grain samples

The samples of winter durum wheats developed in Bulgaria were used in this study. A total of 589 samples of durum breeding lines and registered varieties grown in experimental trials during a nineteen year period (1986-2005) were evaluated.

Quality analysis

The physical properties of wheat - test weight (TW) and weight per 1000 kernels - were determined by Bulgarian standards methods (BSS). The percentage of vitreous kernels was determined by BSS13 378 and ICC standard 129. Grain total vitreousness by BSS includes the part of fully vitreous kernels and the part of semi-vitreous kernels. Grain vitreousness by ICC standard includes the part of fully vitreous kernels. Particle size index (PSI), a measure of kernel hardness, was determined by the method of Belcheva (1997). Higher values indicate softer kernel texture. Wheat Falling number (FN) as a measure of the α-amylase activity was determined on a 7-g sample of ground wheat using ISO standard 3093. Ash content was determined using BSS 13491 method on a 3-g incinerated in a muffle furnace at 600 ^{o}C sample.

Protein content of wheat and semolina (%N x 5.7) was determined by the Kjeldahl method (BSS 13490). Viscoelasticity of wet gluten (BSS 13375) and sodium dodecyl sulfate (SDS) sedimentation test for ground grain assessed the gluten strength. The SDS - sedimentation volume of wheat was determined by a modified version of ICC method 151, using 3% SDS as described by Dexter et al. (1980). Gluten strength was graded by IDK apparatus compressibility with score ranging from 0 to 120 as follows: 45-75 units = strong; 20-40 and 80-100 = middle; 0-15 and 105-120 = weak gluten. The grading according to gluten softening was 5-8 mm=strong, 9-12 mm = middle and over 12 mm = weak gluten. Physical dough properties were determined according to method of Irvine et al. (1961) using a farinograph equipped with a 50-g bowl and water absorption of 36.5%. Parameters measured were mixing time (the time to reach peak curve), tolerance index (decrease in consistency 4 min after the peak) and bandwidth (curve width 4 min after peak time).

Wheat samples of 300-g grain portions were cleaned and tempered overnight to 16,5% moisture and milled on a QC-109 laboratory mill into semolina as described by Petrova (1993). Semolina processing into microdisk (7-mm diameter) and cooked disks quality, expressed as cooking score from 1 (very poor) to 8 (very good) were carried by the microprocedure described by Alause (1977).

Yellow pigment content of wheat, semolina and pasta disc was determined according to ICC method 152 as β-carotene from a standard curve. Semolina colour was measured by the CIE 1976 L*a*b* colour system with Momcolor colorimeter (Hungary). L* indicates lightness, a* represents redness, and b* represents yellowness of colour.

All analytical tests were performed in duplicate and are expressed on a dry matter basis.

Results and Discussion

Wheat physical properties and ash content

Wheat physical condition is the most important factor determining wheat milling potential and end-product quality (Dexter and Edwards, 1998). There are fundamental differences between milling common wheat and durum wheat. While common wheat is milled to produce flour, the main objective of milling durum wheat is to produce semolina and minimize the production of durum flour. Desirable characteristics for semolina include good colour, minimum dark or bran specks and uniform granulation. The yield of semolina is affected by kernel vitreousness, size and weight, and damaged kernels content. The major degrading factors in each crop year in Bulgaria are bug damage, black - point, hard vitreous kernels count, and in some years sprouted and mildewed kernels and Fusarium infected kernels (Petrova, 2000).

Figure 1 shows the variation of annual mean physical characteristics since 1986. Date show an increase or decrease in kernel characteristics depending on environmental conditions during crop year.

Test weight is the most widely used and simplest criteria of wheat and rough index of semolina yield. Test weight is a measure of soundness of wheat, free of damage. There is a positive correlation between test weight and semolina yield (Dexrer et al., 1987). 1000 kernel weight is function of kernel size, shape, dryness, purity and density and also is an index of potential milling yield (Matsuo and Dexter, 1980). The acceptable test weight and 1000 kernel weight for durum wheat is 78 kg/hl and 30-35 g db, respectively. The average annual data indicate that test weight (average of 80.5 kg/hl) and 1000 kernel weight (average of 40 g db) of winter durum wheat produced in Bulgaria are higher than shown values.

Vitreousness is one of the International key quality-grading factors for durum wheat and the best milling quality will be

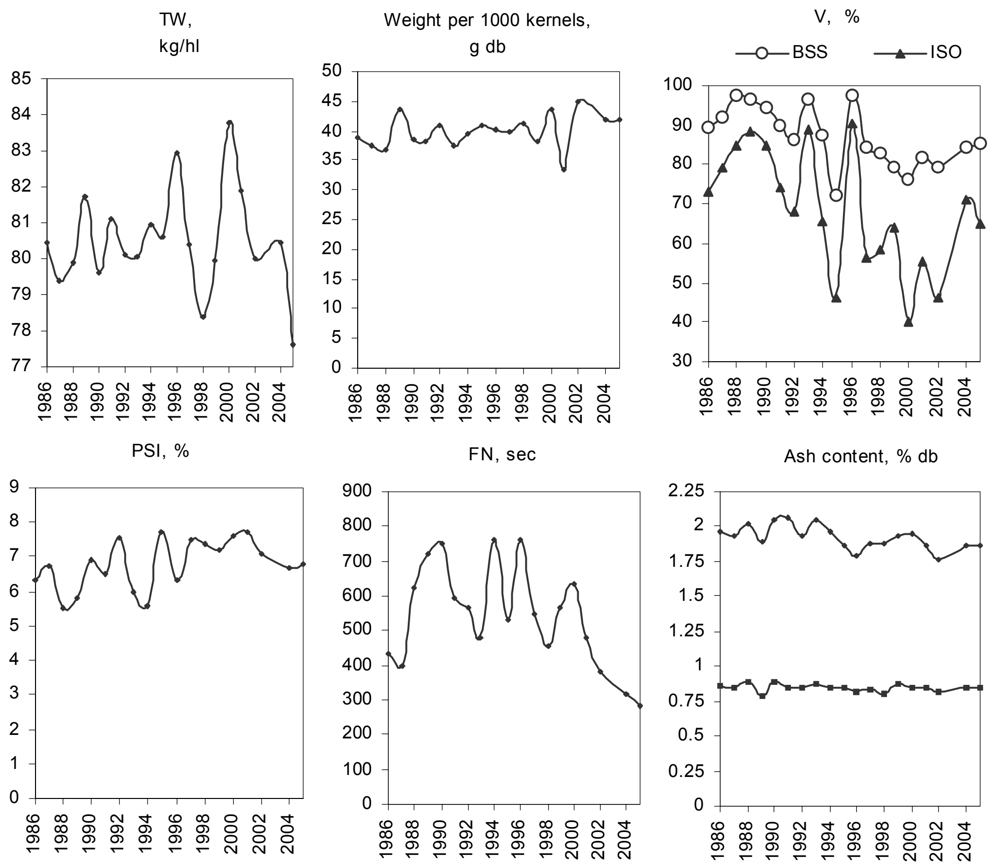


Fig. 1. Wheat phisical parameters and ash content of Bulgarian durum wheat by years

found in those wheats of highly vitreous kernels. Kernel vitreousness is associated with semolina yield and granulation, colour and protein content. (Dexter and Matsuo, 1981; Dexter et al., 1988; Dexter et al., 1989; Matsuo and Dexter, 1980) Therefore quality conscious markets require to guarantee minimum vitreous levels. The acceptable minimum value of kernel vitreousness is 80%. The average percentage of vitreous kernel of Bulgarian durum by the ISO definition amounts to 80% and by the BSS is 87%. It shows that total vitreousness by BSS is formed mainly from fully vitreous kernel. The PSI index amounts to 6.7% and corresponds to highly vitreous durum wheat.

Falling number is associated with preharvest sprouting in the field under prolonged periods of moisture during harvest. Adverse effect of preharvest sprouting in durum is well clarified (Dexter et al., 1990; Petrova and Bojilov, 2003). FN values of the order of 250-500 sec are considered acceptable. A FN of 300 and above is desirable (CWC, 2005). FN of Bulgarian durum wheat has high values (over 500 sec), indicating that sprout damage is not a factor in Bulgarian durum crops. Lower wheat FN values for the past two years than rest values indicate poor growing and harvest conditions.

Ash content in the endosperm of durum is inherently higher than in the endosperm of other hard wheats, but can be used as a relative measure of bran or mineral content in the semolina. Durum wheat usually contains 1.6 to 2.3% ash db (CWC, 2005). Ash content in commercial semolina of about 65% extraction (wheat basis) normally ranges from 0.64 to 0.87% db. Average ash content of Bulgarian wheat and semolina by year is 1.92 and 0.84% db, respectively and is within the acceptable range.

Colour

Yellow colour in semolina and pasta is a traditional rather than functional mark of quality. In general all registered durum wheat varieties in Bulgarian have lower yellow pigment levels (average of 6.5 ppm db) and consequently duller pasta colour by the standards of today (Table 1). Registered at present varieties in most wheat producing countries have yellow pigment content in grain over 9.5 ppm db resulting in more intense pasta colour (AWB, 2004; CGC, 2005; CWC, 2004; NDWC, 2004, 2005; Dexter and Marchylo, 1996; Edwards et al., 2004). Some varieties supported for registration in system of State Variety Testing Commission in the 2004-2005 period have improved wheat, semolina and pasta yellowness and higher Momcolor L* and b* values for the semolina.

Content and functional quality of protein/gluten

Durum protein content is important for both nutritional and functional reasons. There is a general agreement that protein is a fundamental durum wheat quality factor influencing the mixing, processing and cooking characteristics (Matsuo et al., 1982; Autran et al., 1986; D`Egidio et al., 1990). As a result improving protein content in durum varieties has remained a primary goal of durum wheat breeders. Durum protein content ranges from 6% to 20%, depending on variety, environmental conditions and cultural practices during growth (CWC, 2005). For quality pasta products, the protein level should be between 12% and 16 % (at 14% mb). A protein content less than 11% will result in poor quality pasta, while protein levels greater than 16% may be related to lower test weight. The modern pasta manufacturing requires durum semolina to contain over 14% db protein, which corresponds to 15% db grain protein content (Landi and Guarneri, 1992).

Figure 2 lists the variation in annual mean protein content for Bulgarian durum wheat crops since 1986. Data show that this quality factor is highly variable, mostly in response to environmental conditions. The average protein content of the 20 du-

Table 1

Colour of Bulgarian durum wheat

	Yellow pigment, ppm db			Semolina CIEL*a*b* colour		
	grain	semolina	disc	L*	a*	b*
Mean (1986-2005)	6.5	5.65	4.16	84.4	-2.7	24.6
Durum wheat in 2004-2005	7.82	7.1	5.43	85.2	-2.5	27.6

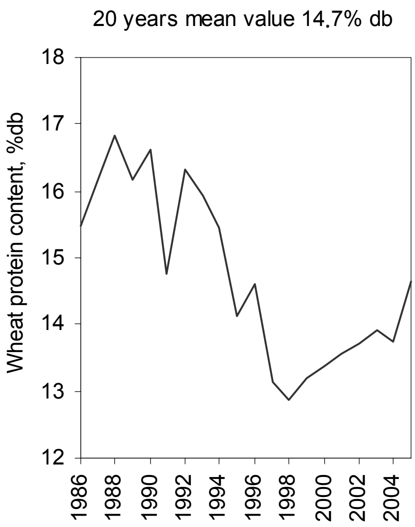


Fig. 2. Mean protein content of Bulgarian durum wheat by years

rum crops is 14.7% db. Wheat protein content in the 1986-1994 period has mean values within the limits of 15.2-16.5% db, that shows the good wheats possibilities for protein accumulation in suitable conditions (agricultural practices, climate). Since 1995 a decline of protein content accompanied with decreased kernel vitreousness is registered. Low protein content of recent Bulgarian harvests is a problem because exact adherence to minimum protein content specifications is becoming an accepted part of durum wheat sales agreements. Therefore, to meet the requirements of premium quality markets Bulgaria must segregates the durum wheat on the basis of protein content so that minimum protein content specifications can be met by grain producers, who will be encouraged to add more nitrogen fertilizer.

Gluten strength is also responsible for the end use quality of wheat. Greater gluten strength is a key priority in conventional durum. Data describing the protein/gluten quality characteristics for samples of the 1986-2005 Bulgarian durum wheat crops are shown in Figure 3.

Lower softening and compressibility values imply better gluten strength properties. Sedimentation volumes of 25 to

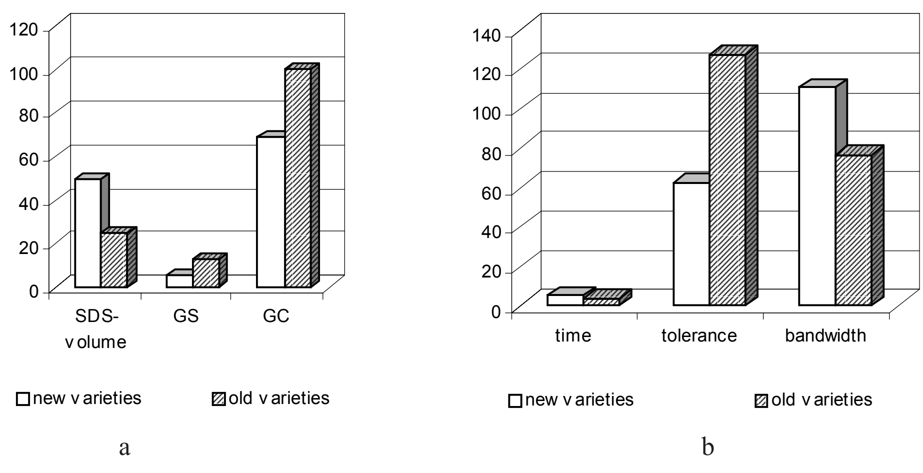
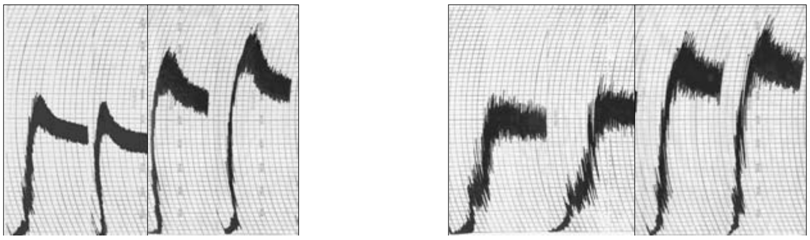


Fig. 3 Gluten quality of Bulgarian durum wheat by indices: a) SDS-sedimentation values (SDS); gluten softening (GS) and gluten compressibility (GC); b) farinograph mixing time, tolerance index and bandwidth



a b

Fig. 4. Farinograms of Bulgarian durum wheats at 36.5% absorption: a-old type varieties, b-new type varieties

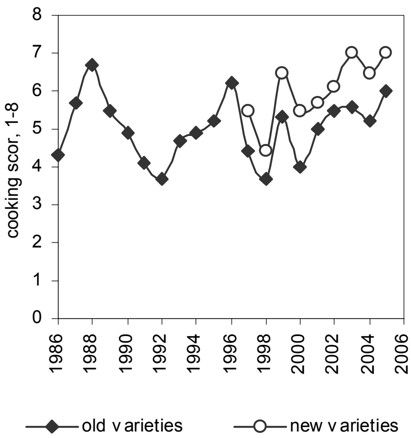


Fig. 5 Quality of cooked pasta discs from Bulgarian durum wheat

35 cm^3 indicate moderate gluten-strength varieties, and volumes greater than 35 cm^3 indicate strong-gluten varieties. The recently released varieties Saturn 1 and Neptune 2 are γ--gliadin 45 type, whereas the old varieties released in the 1980's are γ-gliadin 42 type (Petrova, 2000; Stoyanova et al., 2000). As a result new durum wheats possess in general much stronger, less-extensible gluten, less sticky doughs with better extrusion properties than the old durum wheats.

As seen in Figure 4, the stronger gluten of new durum generation is readily apparent from longer farinograph development time, wilder curve, and less rapid drop in dough consistency compared to old durum varieties.

Pasta cooking quality

Cooking quality for the recent years is superior to former years (Figure 5). The improvement of pasta quality is associated with the increase in gluten strength illustrated by pharinograph and gluten quality values. For that reason the new variety Saturn 1 since 2000 replace the old type variety Zagorka as standard for technological durum quality in the Bulgarian official variety testing.

Conclusions

Bulgarian winter durum wheat has large grain with high-test weight and vitreousness, which is a prerequisite for its good milling performance. Durum wheat meets the requirements for protein accumulation in favourable conditions. The decline of protein content for the past several years is a problem, as protein content requirement is part of the sales agreements on durum wheat. With the exception of Saturn 1 and Neptune 2 all Bulgarian durum wheat varieties have weak extensible gluten. Saturn 1 and Neptune 2 are new generation durum of γ-45 electrophoretic type with stronger gluten and improved pasta-making quality. All registered Bulgarian durum wheat varieties have lower yållow pigment concentration and inferior pasta colour according to present standards. So the development of genetically improved varieties with higher technological suitability for pasta industry remains the main quality priority in the Bulgarian durum-breeding program. Some varieties supported for registration in the 2004-2005 period show that they combine higher yellow pigment content, strong gluten, good pasta colour and good cooking quality.

Bulgaria has been given the statute of a country which is a traditional producer of durum wheat in the regions of Stara Zagora, Haskovo, Sliven, Yambol, Burgas, Dobrich and Plovdiv. Therefore State Variety Testing Commission should register varieties that have good intrinsic quality as a guarantee for high quality Bulgarian durum wheat.

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