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Grain quality of durum wheat varieties

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Abstract. Fourteen commercial varieties of durum wheat bred in Kazakhstan and Siberia along with Barilla Italy varieties from Kostanay, Akmola, North Kazakhstan, Aktobe and Karaganda regions were analyzed for test weight, ash, protein content, gluten quality, carotene and amylose content, vitreousness, ratios of gliadin and glutenin. The regions differed in mean values of the traits. The region of Aktobe was characterized by high protein content (by maximizing gliadin fraction) with the best gluten quality, with the maximum ratio of gliadin/glutenin and ash content. In Kostanay region vitreous grain was formed with a relatively high carotene content and in Karaganda region the highest amylose content. Ranking of varieties based on integrated assessment of 11 traits in 4 regions resulted in the following order: Kargala 29 (1.983) > Zhemchuzhina Sibirii (2.002) > Altaiskaya Niva (2.158) > Kustanaiskaya 12 (2.270) > Damsinskaya yantarnaya (2.308).

Keywords. Durum wheat – Test weight – Ash – Protein and gluten quality – Carotene – Amylose – Vitreousness.

Qualité des grains des variétés de blé dur

Résumé. Quatorze variétés commerciales de blé dur sélectionnées au Kazakhstan et en Sibérie, avec des variétés Barilla d'Italie provenant des régions de Kostanay, Akmola, Nord Kazakhstan, Aktobe et Karaganda, ont été analysées pour évaluer le poids spécifique, les cendres, la teneur en protéines, la qualité du gluten, la teneur en carotène et en amylose, la vitrosité, le rapport gliadine/gluténine. Les régions diffèrent par les valeurs moyennes des caractères. La région d'Aktobe est caractérisée par une teneur en protéines importante (maximisation de la fraction gliadine), la meilleure qualité du gluten, le rapport gliadine/gluténine et la teneur en cendres les plus élevés. Pour la région Kostanay, la vitrosité du grain était associée à une teneur relativement élevée en carotène alors que pour la région de Karaganda, on a observé la teneur en amylose la plus importante. A travers une évaluation intégrée de 11 caractères dans 4 régions, il a été possible de classer les variétés selon l'ordre suivant : Kargala 29 (1.983) > Jemtchoujina Sibirii (2.002) > Altaiskaya Niva (2.158) > Kustanaiskaya 12 (2.270) > Damsinskaya Yantarnaya (2.308).

Mots-clés. Blé dur – Poids spécifique – Cendres – Qualité des protéines et du gluten – Carotène – Amylose – Vitrosité.

I – Introduction

Durum wheat is an important cereal crop for different end-use (pasta, spaghetti, noodles, cous-cous, and bread-baking). The success of the breeding is defined by germplasm collection, effective breeding approaches and methods of grain identification for high quality. The climate conditions of spring sowing area in Kazakhstan favors high protein grain formation which also depends on the cultivars. The aim of this work was evaluation of grain quality of durum wheat cultivars from 5 regions under Kazakhstan-Siberian Network trials (KASIB 4-5, 2003-2004) and 14 commercially released cultivars from CIMMYT trials on quality characteristics of grain, gluten, semolina, and flour to reveal pasta and bread-making potential.

II – Material and methods

The material for investigations included 15 varieties of durum wheat grown in 5 regions (Akmola, Kostanay, Petropavlovsk, Aktobe, and Karaganda) under KASIB trials and 14 commercially

released varieties from CIMMYT trials. The check varieties (Altaiskaya Niva, Damsinskaya yantarnaya, Zhemchuzhina Sibirii, Kargala 29 and Kostanayskaya 12) were used for investigation of grain quality stability in different regions. The content of protein, gliadin and glutenin was determined according to Kjeldahl using NIR-calibrations (Peruanskyi *et al.*, 1996). The test weight, vitreousness, gluten quality and quantity, carotenoid and ash content, total macaroni values were determined according to the State Standards. Sedimentation was determined in 2% acetic acid and hardness index by SKCS 4100. The physical properties were evaluated by farinograph (Brabender) and alveograph (Shopen) methods. The whiteness of flour was determined in accordance with the Russian Federation Standards 26361-84.

III – Results

The five check varieties were characterized by the highest variability of amylose content (5.1-16.3%) (Table 1). High variability in different regions was found for ash content. Variety Kargala 29 was superior for test weight and amylose content; variety Kostanayskaya 12 had highest protein content and gliadin/glutenin ratios; Altaiskaya Niva and Kostanayskaya 12 had the highest vitreousness and grain hardness index; Zhemchuzhina Sibirii had highest carotenoid content. Quality parameters of these varieties varied depended on cultivation region. Test weight of Kargala 29 ranged from 815 to 835 g/l.

Table 1. The grain quality variability of 5 spring durum wheat cvs in different growth conditions.

| Indicator | Zhemchuzhina Sibirii | Altaiskaya Niva | Damsinskaya yantarnaya | Kustanayskaya 12 | Kargala 29 |
|-----------------------|-------------------------|--------------------|---------------------------|---------------------|---------------|
| Nature mass, g/l | 780-817 | 769-820 | 774-814 | 758-809 | 815-835 |
| Vitreousness, % | 58-64 | 62-69 | 57-80 | 54-82 | 54-65 |
| Hardness index | 107-112 | 98-118 | 96-108 | 99-121 | 103-111 |
| Ash content, % DM | 1,49-2,17 | 1,49-2,17 | 1,45-2,12 | 1,42-2,33 | 1,34-2,10 |
| Protein, % DM) | 15,3-19,0 | 15,4-17,6 | 16,0-18,5 | 16,4-20,8 | 15,4-18,0 |
| Gliadin, % protein | 30,9-37,1 | 31,6-36,9 | 30,8-35,4 | 31,1-37,9 | 30,1-36,1 |
| Glutenin, % protein | 21,4-23,2 | 20,9-22,8 | 20,1-22,4 | 21,0-22,4 | 21,3-23,1 |
| Gliadin + glutenin, % | 53,1-59,5 | 53,1-59,1 | 51,5-56,8 | 52,3-59,4 | 53,2-58,7 |
| Gluten quality score | 3,1-4,2 | 3,7-4,6 | 4,3-5,2 | 3,3-4,0 | 2,6-3,4 |
| Carotenoids, % yellow | 25,7-27,6 | 18,5-20,4 | 18,9-20,4 | 19,1-22,1 | 19,8-20,6 |
| Amylose, 5 DM | 5,76-16,26 | 5,13-14,65 | 5,76-15,87 | 6,91-12,13 | 6,91-14,65 |

The ash content ranged from 1,34 to 2,12%. Kostanayskaya 12 was distinguished by a number of traits: vitreousness (54-82%), protein content (16,4-20,8%), gliadin content (31,1-37,9%) and the gliadin+glutenin (52,3-59,4%), amylose content ranged from 5,1-16,3%. Ranking of spring durum wheat by grain quality depended on cultivation region. Variety Altaiskaya Niva was superior for five traits in Akmola region: vitreousness, hardness, gliadin content, gliadin/glutenin ratio and amylose content (Fig. 1).

In Kostanay region variety Kostanayskaya 12 had high protein content, vitreousness, hardness, gliadin content and the gliadin/glutenin ratio. Variety Kargala 29 had high quality indicators: test weight, gliadin and gliadin + glutenin content in the 1st Karaganda region. Variety Zhemchuzhina Sibirii ranked first in Aktobe region for carotene content, hardness index, and gliadin content. Among the studied durum wheat varieties Kargala 29 showed stability for amylose and glutenin content in all environments and variety Zhemchuzhina Sibirii had stability for high carotene and glutenin content. Regions differ for quality values for the same set of varieties. Thus, Aktobe region was characterized by high-protein grain with maximum gliadin fraction content and with the best gluten quality and ash content. In Kostanay region high vitreousness grain with a high

carotene content was formed and in Karaganda region grain was mostly characterized by high amylose content (Table 2).

Figure 1. Ranking of spring durum wheat varieties in terms of grain quality, depending on the growing region.

Table 2. Average value of spring durum wheat grain quality by region.

| Indicator | Akmola | Kostanay | Aktyubinsk | Karaganda |
|---------------------------|--------|----------|------------|-----------|
| Test weight, g/l | 820 | 828 | 792 | 803 |
| Vitreousness, % | 64 | 73,5 | 65 | 57 |
| Hardness (SKCS 4100) | 102 | 97 | 102 | 99 |
| Ash content, % DM | 1,52 | 1,71 | 2,00 | 1,45 |
| Protein, % DM | 15,9 | 14,9 | 18,5 | 17,5 |
| Gliadin, % protein | 31,2 | 30,5 | 33,5 | 31,8 |
| Glutenin, % protein | 22,4 | 22,4 | 21,9 | 21,1 |
| Gliadin/glutenin | 1,4 | 1,4 | 1,6 | 1,5 |
| Gluten by ball | 3,8 | 3,7 | 3,8 | 3,9 |
| Carotenoids content, % DM | 20,3 | 21,5 | 21,3 | 20,4 |
| Amylose content, % DM | 12,9 | 11,7 | 8,5 | 12,4 |
| Gliadin + glutenin | 53,8 | 53,5 | 58,7 | 52,9 |

KASIB trial is a comparison of the best varieties and lines from Russia and Kazakhstan with the aim to select the most high-quality genotypes for each of the limiting characteristics and their combination. Thus, for protein content varieties Damsinskaya yantarnaya, Kargala 30, Kostanayskaya 12 were superior in 2-3 regions out of five; variety Kargala 28 in 4 regions and varieties Asangali, Kargala 29 and Kostanayskaya 12 in 2 out of 5 regions. For gluten quality variety Collectivnaya 2 was the best in all 5 regions and variety Damsinskaya yantarnaya was best in 2 out of 5 regions. For amylose content variety Zhemchuzhina Sibiri and for sedimentation index varieties Collectivnaya 2 and Kargala 28 were superior in two out of three regions.

Comparison of varieties on all indicators of quality achieved by integrated assessment is demonstrated in Table 3. The most consistently balanced for all traits was variety Collectivnaya 2 (1th rank in North, Karaganda and 2th rank in Barnaul) and variety Gordeiforme 417 (rank 1 in Karabalyk, Omsk and rank 3 in Karaganda). Varieties Gordeiforme 417, Gordeiforme 415, Collectivnaya 2, Kargala 28 and Zhemchuzhina Sibiri were the best in all regions.

Analysis of the gliadin component composition revealed a close similarity in quality of cvs: Kargala 29 and Kargala 30 (rank 12, 14); Gordeiforme 91-144-4 and Kostanayskaya 12 (rank 13,

15); Gordeiforme 415 and Kargala 28 (rank 2 and 4). The best pasta evaluation and pasta color was observed for Zhemchuzhina Sibiri and Gordeiforme 91-144-1 and then varieties Asangali, Gordeiforme 415, Gordeiforme 417, Kargala 28 and Kargala 30. The flour produced from durum was studied for whiteness. The samples different from the second type to first, mostly for varieties Kargala 29 (50,2); Asangali (49,3); Gordeiforme 415 (49,1); Collectivnaya 2. According to the mixing values (farinograph), varieties Gordeiforme 415, Kargala 28, Kargala 30, and TS-15 had good quality (>60%). The maximum values of gluten quality were observed for varieties Damsinskaya yantarnaya, Damsinskaya 90, Kargala 34; for flour whiteness – Asangali, Kargala 34, Orenburgskaya 10, Nauryz 6, Kievlyanka. Maximum value of sedimentation was found for Damsinskaya yantarnaya, Damsinskaya 90 and Kargala 34; of amylose content for Kargala 34; strength of flour for Kargala 34 (W=210) and Damsinskaya 90 (W=202). Damsinskaya yantarnaya (W=192); valormetric value (farinograph) for Kargala 34 was 60-55f, Damsinskaya yantarnaya 70-51f (Tohtabakieva and Abugalieva, 2006). Analysis of flour and dough physical properties and baking to evaluate selected varieties as having potential for bread-making (30-60 u.f.) as shown for Moroccan wheat (Benjnah *et al.*, 1999; Hareland *et al.* 1999).

Table 3. Integral assessment of the KASIB durum wheat varieties by grain quality (11 index).

| Variety | 2004 | | | 2005 | | | Total Average | | Rank |
|------------------------|------|----|----|------|----|------|---------------|----|------|
| | B* | O | K1 | K2 | A | Rank | Rank | | |
| Hiton | 6 | 11 | - | - | - | 17 | 8,5 | 11 | |
| Collectivnaya 2 | 2 | 13 | 1 | 10 | 1 | 27 | 5,4 | 3 | |
| Zhemchuzhina sibirii | 8 | 5 | 4 | 6 | 10 | 33 | 6,6 | 5 | |
| Gordeiforme 91-144-4 | 7 | 3 | 14 | 15 | 9 | 48 | 9,6 | 13 | |
| Altayskaya Niva | 13 | 6 | 8 | 3 | 5 | 35 | 7,0 | 6 | |
| Gordeiforme 415 | 9 | 4 | 5 | 5 | 2 | 25 | 5,0 | 2 | |
| Gordeiforme 417 | 11 | 1 | 3 | 1 | - | 16 | 4,0 | 1 | |
| Damsinskaya yantarnaya | 14 | 9 | 10 | 2 | 4 | 39 | 7,8 | 8 | |
| L 173/93-1 | 5 | 8 | 9 | 11 | - | 33 | 8,2 | 9 | |
| Kostanayskaya 12 | 12 | 12 | 7 | 13 | 6 | 50 | 10,0 | 14 | |
| Asangali | 10 | 7 | 6 | 12 | 7 | 42 | 8,4 | 10 | |
| Kargala 28 | 4 | 2 | - | 9 | 11 | 26 | 6,5 | 4 | |
| Kargala 29 | 3 | 10 | 11 | 8 | 12 | 44 | 8,8 | 12 | |
| Kargala 30 | 1 | 14 | 13 | 14 | 8 | 50 | 10 | 14 | |
| TS-15 | - | - | 12 | 7 | 3 | 22 | 7,3 | 7 | |

*Locations: B = Barnaul; O 0 Omsk; K1 = Karaganda; K2 = Karabalik; A = Aktobe.

Analysis of the gliadin component composition revealed a close similarity in quality of cvs: Kargala 29 and Kargala 30 (rank 12, 14); Gordeiforme 91-144-4 and Kostanayskaya 12 (rank 13, 15); Gordeiforme 415 and Kargala 28 (rank 2 and 4). The best pasta evaluation and pasta color was observed for Zhemchuzhina Sibiri and Gordeiforme 91-144-1 and then varieties Asangali, Gordeiforme 415, Gordeiforme 417, Kargala 28 and Kargala 30. The flour produced from durum was studied for whiteness. The samples different from the second type to first, mostly for varieties Kargala 29 (50,2); Asangali (49,3); Gordeiforme 415 (49,1); Collectivnaya 2. According to the mixing values (farinograph), varieties Gordeiforme 415, Kargala 28, Kargala 30, and TS-15 had good quality (>60%). The maximum values of gluten quality were observed for varieties Damsinskaya yantarnaya, Damsinskaya 90, Kargala 34; for flour whiteness – Asangali, Kargala 34, Orenburgskaya 10, Nauryz 6, Kievlyanka. Maximum value of sedimentation was found for Damsinskaya yantarnaya, Damsinskaya 90 and Kargala 34; of amylose content for Kargala 34; strength of flour for Kargala 34 (W=210) and Damsinskaya 90 (W=202). Damsinskaya yantarnaya (W=192); valormetric value (farinograph) for Kargala 34 was 60-55f, Damsinskaya yantarnaya 70-51f (Tohtabakieva and Abugalieva, 2006). Analysis of flour and dough physical properties and baking to evaluate selected varieties as having potential for bread-making (30-60 u.f.) as shown for Moroccan wheat (Benjnah *et al.*, 1999; Hareland *et al.* 1999).

IV – Conclusions

The studied durum wheat varieties ranged for the most high-quality pasta traits 1) released varieties Kostanayskaya 12, Damsinskaya Yantarnaya, Zhemchuzhina sibir, Altayka, Sid-88, and Damsinskaya 90, 2) varieties being officially tested - Damsinskaya Yantarnaya, Asangali, Kargala 34, Damsinskaya 90, Zhemchuzhina Sibiri, Toma; 3) germplasm from KASIB trial: Gordeiforme 417, Gordeiforme 415, Collectivnaya 2, Kargala 28, and Zhemchuzhina Sibiri. Cultivars Kargala 29 and Zhemchuzhina Sibiri were characterized for stability of grain quality (gluten quality and carotene content) formation in different conditions. Bread-making potential was revealed for the following durum wheat cultivars: Damsinskaya yantarnaya, Asangali, Kargala 34, Nauryz 7 and Nauryz 8. Varieties in Aktobe region excelled in formation of high-protein grain (due to maximum gliadin fraction) with the best gluten quality and ash content.

References

- Peruanskiy Yu.V., Abugaliev A.I., Savin V.N., 1996.** Biochemical evaluation methods of collection and breeding material – Almaty, pp. 123.
- Benjnah M., Chanrand M., Jaonhari A., Lasserre N.M., Surget A., Abecassis J., 1999.** Assessment of durum wheat for Moroccan bread-making. - In : *17th ICC Conference*, Valencia, Spain, pp. 89.
- Hareland G.A., Puhr D.P., Joppa L.R., Klendworth D.L., 1999.** Durum flour in bread-making. In: *17th ICC Conference*, Valencia, Spain, pp. 163.
- Ammar K., Kronstad W.E., Morris C.F., 2000.** Bread making quality of selected durum wheat genotypes and its relationship with high molecular weight glutenin subunits: Allelic variation and gluten protein polymeric composition. *Cereal Chemistry*, 77, pp. 230-236.
- Tohtabakieva M.I., Abugaliev A.I., 2006.** Grain quality of durum wheat cultivars. The collection: new trends in the development of agricultural science for young scientists. In: *International Scientific and Practical Conference of Young Scientists*, 20-21 April 2006, vil. Krasnoobsk, Novosibirsk, pp. 290-293.