PHYSICOCHEMICAL PROPERTIES OF WHEAT (*TRITICUM AESTIVUM* L.) AVAILABLE FOR CONSUMPTION IN PAKISTAN

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ABSTRACT

Major quality characteristics of wheat grown in southern-zone of Pakistan were assessed and compared with wheat imported from Australia, USA, Russian federation and Canada. The physicochemical characteristics tested were grain size (GS), shriveled and broken grains (SBG), test weight (TW), thousand grain mass (TGM), moisture content (MC), protein content (PC), wet gluten (WG), dry gluten (DG), gluten index (GI), hardness score (HS) and falling number (FN). Canadian and American wheat had the highest TW (78 kg/hL). The respective highest (12.2%) and lowest (9.1%) mean value for MC were found in Russian and American wheat. The respective highest (14%) and lowest (10.7%) PC was found in Canadian and American wheat. The highest and lowest contents of gluten (WG & DG) were found in Australian (32.8% & 10.5%) and Russian (23.4% & 7.5%) origin wheat respectively. Russian and Sindh wheat possessed the highest (83%) and lowest (49.5%) GI, respectively. Sindh and Australian wheat had the lowest activity of α-amylase revealed by falling numbers of 526 sec and 508 sec, respectively. Significant correlation was found between protein and wet gluten contents. Findings of the present study is useful for the breeding programs, milling and processing industry in evaluations of wheat quality.

Key words: wheat quality, consumer market, southern-zone of Pakistan.

INTRODUCTION

Wheat is the major component of our staple food. Wheat is consumed in many form in break fast. A little over 20 MT is consumed in our country yearly. In year 2004, our production of wheat was about 19,192 thousand metric tons (USDA-FAS 2004). So, Pakistan had to import wheat from the wheat exporting countries that is Australia, USA, Canada and Russia to build up strategic reserves after a shortfall in production.

Wheat is used to make a wide range of bakery products which require wheat flours of specific physico-chemical characteristics that primarily influenced by environmental conditions (Mikhaylenko *et al.,* 2000). A number of quality tests are used to evaluate the wheat quality. Among these, the physical condition is considered to be the most important quality factors which determine the processing value of wheat (Dexter and Tipples, 1987; Dexter, 1993). Mattern *et al.* (1970) have reported that protein content of wheat ranges from 5.6-21% and it is a key quality factor to determine its suitability for a particular type of product and it depends on the genotype and environment (Peterson *et al.,* 1992; Huebner *et al.,* 1995). Moreover, the functional properties of wheat largely depend on its gluten quantity and quality (Schofield, 1994). Hardness is one of the major parameter that is needed to categorize the wheat for specific end-use purpose (Williams and Sobering, 1967).

From few years, wheat is available in the consumer markets in southern-zone of Pakistan from two sources that is domestic and foreign. So, the objective of this study was to assess the quality of wheat grown in the southern-zone of Pakistan and compare it with the foreign origin wheat that were imported by Pakistan in 2004.

MATERIALS AND METHODS

Physical characteristics

Each sample was mixed thoroughly by precision electronic divider and thereafter cleaned manually. Shriveled and broken grains were obtained by passing the sample through a sieve with long rounded apertures 1.7 mm wide. Cleaned samples were fractionated over slotted sieves to yield three portions: held on 7/64*3/4, held on 6/64*3/4 and held on 5/64*3/4 inches sieves. Test weight was determined using a standard 1L bucket procedure requiring 1000 g of wheat (unit of test weight; kilograms per hectolitre (kg/hL) (Dexter and Tipples, 1987). Shriveled, broken and severely damaged kernels were separated by handpicking from a sample to create a sub-sample that was then used to determine thousand grain mass using electronic seed counter. Moisture content of grains was determined through digital moisture tester (Burrows Model 700) duly calibrated with air oven method.

Chemical characteristics

Cleaned samples (free of foreign matter) of approx. 300 g were milled through Perten laboratory mill 3100 installed with 0.8 mm sieve. Protein content and hardness were analysed through NIR-technique according to the procedure described in the instruction manual of Inframatic 8620A system of Perten. Gluten content and gluten index were determined according to AACC (2000) method no. 38-12. Falling Number apparatus was used for the determination of α-amylase activity and it was determined according to AACC 56-81B.

Experimental design and statistical analysis

About 93 wheat samples were collected from several locations of major wheat producing districts in southern-zone of Pakistan viz. Hyderabad, Nawabshah, Nausheroferoz, Sanghar, Mirpurkhas and Khairpur. The samples of foreign origin wheat used in this study were received from Trade Corporation of Pakistan. The quality tests were performed in triplicate and results reported in range as an average with standard deviation. Pearson's correlation coefficients were determined using SPSS Data Editor 10.0 and statistical significant levels were $P<0.05$ and $P<0.01$.

RESULTS AND DISCUSSION

The physicochemical characteristics of wheat grown in southern-zone of Pakistan

The study of physical and chemical characteristics of wheat samples collected from major wheat producing districts in southern-zone of Pakistan is presented in Table 1 and Table 2, respectively. The study revealed that wheat samples collected from Mirpurkhas district contained the highest portion of large size kernels. The wheat grown at Nawabshah contained the lowest portion of large size kernels in the presence of the mean temperature was 21.4 ^{o}C and mean precipitation was 0.28 mm during the crop year that is from October 2003 to March 2004. Moreover, the respective highest and the lowest proportion of shriveled and broken grains were found in the wheat samples of Nawabshah and Mirpurkhas districts.

Both the samples that is from Nawabshah and Mirpurkhas were found with the lowest and the highest bulk density respectively. It is obvious that test weight depends on environmental conditions. So, the resistance of variety to adverse environmental conditions i.e., air drought and high temperature at grain fill can be determined by test weight (Misic and Mladenov, 1998). Hence, test weight is being used as indicator for the evaluation of cultivar's adaptability to different environment (Fowler and Roche, 1975).

Morgan *et al.* (2000) have demonstrated that kernel weight affects positively the flour yield and color. More healthy the grains greater the thousand grain mass. The respective highest and the lowest TGM were found in the samples of Mirpurkhas and Hyderabad districts. MC of all wheat samples were found in a narrow range that is 9.2 to 12.4% and the respective highest and the lowest MC were found in Mirpurkhas and Nawabshah wheat samples.

In order to determine the strength of dough, the formation and amount of protein matrix consider to be an important factor that is more protein matrix, stronger the dough. The content of protein mainly depends on the environment and crop management practices however the quality of protein is genetically determined (Cornish *et al.,* 1991). In this study, a relatively narrow range of PC which can be seen at Table 2 is 11.2 to 15.8% in Sindh wheat. High protein content is usually desirable in bread-making because increased PC is associated with higher loaf volumes (Mailhot and Patton, 1988).

The highest and the lowest gluten contents were observed in the wheat samples of Nawabshah and Nausheroferoz districts respectively. Such a wide range of gluten index of varied strength from weak to strong obtained in Sindh wheat, particularly the highest and the lowest gluten index were observed in wheat samples of Nausheroferoz and Nawabshah respectively. Moreover, Falling number was also observed which indicates α-amylase activity in flour (Koksel *et al.,* 2000). The falling number results as shown in Table 2 reveal that wheat flour samples were deficient in α-amylase activity that may create problems in the crumb and crust of the breads produced (Hoseney, 1994).

Relationships between quality characteristics of wheat were evaluated. Protein had significantly positive relationship with wet gluten (Fig. **1(a))**. Many workers (Wang and Kovacs, 2002; Mladenov *et al.,* 2001) have demonstrated the significant relationship between protein content and wet gluten. Wang and Kovacs have studied on Canadian wheat in 2002 and they reported that gluten index is not significantly correlated with wet gluten. Similarly, we have found a non-significant and weak relationship between WG and GI (Fig. **1(b))**.

Quality characteristics of domestic and imported wheat

The physical and chemical characteristics of domestic and foreign origin wheat (America, Australia, Canada and Russia) that were import by Pakistan in 2004 are given in Table 3 and Table 4. The first quality evaluation by a

consumer is visual assessment that usually includes color of the product and is usually associated with freshness, cleanliness, and general product quality. The desired flour color varies with the product and market. For example, creamy colored flour is preferred for noodles (Mares and Campbell, 2001). Herein South Asia, chapatti is mainly prepared from white flour in cities and preference is given to white color. In Russian wheat, reddish brown color is observed that might not be preferred by chapatti consumer. Wheat kernel color depends on genetics, growing condition and characteristics of kernel (Ram and Singh, 2004).

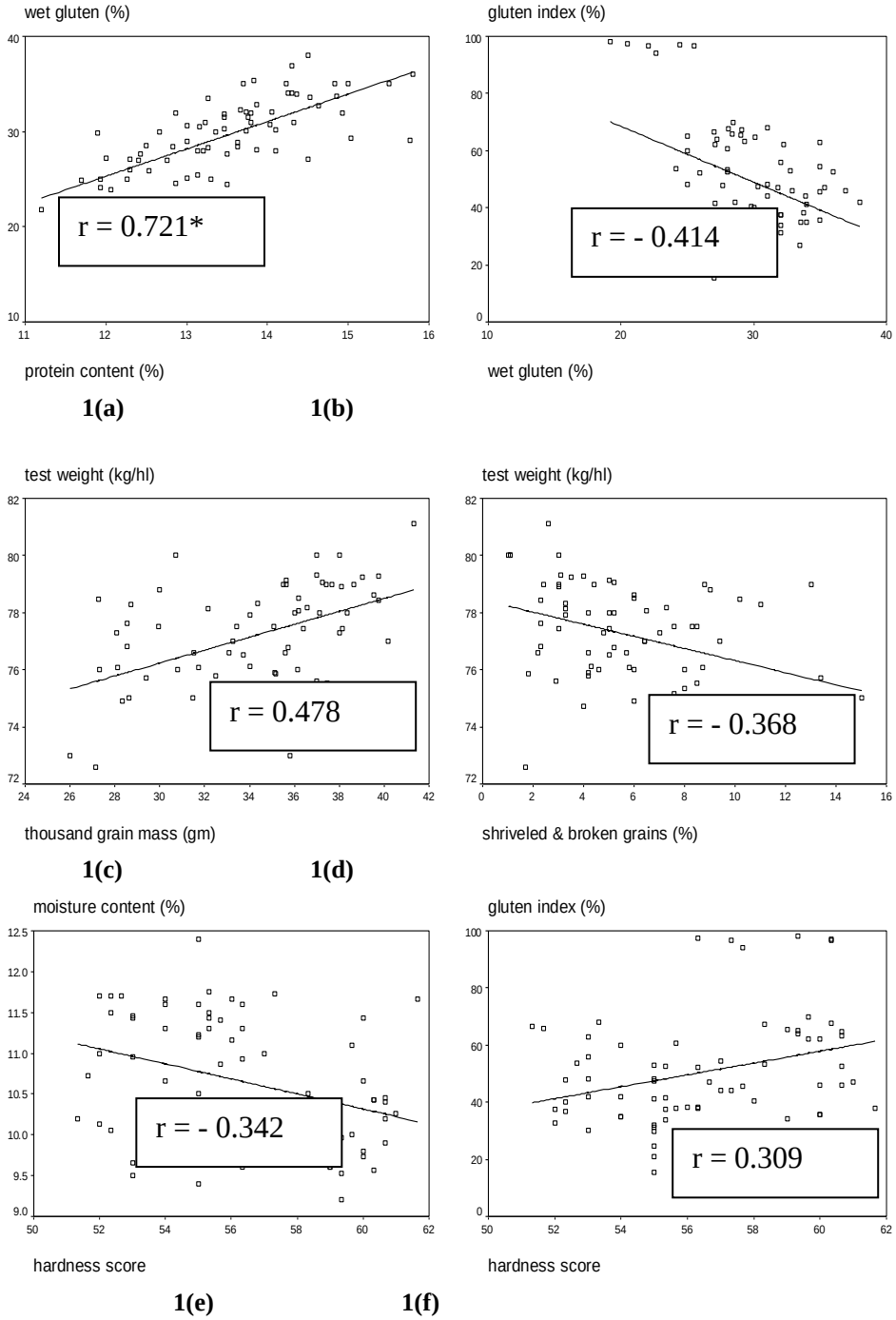

Fig. 1. Illustration of some statistically significant correlations among studied quality traits of Sindh wheat.

Table 1. The physical characteristics of wheat samples collected from major wheat producing districts in southern-zone of Pakistan.

Name of District	Grain Size (%)			Shriveled and broken grains (%)	Test weight (kg/hL	Thousand grain mass (g)	Moisture content (%)
	7/64*3/4	6/64*3/4	5/64*3/4				
Nawabshah	17	57.6	17.5	6.9	76.6	34.8	10.4
Mean	11.5	9.9	6.2	3.3	1.7	3.2	0.7
SD	0.1	35.5	10.0	4.0	73	28.3	9.2
Min	43	77.0	34.0	15.0	79.1	40.2	11.7
Max							
Hyderabad	25	48.2	21.4	5.2	76.1	34.2	11.2
Mean	15.8	19.6	20.2	3.7	2.4	4.8	1.2
SD	0.6	11.6	6.0	1.7	72.6	26.0	10.0
Min	55	70.0	67.3	11.7	79.1	38.0	11.6
Max							
Nausheroferoz	13.4	58.8	17.8	6.3	77.5	32.5	10.1
Mean	9.6	6.8	3.1	3.0	1.4	3.0	0.5
SD	3.7	51.3	13.2	3.0	75	28.7	9.5
Min	29.6	70.7	21.6	11.0	78.9	38.1	11.1
Max							
Mirpurkhas	33	53.1	9.8	2.5	79.7	36.4	11.6
Mean	14.4	15.2	3.0	1.8	24.9	4.3	0.3
SD	7.3	23.6	5.0	1	77.9	30.7	11.2
Min	70	77.4	14.0	7.3	80	40	12.4
Max							
Sanghar	25.6	52.4	14.5	5.6	77.9	31.7	11.2
Mean	18.6	13.0	6.1	2.7	1.2	4.9	0.4
SD	4.0	34.0	5.6	2.3	75	27.3	10.5
Min	59	70.0	23.4	10.2	79.3	39.0	11.7
Max							
Khairpur	20.3	55.7	16.4	5.6	77.1	35.3	10.3
Mean	14.2	11.3	5.2	2.3	1.7	4.1	0.6
SD	3.5	29.0	6.2	2.3	75.2	28.1	9.6
Min	50	73.0	24.3	8.7	81.1	39	11.7
Max							

Wheat samples can be graded with respect to kernel size. Generally, millers presume the small grains with low flour extraction and quality but few of the workers have demonstrated that the relationship is complex and vary among wheat of different classes and origin (Dexter and Tipples, 1987). Another aspect is the uniformity of grain size. In our opinion, large difference among sizes of grain that is a mixture of large and small kernels reduces flour extraction as it is difficult to optimize roll gap. In other words, a wheat mixture of maximum small kernels can produce good quality flour at commercial flour mills. Russian and Australian wheat contained the respective highest and the lowest proportion of large size kernels. While Canadian wheat contained the lowest proportion of small size kernels.

Table 2. The chemical characteristics of wheat samples collected from major wheat producing districts in southern-zone of Pakistan.

Name of District	Protein Content (%)	Wet Gluten (%)	Dry Gluten (%)	Gluten Index (%)	Hardness Score	Falling Number (sec)
Nawabshah	13.7	30.6	9.8	47.6	55	529.5
Mean	1.1	3.9	1.3	15.3	3.9	54.9
SD	11.9	24.6	7.9	8.6	42	352.0
Min	15.8	38.0	13.0	67.3	61	632.0
Max						
Hyderabad	13.7	30.0	9.7	47.7	54	550.7
Mean	0.9	3.3	1.2	16.5	1.8	70.6
SD	12.3	25.0	8.0	24.5	52	474.0
Min	15.0	35.0	11.5	68.0	58	688.0
Max						
Nausheroferoz	13.3	27.5	8.7	67.1	59	490.6
Mean	0.9	6.2	1.8	26.9	1.8	40.0
SD	11.6	19.2	6.2	34.2	56	430.0
Min	14.1	35.3	10.8	98.1	61	557.0
Max						
Mirpurkhas	12.8	28.1	8.9	35.6	54	516.8
Mean	0.9	3.4	1.1	11.4	1.6	24.5
SD	11.2	21.8	7.0	15.5	52	484.0
Min	14.1	32.1	10.5	53.7	56	563.0
Max						
Sanghar	13.4	29.7	11.7	42.8	55	520.4
Mean	1.1	3.8	7.1	10.1	1.7	111.3
SD	12.1	23.9	8.0	21.1	52	363.0
Min	14.9	33.9	29.2	53.0	57	659.0
Max						
Khairpur	13.4	29.1	9.8	56.6	58	553.8
Mean	1.0	3.9	1.2	25.5	5.4	65.0
SD	11.9	22.6	7.0	23.2	40	466.0
Min	14.8	36.9	11.4	97.0	62	709.0
Max						

Wheat grains if not fully filled out during grain fill properly will have a shriveled appearance. It was observed during study that American and Canadian wheat had the lowest proportion of shriveled and broken grains while Australian wheat had the highest proportion among the studied wheat. Some of the wheat samples collected from southern-zone of Pakistan was found with very high proportion of Shriveled and broken grains.

The grains if sound, mature and fully filled have the highest possible bulk density and the millers prefer such wheats (Donelson *et al.*, 2002). During study of samples the higher yield of flour was expected in the wheat of Canadian and American origin. On other hand, the respective lowest and the highest mean values for moisture content were found in American and Russian wheat.

Cornish *et al.* (1991) have described that the content of protein mainly depends on the environmental conditions and crop management practices and the higher accumulation of protein content in the grain depends on the temperature if it remains higher during grain fill period (Hoseney, 1994). The respective highest and the lowest mean values for protein content were found in Canadian and American wheat.

Although the Australian wheat had the highest mean value for the content of gluten but some of the samples of domestically grown wheat had highest gluten content in comparison to Australian wheat. On the other hand the Russian wheat had the lowest gluten content. The lowest and the highest mean values for gluten index were found in the wheat grown in southern-zone of Pakistan and Russian federation respectively. Many of the workers have

demonstrated for good chapatti making, the harder grains and medium strong gluten is required and softer grains and weak gluten is requirement of good cookie-making (Hoseney *et al.,* 1988; Souza *et al.,* 1994).

Increase in α-amylase activity was due to the late season rain which is referred as the pre-harvest sprouting in wheat grain. This adversely affects the processing quality in shape of the partial degradation of starch. Hence, minimum falling number is usually specified for wheat shipments (Graybosch *et al.,* 2000). The samples of Australian and domestically grown wheat had lower activity of α-amylase then Canadian, American and Russian wheat.

It was concluded that all foreign origin and domestically grown wheat were found suitable for bread. The wheat was imported for Pakistan with distinguish variation which revealed that the Government policy needs to be uniformed. A wide range of quality characteristics were found in wheat samples collected from southern-zone of Pakistan.

Table 3. The physical characteristics of wheat samples collected from southern-zone of Pakistan and foreign origin wheat that were import by Pakistan.

Name of origin	Shriveled and broken grains (%)	Test weight (kg/hL)	Moisture content (%)
Sindh			
Mean	5.3	77.5	10.8
SD	1.5	1.3	0.6
Min	1	72.6	9.2
Max	15	81.1	12.4
America			
Mean	2	78	9.1
SD	0.53	0.57	0.46
Min	3	77.5	8.7
Max	4	78.5	9.5
Australia			
Mean	5.6	76.7	10.4
SD	0.79	0.5	0.3
Min	5	76	10
Max	6	77	11
Canada			
Mean	2	78	12
SD	0.57	0.57	0.46
Min	1.5	77.5	11.7
Max	2.5	78.5	12.5
Russia			
Mean	2.8	77	12.2
SD	0.37	0.67	0.56
Min	2.5	76	11
Max	3.5	78	13

Table 4. The chemical characteristics of wheat samples collected from southern-zone of Pakistan and foreign. origin wheat that were import by Pakistan.

Name of origin	Protein Content (%)	Wet Gluten (%)	Dry Gluten (%)	Gluten Index (%)	Hardness Score	Falling Number (s)
Sindh	13.4	29.2	9.8	49.5	56	526
Mean	0.33	1.2	1.1	11	2.1	23
SD	11.2	18.9	6.2	15.5	42	423
Min	15.9	36.9	13	98.2	62	625
Max	10.7	25	8	52	41	267
America	0.28	0.57	0.23	2.3	1	3.67
Mean	10.5	24.5	7.8	50	40	263
SD	11	25.5	8.2	54	42	272
Min	13.5	32.8	10.5	79.6	52	508
Max	0.4	0.9	0.7	3	1.3	42
Australia	13	32	10	81	51	430
Mean	14	33	11	82	53	652
SD	14	29.5	9.5	51	52	251
Min	0.23	0.57	0.57	8.8	0.69	6.5
Max	13.8	29	9	43.3	50	246
Canada	14.2	30	10	58.6	53	260
Mean	10.9	23.4	7.5	83	45	264
SD	0.48	0.95	0.53	1.9	0.74	42
Min	10	22	7	80	45	240
Max	12	24	8	85	47	342
Russia						
Mean						
SD						
Min						
Max						

REFERENCES

American Assoc. of Cereal Chemists (2000). *Approved Methods of the AACC*, 10th ed. Method 38-12; 56-81B. The Assoc.: St. Paul, MN.

Cornish, G.B., G.A. Palmer and N.K. Singh (1991). Screening for wheat protein quality using SDS-PAGE. *In:* Martin, O. J. & Wrigley, C. W. (Eds.), *Cereals International.* RACI, Parkville, Australia, pp. 202-204.

Dexter, J.E. and K.H. Tipples (1987). Wheat milling at grain research laboratory. *2. Milling*., 180(70): 16, 18-20.

Dexter, J. E. (1993). End use quality implications of grading factors in wheat. *In:* Bass, E. J. (Ed.), *Grain and Oilseeds: Handling, Marketing, Processing,* Canadian International Grains Institute, Winnipeg, Canada, pp. 697-722.

Donelson, J.R., C.S. Gaines, L.C. Andrews and P.F. Finney (2002). Prediction of test weight from a small volume specific gravity measurement. *Cereal Chem.,* 79: 227-229.

Fowler, D.B. and I.A. De La Roche (1975). Wheat quality evaluation.3. Influence of genotype and environment. *Can. J. Plant Sci.,* 55: 263-569.

Graybosch, R.A., G. Guo and D.R. Shelton (2000). Apparent falling numbers of waxy wheats independent of α-amylase activity. *Cereal Chem.,* 77(1): 1-3.

Hoseney, R.C., P. Wade and J.W. Finley (1988). Soft wheat products. *In:* Pomeranz, Y. (Ed.) *Wheat chemistry and technology,* Am Assoc Cereal Chemist, St Paul, Minnesota, USA, pp. 407-456.

Hoseney, R.C. (1994). *Principle Of Cereal Science And Technology*. The American Association of Cereal Chemists, Minnesota, USA, pp. 91-94.

Huebner, F.R., T.C. Nelson and J.A. Bietz (1995). Differences among gliadins from spring and winter wheat cultivars. *Cereal Chem.,* 72: 341-343.

Koksel, H., O. Sivri, O. Ozbay, A. Baswan and H. Karacan (2000). *Hububat Laboratory El. Kitaby,* Hacettepe University Press, Ankara, Turkey, pp. 42-45.

Mailhot, W.C. and J.C. Patton (1988). Criteria of wheat quality. *In:* Pomeranz Y, (Ed.) *Wheat Chemistry and Technology,* AACC, St Paul, Minnesota, pp. 69-90.

Mares, O.J. and A.W. Campbell (2001). Mapping components of flour and noodle color in Australian wheat. *Aust. J. Agric. Res.,* 52: 1297-1309.

Mattern, P.P.J., J.W. Schmidt and V.A. Jhonson (1970). Screening of high lysine content in wheat. *Cereal Sci. Today,* 15: 409.

Mikhaylenko, G.G., Z. Czuchajowska, B.K. Baik and K.K. Kidwell (2000). Environmental influences on flour composition, dough rheology and baking quality of spring wheat. *Cereal Chem.,* 77(4): 507-511.

Misic, T. and N. Mladenov (1998). Results of winter wheat breeding at the Novi Sad Institute. In: Proc 2nd Balkan Symp Field Crops, (S. Stamenkovic, ed.) pp. 15-22, Institute of Field and Vegetable Crops, Novi Sad, Yugoslavia.

Mladenov, N., N. Przulj, N. Hristov, V. Djuric and M. Milovanovic (2001). Cultivar-by-environment interactions for wheat quality traits in semiarid conditions. *Cereal Chem.,* 78(3): 363-367.

Morgan, B.C., J.E. Dexter and K.R. Preston (2000). Relationship of kernel size to flour water absorption for Canada Western Red Spring wheat. *Cereal Chem.,* 77(3): 286-292.

Peterson, C.J., R.A. Graybosch, P.S. Baenziger and A.W. Grombacher (1992) Genotype and environment effects on quality characteristics of hard red winter wheat. *Crop Sci.,* 32: 98-103.

Ram, S. and R.P. Singh (2004). Solvent retention capacities in Indian Wheats and their relationship with cookie making quality. *Cereal Chem.,* 81: 128-133.

Schofield, J.D. (1994). Wheat protein: Structure and functionality in milling and bread-making. *In:* Bushuk, W. and V. Rasper (Ed.), *Wheat: Production, Properties and Quality,* Blackie Academic and Professional, Glassgow, UK, pp. 73-106.

Souza, E., M. Kurk and D.W. Sunderman (1994). Association of sugar-snap cookie quality with high molecular weight glutenin alleles in soft white spring wheats. *Cereal Chem.,* 71: 601-605.

USDA-FAS [United States Department of Agriculture- Foreign Agricultural Service]. 2012. World Agricultural Production. Available on the World Wide Web: http://www.fas.usda.gov/wap/current/default.asp.

Wang, C. and M.I.P. Kovacs (2002). Swelling index glutenin test. I. Method and comparison with sedimentation, gel protein, and insoluble glutenin test. *Cereal Chem.,* 79: 187-189.

Williams, P.C. and D.C. Sobering (1967). Relation of starch damage and related characteristics of kernel hardness in Australian wheat varieties. *Cereal Chem.,* 44: 383.

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