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Quality Evaluation of Some Sindh (Pakistan) Wheat Varieties. II. Correlation Among Various Quality Traits

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Abstract. Some physicochemical and rheological properties of five commercial wheat varieties cultivated in Sindh, Pakistan, namely, Mehran-89, Kiran-95, TJ-83, Anmol-91 and Sarsabz were analyzed. These wheat varieties were obtained from Wheat Research Institute, Sakrand, Sindh, Pakistan in August 2004. The results revealed that the shriveled and broken grains ranged between 0.5 to 9.0%, test weight 75 to 79kg/hectoliter, thousand grain mass 31.8 to 42.2 g, moisture content 10.3 to 10.8%, protein content 11.9 to 15.5%, wet gluten 23 to 39.7%, dry gluten 7 to 12%, gluten index 36.6 to 85.8%, near-infrared (NIR) hardness score 53 to 61, farinograph water absorption 69.1 to 73.3%, dough development time 2 to 4.5 min, dough stability 2 to 11 min, and degree of softening 30 to 100 Brabender unit. The coefficients of correlation (r) between various quality parameters were also calculated. A significantly positive correlation existed between the hardness score and test weight (r = 0.886). The degree of softening was found to be significantly correlated with moisture content (r = 0.943) and gluten index (r = − 0.886). It was also observed that the capacity of gluten to bind water was positively correlated with farinograph water absorption (r = 0.891).

Keywords: wheat varieties, wheat quality traits, wheat variety correlations, wheat rheology, wheat physicochemical characteristics, baking properties, dough rheology

Introduction

Wheat is the most important component of Pakistani diet. It is consumed in the form of 'tandoori roti' and 'chapatti' (unleavened bread). Such kinds of breads are mostly prepared from whole-wheat flour. Wheat flour is also used in several bakery products, particularly biscuits, leavened breads and pizza. Generally, the priorities of growers, millers and bakers are high yields of grain, good quality flour, and the making quality of bread, respectively. The most important considerations for the consumer are high nutritive value and good organoleptic properties of the bread (Mladenov *et al.*, 2001). The wheat quality characteristics are, therefore, of prime importance for millers, processors and consumers. The quality of wheat grain is influenced by the variety and cultivation environment (Lin and Czuchajowska, 1997).

Various traits have been used for the evaluation of wheat quality, which may be primarily classified into three main groups: physicochemical, rheological and baking properties. Test weight is one of the basic quality traits and can be used as a reliable indicator of the biological plasticity of cultivars and their adaptability to different environments (Fowler and De La Roche, 1975). The resistance of a wheat variety to air drought and high air temperatures at grain fill can also be evaluated by determining the test weight (Misic and Mladenov, 1998).

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Dough is formed when wheat flour is mixed with water and is capable of retaining gas produced during fermentation (Walker and Hazelton, 1996). The viscoelastic properties of dough are strongly related to the gluten proteins (Janssen *et al.,* 1996; Faubion and Hoseney, 1990). Many instruments have been developed for determining the rheological properties of dough. One of these is the farinograph that uses shear and extential deformations for the evaluation of dough properties (Schluentz *et al.,* 2000; Campos *et al.,* 1997; 1996).

Tests to determine the quality characteristics of whole-wheat flour are needed to be performed when the ultimate finished product is made of this flour. These tests can be used for screening of varieties in breeding programmes for improving the end-product making quality as demonstrated by Ram and Singh (2004) for the cookie-making quality of Indian wheats. The consumption of whole-grain and whole-grain products results in the reduction of incidence of chronic diseases, such as cardiovascular diseases (Jacobs *et al.,* 1998; Thompson, 1994), diabetes (Meyer *et al.,* 2000), and cancer (Kasum *et al.,* 2002; Nicodemus *et al.,* 2001; Jacobs *et al.,* 1995; Smigel, 1992).

In Sindh, Pakistan, a large number of wheat varieties have been released and cultivated commonly by the farmers. However, little is known about their overall field performance and suitability in relation to their end-use. The objective of the present study was, therefore, to evaluate the quality of more commonly grown wheat varieties in Sindh by evaluating their physicochemical and rheological properties. The correlation among quality traits was also evaluated.

Materials and Methods

Physicochemical characteristics. Non-infested samples of five wheat varieties, viz., Mehran-89, Kiran-95, TJ-83, Anmol-91 and Sarsabz were obtained from Wheat Research Institute, Sakrand, Pakistan. These were separately mixed thoroughly by precision electronic divider (Seedburo Equipment Company, Chicago, USA, model SB-106), and thereafter cleaned manually. Shriveled and broken grains were obtained by passing the sample through a sieve with long rounded apertures, 1.7 mm in dia. Test weight was determined using the standard one-liter bucket procedure for wheat as described by Dexter and Tipples (1987). Broken kernels and foreign matter were separated by handpicking from a sample lot to create a subsample that was then used to determine the thousand grains mass using electronic seed counter. Moisture content of grains was determined through digital moisture tester (Burrows, model 700, Seedburo Equepment Company, Chicago, USA) duly calibrated with the air oven method.

Grains of each wheat variety (300 g) were milled through a Perten laboratory mill (Perten Instruments, Huddinge, Sweden, model 3100) installed with 0.8 mm sieve. The flour obtained from this mill was used for the analysis of chemical characteristics which included protein content and hardness using near infrared (NIR)-technique (Inframatic, Perten Instruments, Huddinge, Sweden, model 8620A). Gluten content and gluten index were determined according to method number 38-12 (AACC, 2000). Falling number apparatus was used for the determination of α-amylase activity, which was determined according to method number 56-81B (AACC, 2000).

Rheological properties. The whole-wheat flour was obtained from the Perten mill model 3100 installed with 0.8 mm sieve as noted above. Farinograph equipped with 50 g mixing bowl was used for the evaluation of water absorption (%), dough development time (min), dough stability (min) and degree of softening (Barbender unit) of whole-wheat flour. These parameters were determined by following method number 54-24 (AACC, 2000).

Experimental design and statistical analysis. With the exception of farinograph, all quality tests were performed in triplicate and results were reported as average with standard deviation that were statistically analysed in accordance with Zar (1974). Pearson's correlation coefficients were determined using SPSS Data Editor 10.0 (A statistical software system for analysis of data, version: 10.ov) and statistically significant levels were determined at $p < 0.05$ and $p < 0.01$.

Results and Discussion

The description related with the source and year of relase for all wheat varieties that were used in this study are shown in Table 1. These are commercially well known varieties and are cultivated by farmers in the Sindh province for many years. Quality parameters analyzed in this study were categorized in two main groups: physicochemical characteristics and rheological properties, as shown in Table 2 and Table 3, respectively. Fourteen quality parameters were assessed for determining the correlation coefficients. Some correlation coefficients are presented in Table 4.

Test weight (TW) is known to be affected by the amount of shriveled and broken grains. The shriveled and broken grains (SBG) were found in the range of 0.5-9.0% with the mean value of 5.0%. Varieties TJ-83 and Anmol-91 contained the highest and the lowest values for SBG, respectively. The most influencing effect of SBG was noted on dough stability having negative correlation coefficient ($r = -0.855$). This clearly indicates that the greater the SBG, lesser will be the dough stability (DST). Test weights of all varieties were found to range between 75-79 kg/hectoliter(hl) with the mean value of 77.2 kg/hl. Generally, the higher bulk density is an expression of sound, mature, fully filled kernels that have not been subject to wet-dry cycles from rain or dew (Donelson *et al.,* 2002). All these samples were, nevertheless, obtained from the same general area where the mean temperature was 21.4 °C and mean precipitation was 0.28 mm during the period of October 2003 to March 2004 *(personal communication).*

The thousand grains mass (TGM) also reflects the soundness of grains. It was found to range between 31.8-42.2 g, with the mean value of 37.8 g for all the studied cultivars. Kiran-95 and Anmol-91 had the highest and lowest values for TGM, respectively. TGM was found to be non-significantly correlated with TW, moisture content (MC), hardness score (HS), farinograph water absorption (FWA), degree of softening (DS), and gluten index (GI) as shown in Table 4.

Table 1. The origin and release of wheat varieties under study

Name of variety	Released by	Year of release
Mehran-89	WRI	1991
Kiran-95	NIA	1996
TJ-83	WRI	1985
Anmol-91	WRI	1993
Sarsabz	NIA	1986

WRI = Wheat Research Institute, Sakrand, Pakistan

NIA = Nuclear Institute of Agriculture, Tandojam, Pakistan

Table 2. The physicochemical characteristics of wheat varieties gown in Sindh (Pakistan) [a]

Wheat varieties	SBG (%)	TW (kg/hl)	TGM (g)	MC (%)	PC (%)	WG (%)	DG (%)	GI (%)	WBWG (%)	HS
Mehran-89	4.9±0.4	77±0.6	40±0.6	10.5±0.4	11.9±0.1	23±0.05	7±0.11	70±0.57	16±0.25	56±0.57
Kiran-95	4.2±0.42	78.1±0.4	42.2±0.4	10.6±0.5	15.5±0.1	39.7±0.25	12±0.25	49.6±0.57	27.7±0.25	61±0.25
T J-83	9.0±0.32	75±0.3	34±0.3	10.4±0.3	13.7±0.1	35.7±0.25	11±0.05	55.5±0.76	24.7±0.25	53±0.57
Anmol	0.5±0.1	77±0.3	31.8±0.3	10.3±0.4	13.8±0.05	28.2±0.4	9±0.25	85.8±0.28	19.2±0.4	59±0.25
Sarsabz	6.4±0.1	79±0.2	41.2±0.3	10.8±0.6	13±0.05	30±0.25	10±0.11	36.6±0.11	20±0.05	60±1.0

[a]average of triplicate analysis; ± standard deviation; SBG = shriveled and broken grains; TGM = thousand grains mass; TW = test weight; MC = moisture content; PC = protein content; WG = wet gluten; DG = dry gluten; GI = gluten index; WBWG = water binding in wet gluten; HS = hardness score; kg/hl = kg per hectoliter

Table 3. The rheological properties of whole-wheat flour dough of different wheat varieties grown in Sindh (Pakistan)

Wheat varieties	Water absorption (%)	Dough development time (min)	Dough stability (min)	Degree of softening
Mehran-89	70	4.5	3.8	40
Kiran-95	73.3	4	5.5	50
TJ-83	71.6	3	3.5	60
Anmol-91	69.1	4.5	11	30
Sarsabz	70.5	2	2	100

Moisture content (MC) was found to be the most influencing quality parameter that affected almost every trait of the wheat quality analysed in this study. MC significantly affected the DS (r = 0.943), that is higher the MC, greater will be the softening of dough. Although the relationships were not significant, many parameters were correlated with MC, like TW, TGM, HS, GI, dough development time (DDT), and dough stability (DST) as shown in Table 4.

The respective ranges of protein content (PC), wet gluten (WG), and dry gluten (DG) were found to be 11.9-15.5%, 23-39.7%, and 7-12% with the mean value of 13.6%, 31.3%, and 9.8%. The WG trait showed a significant positive correlation with PC (r = 0.895). This relationship is also reported by Wang and Kovacs (2002) and Mladenov *et al.* (2001). PC was also positively correlated with HS (r = 0.44) and FWA (r = 0.711), though the relationship was not significant. It is very obvious that WG is significantly correlated with DG and water binding in wet gluten (WBWG) as shown in Table 4.

The GI of all wheat varieties was found to be in the range of 36.6-85.8%, with the mean value of 59.5%. Most of the varieties had medium-strong gluten, which is a positive requirement for good 'chapatti'-making (Hoseney *et al.,* 1998; Souza *et al.,* 1994). GI had negative effect on the FWA (r = − 0.604), that is gluten of greater strength will have lower FWA. Falling number indicates the α-amylase activity in wheat and flour (Anjum and Walker, 2000). The hardness score (HS) of all varieties was found in the range of 53-61, with the mean value of 56. Most of the cultivars showed higher HS, which is required for good 'chapatti'-making quality as demonstrated by Hoseney (1998) and Souza *et al.* (1994). To characterize the wheat flour dough on the basis of rheological properties, viz., textural characteristics of the finished product, farinograph observations indicating dough development time, peak and breakdown time were obtained. It was found that FWA was influenced by SBG (r = 0.402), TGM (r = 0.499), PC (r = 0.711), WG (r = 0.873), DG (r = 0.804), and GI (r = − 0.604). A significant dependence of farinograph water absorption (FWA) was recorded on water binding in wet gluten (WBWG). Greater the capacity of WG to bind water, higher will be the FWA as reflected in Table 4. Boehm *et al.* (2004) demonstrated that higher water absorption is an indication of increased grain protein content (PC). In the present study, FWA was observed to be positively correlated with PC (r = 0.711), though the relationship was not significant. A significant negative correlation (r = − 0.965) between dough development time (DDT) and degree of softening (DS) was observed. DDT was found to be dependant on SBG (r = 0.68), MC (r = − 0.827), and GI (r = 0.829), though the relationship was not significant. Dough stability of the studied wheat varieties was found in the range of 2-11 min, with the mean value of 5.2 min. The

Table 4. Correlation among eleven quality traits in wheat varieties grown in Sindh (Pakistan)

Traits	PC	DG	WBWG	HS	TW	DS	MC	GI	DDT	FWA
WG	.895*	.981**	.997**	.165	−.078	.175	.124	−.484	−.264	.873
PC		.868	.896*	.441	.067	−.108	−.061	−.181	.054	.711
DG			.962**	.230	.018	.317	.257	−.559	−.408	.804
WBWG				.137	−.117	.114	.068	−.448	−.201	.891*
HS					.886*	.158	.429	−.202	.007	.137
TW						.462	.719	−.424	−.249	.021
DS							.943*	−.886*	−.665	.183
MC								−.875	−.827	.209
GI									.829	−.604
DDT										−.178

*, ** = significant at $p < 0.05$ and $p < 0.01$, respectively; WG = wet gluten; PC = protein content; DG = dry gluten; WBWG = water binding in wet gluten; HS = hardness score; TW = test weight; DS = degree of softening; MC = moisture content; GI = gluten index; DDT = dough development time; FWA = farinograph water absorption

dough stability trait (DST) significantly depended on SBG ($r = -0.855$) and GI ($r = 0.811$), that is greater strength of gluten and less proportion of SBG resulted in the dough of higher stability. All wheat varieties were found to have a wide range of DS, that is 30-100 Brabender unit (BU), with the mean value of 56 BU. It was significantly correlated with MC ($r = 0.943$), GI ($r = -0.886$) and DDT ($r = -0.965$).

Conclusion

All the studied quality traits were found to have a wide range, except moisture content. The wheat varieties seem to have good storage stability and were found to be suitable for bread-making. Kiran-95 was found to be the most hard and contained the highest protein and gluten contents among the studied varieties of wheat. The research on evaluation of interrelationships among quality traits should be expanded to short-list the most effective traits that may help in making early decisions in the breeding programmes. In the present study, some significant correlations were obtained: test weight was found to be the most affected with the hardness score; and the degree of softening was found to be negatively affected with the strength of gluten. But the most effective trait was found to be the moisture content that affected almost all the studied quality traits. Hence, some parameters, such as test weight, moisture content, protein content, gluten content, and hardness score should be evaluated to support early conclusion of the breeding programmes.

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