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# Kernel Size in Relation to Hardness Score and Other Physicochemical Characteristics of Wheat

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**Abstract.** Twelve Pakistani wheat cultivars were studied for the effect of kernel size on the physicochemical characteristics. Thousand-kernel weight (TKW) ranged from 40-48.2 g for large kernels, 32-39 g for medium size kernels and from 24-29.2 g for small kernels. A highly significant relationship (r = 0.650) was found between TKW and NIR hardness score. Shrivelled kernels contained the highest protein content and broken kernels, the lowest. Other consistently positive but statistically non-significant relationship was observed between TKW and the gluten content. No consistent relationship was found between the gluten index, the falling number, the moisture content and the kernel size and form.

**Keywords:** wheat kernel size, hardness score, gluten index, protein content

## Introduction

The market value of wheat is determined by various factors such as kernel morphology, texture and test weight. Common wheat, which is used to manufacture different products, requires specific kernel characteristics, kernel shape and uniformity which influence its milling and end-use quality (Campbell *et al.*, 1999). Similarly, kernel weight, size and density have favourable effect on the agronomic and flour yield of wheat (Chasten *et al.*, 1995; Blair, 1992). There have been many studies on the influence of wheat kernel size on milling potential (Li and Posner, 1987; Marshell *et al.*, 1986; Shuey and Gilles, 1969), but few studies demonstrated the relationship between wheat kernel size and physicochemical attributes. Protein content, gluten content and hardness are the key quality parameters that influence the end-use quality of wheat (Dexter, 1993).

The wheat kernel size, like most of the traits of biological interest and agricultural importance, is a complex character that influences other quality characteristics (Ammiraju *et al.*, 2001). Moreover, the relationship of kernel size to other quality attributes varies with the class and the origin of wheat (Dexter *et al.,* 1987). Sutton *et al.* (1992) reported that kernel weight is positively correlated to the bread baking performance of New Zealand wheat. Other studies have suggested that large kernel size is not necessarily an asset. Miller *et al.* (1997) presented evidence that for UK wheat, large kernel size is associated with inferior quality due to low falling number. It is also important to distinguish between small kernels and shrivelled kernels. Kernels, that are shrivelled due to frost, immaturity, heat stress, *Fusarium* damage and other environmental factors, deleteriously affect the milling and end-use quality of wheat (Gibson *et al.*, 1998; Dexter *et al.*, 1996; Gaines *et al.*, 1992; Thachuk *et al.*, 1990). However, small soft kernels produce slightly superior quality of cookies (Gaines *et al.*, 1997).

In Pakistan, kernel size is considered one of the important parameters for determing the economic value of wheat. The present study is, therefore, designed to analyze the effect of kernel size on the physicochemical characteristics that largely influence the end-use quality of Pakistani wheat cultivars.

## Materials and Methods

Twelve Pakistani wheat cultivars (Hamal Faquir, Sarsabz, Moomal, Inqlab, TJ-83, Bhittai, V-7001, Wattan, Anmol, Imdad, TD-1 and Mehran) were grown at Wheat Research Institute, Sakrand during 2004-5. All the cultivars were grown under irrigated conditions from mid-November to early December and harvested during May. The samples of each cultivar were divided by precision electronic divider (Seedburo Equipment Company, Model No. SB-106) and thereafter cleaned manually. Shrivelled kernels were sorted by passing the sample through a sieve with long rounded apertures, 1.7 mm wide. Broken kernels were separated by handpicking from the samples. The samples, free from shrivelled and broken kernels, were fractionated over slotted sieves to yield three portions: held on 7/64 × ¾ mm; held on 6/64 × ¾ mm and passed through 6/64 × ¾ mm. In the present study, these three portions were designated as large, medium and small kernel size groups, respectively.

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The samples of wheat cultivars were analyzed for the physicochemical characteristics. The test weight was determined using a standard one litre bucket procedure for wheat as described by Dexter and Tipples (1987). Moisture content was determined using digital moisture tester (Burrows Model 700) duly calibrated with air oven method. The samples free from shrivelled and broken kernels were separated for the determination of thousand-kernel weight using the electronic seed counter (Seedburo Model No. 801). Samples of each cultivar were milled through Perten Laboratory Mill 3100 installed with 0.8 mm sieve. The flour obtained from this mill was used for the analysis of protein content and hardness score using NIR technique (Inframatic 8620A) by following the method described in AACC 39-10 and AACC 39-70A, respectively. Gluten content and gluten index were determined according to AACC (2000a), method no. 38-12. Falling number apparatus was used for the determination of α-amylase activity according to AACC (2000b), method no. 56-81B.

The sub-samples based on three different kernel size groups (large, medium and small) were analyzed also for thousand-kernel weight, moisture content, protein content, wet gluten, dry gluten, hardness score and falling number, as described earlier. All these parameters (except thousand-kernel weight) were also determined for the samples based on shrivelled kernels and broken kernels.

**Statistical analysis.** All quality tests were performed in triplicate and results are reported as average values with standard deviation. Statistical analyses were carried out for each measured parameter through analysis of variance (ANOVA) and correlation of 5 measured characteristics was determined using MINITAB software.

## Results and Discussion

The physicochemical characteristics of wheat cultivars are summarized in Table 1. Test weight ranged from 76.4 to 80.4 kg/hl and moisture content was less than 10.5%. The hardness scores ranged from 55-60 with a mean value of 58. The range of the contents of protein, wet gluten and dry gluten was 11.5-15.6%, 22.2-38% and 7.3-11.5% with mean values of 13.7%, 33% and 10.2%, respectively. All cultivars were in a wide range (30-98) of gluten index with a mean value of 56. All samples had high falling number (above 460 sec), indicating that no pregermination had taken place and all the kernels were sound (Carcea *et al.*, 2006)

It is well known that thousand kernel weight (TKW) reflects the soundness of kernels. Obviously, the large kernel group showed the highest TKW and small kernel group, the lowest (Table 2), the groups being highly different from each other in their TKW ($F = 161.77$, $P = 0.000$). Breseghello and Sorrells (2006) also observed high correlation between the weight and the volume of wheat kernels.

Hardness is an important parameter that is often used to classify wheat according to end-use potential (Symes, 1961). It can be determined through NIR technique. NIR absorption increases with an increase in particle size (Williams *et al.*, 1986), with hard wheat generally producing larger particles.

In the present study, the three kernel size groups *viz.* large, medium and small were subjected to analysis for the hardness score. A highly significant difference ($F = 11.33$, $P = 0.000$) was found among the groups, within the wheat cultivars. The observation supports the results presented at the annual meet-

**Table 1.** The physicochemical properties of wheat samples used in the study

| Wheat cultivars | SBG (%) | TKW (g) | TW (kg/hl) | MC (%) | PC (%) | WG (%) | DG (%) | GI | HS | FN (s) |
|---|---|---|---|---|---|---|---|---|---|---|
| Hamal Faquir | 1.8±0.10 | 33.6±0.40 | 77.5±0.40 | 10.5±0.20 | 13.8±0.10 | 33±0.10 | 11.0±0.14 | 52±0.50 | 57±0.57 | 475±4.0 |
| Sarsabz | 0.5±0.14 | 40±0.45 | 80.4±0.45 | 9.9±0.50 | 11.8±0.07 | 25±0.25 | 7.9±0.15 | 40±0.55 | 59±0.57 | 500±4.0 |
| Moomal | 2.7±0.23 | 31.2±0.52 | 77.7±0.50 | 10.0±0.42 | 14.60±10.0 | 32±0.30 | 10.2±0.15 | 64±0.45 | 59±0.11 | 465±5.0 |
| Inqlab | 2.6±0.40 | 34.5±0.35 | 76.4±0.60 | 9.6±0.48 | 15.0±0.10 | 38±0.24 | 11.3±0.27 | 50±0.56 | 60±0.57 | 460±5.0 |
| TJ-83 | 1.8±0.12 | 37±0.47 | 77.9±0.43 | 10.3±0.53 | 12.0±0.10 | 33±0.26 | 10.2±0.18 | 30±0.18 | 56±0.57 | 490±4.0 |
| Bhittai | 0.8±0.30 | 37.2±0.48 | 76.5±0.30 | 10.0±0.60 | 11.5±0.10 | 24.0±0.25 | 7.4±0.15 | 80±0.30 | 57±0.57 | 520±3.5 |
| V-7001 | 2.3±0.32 | 31.8±0.56 | 76.6±0.42 | 9.9±0.58 | 14.8±0.05 | 35.9±0.2 | 10.5±0.15 | 40±0.45 | 58±0.11 | 525±3.4 |
| Wattan | 0.6±0.41 | 42±0.63 | 77.5±0.45 | 10.5±0.65 | 13±0.08 | 22.2±0.25 | 7.3±0.15 | 98±0.28 | 55±0.11 | 480±4.2 |
| Anmol | 0.7±0.27 | 32±0.70 | 77±0.52 | 10.2±0.40 | 15.6±0.10 | 35±0.30 | 11.0±0.28 | 50±0.44 | 59±0.11 | 510±2.5 |
| Imdad | 0.5±0.21 | 40±0.45 | 78±0.60 | 10.3±0.38 | 13.8±0.09 | 30±0.10 | 9.6±0.25 | 65±0.45 | 60±0.57 | 467±3.6 |
| TD-1 | 1.0±0.18 | 38±0.39 | 77.2±0.44 | 10.2±0.47 | 14.0±0.08 | 33.4±0.10 | 10.2±0.25 | 48±0.50 | 57±0.40 | 512±2.6 |
| Mehran | 4.0±0.36 | 40±0.36 | 77±0.56 | 10.0±0.44 | 14.6±0.10 | 34±0.10 | 10.5±0.25 | 55±0.50 | 58±0.57 | 500±3.7 |

values are means ± standard deviation ($n = 3$); SBG = shrivelled and broken grains; TKW = thousand-kernel weight; TW = test weight; MC = moisture content; PC = protein content; WG = wet gluten; DG = dry gluten; GI = gluten index; HS = hardness score; FN = falling number.

**Table 2.** Relationship of kernel size to thousand-kernel weight (TKW)

| Wheat cultivars | TKW (g) | | |
|---|---|---|---|
| | Large size kernels | Medium size kernels | Small size kernels |
| Hamal Faquir | 46.6 | 35.6 | 25 |
| Sarsabz | 45 | 37.8 | 29 |
| Moomal | 40 | 32 | 24 |
| Inqlab | 43.6 | 36.6 | 27.4 |
| TJ-83 | 41 | 33.4 | 28.6 |
| Bhittai | 46.4 | 39.0 | 27.0 |
| V-7001 | 42.2 | 35.8 | 27.0 |
| Wattan | 48.2 | 38.8 | 27.0 |
| Anmol | 41 | 33 | 25 |
| Imdad | 45.2 | 38 | 29 |
| TD-1 | 46 | 39 | 28 |
| Mehran | 46 | 38.4 | 29.2 |

ing of AACC (2000a) in which it was mentioned that the large kernel group showed hardness score different from the medium and the small kernel group.

A highly positive relationship was found between TKW and hardness score (r = 0.650). Fig. 1, which supports earlier findings that the hardness (measured by PSI, break yield and flour particle size) is positively related to the kernel size of wheat (Gaines *et al.*, 1997).

Protein is a key quality factor in the suitability of wheat for a particular type of product (Huebner *et al.*, 1995; Peterson *et al.*, 1992). The analysis of variance of the protein content in kernels of different sizes revealed existence of a difference,

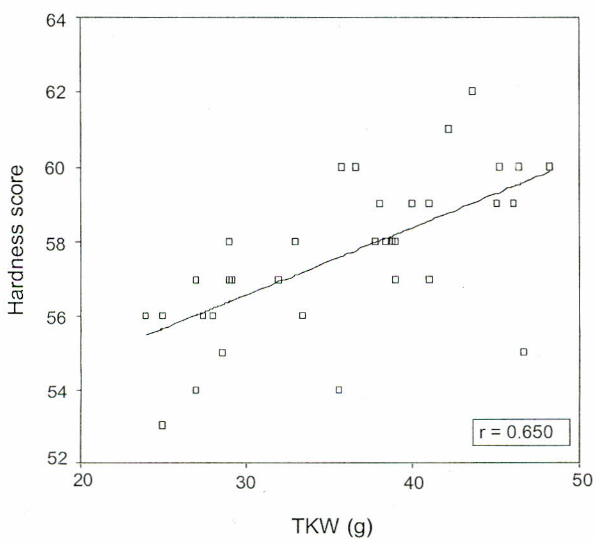


**Fig. 1.** The relationship of thousand-kernel weight (TWK) to hardness score.

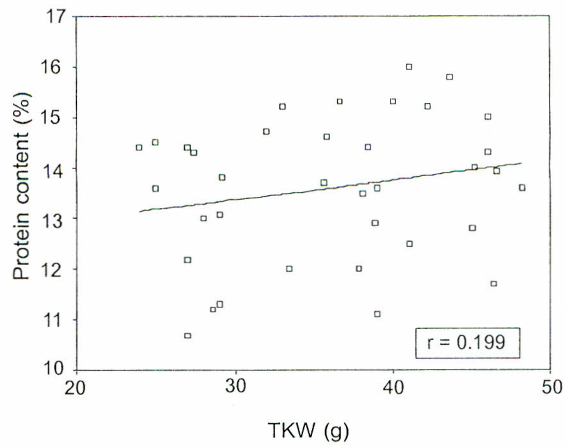


**Fig. 2.** The relationship of thousand-kernel weight (TWK) to protein content.

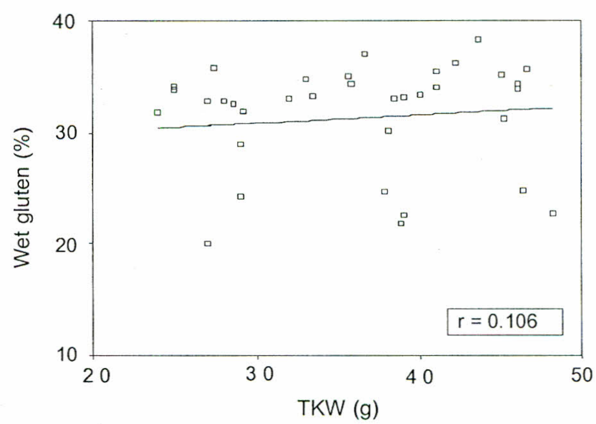


**Fig. 3.** The relationship of thousand-kernel weight (TWK) to wet gluten.

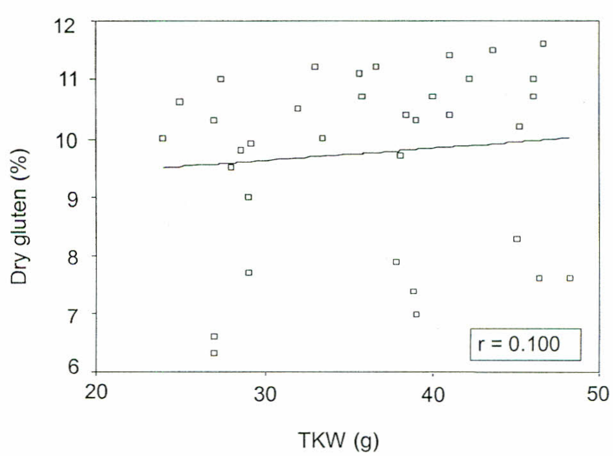


**Fig. 4.** The relationship of thousand-kernel weight (TWK) to dry gluten.

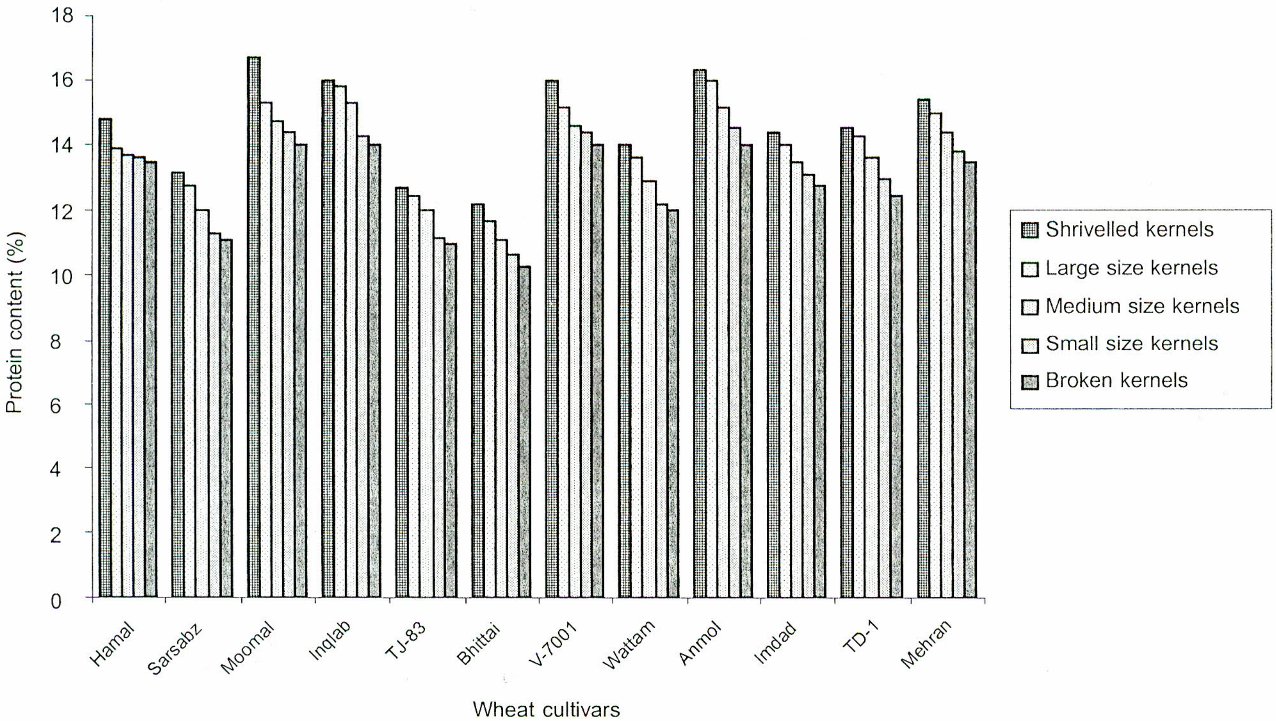


**Fig. 5.** Protein content of shrivelled kernels, large size kernels, medium size kernels, small size kernels and broken kernels.

but not statistically significant (F = 2.07; P = 0.142). As presented in Fig. 2, TKW was positively correlated with protein content (r = 0.199) though the relationship was not significant. Higher protein content in the large kernel group could be due to a higher proportion of seed coat to endosperm in large kernel (Marshell *et al.*, 1984). However, shrivelled kernels contained the highest protein content while the broken kernels, the lowest (Fig. 5).

The functional properties of wheat are largely dependent on its gluten quantity and quality (Schofield, 1994). Although the difference was not significant the kernel size groups contained different wet gluten (F = 1.08; P = 0.350) and dry gluten (F = 1.04; P = 0.365) contents. Similarly, the relationships between TKW and the gluten content (wet & dry) was found consistently positive but not statistically significant as presented in Fig. 3 & 4. Konopka *et al.* (2007) stated that the amount of glutenin (major fraction of gluten) decreased with decreasing kernel size. We have also determined the gluten contents of shrivelled and broken kernels but consistent results were not obtained (data not shown).

In our study, inconsistent relationships were observed between the falling number, the gluten index, the moisture content and the kernel size. Clarke *et al.* (2004) observed that there was no clear correlation between the kernel size and the falling number.

## Conclusion

The three different kernel size groups, *viz.* large, medium and small of the Pakistani wheat cultivars differ in the values for the hardness score, the protein content and the gluten content. But, within the same kernel size group, only hardness score was statistically different. Similarly, these attributes were positively correlated with TKW while only hardness score was significantly correlated with TKW. The results suggest that wheat kernel groups that had different kernel sizes within a variety could have different physicochemical characteristics that ultimately influence the end-use properties.

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