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Comparative Study of Fine and Whole Wheat Flour of Selected Varieties Grown in Khyber Pakhtunkhwa

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Abstract | Due to lake of information regarding the wheat varieties grown in Khyber Pakhtunkhwa, this study was design to investigate the chemical composition, functional properties and microstructure of fine wheat flour (FWF) and whole wheat flour (WWF) of the selected varieties. These varieties were collected from different research stations located in the province. The grains were milled using laboratory scale flour mill. Part of the flour of each variety was passed from mesh to remove the bran and get fine flour. Both whole and fine flour of the selected wheat varieties were subjected to qualitative study. The data disclosed that L* value was more in FWF than WWF. FWF had high Water absorption index (WAI) 9.19-9.25g/g, Swelling Index (SI) 6.6-8.7g/g, Water Solubility Index (WSI) 5.7-9.77% and gluten (20.76-34.45%) content while WWF was high in moisture (6.08-8.03%) and ash (0.95-0.98%). It is cleared from the data that FWF of all the selected varieties especially Shahkar-13 could be used in the production of various bakery products especially noodles.

Introduction

Both cultivated and wild wheat belongs to grass family. There are many species in the world, but the most important are common or bread wheat (*Triticum aestivum*) and durum or pasta wheat (*Triticum durum*). Compare to common wheat, durum wheat has hard and elongated kernel containing more protein and large starch granules (Heneen and Brismar, 2003; Wiseman, 2001). Common wheat is hexaploid and cultivated about 90-95% all over the world.

Wheat grain is composed of endosperm enriched with protein and starch, germ containing protein and lipids and bran composed of dietary fiber and minerals (Marquart et al., 2007). During milling, these fractions are separated in the refining process

for the production of white flour and the germ and bran are removed and discarded. The discarded fractions contain vitamins, natural antioxidants and dietary fiber which are crucial for health (Rosa et al., 2014; Seibel, 1996; Onyeneho and Hettiarachchy, 1992). Utilization of whole grain products has been accossiated to reduce the risk of cancer, diabetes and cardiovascular disease (Liu, 2007).

The major component of wheat grain is starch (70-75%) present in endosperm. Starch is composed of two component amylose and amylopectin. Amylose is straight chain consisting of α-(1, 4)-linked d-glucopyranosyl units. Amylopectin has highly branched chain consisting α-(1, 6)-linkages (Hung et al., 2006; Tester et al., 2004). In normal wheat starch the ratio of amylose to amylopectin is 22-

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35% and 65- 78% depending on botanical source (Cai and Shi, 2010). The difference in the ratio of amylose and amylopectin influences the processing, physicochemical and edible properties of the products (Kozlov et al., 2007; Kozlov et al., 2006). Protein is the second important constituent of the wheat flour. Various types of protein are present in wheat but the most important structural protein is gluten which is formed by the hydration of gladin and glutenin. This protein is responsible for elasticity, viscosity and cohesiveness of the dough (Misra et al., 2015; MacRitchie, 1984).

The use of whole grain flour containing bran in food products has linked with several technological, nutritional and sensorial challenges (Liu et al., 2017; Le et al., 2015). Mostly the insoluble fraction of bran creates technological problems by disturbing the gluten network formation resulting low elastic dough, poor loaf volume and baking quality (Aktas-Akyildiz et al., 2017; Pruckler et al., 2014).

In the world Pakistan is the leading country in wheat production contributing 2% of the total production (Anjum and Walker, 2000). Wheat contributes about 10% to agriculture in the country and shares 2.1% in GDP (GOP, 2014-15). In Khyber Pakhtunkhwa the area under cultivation is 680.31 hectare with annual production of 1251.48 tons (Kpbos, 2013-14). Pakistani varieties have high protein content ranging 11 to 13%. These varieties can be used in the production of numerous products including noodles, bread, pasta and Naan (Alam et al., 2009). Previous data in literature conform that there is a continuous development in these varieties in term of production and disease resistance such as Pirsabak-2008, Pakhtunkhwa-2015, Hashim-8, Zam-04, Fareed-06, pirsabak-2013, Shahkar-2013 (Shah et al., 2017; Khan et al., 2011; Hussain et al., 2010; Shah et al., 2010; Uddin et al., 2005).

The aim of this study is to characterize the local varieties for the production of various products especially noodles. This will help both the farmers to sell their produce as well as manufacturer to get the cheap raw material.

Materials and Methods

Collection of wheat varieties
Selected wheat varieties namely; Pirsabak-2013, Pirsabak-2008, Shahkar-2013, Pakhtoonkhwa-2015 and Durum-97 were collected from cereal crop research institute, Pirsabak nowshera, NIFA insaf-2015 from nuclear institute for food and Agriculture turnab, KT-2014 from Barani research station kohat, Shahid-2017 from Agriculture research station D.I. Khan and Janbaz and Ghanemat-2015 from the plant breeding and genetics department The University of Agricultural Peshawar.

Milling of wheat grain
The grain of all selected varieties was brought to the laboratory of Food science and Technology, The University of Agricultural Peshawar. Straws and other foreign materials were removed from grains and then grains were milled using a laboratory scale flour mill (Thomas-Wiley, Model 4. USA). The flour was divided in to two lots, whole wheat flour and fine flour received after passing it from 100 mesh. The flour was packed in airtight polyethylene bags and stored in a refrigerator for further analysis.

Color
Color of the fine and whole wheat flour of the selected varieties were studied by using Color Tec in three replicates. Three parameters of color were recorded as L* (index of lightness/darkness), a* (index of hue, red/green) and b* (index of yellowness).

Micro structure analysis of wheat flour
The scanning of samples was carried out by a focused electron beam of 10kV and the magnification power of the SEM images ranged between 100 x to 5000 x using a scanning electron microscope (Niu et al., 2014). The samples were dehydrated and then mounted on an aluminum stub with the help of double sided tape. The samples were coated with 50 nm gold and observed at 10 kV.

Proximate composition of wheat flour
The fine and whole wheat flour of selected varieties was characterized for moisture, ash, wet and dry gluten according to the method of (AACC, 2013).

$$Moisture\ (\%) = \frac{loss\ in\ moisture}{wt.\ of\ flour} \times 100$$

$$Ash\ (\%) = \frac{Weight\ of\ residue}{wt.\ of\ flour} \times 100$$

$$Gluten\ (\%) = \frac{Weight\ of\ gluten}{wt.\ of\ flour} \times 100$$

Iodine method was used for the determination of amylose content of the flour of selected wheat verities according to the method of (Juliano, 1971).

Functional properties

Functional properties namely swelling power (SP), water absorption index (WAI) and water solubility index (WSI) of the flour of selected wheat varieties were analyzed by the method of (Schoch, 1964; Qazi et al., 2014) with little modification. Flour sample (0.2 g) of each wheat varieties were taken in a pre cleaned and pre weighed test tubes in triplicate and to each test tube 10 ml of distilled water was added. Each test tube was subjected to 30 minutes heating on water bath and shake with 10 minutes interval to avoid grit formation. After 30 minutes test tubes were removed from water bath and cooled to room temperature. The test tubes were then placed in a centrifuge machine and centrifuged to 3000 rpm for 15 minutes. After 15 minutes the supernatants were collected in a pre cleaned and weighed Petri dishes and the sediments were weight. The petri dishes along with supernatants are heated in an oven at 105^{0}C for 24 hours and weighed. After complete dehydration the swelling power and solubility of the wheat flour were calculated according to the following formula.

$$WAI = \frac{wt.\ of\ wet\ sediment}{dry\ wt.\ of\ flour}$$

$$WSI\ (\%) = \frac{wt.\ of\ dried\ supernatant}{dry\ wt.\ of\ flour} \times 100$$

$$SP = \frac{wt.\ of\ sediment}{wt.\ of\ flour - wt.\ of\ dried\ supernatant}$$

Results and Discussion

Color

Results of color measurements are shown in Table 1, Figures 2, 3, 4. It is clear from the data that there was significant difference (p<0.05) between FWF and WWF. The L* value of the FWF is more than WWF. The L* values of FWF were in range of 75.28 to 78.94 while the L* value of WWF were in range of 73.05 to 76.52. The results were consistent with the early findings of Chen et al. (2011) and Chillo et al. (2008) who reported an increased trend in L* value with the addition of coarse bran in refined flour. The a* showed reversed tendency. The a*value was lesser for FWF as compared to WWF. This phenomenon was in agreement with the study of Chen et al. (2011) and Reungmaneepaitoon et al. (2006). No significant difference (p < 0.05) was occurred in the b* value of the

FWF and WWF. A slight fluctuation was recorded in the b* value. Our results were consistent with the findings of Cao et al. (2017) who reported that yellowness is slightly affected by addition of WWF. Similarly, Pedreschi et al. (2006) reported that several factors like inherent pigments, reducing sugar, protein and poly-phenol oxidase activity would contribute to yellow color during oxidation and Maillard reaction.
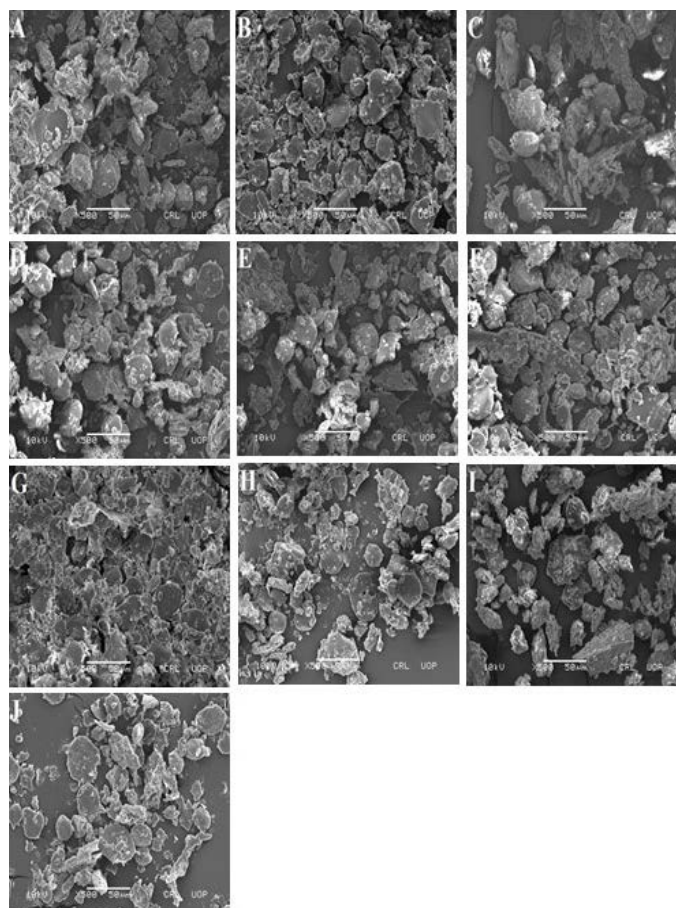

Figure 1: *Micro photograph of selected wheat varieties; A (Shahid-2017); B (Shahkar-13); C (Ghanemat-15); D (Janbaz); E (Pirsabak-08); F (Pirsabak-13); G (Pakhtunkhwa-15); H (KT-17); I (NIFA insaf-15) and J (Durum-97).*

SEM

The microstructure of selected wheat varieties was examined under scanning electron microscope (Figure 1). The microphotograph of the wheat flour indicated circular and lentil shaped starch granules with different sizes. Adhesive protein areas attached to starch granules and the protein matrix can be observed in all SEM images which were also observed by Gutierrez et al. (2002). These microphotographs also showed that wheat starch contains round, oval and irregular shaped of starch granules. In some scanning electron micrograph (Figure 1F) disk shape and elongated starch granules were also present. Additionally, these starch granules were embedded by the protein matrix

Table 1: *Color (L*, a*, b*) of fine and whole wheat flour of selected varieties.*

| Variety	L*		a*		b*	
	FWF	WWF	FWF	WWF	FWF	WWF
Shahid-17	77.61±0.02b	75.05±0.04ef	3.22 ± 0.03 ij	3.36 ± 0.02 f	13.33 ± 0.05b	13.97 ± 0.01 b
Shahkar-13	78.60 ±0.02a	76.43±0.04cd	2.70 ± 0.02 n	3.28 ± 0.03 gh	14.11 ± 0.02 b	13.52 ± 0.03 b
Ghanemat-15	76.39±0.05cd	75.05±0.06ef	3.17 ± 0.07kl	3.45 ± 0.03 e	12.84 ± 0.05 b	13.24 ± 0.05 b
Janbaz	76.82 ± 0.03c	74.69 ± 0.06f	2.58 ± 0.02o	3.07 ± 0.02 m	14.20 ± 0.01 b	12.86 ± 0.04 b
Pirsabak- 08	78.94 ± 0.03a	75.48 ± 0.03e	3.82 ± 0.03 c	3.19 ± 0.03jk	12.56 ± 0.05 b	12.95 ± 0.01 b
Pirsabak- 13	77.65 ±0.05b	76.25 ±0.04d	3.12 ± 0.02 l	3.37 ± 0.02 f	11.84 ± 0.05 b	11.85 ± 0.05 b
Pakhtunkhwa-15	76.23 ±0.05d	75.46 ± 0.02e	2.16 ± 0.03 p	3.26 ± 0.02hi	12.85 ± 0.05 b	12.50 ± 0.02 b
KT-14	78.89 ± 0.03a	72.87 ±0.02g	3.64 ± 0.04 d	4.27 ± 0.02 a	11.94 ± 0.04 b	14.15 ± 0.03 b
NIFA insaf-15	77.96 ±1.17b	76.52±0.03cd	3.90 ± 0.02 b	3.45 ± 0.03 e	13.44 ± 0.04 b	13.46 ± 0.02 b
Durum- 97	75.28 ± 0.03e	73.05 ±0.03g	2.59 ± 0.02 o	3.31 ± 0.01 g	22.71 ± 0.02 a	14.06 ± 0.02 b
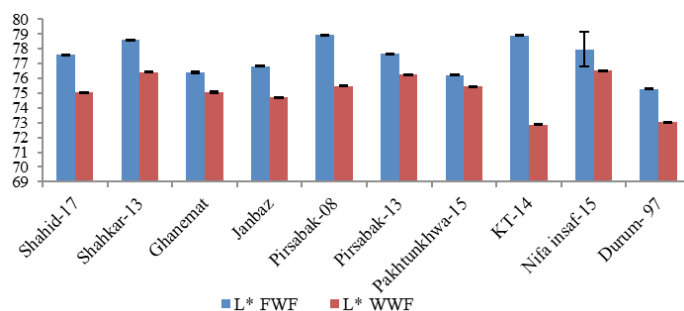
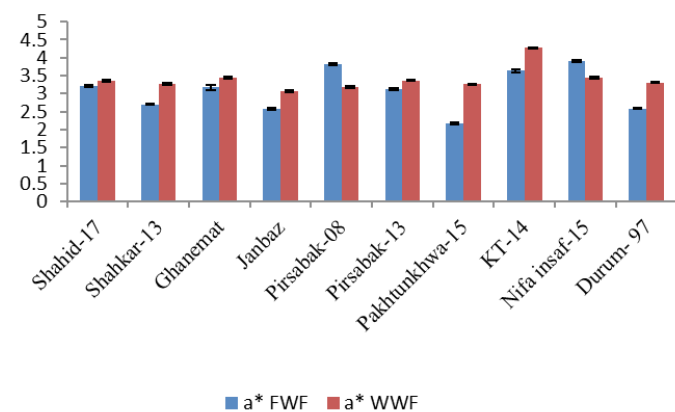**Figure 2:** *L* (lightness/darkness) of fine and whole wheat flour.*

Figure 3: *a* (hue, red/green) of fine and whole wheat flour.*
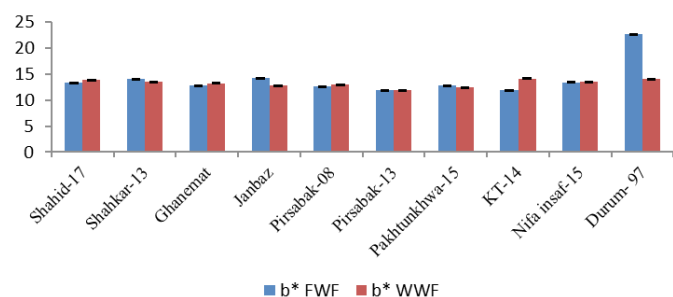

Figure 4: *b (index of yellowness) of fine and whole wheat flour.*

as shown in all SEM images. The present study results were similar to that of Parda and Aguilera (2011), Peressini et al. (2008), Autio et al. (2005), Bellido and Hatcher (2011) who found that gluten matrix surrounded the wheat starch granules. The damaged starch granules can also be seen in Figure 1H. Similarly, Figure 1A showed double disk structural starch granules and simple granules covered by protein matrix as reported by Le et al. (2015) who reported double disk starch granules in wheat starch.

Composition of fine and whole wheat flour starch

Amylose: Amylose is an important parameter for the quality of noodles (Qazi et al., 2011; Fu, 2008). Statistical analysis showed significant ($p < 0.05$) difference in Amylose content of the selected wheat varieties (Figure 5). Maximum amylose was found in Pakhtunkhwa-15 (31.22 %) while minimum amylose was found in KT-14 (20.47 %). The data from the table disclosed that the amylose content of the selected varieties was in the acceptable range for the production of noodles as described by Saeid et al. (2015), Konik-Rose et al. (2007) who reported the normal range of the amylose of wheat starch between 20 – 30 % and amylopectin 70–80 %. Similarly, it was reported that the range of amylose of different starches is in between 15.5 % -35 %. This variation may be explained by botanical source, growing conditions, fertilizer, growing area, genetic makeup of the kernel, as well as the extraction methods and amylose determination (Saeid et al., 2015). Amylose content is responsible for the pasting properties of the starch (Singh et al., 2006) and hardness of the noodles is due to the strong matrix bounded to each other (Sandhu et al., 2010). Wheat starch has round lenticular shape with 25 % amylose, having gelatinization temperature 58 to 64 °C, pasting temperature 77 °C and produce opaque gel (Murphy, 2000). The strength of the gel is associated with the degree of amylose content of

the starch, higher the amylose content high will be the gel strength (Ishiguro et al., 2000). Texture of the noodle is also affected by the amylose content of the flour (Park and Baik, 2004). Amylose has less water retention capacity than amylopectin because the solubility power of amylopectin is more than amylose (Vandeputte et al., 2003). Similarly, solubility and swelling power of the starch was influenced by the amylose content of the starch and subsequent quality of noodles (Liu and Shen, 2007). They further reported that high amylose starches are preferred for good quality noodles.
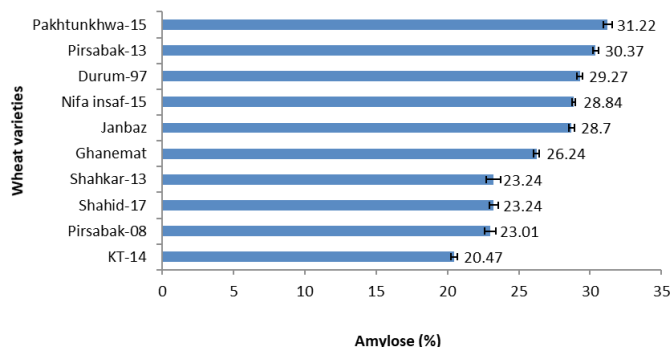

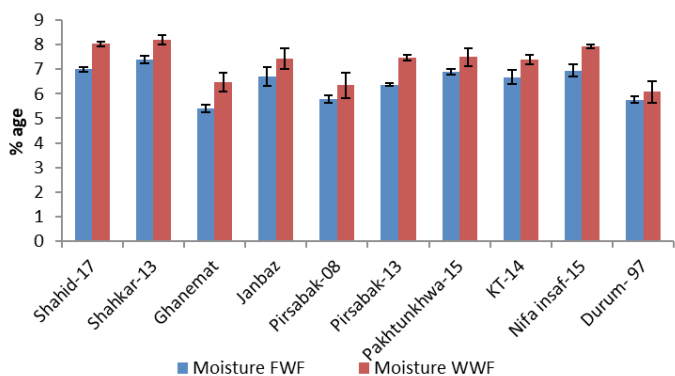**Figure 5:** *Amylose content of selected wheat varieties grown in Khyber Pakhtunkhwa*

Figure 6: *Percent moisture content of fine and whole wheat flour.*

Moisture: Moisture is an important quality parameter for the quality of flour. The data from the Table 2 and Figure 6 disclosed that there was minimal significant ($p < 0.05$) difference in the moisture content of fine and whole wheat flour. Whole wheat flour contained more (6.08-8.18 %) moisture than fine flour (5.40-7.40%). This is due to the high fiber content in whole wheat flour as reported by Maneju et al. (2011) who concluded that flour having high fiber content will have more moisture. Our results were in agreement with the findings of Yadav et al. (2014) and Akanbi et al. (2011), who concluded that the moisture content of wheat flour was in the range of 4.65-8.50 %. Flour having 10% or below moisture content has long

shelf life (Omeire, 2014; SON, 2007; Nnam, 2002). Similarly, Ajani et al. (2012) reported that flour having low moisture content has good storage potential while high moisture content flour has short storage life as they encourage the microbial growth (Ngozi, 2014; Ezeama, 2007). Likewise, storage condition and variety of wheat also influenced the moisture content of wheat flour (Oppong et al., 2015).

Ash: Ash is the amount of minerals present in flour which reflects the milling efficiency (Saeid et al., 2015). The results of ash for fine and whole wheat flour are tabulated in Table 2 and Figure 7. Significant difference ($p < 0.05$) was present in the values of fine and whole wheat flour. Data showed that WWF had high ash content ranged between 0.95-0.98% while the FWF contain 0.54-0.69 %. WWF contained bran layer which is reach in minerals and have high ash content, as described by Liu et al. (2015). Likewise, Banu et al. (2012) observed the same result that addition of 3-39 % bran to FWF raised the ash content. Various factors, such as climate, soil, variety, origin, agronomic practices and milling process influenced the ash content of the flour (Kassegn, 2018; Saeid et al., 2015; Bilgicli, 2013; Han et al., 2011). The results were in the agreement with the findings of Ngozi (2014) and Han et al. (2013) who observed that the range of the ash content of the wheat flour was in between 0.08 to 2.29 %. High ash content had negative effect on the color of the products as described by Aravind et al. (2012a) who concluded that addition of high level of pollard in semolina produce undesirable color in spaghetti.
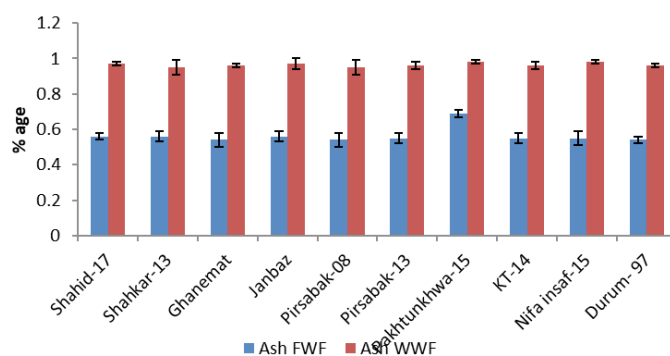

Figure 7: *Ash content of fine and whole wheat flour.*

Gluten: Gluten is formed by the hydration of glaidin and glutenin during the mixing step of the dough preparation and is an important parameter for dough quality. Gluten gives strength and elasticity to dough and is responsible for the structure of different products. Statistical analysis showed significant

difference (p < 0.05) in gluten content of both FWF and WWF of selected varieties (Table 2 and Figures 8, 9). The range of wet and dry gluten in fine wheat flour was 13.96g (Janbaz) -34.45g (Shahkar-13) and 6.84g (Ghanemat-15) – 16.61g (Shahkar-13) respectively. Furthermore, the wet and dry gluten of the whole wheat flour were in the range of 8.77 g (Janbaz) to 30.07g (Shahkar-13) and 4.18 g (Ghanemat-15) to 11.80g (Shahkar-13) respectively. The results were similar to the findings of Samaan et al. (2006) who concluded wet and dry gluten in the range of (24.41g-29.37g) and (8.96g- 10.6g) respectively. Similarly, Pasha (2006) concluded that the ranges of the dry gluten in Pakistani varieties were 7g-17g. The reason for the low gluten in WWF may due to the dilution effect of bran on WWF. Similarly, the bran particles also negatively affect the hydration of gluten (Sobota et al., 2015).
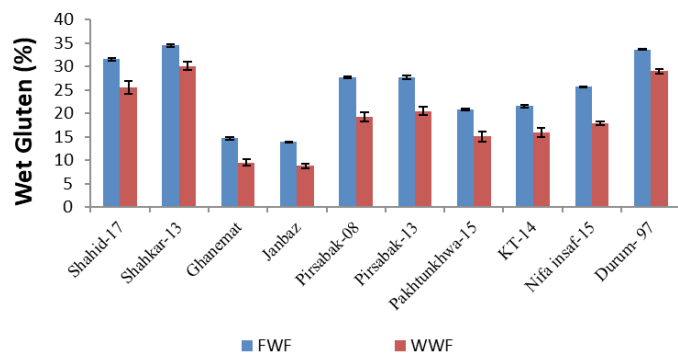
et al. (2008) concluded that water absorption index of starch decreased in food system that containing bran, because bran content competes starch for water. In addition, WAI decreased by the addition of pollard in salmonella (Ramy et al., 2002). Among the tested varieties FWF of Janbaz and NIFA insaf-15 showed high WAI values (9.25 g/g and 9.19 g/g) while in case of WWF Shahid-17 and NIFA insaf-15 varieties showed high WAI index (7.09 g/g and 8.29 g/g) respectively. The variation in the WAI of the tested varieties may be due to fiber, protein and amylose (Chandra et al., 2013; Thumrongchote et al., 2012; Nura et al., 2011). Similarly, another study conducted by Olukeim et al. (2013) showed that high protein molecule exhibited high hydrogen bonding between water and protein and thus absorbed more water. Carbohydrates also weaken the WAI of the flour (Kinsella, 1979).

Figure 8: *Wet gluten of fine and whole wheat flour.*

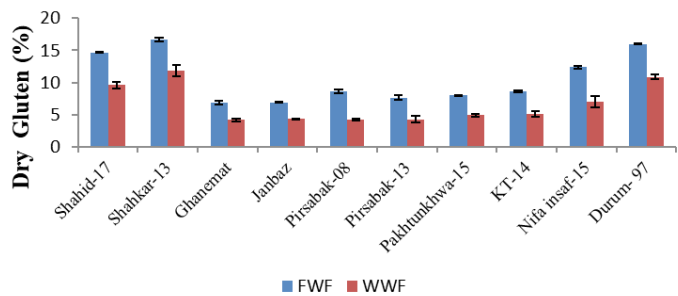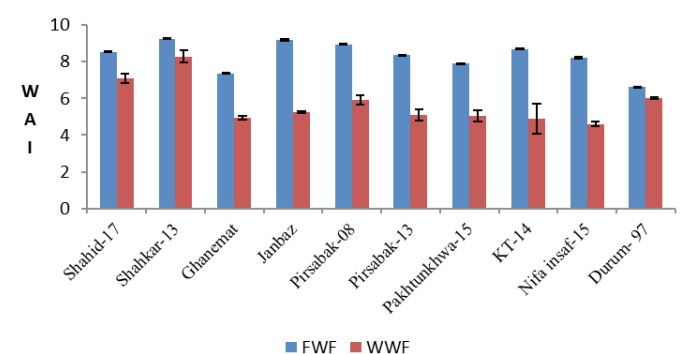Figure 10: *Water absorption index of fine and whole wheat flour.*

Figure 9: *Dry gluten of fine and whole wheat flour.*

Functional properties of fine and whole wheat flour
Water absorption index: The water absorption index of the FWF and WWF is represented in Table 3 and Figure 10. The data disclosed (p < 0.05) that FWF has high WAI as compared to WWF. The low WAI value for WWF may be due to high quantity of bran and germ. High value of WAI for FWF represented small particle size which promotes the development of protein starch matrix that absorbed more water. The results were similar to the findings of Vignola et al. (2018) and Aravind et al. (2012). Likewise, Brennan

Swelling power (SP): Swelling power is the ability of starch granules to hold water, which is due to the amylopectin fraction of the starch and the difference in SP indicates the extent of the action of water to the internal of the starch granules (Ruales et al., 1993). The SI values for FWF were in the range of 6.60 g/g to 8.790g/g while the range of SP for WWF were in the range of 4.58g/g to 5.99g/g. Statistical analysis showed significant difference (p < 0.05) between the varieties and also between the FWF and WWF (Table 3 and Figure 11). Fine flour showed high SI value as compared to whole wheat flour. The variation between the FWF and WWF is due to presence of bran and germ in whole wheat flour as reported by Kaur et al. (2012) who concluded that the bran and germ decrease the SP of the flour. The granule swelling and water holding ability of swollen granules is mostly dependent on the intact structure of the amylopectin molecule in starch granules (Wang and Copeland, 2012a, 2012c).

Table 2: *Chemical characterization of Fine and whole wheat flour of selected varieties.*

Variety	Moisture (%)		Ash (%)		Wet Gluten (%)		Dry Gluten (%)	
	FWF	WWF	FWF	WWF	FWF	WWF	FWF	WWF
Shahid-17	6.99±0.11ce	8.03±0.09a	0.56 ± 0.02c	0.97±0.01a	31.55 ±0.29 b	25.51±1.32f	14.65±0.11c	9.59±0.50f
Shahkar-13	7.40±0.16bc	8.18±0.19a	0.56 ±0.03 c	0.95±0.04a	34.45 ±0.29 a	30.07±0.89c	16.61±0.30a	11.80±0.86d
Ghanemat-15	5.40 ± 0.16 j	6.47±0.37fh	0.54 ±0.04 c	0.96±0.01a	14.64 ±0.36kl	9.52±0.65n	6.84 ±0.25 k	4.18±0.23n
Janbaz	6.69±0.39eg	7.43±0.43bc	0.56 ±0.03 c	0.97±0.03a	13.96 ±0.09 l	8.77±0.44n	6.94 ±0.14 k	4.33±0.11mn
Pirsabak-08	5.79 ±0.16 ij	6.34±0.52gh	0.54 ±0.04 c	0.95±0.04a	16.69 ± 0.13 i	11.32±1.0m	8.64 ±0.29 g	4.28±0.17mn
Pirsabak- 13	6.37±0.07gh	7.47±0.11b	0.55 ± 0.03c	0.96±0.02a	27.67 ±0.33e	20.49±0.93g	7.62 ± 0.38ij	4.26±0.51n
Pakhtunkhwa-15	6.88 ±0.11ef	7.49±0.35 b	0.69 ±0.02b	0.98±0.01a	20.76 ±0.21 g	15.08±1.04k	7.97 ±0.09hi	4.90±0.16lm
KT-14	6.68±0.29efg	7.38±0.19bd	0.55 ±0.03 c	0.96±0.02a	21.52 ±0.27 g	15.87±0.97ij	8.58±0.17gh	5.12±0.47e
NIFA insaf-15	6.94 ± 0.24de	7.93±0.09a	0.55 ±0.04 c	0.98±0.01a	25.65 ± 0.10 f	17.86±0.45h	12.35±0.26d	6.99±0.85jk
Durum 97	5.75 ±0.13 ij	6.08±0.44 hi	0.54 ±0.02 c	0.96±0.01a	33.60 ±0.14 a	28.97±0.43d	15.95±0.07b	10.87±0.36e

Table 3: *Functional properties of fine and whole flour of selected wheat.*

| Variety	WSI (%)		WAI (g/g)		SP (g/g)	
	FWF	WWF	FWF	WWF	FWF	WWF
Shahid-17	7.24 ± 0.08 de	7.22 ± 0.81de	8.53 ± 0.03 bcd	7.09 ± 0.27 f	8.27 ± 0.18 b	5.99 ± 0.12 g
Shahkar-13	9.77 ± 0.19 a	7.82 ± 0.52 bc	9.25 ± 0.03 a	8.29 ± 0.34 cde	8.23 ± 0.28 b	5.21 ± 0.04 h
Ghanemat-15	8.16 ± 0.08 b	5.67 ± 0.39 fg	7.37 ± 0.02 f	4.94 ± 0.10 ij	7.63 ± 0.19 d	4.91 ± 0.15 hi
Janbaz	8.25 ± 0.23 b	5.35 ± 0.12 g	9.19 ± 0.03 a	5.24 ± 0.06 i	7.52 ± 0.32 d	4.58 ± 0.34 i
Pirsabak- 08	5.78 ± 0.12 fg	6.09 ± 0.47 f	8.94 ± 0.02 ab	5.91 ± 0.27 h	8.79 ± 0.16 a	5.88 ± 0.83 g
Pirsabak- 13	7.51 ± 0.24 cde	4.26 ± 0.37 h	8.37 ± 0.02 cd	5.10 ± 0.32 i	8.14 ± 0.18 bc	5.07 ± 0.29 h
Pakhtunkhwa-15	7.72 ± 0.10 bcd	5.76 ± 0.48 fg	7.89 ± 0.03 e	5.04 ± 0.29 ij	7.72 ± 0.26 cd	5.01 ± 0.06 hi
KT-14	9.41 ± 0.06 a	7.03 ± 0.61 e	8.70 ± 0.03 bc	4.89 ± 0.83 ij	6.93 ± 0.07 e	4.86 ± 0.09 hi
Nifa insaf-15	7.77 ± 0.28 bcd	5.62 ± 0.31 fg	8.21 ± 0.04 de	4.61 ± 0.15 j	7.54 ± 0.20 d	6.30 ± 0.01fg
Durum- 97	9.48 ± 0.29 a	5.73 ± 0.21 fg	6.62 ± 0.03 g	6.03 ± 0.04 h	6.60 ± 0.09 ef	6.00 ± 0.27g
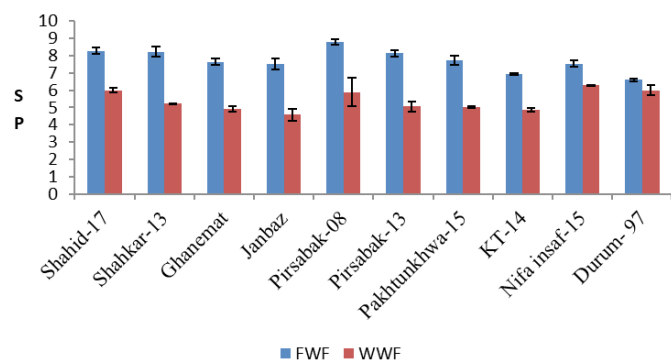
Figure 11: *Swelling power of fine and whole wheat flour.*

Water solubility index (WSI): The WSI values are tabulated in Table 3 and Figure 12. The data disclosed that the FWF has high WSI values as compared to WWF. The range of WSI for FWF was 5.78%-9.77% and for WWF the range was 4.26%- 7.82%. The results were in the close proximity to that of (Saeid et al., 2015; Heo et al., 2013; Thumrongchote et al., 2012; Wadchararat et al., 2006) who observed the WSI in the range of 0.06% - 8.99%. The difference in

the range may be due to the difference in temperature (Wadchararat et al., 2006) and milling procedure (Heo et al., 2013). Flodin (1997) concluded that high water absorption leads to increase the swelling power which results in improved solubility. Flour having high solubility is more digestible (David et al., 2015). WSI is dependent on the disruption of starch granules, semi crystalline structure of starch granule and bonding of water molecule to amylose and amylopectin (Eliasson and Gudmundsson, 1996).
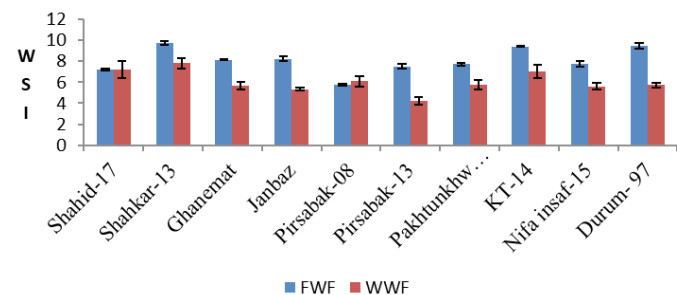

Figure 12: *Water solubility index of fine and whole wheat flour.*

Conclusions and Recommendations

This research has characterized the functional and chemical properties of the fine and whole wheat flour. It is concluded that the functional properties of fine flour of all varieties showed that the fine flour has high potential to use as ingredients in various food products as functional ingredient. Whole wheat flour might be creating problems in food system due to high ash and low functional properties.

Novelty Statement

The study investigates the chemical composition, functional properties and microstructure of fine wheat flour (FWF) and whole wheat flour (WWF) of selected wheat varieties grown in Khyber Pakthunkhwa was. Thus, it will be helpful for production of various bakery products especially noodles.

Author's Contribution

Saifullah, Collect the wheat varieties, performed the experiments, analyzed the data. Ihsan Mabood Qazi, Design the research and edited the article.

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