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Research Article

Comparative Studies on Flour Proximate Compositions and Functional Properties of Selected Pakistani Rice Varieties

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Abstract: The aim of this study was to evaluate the proximate and functional properties of flours obtained from various rice varieties, i.e., Super Basmati Shaheen, Super Basmati Kainat, Super Fine, JP5, Basmati 385, Fakhr-e-Malakand grown in different areas of Pakistan. Moisture content, ash content, crude protein, crude fat, water absorption index, water solubility and swelling power varied significantly ($P<0.05$) from each other. Moisture content, ash content, crude protein and crude fat of rice flour ranged from 5.46–7.08%, 0.48–1.23%, 8.02–9.85% and 0.43–1.5%, respectively. While, functional properties such as water absorption index, water solubility index and swelling power were found in the range of 5.38–6.26 (g/g), 1.95–4.94% and 5.74–7.64 (g/g), respectively. The results showed that the functional properties of rice flour were greatly influenced by the compositional variations of various rice varieties.

Keywords: Rice flour, proximate composition, water absorption index, water solubility index, swelling power

1. INTRODUCTION

Rice is an important cereal grain and is one of leading food crops in the world. Rice is a member of the family Poaceae (Gramineae) and is generally considered as annual grass, semi aquatic plant. Rice is a staple food in many Asian countries. South Asia alone produces about 30 % of global rice production [1]. The functional properties of rice grains such as, pasting profiles, gel texture and water holding capacity and cooking characteristics are important factors which determine the end use and marketing of rice grains, Rice has many beneficial properties as it is easy to digest, has mild taste and hypoallergenic properties [2-3]. Rice provides 45% of calories and 40% total protein requirement of an average population [4].

Different rice varieties are grown all over the world and have showed compositional variations in term of protein, lipid, starch content (amylose and amylopectin), minerals, vitamins, thermal properties, texture profile and pasting profile [5-7]. The variation in composition of rice depends on the genetic and environmental factors [8-9]. It is also observed that the properties of rice flour are also influenced by particle sizes, pasting properties and texture properties [10-12]. Rice grain quality is also influenced by various physicochemical characteristics [13-14]. The chemical and physical properties of rice flour such as starch gelatinization, water absorption and viscosity differ due to the compositional variation of rice flour [5-15].

A wide range of rice varieties are reported and their physicochemical and functional characteristics vary from one another [6]. The characterization of rice flour would facilitate the understanding of its possible applications [16]. Similarly, different rice varieties are grown in

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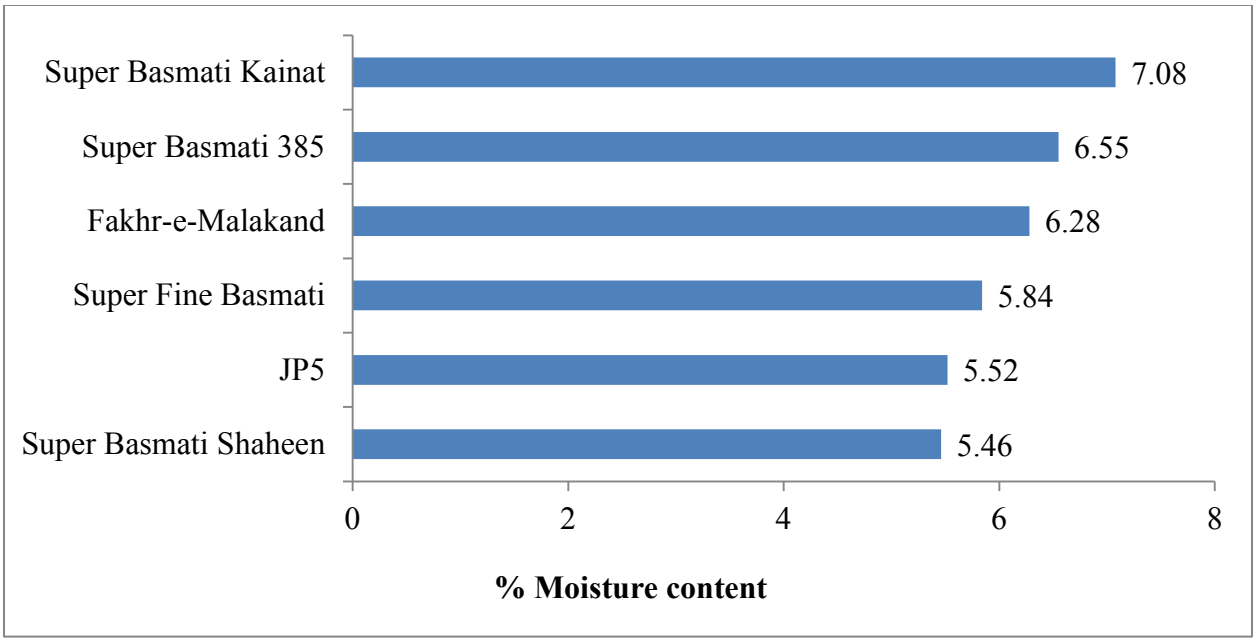

Fig. 1. Moisture content (%) of flour of selected rice varieties grown in Pakistan.

different part of Pakistan. However, no scientific work is reported in literature on the composition and especially on the functional properties of these varieties. Primarily, the aim of this study is to determine and compare the physicochemical and functional properties of selected rice varieties namely, Super Basmati Shaheen Rice, Super Basmati Kainat Rice, Super Fine Rice, JP5, Basmati 385, Fakhr-e-Malakand, cultivated in different areas of Pakistan.

2. MATERIALS AND METHODS

In this study, experiments were performed in the laboratory of Food Science and Technology Department, The University of Agriculture, Peshawar. The rice varieties were selected from various places for the study purpose. Fakhr-e-Malakand and Basmati 385 were procured from Agricultural Research Station Chitral. Super Fine and JP5 were procured from The University of Agriculture Peshawar. While two varieties

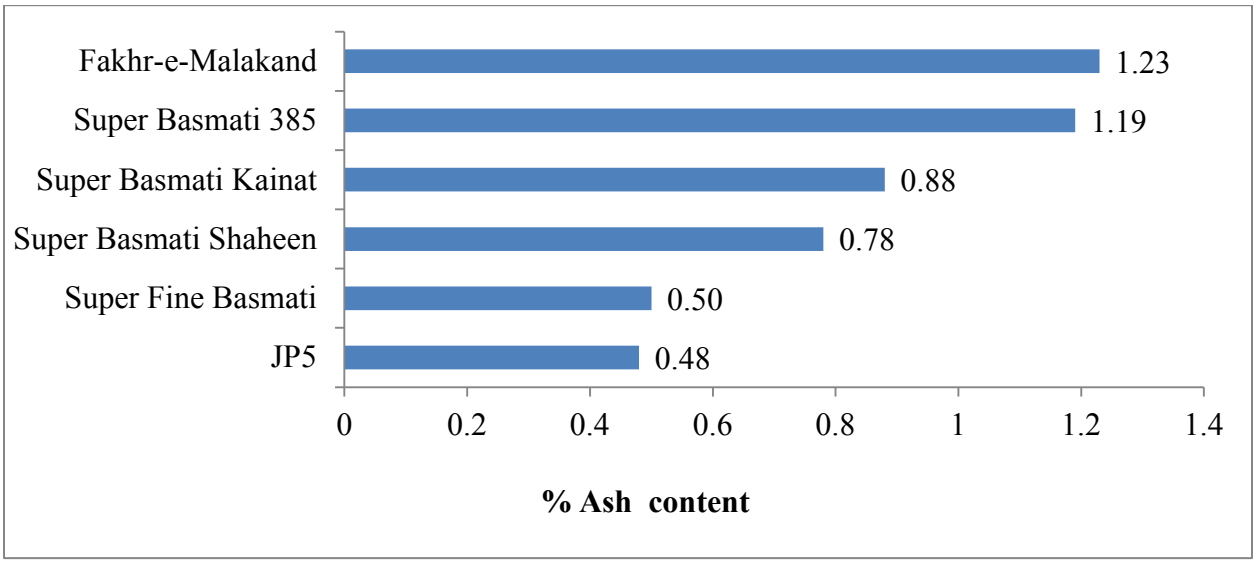

Fig. 2. Ash content (%) of flour of selected rice varieties grown in Pakistan.

namely, Super Basmati Shaheen and Super Basmati Kainat were purchased from the main market of Peshawar, on 5th May 2014. Three samples (2 kg) of each variety were collected from the respective sources and brought to the laboratory of Food Science and Technology Department for further research work. Rice varieties were properly cleaned and brought to mill house to obtain the flour. The chemicals and reagents used in the research work were extremely pure with analytical grade.

2.1 Preparation of Rice Flour

Rice was grinded to flour by the method as suggested by Fari et al [6] using manual laboratory mill (Thomas Wiley, Model 4 USA). The flour was sifted through 100 mesh sizes at Food Technology Laboratory, Nuclear Institute for Food and Agriculture (NIFA), Peshawar, Pakistan. Rice flours were packed in plastic bags and stored at 4 °C for further study. Results were collected in three replications for each sample.

2.2 Proximate Composition of Rice Flour

The moisture content, ash content, crude protein and crude fat content of rice flour were determined by the method of AOAC [17].

2.3 Functional Properties of Rice Flour

The functional properties including water absorption index (WAI), water solubility index (WSI) and swelling power (SP) of the rice flour were analyzed by the method of Thumrongchote et al [18]. For the determination of water absorption and water solubility index 1 g of rice flour sample was weighed and placed in a centrifuge tube. Then 6 ml of distilled water was added for suspension. The tubes along with the samples were heated in shaking water bath at the temperature of 80 ^{0}C for 30 minutes. The solution was centrifuged at 2500 rpm for 10 minutes. After the centrifugation, the supernatants were carefully poured into Petri dish for drying at 105 ^{0}C for 10 hours in an oven, while the sediments were weighed as such. Water absorption index was calculated on the basis of wet sediments, while water solubility index was calculated on the basis of difference in the weight of dried supernatant and initial sample (equation 1 and 2).

$$WAI = \frac{wt.\ of\ wet\ sediment}{dry\ wt.of\ flour} \quad \text{Eq. 1}$$

$$WSI = \frac{wt.\ of\ dried\ supernatant}{dry\ wt.of\ flour} \quad \text{Eq. 2}$$

On the other hand, 0.5 g flour sample were taken in a centrifuge tube (pre-weighed) and diluted with 15 ml of distilled water in order to determine swelling power. The suspension was heated in water bath at a temperature of 80 ^{0}C for 30 minutes and then centrifuged at 4000 rpm for

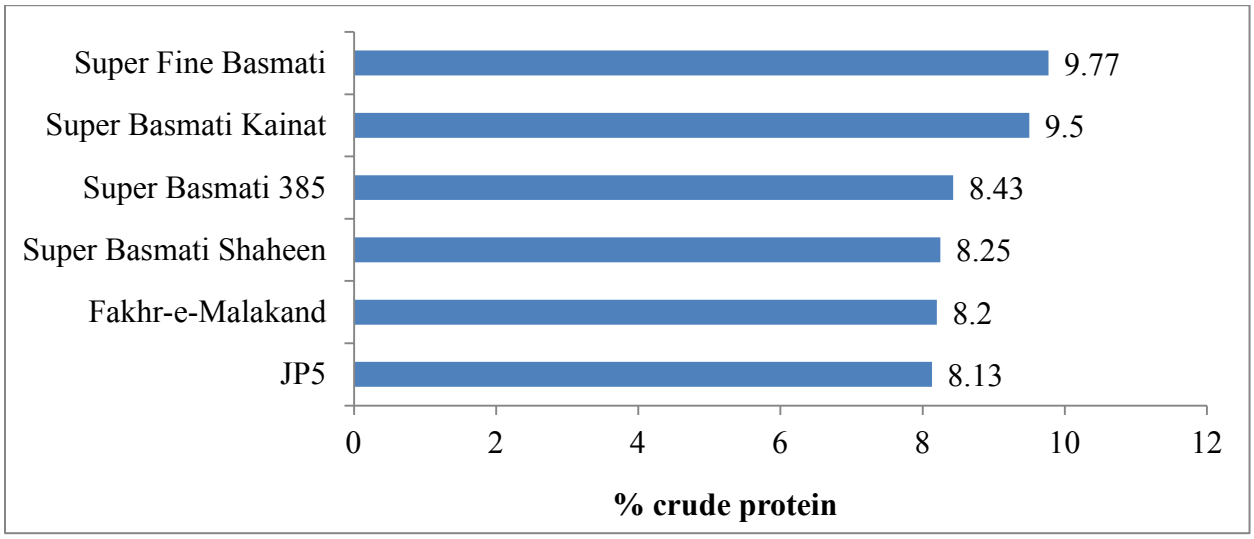

Fig. 3. Crude protein (%) of flour of selected rice varieties grown in Pakistan.

20 minutes. After centrifugation, the supernatants were poured into Petri-dish of known weight and dried at 105 ^{0}C for 10 hrs. After complete dehydration, the supernatants were weighed and the sediments from the centrifuge tube were also weighed. Swelling power was calculated by wet sediment and dried supernatant of rice flour (equation 3).

$$SP = \frac{wt.\ of\ sediment}{wt.of\ flour - wt.of\ dried\ supernatant} \quad \text{Eq. 3}$$

2.4 Statistical Analysis

Statistical analyses were performed via the software Stitistix 8.1. Data regarding the rice flour were analyzed by complete randomize design (CRD) one way ANOVA with three replications. Mean values were separated by Least Significant Difference Test (LSD) as described by Steel and Torrie [19].

3. RESULTS AND DISCUSSION

3.1 Proximate Analysis of Rice Flour

Proximate composition including moisture content, ash content, crude protein and crude fat of rice flour are presented in Table 1. The moisture content of selected rice varieties showed significant (P<0.05) difference. The moisture content of rice flour ranged from 5.46% (Super Basmati Shaheen) to 7.08% (Super Basmati Kainat). The data revealed that moisture content of Super Basmati Kainat flour is significantly different than rest of the rice samples. The present findings are in agreement with the results reported in previous literatures [18, 20-21]. Thumrongchote et al [18] found moisture content of 5.00-5.88 % among non-glutinous rice varieties. In contrast, Islam et al [20] and Nura et al [21] observed comparatively higher moisture content (8.00-9.61%) in rice flour. Milling method, processing procedure and temperature affect the moisture content in rice flour [22]. Similarly, fiber content affects the moisture content of the flour. As the percentage of fiber content is higher in flour, the moisture content would be higher [23]. Moisture content above 20 percent accelerates microbial growth, so moisture content below this limit is preferable [24].

Table 1 shows the ash content of rice flour of different varieties which are significantly (P<0.05) different from each other. The ash content of rice flour of these selected varieties ranged from 0.48% (Fakhr-e- Malakand) to 1.23% (JP5). The present results are in accordance with literature reported previously. According to Han et al [25], the ash content ranged from 0.40-0.80% in rice flour of different Korean rice varieties. Similarly, Thumrongchote et al [18] studied that the ash content of rice flour varied from 0.30-0.40%. The ash content of rice flour of three selected varieties was in the range of 0.17-0.48% [21, 26]. Similarly, Islam et al [20] reported that rice flour has 1.5% ash content. Rice bran contain higher ash content (6.73%) as compared to other cereal bran [20]. It was observed that the variations in ash content of rice flour are due to varietal differences, sources and milling methods [25].

Table 1 illustrated that the protein content of rice flour of selected rice varieties varied

Table 1 Proximate composition of rice flour of selected rice varieties grown in Pakistan.

Varieties	Moisture %	Ash %	Protein %	Fat %
Super Basmati Kainat	7.08 ± 0.166 a	0.88 ± 0.06 b	9.50 ± 0.55 b	0.8 ± 0.05 c
Super Basmati Shaheen	5.46 ± 0.12 c	0.78 ± 0.06 b	8.25 ± 0.05 d	1.5 ± 0.2 a
Super Fine Basmati	5.84 ± 0.35 c	0.5 ± 0.05 c	9.77 ± 0.06 a	1.06 ± 0.15 b
Fakhr-e-Malakand	6.28 ± 0.22 b	1.23 ± 0.10 a	8.20 ± 0.02 e	0.43 ± 0.05 d
JP5	5.52 ± 0.13 c	0.48 ± 0.02 c	8.13 ± 0.07 f	0.58 ± 0.05 d
Super Basmati 385	6.55 ± 0.37 b	1.19 ± 0.07 a	8.43 ± 0.02 c	0.53 ± 0.05 d

Mean values following different letters are significantly (P < 0.05) different from each other.

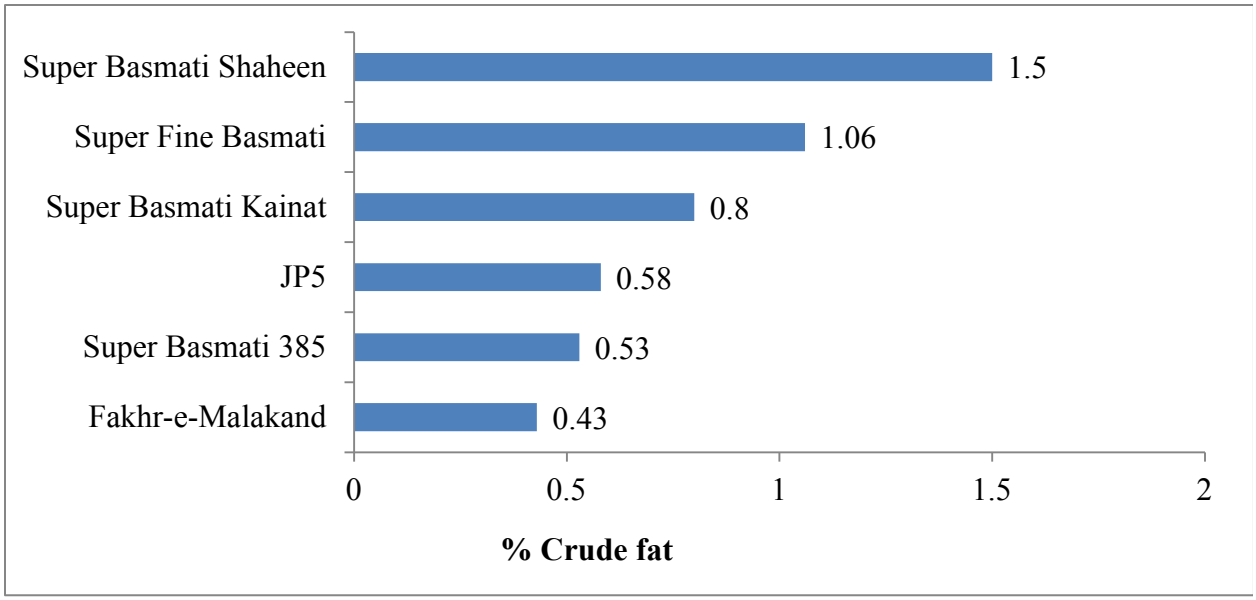

Fig. 4. Crude fat (%) of flour of selected rice varieties grown in Pakistan.

significantly ($P<0.05$) from each other. The protein content of rice flour of these selected varieties ranged from 8.13% (JP5) to 9.77% (Super Fine Basmati). The data revealed that protein content of Super Basmati Kainat and Super Fine basmati is significantly higher than rest of the varieties. The results are in agreement with the findings of Islam et al [20], Nura et al [21], Han et al [25] and Wadchararat et al [26]. They reported that protein content of rice flour was in the range of 6.0% to 9.0%. Similarly, Fari et al [6] analyzed the protein content (6.84-11.18%) of rice flour obtained from selected eight varieties of Sri Lanka. The variation of protein content within varieties is influenced by the method of milling, as protein is mostly found in embryo tissue (aleurone layer), which is removed during milling of grain [27]. However, the physicochemical properties of

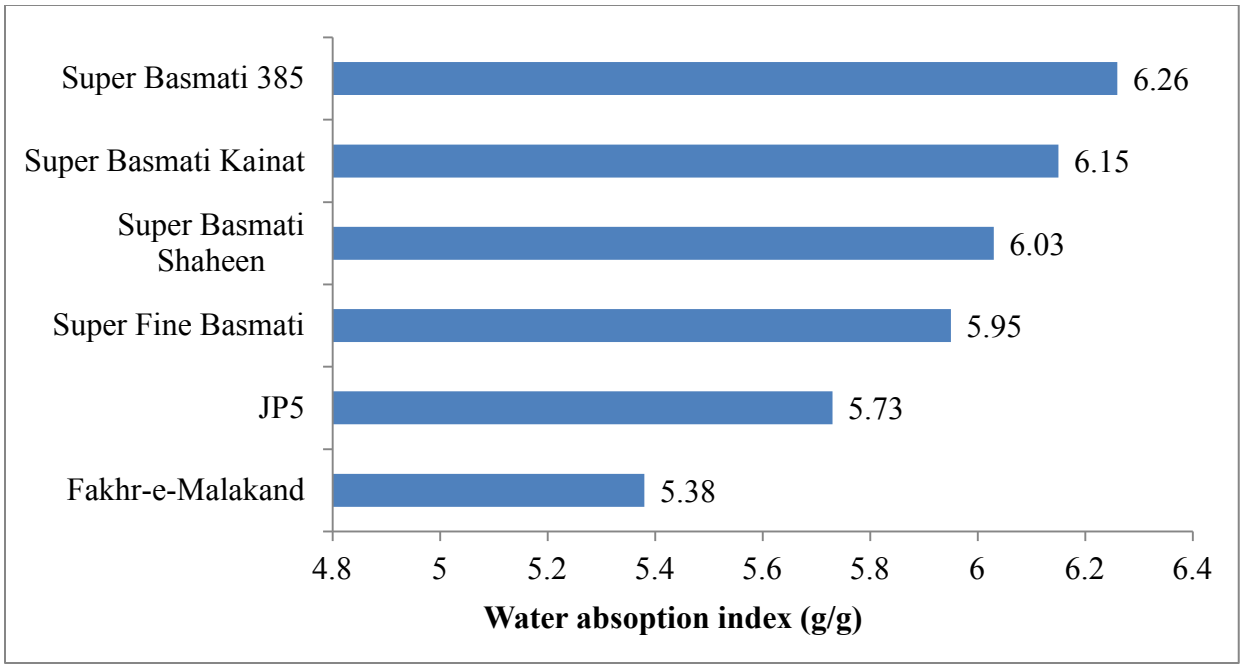

Fig. 5. Water absorption index of flour of selected rice varieties grown in Pakistan.

rice flour is also influenced by various environmental factors, genetic modification, storage condition (time and temperature) and equipment used. The changes may directly or indirectly affect the properties of rice flour [28-30]. Protein and starch molecules are bound together to form a strong network, which substantially affect the pasting profile of flour. Higher protein content in flour will be able to form bonds with greater starch content, thereby increasing the water holding capacity of the flour [31-32]. High protein content improves the nutritional and textural profile of product prepared from such flour [26].

Statistical analysis showed that crude fat content of rice flour of selected varieties differed significantly ($P<0.05$) from each other (Table 1). It was found that Fakhr-e-Malakand has lowest (0.43%) crude fat content, while Super Basmati Shaheen has highest (1.5%) crude fat content among the varieties. Similarly, Fari et al [6], Thumrongchote et al [18], Han et al [25] and Islam et al [33] observed that fat content of rice flour of different varieties were in the range of 0.56-1.36%, 0.63-2.17%, 0.27-0.30% and 2.80% respectively. The fat content varies significantly among different rice varieties, which might be due to varietal differences, environmental factor, sample processing and milling methods [25-26, 28]. Storage condition (temperature and storage time) also influence the physicochemical properties of rice flour. These variations may directly or indirectly influence the properties and composition of rice flour [28]. Fat content was found in greater amount in rice bran as compared to other cereal bran. However, some portion of bran is removed during milling which substantially reduce the fat content. So milling process must be optimized, if higher fat content is desired in flour [25-26].

3.2 Functional Properties of Rice Flour

The functional properties of flour have great importance in the manufacturing of products and it is the basic property that reveals the relations between the structure, composition and molecular arrangement of food components with the nature of environment where it is measured and associated. Functional properties provide useful information for industrial purpose determined by their chemical, physical and organoleptic properties [33]. The functional properties of rice flour such as water absorption index; solubility and swelling power of different rice varieties grown in Pakistan were studied and are presented in Table 2.

3.2.1 Water Absorption Capacity (WAI)

Water absorption capacity of rice flour of different selected rice varieties showed significant ($P<0.05$) difference (Table 2). The water absorption capacity of Super Basmati 385 is higher (6.26 g/g) than rest of the rice varieties. While, lower (5.38 g/g) water absorption index was recorded for Fakhr-e-Malakand. The difference in water absorption index of rice flour might be due to various factors such as methods of milling (dry or

Table 2 Functional properties of rice flour of different selected rice varieties grown in Pakistan.

Varieties	Water Absorption index (g/g)	Water Solubility %	Swelling Power (g/g)
Super Basmati Kainat	6.15 ± 0.05 b*	1.95 ± 0.046 c	7.64 ± 0.03 a
Super Basmati Shaheen	6.03 ± 0.015 c	4.94 ± 0.045 a	6.72 ± 0.02 d
Super Fine Basmati	5.95 ± 0.01 d	1.98 ± 0.005 c	6.94 ± 0.04 c
Fakhr-e-Malakand	5.38 ± 0.01 e	1.95 ± 0.046 c	5.74 ± 0.045 e
JP5	5.73 ± 0.015 f	3.92 ± 0.03 b	6.71 ± 0.015 d
Super Basmati 385	6.26 ± 0.01 a	1.96 ± 0.01 c	7.26 ± 0.01 b

*Mean values followed by different letters are significantly different from each other ($P < 0.05$).

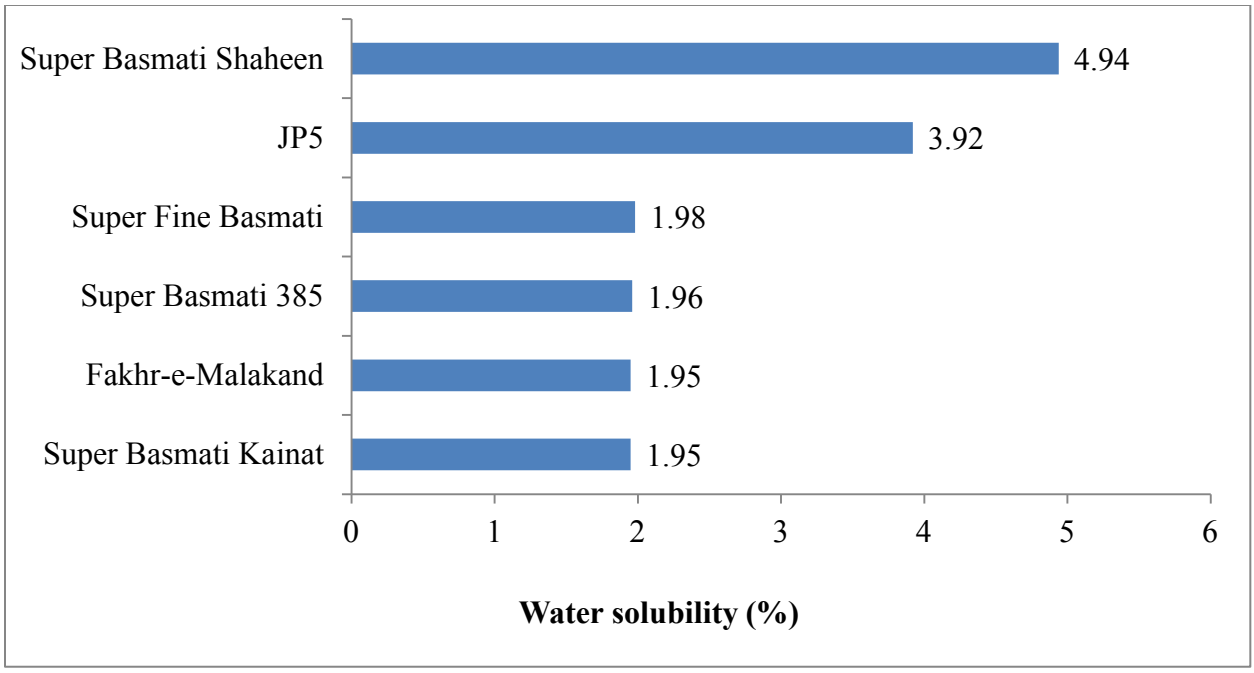

Fig. 6. Water solubility (%) of flour of selected rice varieties grown in Pakistan.

wet), level of starch damaged and processing temperature [34]. Similarly, the results presented in this study are in agreement with the findings of Thumrongchote et al [18] and Heo et al [34], who observed WAI of 6.0–8.0 and 3.3–5.0 g/g, respectively, in flour obtained from different rice varieties. Water absorption is the ability of flour to associate with water under specific conditions where water is limited [35-36]. The composition of flour such as carbohydrate, fiber, protein and amylose content are the major factors influencing water absorption index [18, 21, 36]. Particle size of flour is another important factor which effect water absorption capacity. Flour with smaller particle size has higher surface area for flour hydration [18, 21]. The WAI is also dependent upon pore size, capillary and protein charges. This is due to strong correlation of extent of protein hydration with polar constituents along with the interaction of hydrophilic components by hydrogen bonding. The higher protein content lead to strong hydrogen bond, which subsequently increase the water absorption capacity of rice flour [35]. The difference in variety and starch granule structure significantly influence the hydration capacity of the flour [21, 37].

3.2.2 Water Solubility Index (WSI)

Water solubility index of rice flour of different selected rice varieties are significantly ($P<0.05$) different from each other (Table 2). The present findings revealed that solubility of rice flour ranged from 1.95% (Super Basmati Kainat) to 4.94% (Super Basmati Shaheen). Similarly, Thumrongchote et al [18], Wadchararat et al [24] and Heo et al [30] investigated the water solubility of rice flour of different rice varieties which ranged from 0.6% to 7.94%. Data also shows that water solubility of rice flour of Super Basmati Shaheen and JP5 are highly significant than rest of the rice varieties. The WSI of flour depends on the temperature and amylose content of rice flour. However, relationship of solubility with temperature was directly related, while amylose content has inverse relation to solubility of rice flour [26]. Other factors which affected water solubility are the presence of protein and starch lipids complex, which reduces solubility [18, 26]. One of the major factors effecting water solubility is the methods of milling and damaged starch content [34]. The degradation of starch granules led to higher water solubility [38].

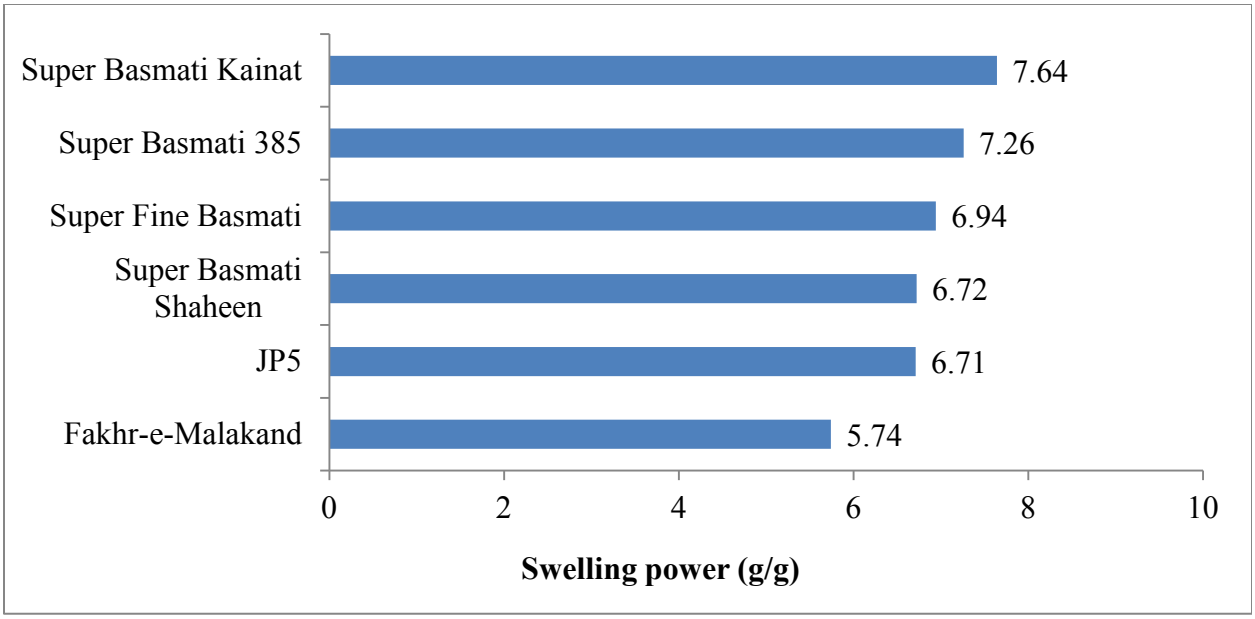

Fig. 7. Swelling power of flour of selected rice varieties grown in Pakistan.

3.2.3 Swelling Power (SP)

The SP of rice flour of selected rice varieties differed significantly ($P<0.05$) from each other, except JP5 and Super Basmati Shaheen. The observed values ranged from 5.74 g/g (Fakhr-e-Malakand) to 7.64 g/g (Super basmati Kainat) among the varieties. The present findings are in agreement with previous literature that found values ranging 4.7–16.23 g/g in rice flour of different rice varieties [6, 18, 26, 36]. The SP of rice flour might be affected by amylose and protein content, which inhibit the granular swelling due to disulphide and intermolecular bonding in protein that result in extensive and strong network [6, 18, 26, 39]. Protein is one of the most important macronutrient, which has the ability to bind starch and form starch granules, which affect the pasting properties of rice flour. The protein and starch content in rice flour are embedded tightly in the lipid matrix and form an amylose lipid complex that influences the pasting properties [40]. Similarly, the ratio of amylopectin and amylose as well as their structural confirmation in a starch granule substantially effect flour swelling power [41]. The SP of wet and dry milled rice flour at 25 ^{o}C and 100 ^{o}C were 3.8 g/g, 12.6 g/g, and 4.7 g/g, 10.9 g/g, respectively [34] that reveals that milling method and processing temperature also influence the swelling capacity or rice flour. Starch degradation also resulted in the reduction of SP or rice flour [42].

4. CONCLUSIONS

In Pakistan different rice varieties are grown and grades as second staple food amongst the crop and as an important cash crop of the country. It was found from the present study that flour of different rice varieties (Super Basmati Kainat, Super Basmati Shaheen, Super Basmati 385, Fakhr-e-Malakand, Super Fine Basmati and JP5) obtained from different sites of Pakistan showed variation in composition and functional properties. Lowest values regarding percent moisture, ash, protein and fat content were observed in Super Basmati Shaheen, JP5, JP5 and Fakhr-e-Malakand, respectively. While highest values regarding all these parameters were recorded in Super Basmati Kainat, Fakhr-e-Malakand, Super Fine Basmati and Super Basmati Shaheen, respectively. In case of water absorption index, water solubility and swelling power, minimum values were noted in Fakhr-e-Malakand, Super Basmati Kainat and Fakhr-e-Malakand, and Fakhr-e-Malakand, respectively, while maximum values were found

in super Basmati 385, Super Basmati Shaheen and Super Basmati Kainat, respectively. The present findings provide the basic information regarding properties of rice flour obtained from various sources and are recommended for the preparation of various rice based products concerning nutritional and health aspects.

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