Physico-chemical and functional properties of buckwheat
(*Fagopyrum esculentum* Moench)

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**ABSTRACT**

Physico-chemical and functional properties studied with two buckwheat varieties, the PRB-1 and a local procured from local market at G.B.P.U.A.T., Pantnagar revealed that the variety PRB-1 had higher value of hydration capacity (1.05 g seed⁻¹), swelling capacity (1.33 g ml⁻¹) and swelling index (0.55) than the local variety. As regards the functional properties, both the varieties differed significantly in water absorption capacity (WAC) and fat absorption capacity (FAC) having the value of WAC (1.60 ml g⁻¹) and FAC (1.24 ml g⁻¹) for variety PRB-1 (P<0.05). The foaming properties of buckwheat flour was found to be a function of pH and the foam capacity and its stability was found inversely related. The PRB-1 variety at pH 4.5 exhibited least foam expansion (120.0 %) but highest foam stability (62 %). The study concludes that buckwheat being suitable for cooking and processing purposes can be used as future health foods.

**Key words:** Buckwheat, Physico-chemical properties, functional properties, foaming properties.

Buckwheat (*Fagopyrum esculentum* Moench) is a traditional underutilized crop in the areas of high altitude of Uttarankhand hill providing food security to rural farmers under subsistence farming (Gupta et al., 2004). It is grown in marginal soil with very less inputs and gives relatively high yields. Currently, the cultivation and production of buckwheat in the hill areas of India is declining due to change in land use pattern (Joshi, 1999). Buckwheat has been grown from centuries and considered as coarse cereal. Many nutraceutical compounds exist in it. It is a rich source of starch, antioxidants, trace elements and dietary fibre etc. Buckwheat proteins have unique amino acids composition with special biological activities. It is valuable raw material for future health foods as it contain several components with healing benefits like flavonoids and flavones etc. (Krkoskova and Mrazova, 2005, Hasler, 1998).

Physico-chemical and functional properties of food grains play an important role in understanding their cooking and processing properties. But, because of very few studies having been carried out on physico-chemical and functional properties of this coarse cereals, the present study was undertaken.

**MATERIALS AND METHODS**

The study was conducted with two buckwheat varieties, the PRB-1, procured from College of Forestry and Hill Agriculture, G.B.P.U.A.T., Ranichauri and a local procured from villages near Krishi Vigyan Kendra, Gwaldum. Buckwheat grains were thoroughly cleaned and dried in hot air oven at 40°C for 6-7 hours to prevent deterioration from biological agents. Well dried grains were subjected to grinding, sieved through 40 mesh sieve size and kept in air tight containers for further evaluation of their physico-chemical and functional properties. Parameters of physical (seed weight, seed volume and seed density.) and physico-chemical characteristics (flour, hydration capacity, hydration index, swelling capacity, swelling index and bulk density) was measured by the methods reported by Williams et al., (1983). The Bulk density was studied according to the method of Asoegwu et al., (2006).

The studies on functional properties involved evaluation of water absorption capacity, fat absorption capacity and foaming properties of buckwheat flour. The water absorption capacity was determined according to the method given by Smith and Circle (1972). Five gram of buckwheat flour was mixed well with 30 ml distilled water in a centrifuge tube using a glass rod. After 5 minutes, the contents were centrifuged at 2000 rpm for 5 minutes. The supernatant was measured using a graduated cylinder. Volume of water absorbed equal to 30 ml minus supernatant. Water Absorption Capacity was recorded as: Volume of water absorbed = 30- supernatant

WAC (ml per g buckwheat flour) = Volume of water absorbed/weight of sample.
The fat absorption capacity (FAC) was determined by the method described by Lin et al. (1974). Weighed quantity (1 g) of flour sample was taken into graduated cylinder tube and mixed with 6 ml of soybean oil with glass rod for 1 minute. After a holding period of 10 minutes, the tubes were centrifuged at 5000 rpm for 25 minutes. The volume of free oil was measured and fat absorption capacity was measured as the amount of oil bound per gram of sample as follows:

\[\text{FAC (ml per g flour)} = \text{Volume of fat absorbed/weight of sample.}\]

The foaming properties were measured in terms of foam capacity (per cent) and foam stability (per cent) according to the procedure given by Nath and Rao (1981) at 1.0, 3.0, 4.5, 7.0, 9.0, and 11.0 pH. For determining foam, stability, volume of foam measured after 30 minutes and the remaining foam was described as foam stability.

The results of physical, physico-chemical and functional properties are presented as averages of triplicate values.

RESULTS AND DISCUSSION

Physical properties of buckwheat grain

Physical properties play an important role in food processing and its knowledge is essential to design the equipment for handling, aeration, storing and processing of food grains. Physical properties of different foods decide its market value and consumer acceptability. Seed weight, seed volume and seed density related information are important for easy post harvest processing of the food grains. Seed weight represents the grain size and big grain size means easy post harvest processing. Big size grain has got more endosperm therefore has more edible portion. Very high density grains requires more pressure for making flour out of it.

The average values of physical properties of buckwheat grain are given in Table 1.

Table 1. Physical properties of buckwheat grains

<table>
<thead>
<tr>
<th>Cultivars</th>
<th>Seed weight (g 100 seeds^{-1})</th>
<th>Seed Volume (ml 100 seeds^{-1})</th>
<th>Seed Density (g ml^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local variety</td>
<td>1.60±0.057</td>
<td>3.33±0.577</td>
<td>0.48±0.060</td>
</tr>
<tr>
<td>PRB-1 variety</td>
<td>2.19±0.31</td>
<td>3.00±0.00</td>
<td>0.73±0.105</td>
</tr>
<tr>
<td>F-value</td>
<td>10.11*</td>
<td>0.99</td>
<td>18.63*</td>
</tr>
</tbody>
</table>

Note * Significant at 5 per cent

The buckwheat grains of both the varieties differed significantly in seed weight and seed density (p<0.05). PRB-1 showed higher value for seed weight and seed density than the local variety. Buckwheat is classified under coarse cereals. Hadimani and Malleshi (1993) reported thousand kernel weight of foxtail millet and barnyard millet (another coarse cereals) as 2.6 g and 3.0 g, respectively which was lower than the weight of 100 seeds of buckwheat grains. Verma (2011) reported thousand kernel weight of rice grains as 18.3 g which was close to the value of buckwheat grains. By comparing all these values of seed weight, it is clear that grain size of buckwheat grains is bigger than foxtail millet and barnyard millet but close to rice grains. Similarly, Hadimani and Malleshi (1993) found that the thousand kernel volume of foxtail millet and barnyard millet were 1.9 ml and 2.4 ml, respectively which was lower than seed volume (100 seeds) of buckwheat grains. Abulude (2004) observed that the seed density of rice grains was 0.58 g ml^{-1} whereas seed density of local and variety PRB-1 buckwheat grains was 0.48 g ml^{-1} and 0.73 g ml^{-1}, respectively.

Pani et al., (1994) studied the inter-relationship between physical characteristics and cooking time. The result revealed that the cooking time showed positive correlation with seed weight, seed volume, hydration capacity and hydration index while the correlation was negative with seed density, swelling capacity and swelling index. In another study conducted with chickpea the seed weight and seed volume were positively and significantly correlated with cooking time (Williams et al., 1983). Raghuvanshi et al., (1996) observed that the physical characteristics i.e. the seed density and swelling index were two criteria which were highly correlated with cooking time. Raghuvanshi et al., 1997, studied the relationship between physical characteristics and cookability of blackgram and the result revealed significant positive correlation(r=.902) between hydration index and open pan cooking.

Physico-chemical properties of buckwheat flour

Higher hydration capacity and swelling capacity permits the grain to absorb more amount of water thereby rendering the grains soft. Soaking leads to solubilisation of pectic substances, faster hydration of interior starch and protein molecules and increased permeability resulting in softening and quick cooking of grains.

The data on various physico-chemical properties viz., hydration capacity, hydration index, swelling capacity, swelling index and bulk density for both, the local variety and PRB-1 grain flour are given in Table 2.
Physico-chemical and functional properties of buckwheat (Fagopyrum esculentum Moench)

Table 2. Physico-chemical properties of buckwheat flour

<table>
<thead>
<tr>
<th>cultivars</th>
<th>Hydration Capacity (g seed(^{-1}))</th>
<th>Hydration Index</th>
<th>Swelling Capacity (g ml(^{-1}))</th>
<th>Swelling Index</th>
<th>Bulk Density (g ml(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local variety</td>
<td>0.83±0.34</td>
<td>0.37±0.15</td>
<td>1.00±0.00</td>
<td>0.30±0.04</td>
<td>0.70±0.05</td>
</tr>
<tr>
<td>PRB-1 variety</td>
<td>1.05±0.25</td>
<td>0.52±0.16</td>
<td>1.33±0.57</td>
<td>0.55±0.34</td>
<td>0.73±0.04</td>
</tr>
<tr>
<td>F-value</td>
<td>0.77</td>
<td>1.18</td>
<td>0.99</td>
<td>1.24</td>
<td>0.40</td>
</tr>
</tbody>
</table>

Information regarding physico-chemical properties of coarse cereals are scanty. Hence, to have an idea about their cooking and processing quality, the physico-chemical properties of buckwheat were compared with different cereals and also of pulse grains. Kushwaha and Raghuvanshi (2010) and Raghuvanshi et al., (2011) reported values of hydration capacity and hydration index of mung bean as 1.99 g seed\(^{-1}\) and 0.40 and of horse gram as 1.29 g seed\(^{-1}\) and 0.45, respectively. Contrary to this the local variety and variety PRB-1 of buckwheat grains recorded hydration capacity of 0.83 g seed\(^{-1}\) and 1.05 g seed\(^{-1}\) and hydration index of 0.37 and 0.52, respectively, showing thereby that the buckwheat grains had lower value of hydration capacity than the pulse grains.

Similarly, swelling capacity and swelling index of mung bean and horsegram were 2.50 g ml\(^{-1}\), 0.64 and 1.33 g ml\(^{-1}\) and 0.44, respectively as per findings of Kushwaha and Raghuvanshi (2010) and Raghuvanshi et al., (2011). The swelling capacity of local variety and variety PRB-1 buckwheat grains were 1.00 g ml\(^{-1}\) and 1.33 g ml\(^{-1}\) and the swelling index was 0.30 and 0.55, respectively. PRB-1 variety of buckwheat showed higher value for hydration capacity and swelling capacity whereas local variety had showed higher value for hydration index and the swelling index. Buckwheat flour of PRB-1 recorded less hydration capacity, swelling capacity and swelling index than pulses indicating that pulses have higher value of physico-chemical properties than the buckwheat.

Bulk density of buckwheat grain flour of variety PRB-1 showed higher mean value (0.73 g ml\(^{-1}\)) than the local variety (0.70 g ml\(^{-1}\)). As per findings of Mepba (2007), the bulk density of wheat flours was 0.63 g ml\(^{-1}\). Rahman et al., (2011) reported the bulk density of bambara groundnut flour as 0.62 g ml\(^{-1}\). Bulk density of buckwheat flour was higher than the wheat flour and groundnut flour. This indicated that the cooking quality of buckwheat is in between cereals and pulses.

Functional properties of buckwheat flour

Functional properties have been defined as “those physical and chemical properties that influence the behaviour of proteins in food systems during processing, storage, cooking and consumption” (Kinsella, 1976). Therefore, the functional properties of food proteins are important in food processing and food product formulation (Wu et al., 1973). These are important in determining the quality (nutritional, sensory, physico-chemical and organoleptic properties) of the final product as well as facilitating processing such as improved mechinability of cookie dough or slicing of processed meats (Kinsella, 1979).

The functional behaviour of proteins in food is influenced by some physico-chemical properties of the proteins such as their size, shape, amino acid composition and sequence, netcharge, charge distribution, hydrophobicity, type of structures, molecular flexibility/ rigidity in response to external environment such as pH, temperature, salt concentration or interaction with other food constituents (Damodaran, 1994). However, these properties vary with the type of food products; for example, proteins with high oil and water, binding are desirable for use in meats, sausages, bread and cakes, while proteins with high emulsifying and foaming capacity are good for salad dressing, sausages, bologna, soups, confectionaries, frozen deserts and cakes (Ahmedna et al., 1999).

Under the functional properties, the water absorption capacity, fat absorption capacity and foaming properties of buckwheat flour was measured and the observed values are reported in Table 3.

Table 3. Functional properties of buckwheat flour

<table>
<thead>
<tr>
<th>cultivars</th>
<th>Water Absorption capacity (ml/g)</th>
<th>Fat Absorption capacity (ml/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local variety</td>
<td>1.39±0.00</td>
<td>0.99±0.003</td>
</tr>
<tr>
<td>PRB-1 variety</td>
<td>1.60±0.08</td>
<td>1.24±0.24</td>
</tr>
<tr>
<td>F-value</td>
<td>19.35*</td>
<td>3.08*</td>
</tr>
</tbody>
</table>

Note *Significant at 5 per cent

The varieties differed significantly in water and fat absorption capacity. Local variety recorded lower values. According to Phartyal (2011), water absorption capacity of raw and germinated oat flour was 2.01 ml g\(^{-1}\) and 1.60 ml g\(^{-1}\).
Buckwheat flour exhibited the least foam expansion at 4.5 pH (119.0 per cent by local variety and 120.0 per cent by PRB-1 variety, respectively). Minimum foaming at around 4.5 pH was due to the lower solubility of the protein. Also, strong intermolecular forces which do not allow protein unfolding and spreading at the isoelectric point is responsible for the observed low foam capacity. Minimum volume increase has been reported to occur in the isoelectric range in the case of other proteins also. As per findings of Rahman et al., (2011) the foaming properties of bambara groundnut flour were affected by pH values revealing increased foam capacity with increased pH values. Their data showed that the maximum increase in foam volume (foam capacity) was 210 per cent at pH 9.0. However, the lowest volume of the foam (116.0 per cent) was observed at pH 3.0. There was inverse relationship between foam capacity and foam stability (Jititngarmkusol et al., 2008). Enujigha (2003) revealed that foaming property measured in terms of foam capacity (per cent) and foam stability (per cent) is a function of pH. Among the factors which influence foaming properties are protein solubility and chemical composition of the food products. The pattern of foaming properties with different pH values are similar as in the findings of Rahman et al., (2011) and the result of Kushwaha and Raghuvanshi (2010) and Raghuvanshi et al., (2011) the fat absorption capacity of horse gram and mung bean was 1.00 ml g⁻¹ and 0.98 ml g⁻¹, respectively. The result revealed that buckwheat flour had lowest value of FAC among all flours i.e. raw and germinated oat flour, rice flour, wheat flour, foxtail millet and barnyard millet flour, but more than the pulses. High water absorption capacity helps in developing a softer product whereas high fat absorption capacity results in increased crispness and shortening for the products like pastries, cake and biscuits etc.

The foaming properties that comprises of foaming capacity and stability of flours are desirable characteristics for the production of whipped toppings, whipped deserts and frozen deserts. These, measured in terms of per cent foam capacity and foam stability as a function of pH is shown in the Table 4.

The foam capacity increased with the increase in pH values and was highest at pH 11.0 i.e. 148.0 per cent in local and 152.0 per cent in variety PRB-1, respectively. Whereas the pattern of foam stability was reverse to the pattern of foam capacity. The foam stability reduced with the increase in pH value. The highest foam stability (61.0 per cent in local and 62.0 per cent in PRB-1 of buckwheat flour) was obtained at pH 4.5, the pH at which the foam capacity is lowest in values. The highest foam stability was obtained at 4.5 pH.

Table 4. Foaming capacity and foam stability of buckwheat flour

<table>
<thead>
<tr>
<th>Cultivars</th>
<th>1.0(pH)</th>
<th>3.0(pH)</th>
<th>4.5(pH)</th>
<th>7.0(pH)</th>
<th>9.0(pH)</th>
<th>11.0(pH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local variety</td>
<td>142.44±0.42 (41.96±1.66)</td>
<td>122.09±1.09 (51.85±1.78)</td>
<td>119.26±2.41 (61.21±2.09)</td>
<td>128.83±1.71 (43.31±0.45)</td>
<td>135.56±1.61 (30.94±0.81)</td>
<td>148.12±1.49 (27.30±1.49)</td>
</tr>
<tr>
<td>PRB-1 variety</td>
<td>144.34±0.55 (42.75±1.04)</td>
<td>123.67±2.47 (53.27±2.83)</td>
<td>119.85±0.91 (62.67±0.87)</td>
<td>132.25±2.07 (45.44±1.57)</td>
<td>136.58±1.41 (30.47±0.81)</td>
<td>151.65±0.66 (27.07±1.05)</td>
</tr>
<tr>
<td>F-value</td>
<td>22.19* (0.489)</td>
<td>1.01 (0.536)</td>
<td>0.404 (1.24)</td>
<td>4.83 (5.07)</td>
<td>0.694 (0.499)</td>
<td>14.02* (0.845)</td>
</tr>
</tbody>
</table>

Note * Significant at 5 per cent. Figures in parentheses denote foam stability.

CONCLUSION

The findings concluded that the cooking quality of buckwheat is in between cereals and pulses. The buckwheat flour can be blended with other cereals and pulse flour for the preparation of different kind of food products because its grains have good physical, physico-chemical and functional properties.

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