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Composition And Functional Properties Of Common Buckwheat (Fagopyrum Esculentum Moench) Flour And Starch

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***Abstract:** Common buckwheat is a pseudo-cereal used in food industry as a functional ingredient in the form of flour and starch. The aim of this study was to isolate the starch from buckwheat grain and assess the physicochemical (Composition, hunter color, and paste clarity) and functional properties (water and oil absorption capacities, swelling power and solubility, least gelation concentration and bulk density) of flour and starch fraction. Process of isolation of starch removed all other components such as protein, fibre and fat which resulted in production of good quality of starch isolate with high proportion of starch and low level of other components except amylose. Chemical composition of flour showed higher nutritional value of buckwheat flour than starch. Color of starch had higher luminosity that increases scope of its utilization as a food ingredient. Paste clarity and gelation capacity of starch were better than flour indicating it a better thickening agent. Swelling power of starch was higher than flour indicating its suitability for application in processed foods. Solubility, oil absorption and water absorption capacities of flour and starch representing their technologically important properties meeting the demand of consumer preference in food industry.*

***Keywords:** Buckwheat; functional; starch; chemical composition*

I. INTRODUCTION

Buckwheat, a pseudo cereal, is an alternative crop belonging to the family Polygonaceae. Buckwheat is generally grouped with cereals due to similarity in cultivation and utilization though it is not cereal grain. Two types of buckwheat are used around the world: common buckwheat (*Fagopyrum esculentum* Moench) and tartary buckwheat (*Fagopyrum tataricum*) depending on the production zone. Generally, common buckwheat is grown more in Asian buckwheat growing countries, such as Japan, Korea, and the central and northern parts of China and the same is true in Europe, USA, Canada, Brazil, South Africa and Australia. In India, both types of buckwheat are grown (Li and Zhang, 2001; Bonafaccia et al., 2003). The cultivation of buckwheat had declined for many years, but in recent times there has been a reappearance of interest in its cultivation because high nutritional value of buckwheat grain due to high levels of protein, starch, dietary fibre, some minerals, vitamins, flavonoids and other bioactive components (Krkoskova and Mrazova, 2005). Buckwheat is a basic food item in porridges and soups, while it is marketed primarily in pancake mixes, which may contain buckwheat flour mixed with wheat, maize, rice or oat flour together with a leavening agent in North America (Joshi and Rana, 1995). Starch is the major component of buckwheat endosperm, which plays a significant role in appearance, structure and quality of food products. Buckwheat seeds mainly contain starch ranging from 59% – 69% which is 15-25% amylose, rest is apmylopectine and 7-37% of resistant starch (Skrabanja et al., 2004). Buckwheat starch granules are spherical, oval and polygonal in shape with large flat areas due to compact packing in the endosperm (Christa and Soral-Śmietana, 2008). Buckwheat is generally utilized as food in the form of flour;

and starch being the major component of flour dominates the functional properties of food, especially composite flours products, containing buckwheat. Suitable textural properties of buckwheat for pasta and other products could be achieved by the balance of protein and starch (Lkeda et al., 1997). Fornal et al. (1987) found very high swelling power of buckwheat starch relative to barley and maize. Bhavsar et al. (2013) reported high oil absorption capacity of buckwheat flour than wheat flour. Physico-chemical and functional properties of starch play an important role in understanding their cooking and processing properties. Relatively little work has been done on buckwheat starch and flour. Thus the aim of present investigation was to analyse the composition and functional properties of starch and flour of common buckwheat.

II. MATERIALS AND METHODS

A. MATERIALS

Grains of common Buckwheat of cultivar named VL-7 were used in this study and procured from National Bureau of Plant Genetic Resources Regional Station, Shimla, India. The grains were screened to remove defective grains and foreign matter if present and stored in sealed container at room temperature previous to their use. The flour were prepared by grinding seeds on laboratory mill and stored in polyethylene bags at 10ºC. Chemicals used for the analysis purpose were of analytical grade.

B. STARCH ISOLATION

Isolation of starch from grain buckwheat was done according to the alkaline steeping method (Choi et al., 2000) and stored in polythethylene bags at room temperature till further analysis. Firstly, grains were steeped in 0.25% aqueous NaOH solution for 18 hours at room temperature and stirred 3-4 times during this period. Grains were washed with distilled water after steeping and ground in kitchen blender at full speed for 3 min, and slurry was filtered step wise through 100 mesh (150µm), and 270 mesh (53µm) sieves. The filtrate was centrifuged at 25,000g for 20 min. The supernatant was discarded, and the top yellowish layer of protein was removed. This step was repeated to obtain a white starch layer. The starch layer was re-suspended in distilled water, shaken and centrifuged as described above. Thereafter, the isolated starch was dried in hot air oven at below 40ºC and stored at room temperature in sealed container.

C. CHEMICAL COMPOSITION

Samples of starch and flour were estimated for their moisture, crude fat, crude fibre ash and protein (N x 6.25) content by employing the standard methods (A. O. A. C., 1990). The amylose content was determined following the modified method of Williams et al. (1970). The standard curve used for amylose was Y = 0.0089X + 0.0528 (r= 0.99), where X = amylose content (%), and Y = absorbance at 680 nm, based on fractionation of rice starch by Montgomery and Senti (1958). All chemical components were calculated on dry basis except moisture content.

D. HUNTER COLOR PARAMETERS

Color of the flour and starch was measured using Ultra Scan VIS Hunter Lab (Hunter Associated Laboratory Inc., Raston Va., U. S. A.). The system determines the L^*, a^* and b^* values , where L^* represents lightness and darkness; a^* represents the opposition between green and red color ranging from positive (red) to negative (green) values; and b^* is the yellow/blue opposition also ranging from positive (yellow) to negative (blue) values.

E. FUNCTIONAL PROPERTIES

a. SWELLING POWER AND SOLUBILITY

Swelling power and solubility of flour and starch were determined by using method of Raina et al. (2006). Flour and starch samples (4g) were heated with 40 ml of water at 90°C for 1 hour. Lump formation was prevented by stirring. The dispersion was centrifuged at 4,500 rpm for 10 min. Starch sediment was weighed and supernatant was carefully taken in pre-weighed petri dish and dried to constant weight in drying oven at 100°C. The residue obtained after drying of supernatant represented the amount of starch/flour solubilized in water. Swelling power was calculated by using following formula-

$$\text{Swelling Power} = \frac{\text{Wt of sediment paste x 100}}{\text{Wt of sample on dry basis x } (100 - \text{ \% solubility})}$$

b. WATER AND OIL ABSORPTION CAPACITY

Water absorption capacity (WAC) and oil absorption capacity (OAC) of flour and starch were determined by method of Ige et al. (1984). A suspension of 1.5g of sample in 10ml distilled water was agitated 4 times allowing 10 minutes resting periods between each mixing and centrifuged at 3250 rpm for 25 minutes. The supernatant was decanted and tubes were air dried and then weighed. For determination of OAC, 3ml refined groundnut oil was added to 0.5g of sample and stirred for 1 minute. After 30 minutes at room temperature the tubes were centrifuged at 3200 rpm for 25 minutes. The volume of unabsorbed oil was determined.

c. BULK DENSITY AND LEAST GELATION CONCENTRATION

Bulk density of flour and starch were determined by as per the method as described by Balandran Quintana et al. (1998). Sample (10g) was put in measuring cylinder, tapped 10-12 times from a particular height and volume of sample was recorded. Bulk density was measured as weight of sample per unit volume. The method described by Mishra and Rai (2006) was used with slight modifications to determine the least gelation concentration. Solutions (5ml) of different concentrations of starch (1-10% w/v) and flour (8-30% w/v) in test tubes were heated at 90°C in a water bath for 1 hour, cooled immediately in ice chilled water bath and kept overnight at 4°C. The gelation was confirmed by inverting the test tubes.

d. PASTE CLARITY

Clarity of pastes of starch and flour were determined as light transmittance (%) measured by following the method of Perera and Hoover (1999) with slight modifications. Aqueous suspension (1%) of starch and flour was heated in water bath at 90ºC for 1 hour with constant stirring to avoid lump formation. The suspension was cooled to room temperature. Samples were stored for days at 4°C, and transmittance was measured at an interval of 24 hour at 640 nm against a water blank using GENESYS 10S UV–VIS Spectrophotometer (Thermo Fisher Scientific, 81 Wyman Street Waltham, MA USA).

III. RESULTS AND DISCUSSION

	Flour	Starch
Moisture Content	10.93±0.6	8.5±1.0
Protein	13.57±0.2	0.84±0.04
Crude fibre	7.13±2.9	0.5±0.02
Crude fat	3.16±0.3	0.8±0.04
Ash Content	2.07±0.1	0.18±0.02
Amylose Content	18.48±0.3	35.66±0.1

Table 1: Chemical composition of flour and starch of common buckwheat

The chemical composition of common buckwheat flour and starch is shown in Table 1. Data represents buckwheat flour a good source of protein and fibre. The values of crude protein, crude fat and ash content of flour were 13.57%, 3.16% and 2.07% respectively and found to be in range reported by Pandey et al. (2015) while fibre content (7.06%) of flour was found to be higher than recorded by Bhavsar et al., (2013). Results are comparable with study of Bonafaccia et al. (2003) reported 6.29% total fibre and 10.3% protein in buckwheat flour. Wei et al. (2003) registered 13.30-15.55% protein content in buckwheat grains. Moisture content of flour was in range reported to maintain the storage life of flour of mostly cereals. Slight difference in composition of flour from previous record might be due to difference in climatic conditions of crops and environment in which experiments were conducted. Results of starch analysis for protein, fat and ash were in consistent with the observation of earlier studies (Mundigler, 1998; choi et al., 2004). There was huge difference in the composition of flour and starch due to decreased level of protein, fat, fibre and ash content in starch. Protein and fibrous materials were removed during starch isolation for purity of product, ash content reduced due to removal of lots of minerals during washing of starch pallet; only starch bound fat could not be removed during isolation process. Additionally the presence of polar lipids interacted with proteins cannot be ruled out (Kikugawa et al., 1981). A smaller amount of moisture content was noticed in starch, which was in ranges generally accepted for dry products in order to obtain desirable shelf life and it was similar to other conventional starches (Sriroth et al., 2000). Amylose content is an important factor affecting functional properties like swelling power and solubility of flour and starch. The fraction of amylose in buckwheat flour was 18.48% which was in range (19-28%) reported by Qin et al. (2010) for thirty nine varieties of buckwheat flour. Amylose content of starch (35.66%) was slightly higher than the range (22%-33%) registered for the amylose content of buckwhwat starch in earlier studies (Li et al., 1997; Pandey et al., 2015) , and comparable to the amylose content of cereal, root, tuber and legume starches. However, amylose content of buckwheat was also reported as high as 46.6% (Qian et al., 1998). The chemical composition is a simple and convenient way of illustrating the purity of the starch extracts whereby lower contents of other components (protein, fat, ash, fiber) are highly desirable and which could be noticed in present study.

Color parameters	Flour	Starch
L	83.19±0.85	100.16±0.04
A	1.62±0.01	0.37±0.03
B	10.13±0.07	3.81±0.0

Table 2: Hunter color properties of starch and flour of common buckwheat

Table 2 represents the color parameters of buckwheat starch and flour. Color and clarity are the most important characteristics that can decide successful applications of functional ingredients in different food products. The colour of starch due to the presence of polyphenolic compounds, ascorbic acid and carotene has impact on its quality. Some pigmentation in the starch is carried over to the final product which reduces the quality, hence acceptability of starch product (Galvez and Resurreccion, 1993). The L^* value of flour (83.19) was found to higher than the range (65-75) reported by Qin et al., (2010) for buckwheat flour. However L^* value of starch (100.16) was higher than that noticed for flour which indicated higher luminosity of starch. Positive values of a^* of flour and starch indicated the presence of slight red shade. However negative value of a^* for some varieties of tartary buckwheat were reported by Li et al., (1997). Positive b^* value indicated presence of yellow components in starch and flour. The higher b* value has been reported to be an indication of presence of higher ash content (Kaur & Singh, 2007) and the present study agreed with it showing higher b^* value for flour (10.13) than starch (3.81) which might be due to higher ash content of flour than starch. Li et al., (1997) observed in his study that compared to tartary buckwheat starches, common buckwheat starch were less yellow and yellowness of tartary buckwheat starch cannot be avoided by the distilled water starch isolation procedure.

Storage period (Days)	Transmittance (%)	
	Flour	Starch
0	7.59±0.2	14.40±0.04
1	5.15±0.03	12.11±0.01
2	4.85±0.02	10.89±0.1
3	4.12±0.2	10.11±0.06
4	3.78±0.03	9.56±0.04

5	3.52±0.01	9.01±0.01

Table 3: Effect of storage on paste clarity of starch and flour of common buckwheat

The transmittance values of paste of starch and flour of buckwheat stored at refrigeration temperature are summarized in Table 3. With progressive storage at refrigeration temperature transmittance was found to decrease in both the samples. In flour samples transmittance values decreased from 7.59 to 3.52 and in starch samples it decreased from 14.40 to 9.01 during storage period of 5 days. Transmittance value of starch was more than flour indicating comparatively higher clarity of starch paste than flour paste. Various factors such as swelling of granules, granule remnants, leached amylose and amylopectine, molecular weight and chain lengths of amylose and amylopectine have been reported to vary with granule size, which ultimately leads to turbidity development and decreased transmittance in starch paste during refrigerated storage (Perera and Hoover, 1999). Decrease in transmittance with refrigeration storage was noticed in paste of corn starch by Sandhu and Singh (2007) and in potato flour paste by Singh et al., (2005). Amylose content affects the transmittance value of paste (Lim and Seib, 1993) which could be responsible for difference in turbidity of flour and starch of buckwheat in present study.

	Flour	Starch
Swelling Power (g/g)	8.34±0.05	16.63±1.05
Solubility (%)	17.01±0.18	13.34±0.65
Water Absorption Capacity (%)	115.73±1.27	53.76±1.89
Oil Absorption Capacity (%)	82.66±9.4	134.66±9.0
Bulk Density (g/ml)	0.67±0.0	0.68±0.02
Least Gelation concentration (%)	20±0.0	18±0.0

Table 4: Functional properties of flour and starch of common buckwheat

The functional properties of buckwheat starch and flour are represented in Table 4. Swelling power and solubility represents the extent of interaction between starch chains, within the amorphous and crystalline domains of the starch granule (Ratnayake et al., 2002). Furthermore, it is influenced by amylose and amylopectin characteristics (Chan et al., 2009). Swelling Power of starch was 16.63g/g which was found to be in comparable with the study of Lui et al. (2014) noticed 13.02g/g swelling power of buckwheat starch. Swelling power of flour was 8.34g/g which was found to be consistent with the results of Pandey et al. (2015) observed 8.38g/g swelling power of buckwheat flour. The low swelling power of buckwheat flour suggests the presence of stronger bonding forces within the interiors of starch granules and more amylose lipid complex (Tester and Morrison, 1990). Solubility of flour (17.01%) was found to be higher than results of Pandey et al. (2015) observed 12.75% for buckwheat flour. Solubility of starch was 13.34% which lower than flour solubility while Lui et al. (2014) recorded 20.50% solubility for buckwheat starch. Overall trend of high solubility and low swelling power of flour than starch was similar to that reported by Singh et al., (2005) for pea flours and starches. Ong et al. (1995) inferred that long chains of amylopectin interact with amylose to form double helix structures that lowers the swelling and leaching of materials on cooking. This could be responsible for low solubility of buckwheat starch. The water absorption capacity (WAC) is the ability of the flour to hold water against gravity wherein proteins and carbohydrates enhance the WAC of flour by providing hydrophilic parts like polar and charged side chains (Pomeranz, 1985). Values of water absorption capacity were higher than oil absorption capacity in flour samples. Similar trend was noticed by Shimelis et al. (2006) for bean flour. Water absorption capacity of buckwheat flour was 115% which was lower than that reported by Bhvsar et al. (2013) for buckwheat flour and wheat flour. The lower water absorption capacity of buckwheat flour could be attributed to the presence of lower level of hydrophilic constituents in it. Water absorption capacity of starch was 53.76% which was lower than study of Lui et al. (2014) observed 110% water absorption capacity of buckwheat starch. OAC of flour is due to interactions between the non-polar amino acid side chains and hydrocarbon chains of lipid determine mouth-feel and flavour retention of products. In this study the value of OAC of flour was 82.66% that was lower than the values reported by Bhavsar et al. (2013) for buckwheat (186%) and wheat flour (167%). Oil absorption capacity of buckwheat starch was 134% which was found to be higher with the results of Lui et al. (2014) noticed 110% oil absorption capacity of buckwheat starch. The value of bulk density of flour and starch was 0.67g/ml and 0.68% respectively. Bhavsar et al. (2013) reported higher bulk density 0.86 g/ml and 0.74 g/ml for buckwheat flour and refined wheat flour. The least gelation concentration is the index of gelation properties which depends on the amount of starch and pasting properties of starch. The least gelation concentration was found to be 20% and 18% for flour and starch respectively. Starch showed the better gelling capacity than flour which could be attributed to presence of low level of protein and lipids.

IV. CONCLUSION

The chemical composition, color parameters and functional properties of starch and flour from common buckwheat propose that these may have broad possibilities as an ingredient in food systems and other industrial application. The purity of starch was confirmed by lower level of protein, crude fibre and ash content in starch. Chemical composition of flour is better than starch from nutritional point of view, however from technological point of view; functional properties of starch are better and enhance the chances for preference of common buckwheat starch for utilization in food process industry. High luminosity observed in starch is a most desirable property in food industry. Superior swelling power was noticed for starch than flour which makes it potentially useful in products subjected to high temperatures. High clarity of starch paste suggests that it gives shine and opacity to the product. Least gelation concentration of flour was higher than starch, which suggests that higher amylose content and lower protein, fat and fibre content in starch increase the gelling capacity of starch granules.

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