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Flour Properties of Selected Roasted and Nonroasted Bean Cultivars

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Abstract: Bean (*Lablab purpureus* L.) is a popular and widely consumed nutritious vegetable because of its high protein and dietary fiber content, as well as fats, carbohydrates, and minerals. The study was carried out to see the powder properties of flour from raw and roasted bean cultivars grown in different parts of Bangladesh. Powder properties were evaluated by established laboratory protocols. The highest bulk density of 0.769 g/cm^3 (*Gheukoly* and *Ashina* cultivars) was found in the nonroasted bean flour sample. The roasted bean flour samples showed the highest tapped density, flowability and cohesiveness. With regard to colour parameters, non-roasted Ashina bean flour exhibited the highest lightness, having an L* value of 91.26, whereas roasted Ashina bean flour showed the highest yellowness and redness having b* value 27.49 and a* value 6.97 respectively among all the flour samples studied. Roasting improves the density, flowability and cohesiveness properties of bean cultivars which indicate that the roasted flours are relatively better to be used in ready-to-eat and ready-to-serve foodstuff development.

Keywords: Roasting; Density; Flowability; Cohesiveness; Gheukoly; Ashina.

INTRODUCTION

Bean (*Lablab purpureus* L.) is a popular and nutritious vegetable around the equatorial countries including Bangladesh. About fifty varieties and several hundred species of the country bean are grown over the globe (Osama *et al*., 2002). A large number of this bean is grown in different districts of Bangladesh with local names viz. *Koda seem, Rangpur-Hybrid Seem, Tetuljhury Seem, Ghewkoly Seem, Ashina Seem, Noldog Seem, IPSA1, BARI Seem1,* and *Kartica* (Islam *et al.*, 2010). These genotypes are commonly known as *deshi seem* and belong to Leguminosae family. The seeds are kidney-shaped with high protein amount.

To achieve sustainable development goal (SDG), nutrition security is very important. In this regard, powder properties analyses of lablab bean or hyacinth bean play a crucial role in nutrition. These properties will be convenient for preparation of new foodstuff, thereby providing an added dimension to protein functionality. Powder properties help to determine the suitability of legume flour for foods system. Protein, the major constituent of food legumes, largely determines the functionality or suitability of legume flour to be used in food industries. Proteins are generally functional in the presence of water, so it is important to understand their interaction with water (Boye *et al*., 2010).

Powder properties of bean flour can be measured through their Bulk density, Tapped density, Flowability, Cohesiveness, Color analysis etc. Bulk density and tapped density determine the bulk and tap powder behavior. Flowability is relevant in many processes and is often the problem at the heart of processing efficiency issues. The way in which powders flow is possibly their most important feature. The word cohesion is usually linked with a powder's flowability and indeed it is often the most dominant property in regard to bulk powder behavior. Cohesion is a mechanism that acts between particles and has the tendency to 'bond' one particle to its neighbor. These tensile forces are an arrangement of electrostatic charges, or surface energies, and Van der Waals forces. However, when a powder is in a loose packing state, the cohesive forces can be huge relative to the other forces acting on the element and may influence bulk powder behavior. As powders are often processed in a low stress packing state, the potency of the cohesive forces can make the difference between good process performance and powder that behaves poorly. On this basis of above views, the study was aimed to evaluate the powder properties of selected roasted bean cultivars and find the correlation between cultivars and roasting with respect to suitable properties.

MATERIALS AND METHODS

The study was carried out at the postgraduate laboratory of the Department of Biochemistry and Molecular Biology, and the Department of Food Technology and Rural Industries, Bangladesh Agricultural University (BAU), Mymensingh. The experiment was conducted during the period of October, 2018 to May, 2019.

Collection of seeds

Bean seeds of five cultivars collected from different location of Bangladesh were used in this study. Koda and Rangpur-Hybrid were collected from Rangpur district and Tetuljhury and Ashina from Mymensingh district Gheukoly was collected from the experimental plot of the Department of Biochemistry and Molecular Biology, Bangladesh Agricultural University, Mymensingh.

Roasting of seeds

The collected bean seeds were cleaned, sundried and stored. Mature and healthy bean seeds were separated for analysis. About 30 g of each sample were used for roasting. The seeds were roasted in a frying pan with sand and seed ratio of 10:1 for five minutes. The roasted bean seeds were cooled immediately and stored for dehulling and milling.

Flouring of seeds

Both roasted and nonroasted seeds were reduced to flour. For milling roasted seeds, they were first broken by hammer, dehulled and made into flour by micro-grinder (A-10 Analytical mill, Tekmar, Staufen, Germany). Finally, the flour was passed through a 60-mesh sieve and the sieved powder thus obtained was stored in an airtight polythene bag for further analysis. For milling non-roasted seeds, they were first broken by hammer, dehulled and made into flour by micro-grinder Finally, the flour was passed through a 60-mesh sieve and stored in an airtight polythene bag until analysis.

Powder properties analysis

Bulk density

Bulk density of samples was determined by following the method of Goula *et al.* (2004) with a slight modification. The bulk density was measured by pouring 1 g flour into a 10 ml graduated measuring glass cylinder and the cylinder was shaken lightly to level the upper surface of powder in the cylinder. Then the bulk density was calculated from the ratio of mass of sample to volume occupied by the sample in the measuring cylinder.

$$\text{Bulk density} = \frac{\text{Mass of sample (g)}}{\text{Volume ocupied by sample (ml)}}$$

Tapped density

Following the method of Ozdikicierler *et al*. (2014) with slight modification tapped density of the powder samples was determined. The tapped density was measured by pouring 1 g flour into a 10 ml graduated cylinder and gently tapped 50 times from placing the cylinder on a soft and stable surface. Then the tapped density was calculated by dividing the weight of powder by the tapped volume.

$$\text{Tapped density} = \frac{\text{Mass of sample (g)}}{\text{After tapping volume ocupied by sample (ml)}}$$

Flowability

Flowability of powder is categorized by the Carr Index which is a ratio of the difference between tapped density and bulk density to the tapped density. The Carr index also represents the compressibility of powder. The high value of Carr index will indicate poor flowability and high compressibility. The Carr index is calculated as follows:

$$CI = \frac{(\text{Tapped density} - \text{Bulk density})}{\text{Tapped density}} \times 100$$

There are different ranges of Carr index categorizing the flowability of a powder. The ranges for Carr index sorting the flowability of powder from Lebrun *et al.* (2012) is given in the Table 1.

Table 1: Ranges for Carr-Index categorizing flowability of powder.

Flowability	Carr-Index, %
Excellent	0-10
Good	11-15
Fair	16-20
Passable	21-25
Poor	26-31
Very poor	32-37
Very very poor	>38

Cohesiveness

The Hausner ratio is used to classify powder cohesiveness which is also a good measure for powder consistency and flowability. There is an inverse relation between cohesiveness and flowability. Lower Hausner ratio will result in for the higher the cohesiveness. Hausner ratio is calculated as:

$$HR = \frac{\text{Tapped density}}{\text{Bulk density}}$$

The Hausner ratio classifies the cohesiveness in different ranges. The different ranges for Hausner ratio by Lebrun *et al*. (2012) is given below (Table 2).

Table 2. Ranges for Hausner ratio (HR) for classifying the cohesiveness

Cohesiveness	Hausner- Ratio (HR)
Excellent	1.00-1.11
Good	1.12-1.18
Fair	1.19-1.25
Passable	1.26-1.34
Poor	1.35-1.45
Very poor	1.45-1.59
Very very poor	>1.60

Color analysis

Color changes of coated and control samples were evaluated using hand-held chroma meter (CR-499/410, KONICA MINOLTA, Japan). Before taking reading the

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chroma meter was calibrated properly using white calibration plate (CR-A43, Japan). The Chroma meter displayed the L, a, b, ΔL, Δa, Δb and ΔE values, needed to explain the internal change of color. C-value and h- value were further calculated by using the following formula-

Hue angle, h = $\tan^{-(b/a)}$

Chroma, C = $\sqrt{(a^2+b^2)}$

According to Plate 4, L-axis represents Lightness (If, L= 0; black and L= 100; white) (Figure 1). The a-axis and b-axis represent the opponent colors (red-green and yellow-blue). The a-axis stands for Redness to Greenness (If, a-value = +a; redder and a value= -a; greener). On the other hand, b-value stands for Yellowness to Blueness (If, b-value= +b; yellower and b-value = -b; bluer). The c-axis represents Chroma or saturation ranges from 0 at the center o 100 or more at the edge of the circle for color purity or saturation. The h-axis represents the hue ranging from 0° (red) through 90° (yellow), 180° (green), 270° (blue) and back to 0°.

Statistical analysis

In all experiments three replicates were used. Data were subjected to analysis of variance (ANOVA), and multiple comparisons (*post-hoc* LSD; least significant-difference test) were used to evaluate the significant difference of the data at $p = 0.05$. Data were expressed as means ± standard deviation. Statistical comparisons were made using SPSS version 23.0software for Windows (SPSS Inc. Chicago, IL, USA).

RESULTS AND DISCUSSIONS

A total of 5 bean flour samples were evaluated for their powder properties. The significant findings obtained in this study have been described in the following sections.

Powder properties analysis

Bulk density

The bulk densities of roasted and nonroasted bean flour samples varied remarkably (Figure 1). The highest bulk density (0.769 g/cm^3) was found in nonroasted bean flour sample Gheukoly and Ashina. The lowest bulk density (0.588 g/cm^3) was found in nonroasted bean flour sample of Koda and Rangpur-Hybrid.

The highest (0.769 g/cm^3) bulk density was observed in roasted bean flour sample of Rangpur-Hybrid and Ashina variety whereas the lowest (0.714 g/cm^3) bulk density was observed in roasted bean flour sample of Koda, Gheukoly and Theuljhury The values of bulk density are comparable with the values of bulk density (0.323g/cm^3 and 0.423g/cm^3) for certain varieties of carboxymethyl cellulose and the maltodextrin coated mint samples reported by Zoheb, (2018). Appiah *et al.* (2011) found bulk density ranged from 0.69 to 0.80 g/cm^3 for certain variety of cowpea. Also, Shumila *et al* (2015) observed bulk density of 0.644 kg m^{-3} for commercial rice flour. Flour with smaller particle size has a higher density. This is because of the arrangement of the particle. The particles are in close form and there are fewer spaces between particles. Higher bulk densities of Red Cowpea flour gives indication that it is havier than Black Cowpea and it would occupy lesser space per unit weight and hence packaging cost would also be lesser when compared with Black cultivar (Appiah*et al.* 2011; Oluwatooyin *et al.*, 2002). Furthermore, higher bulk density of Red Cowpea flour is diserable for greater ease of dispersibility of flours. In contrast, however, lower bulk densities of Black Cowpea flour would be advantageous in the formulation of complementary foods (Appiah *et al.* 2011). Black Cowpea flour would also be favorable in infant feeding where less bulk density is desirable (Iwe and Onalope 2001). Therefore, the flour can be used in baby food preparation with a very low cost.

Tapped density

Roasting resulted in an increase in the tapped density of bean flour samples (Figure 3). The highest (0.909 g/cm^3) tapped density was observed in the non-roasted Ashina bean flour. The lowest (0.666 g/cm^3) tapped density was observed in the nonroasted Rangpur-Hybrid bean flour. The highest (1.0 g/cm^3) tapped density was observed in roasted Gheukoly, Tetuljhury and Ashin bean flours while the lowest (0.909 g/cm^3) was the roasted Koda and Rangpur-Hybrid bean flours.

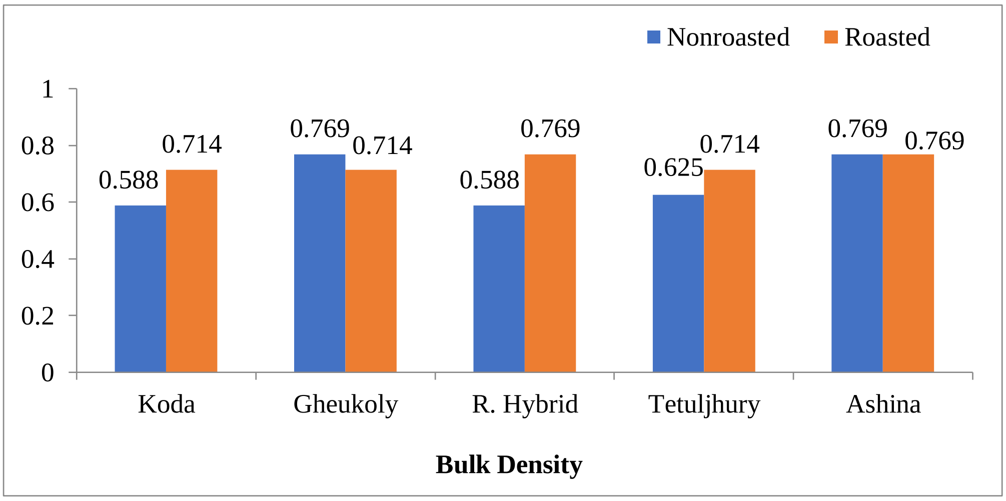

Figure 1. Bulk density of roasted and nonroasted bean flour samples.

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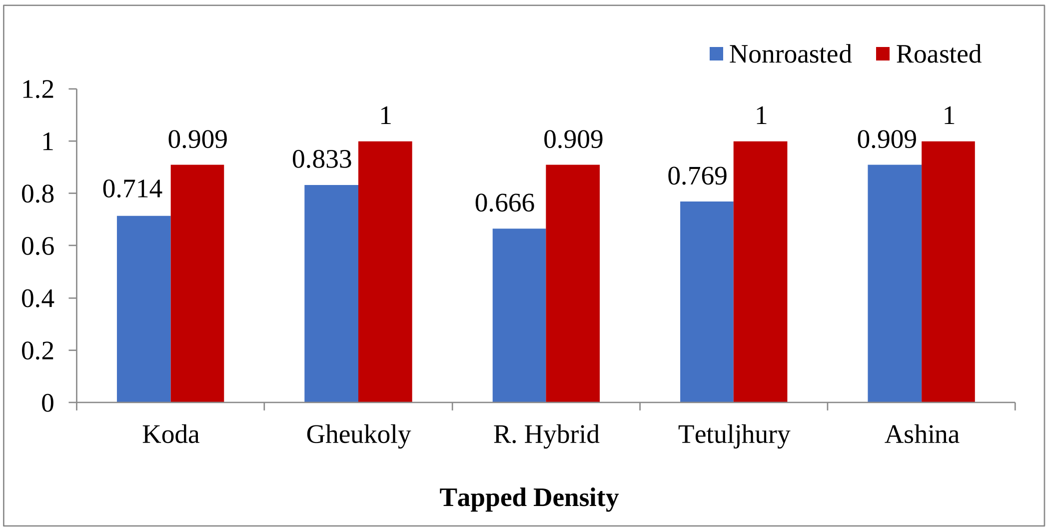

Figure 2. Tapped density of roasted and nonroasted bean flour samples.

The values of tapped density are comparable with that of 0.492g/cm^3 and 0.577g/cm^3 respectively for carboxymethyl cellulose and maltodextrin coated mint samples reported by Zoheb, (2018). Shumila *et al.* (2015) observed tapped density of 0.762 kg m^{-3} for commercial rice flour. Ripon (2016) found the value of taspped density of different BINA Chickpea cultivars varied from the highest (622.58 kg m^{-3}) for BINA sola-7 and the lowest (567.77 kg m^{-3}) for BINA sola-8. The tapped density of a powder represents its random dense packing. Tapped density values are higher for more regularly shaped particles (ie, spheres), as compared to irregularly shaped particles such as needles (Amidon *et al.*, 2017).

Flowability

To determine the flowability of the roasted and nonroasted bean flour samples, Carr-Index (Given at materials and method section) was calculated and categorized according to the sorting range given by (Leburn *et al*. 2012). The Carr-Index was calculated for the roasted and nonroasted flour bean samples and was found nonroasted Gheukoly bean flour as highly flowable (CI: 7.683). In roasted bean flour samples, Rangpur-Hybrid ranked as good flowable with CI 15.4 whereas Gheukoly and Tetuljhury bean flours exhibited poor in flowability (CI: 28.6) (Figure 3).

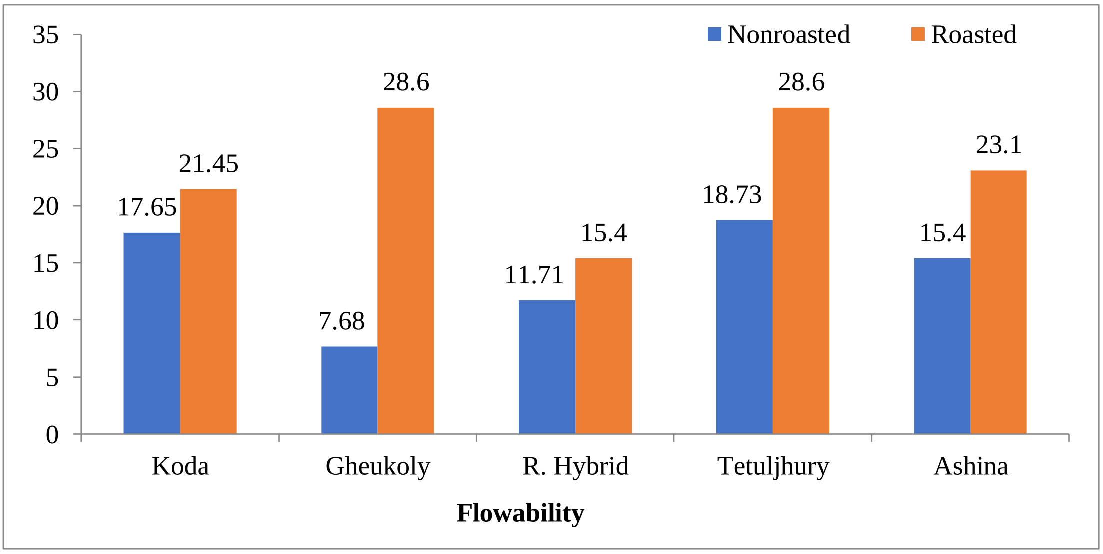

Figure 3. Flowability of different samples expressing by Carr-Index (nonroasted and roasted bean flour samples).

The values of Carr's index are comparable with that of 34.40 and 26.78 respectively for carboxymethyl cellulose and maltodextrin coated mint samples reported by Zoheb, (2018). Shumila, (2015)found the Carr's index of commercial rice flour as 15.480. Flour with higher bulk density has poor flowing properties**.** Poor flowability is related to van der Waals forces and electrostatic forces.

Cohesiveness

Cohesiveness was calculated by calculating the Hausner Ratio (HR) from the bulk and tapped density of roasted and

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non-roasted bean flours using equations described in the materials and method section. Nonroasted Gheukoly bean flour samples exhibited highly cohesive having HR of 1.08 followed by Ashina bean flour sample with HR 1.33 ranking passable cohesiveness. In roasted bean flour samples, Rangpur-Hybrid showed good cohesiveness which had HR of 1.18 whereas Gheukoly and Tetuljhury flour poorly cohesive scoring HR of 1.4 (Figure 4).

The values of Hausner ratio are comparable with that of 1.52 and 1.37 respectively for carboxymethyl cellulose and maltodextrin coated mint samples reported by Zoheb, (2018). (Shumila, 2015) found Hausner ratio of commercial rice flour 1.183. Hausner ratio and Carr's index increased with the decrease of mean particle size that means increase of bulk density. The correlation between flowability and cohesiveness directly inverse that means very very poor flowability indicates highly cohesiveness of flour.

Color analysis

The color value of the roasted and nonroasted bean flour samples were measured (Table 3). The values of chroma and hue angle were calculated by the equation given in methodology section. The highest L* value was found in nonroasted bean flour sample 91.26 (Ashina) whereas the lowest L* value was found in roasted bean flour sample 59.03 (Gheukoly) respectively. The higher L*value represents lighter color whereas the lower L value represents a darker color. On the other hand, negative a* values for all samples expressed the green color of the samples which is opposite to the red color value.

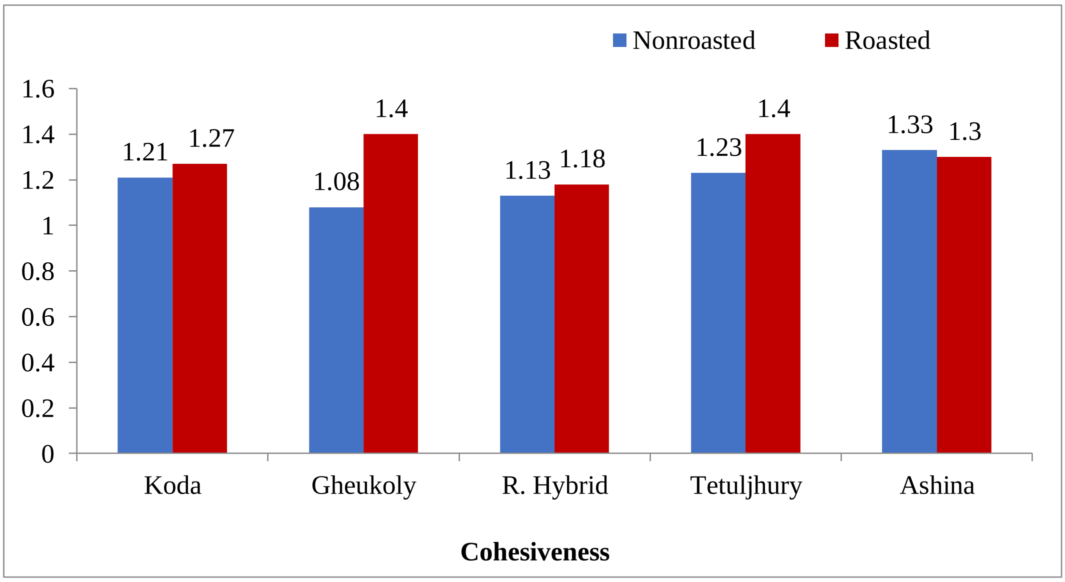

Figure 4. Cohesiveness for different samples expressed by Hausner-Ratio (roasted and nonroasted bean flour samples).

Table 3. Change in color parameter in different sample.

Treatment	Sample Name	Result (Color)				
		L*	a*	b*	h*	c*
Nonroasted	Koda	89.09	-1.20	10.11	83.23	10.181
	Gheukoly	83.21	-1.06	11.90	84.91	11.947
	R. Hybrid	84.80	-1.45	10.97	82.11	11.065
	Tetuljhury	88.26	-1.52	10.07	81.42	10.184
	Ashina	91.26	-1.10	10.89	84.23	10.95
Roasted	Koda	82.22	1.25	19.68	86.37	19.719
	Gheukoly	59.03	4.80	19.15	75.93	19.742
	R. Hybrid	66.14	3.97	20.08	78.82	20.468
	Tetuljhury	75.02	2.14	18.23	83.30	18.355
	Ashina	66.82	6.97	27.49	75.77	28.36

The positive value of b* represents the yellow color of the samples and the negative value of b* represents the blue color. The value for b* was the highest for roasted bean flour sample with a figure of 27.49 (Ashina). Thus, the

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roasted bean flour samples were much yellower than the nonroasted bean flour samples. The chroma of the certain sample says about the color saturation range of the product. C-axis indicates chroma or saturation ranges from 0 at the center to 100 or more at the edge of the circle for color saturation. h-axis represents the hue ranging from 0° (red) through 90° (yellow), 180^0 (green), 270° (blue) and back to 0°. The chroma values for the roasted bean flour samples were higher than the nonroasted bean flour samples. The values represented more saturated color in the roasted bean flour sample and retention of natural color in the nonroasted bean flour sample. The hue angle value reduced from the nonroasted bean flour sample to the roasted bean flour sample. Nonroasted bean flour samples had a higher hue angle of 86.22 whereas the roasted bean flour sample had lower 75.77, respectively. The retention of color is slightly high in the dried samples after treatment as it showed darker and fell in the range of green to blue (180° to 270°).

Aditya Joshi (2012) reported that color (L*, a* and b*) readings of the full fat chickpea flours were L* = 86.38, a* = 2.96 and b* = 19.87 and defatted chickpea flours were L* = 88.11, a* = 1.46 and b* = 14.71. Sanjeewa (2008) compared the color value of Desi and Kabuli chickpea cultivar flours (Kabuli; L* = 87.24, a* = 1.91 and b* = 20.40 and Desi; L* = 81.88, a* = 2.33 and b* = 19.69) and found higher L* and b* value in Kabuli cultivars. Maskan (2001) reported for kiwi fruit that an L* value of about 40 was reached after 5 min of microwave drying and about 325 min of hot air drying; therefore, microwave would give a destruction rate 65 times faster than hot air (60 °C). (Zoheb, 2018) found lower L* value 32.81 for carboxymethyl cellulose and the 34.2 for maltodextrin coated mint samples respectively. He found higher –a* value as -3.4 and lower b* value 11.68 for carboxymethyl cellulose coated mint samples. Ripon (2016) found L* range from (83.29-88.46) and the higher value was 88.46 for BINA sola-2 than BINA sola-5 (83.29) that means BINA sola-2 was whiter than BINA sola-5. He found a* value ranged between 1.35-1.80 and was significantly higher for BINA sola-3 (1.80). It means that a* is positive and red in direction. The color parameters of different cultivars are varied due to varietal difference, environmental effect, milling process, degree of contamination, moisture, protein and starch. Jang *et al. (*2018) found that the roasting time and temperature had the same influence on L*, a* and b* color parameters of the pepper seeds. As shown, L* value decreased continuously from 69.4 (10 min) to 56.8 (40 min) while a* and b* values increased with increased roasting time firstly and then decreased during the time range from 30 to 40 min at 160^0C.

CONCLUSION

As a rich source of proteins and dietary fiber, bean (*Lablab purpureus* L.) is a more consumed legume in Bangladesh as well as in the world. Powder properties such as bulk density, tapped density, flowability and cohesiveness of flour from raw and roasted beans of five samples were evaluated following standard protocols. Based on the research conducted and results obtained, it is now known that the powder properties of Koda, Gheukoly, Rangpur Hybrid, Tetuljury and Ashina bean flour are improved on roasting, which could be exploited in food formulation.

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