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The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.03
TPI 2019; 8(7): 33-37

www.thepharmajournal.com
Received: 22-05-2019
Accepted: 23-06-2019

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Physico - chemical properties of black and yellow soybean (*Glycine max* L.) Genotype

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Abstract
A total of three soybean genotypes including two black - Kalitur and DSM with one yellow – DSb 21 were procured during *kharif*, 2017, University of Agricultural Sciences, Dharwad were analyzed for physico-chemical composition, cooking quality and acceptability. A significant variation was found in physical and functional characteristics of black and yellow soybean genotypes. The DSM genotype had highest weight (16.85 g), length (7.26 mm), breadth (6.69 mm), thickness (5.53 mm) and swelling capacity (0.20 ml) compared to Kalitur and DSb 21. Significant variation was observed in the proximate and mineral matter contents of soybean genotypes. The highest moisture was recorded in Kalitur (12.00 g). The fat content of soybean genotype ranged between 17.86 - 19.76 g per 100 g with maximum in Kalitur followed by DSb 21 and DSM. Significantly high amount of protein was observed in the DSb 21 (43.63 g). Black soybean DSM genotype had significantly high content of crude fibre (6.30 g) and ash (5.82 g) respectively. Among the mineral matter, calcium was found to be highest in DSb 21. The iron content of soybean genotypes with and without hull ranged between (268 to 341 ppm and 218 to 292 ppm).

Keywords: DSM – Dharwad soybean mutant, Kalitur

Introduction
Soybean (*Glycine max* L.) has a rich history and dates back nearly 5,000 years to their native East Asia. It is widely grown for its edible bean, which has numerous uses. The soybean (*Glycine max*) is a species of legume (family – *fabaceae*). The etymology of the genus *Glycine* comes from Linnaeus. The genus *Glycine* is divided into two subgenera, *Glycine* and *Soja*. Both species are annuals in which *Glycine soja* is the wild ancestor of *Glycine max* grown in China, Japan, Korea and Russia. Most commonly the black soybean was used historically and today is still used to produce the famous Chinese flavoring ingredient- fermented black soybeans.

According to the Foreign Agriculture service, USDA - United States Department of Agriculture Office of Global Analysis report - 2018 (Circular Series WAP 5-18), the main countries growing soybeans are the United States (354.54 million tons), Brazil (116.48 million tons), China (14.10 million tones and India (10.80 million tons), which is in 4th place in production. In India, Madhya Pradesh is the highest producer of soybean (42.00 million tons) followed by Maharashtra (29.00 million tons) and Karnataka (1.73 million tons). Of the total soybean produced worldwide, only 2 per cent of tha total accounts for the black soybean poduction. The soybean includes other nutrients and non-nutrients such as saponins, phytates, protease inhibitors, phenolic acids, lecithin, phytosterols, is oflavones and omega-3 fatty acids. In addition to these compounds, black soybean has unique properties owing to its black hull which is different from yellow soybean and green soybean. The black hull contains various polyphenols such as anthocyanins, pro cyanidins and catechins. Black seed coat of soybeans have been found to contain high contents of tocopherol, isoflavones and flavonoids which possess biological activity (Correa *et al.* 2010; Jeng *et al.* 2010; Kumar *et al.* 2010) [2, 8, 9]. Antioxidant properties such as ferric reducing antioxidant power, free radical-scavenging effect and total phenolics have shown to be comparatively high in black soybean in the yellow soybean (Xu *et al.* 2007; Xu and Chang, 2008; Kumar *et al*. 2010) [18, 17, 9]. In addition, the greater inhibition of low density lipoprotein oxidation has been recorded in black soybeans over that of yellow soybeans (Takahashi *et al.* 2005) [14]. (Kumar *et al.* 2010) [9] indicated that yellow, green and black soybean seeds had similar contents of total phenolics and isoflavones. Keeping the points in the mind, the research focussed on physic - chemical characteristics of black soybean has been put forth with the following objectives.

1) To study the physical characteristics of black soybean.
2) To analyze chemical composition of the black soybean.

Material and Methods

The present study on physico chemical characteristics and cooking quality of black soybean has been put forth at the Department of Food science and Nutrition, College of Community Science, UAS, Dharwad during 2017-18. A total of three soybean genotypes including two black soybeans - Kalitur and DSM (Dharwad Soybean Mutant) with one yellow soybean - DSb 21 were procured from Department of Crop Physiology, University of Agriculture Sciences, Dharwad during Kharif - 2017.

The physical characters of seeds

The physical characters of seeds of three soybean varieties were studied for length, width, thickness, diameter, sphericity, 100 seeds weight, volume, bulk density, hydration capacity, hydration index, swelling capacity and swelling index using standard methods in triplicate.

Length, width and thickness of seeds were measured using vernier calipers having a least count of 0.001mm and results were recorded in mm (Vilas *et al*., 2012) [15].

Hundred seeds of three soybean genotypes were selected randomly and weighed in an electronic weighing balance. The weight was recorded in gram (Vilas *et al*., 2012) [15].

The hundred seeds selected for weight determination were transferred into a measuring cylinder containing known volume of water. The difference in volume was recorded as 100 seed volume and expressed in ml-1 (Sharma *et al*., 2004) [9, 12].

Bulk density of the seeds was calculated using hundred seed weight and volume and results were expressed as g ml-1 (Vilas *et al*., 2012) [15].

$$\text{Bulk density (g/ml)} = \frac{\text{Seed weight (g)}}{\text{Seed volume (ml)}}$$

Sphericity: The sphericity of seeds were calculated using formula

$$\Phi = (LWT/L)1/3$$

Where L is the length, W is the width and T is the thickness in mm (Vilas *et al*., 2012) [15]. Hydration capacity and hydration index; about 100 g of seeds were weighed and transferred to measuring cylinder of 100 ml capacity to which 50 ml distilled water was added. The sample was then allowed to stand at room temperature for overnight. Next day grains were drained and excess water was removed with filter paper and swollen grains were weighed. Hydration capacity and hydration index were determined by using the following formula (Shridara *et al*., 1997) [13].

$$\text{Hydration capacity (g/100 grains)} = \frac{\text{Weight of grain after soaking (g) - Weight of grain before soaking (g)}}{\text{Total number of grains (N)}}$$

Hydration index

Hydration index was calculated using the following formula:

$$\text{Hydration index} = \frac{\text{Hydration capacity per 100 grains}}{\text{Weight of total number of seeds}}$$

Swelling capacity and Swelling index

A total of 100 grains were soaked in 50 ml distilled water for 24 hrs. Grains were drained and excess water was removed with filter paper. The volume of soaked grains was determined (Shridara *et al*., 1997) [13].

Swelling index Swelling index was calculated by using the formula,

$$\text{Swelling index} = \frac{\text{Swelling capacity per 100 seed}}{\text{Volume of 100 seeds}}$$

Chemical composition

The hull of three soybean genotypes - DSb 21 Kalitur and DSM was e removed by soaking seeds overnight followed by oven drying for 24 - 48 hrs at 60 - 70 º C. The seed coat was removed by rubbing with hands. The whole grain, dhal and hull were powdered separately. The composition including proximate principles, minerals and anti-nutrients of soybean genotypes were analyzed in triplicates using standard procedures.

The proximate principles such as protein, fat, crude fiber and ash were analyzed by standard AOAC method. The carbohydrate content was assessed by difference method and energy values were computed. Minerals - calcium was analysed by titration method and iron was estimated by AAS method (Anon., 2005).

Statistical analysis

The SPSS version of 16 software programmer was used to estimate the mean, standard deviation, standard error of mean, 'S. E difference, 'CD', 'F' value. One way ANOVA was employed to know the difference between the genotypes and recipes (Fisher and Yuest, 1963) [3]. The critical difference was tested at 1 and 5 per cent significance level.

Results Discussion

The experimental results of the study entitled "Physico-chemical characteristics of black soy bean" conducted with the objectives to assess physical and functional characteristics and nutritional composition of soybean genotypes are presented under the following sub-headings, 1) Physical characteristics of soybean genotypes 2) Composition of soybean genotypes.

The physical characteristics such as weight, volume, length, breadth, thickness, diameter, sphericity and functional characteristics viz., hydration capacity, hydration index, swelling capacity and swelling index of black and yellow seeds of soybean genotypes are presented below.

Table 1 depicts the physical characteristics of seeds of soybean genotypes. Significant ($p \geq 0.01$) difference was found w.r.t. 100 seed weight among soybean genotypes which ranged between 12.13 - 16.85 g. The highest weight was found in DSM black soybean (16.85 g) followed by DSb 21 (13.4 g) while Kalitur (12.13 g) weighed least. Volume of 100 seeds varied between 8.67 to 14.33 ml, which was significantly ($p \geq 0.01$) high in DSM black soybean genotypes (14.33 ml). Bulk density was found to be least in DSM black

soybean (1.18 ml). The length of soybean seeds varied between 6.48 - 7.26 mm, with highest in DSM genotype (7.26 mm) followed by DSb 21 (6.69 mm) and least was evidenced by seeds of Kalitur (6.48 mm). The Kalitur, a local genotype of black soybean had lowest breadth (5.57 mm) and the results were found to be statistically significant ($p \geq 0.01$). The thickness of soybean seeds varied between 4.29 - 5.53 mm. Thickest seeds were noted in DSM black soybean, UAS, Dhrawad genotypes (5.53 mm) followed by Kalitur genotypes (4.70 mm) and least was found in DSb 21 (4.29 mm). The diameter of soybean seeds ranged between 5.44 - 5.53 mm which was significantly ($p \geq 0.01$) high in DSb 21 (5.53 mm). The sphericity of seeds varied between 0.73 - 0.88 M3 and the results were found to be non-significant. Functional characteristics of seeds of soybean genotypes are presented in Table 2. Hydration capacity of seeds varied between 0.17 - 0.33 g per grain. The highest hydration capacity was noted for Kalitur seeds (0. 33 g /grain) followed by DSM (0.22 g /grain) and least was found in DSb 21 (0.17 g /grain) and the results were found to be statistically significant ($p \geq 0.01$). The hydration index of soybean genotypes ranged between 0.01 - 0. 04. The highest hydration index was found in DSM (0.13) followed by Kalitur (0.04) and least was observed in DSb 21 (0.01). and the results did not vary significantly among the soybean genotypes the swelling capacity of soybean seeds varied significantly ($p \geq 0.01$) between genotypes that ranged from 0.13 to 0.20 ml /grain. The highest swelling capacity was found in DSM black soybean (0.20 ml) followed by Kalitur (0.15 ml) and least was found in DSb 21 (0.13 ml). The swelling index for seeds of DSb 21 and Kalitur was 0.01. The genotype DSM had zero swelling indexes. The results were found to be non significant. The black soybean genotypes - DSM and Kalitur had highest weight that ranged between 12.13 - 16.85 g, volume; 8.67 - 14.53 ml, bulk density; 1.18 - 1.18 ml, length; 6.48 - 7.26 mm, breadth; 5.57 - 6.69 mm, thickness; 4.70 - 5.53 mm, diameter; 5.44 - 5.49 mm and spericity; 0.80 – 0.88 M3 (Table 1) which were higher than the DSb 21 soybean.

The results pertaining to physical characteristics of soybean genotypes in the functional properties viz., hydration capacity and swelling capacity varied among the soybean genotypes (Table 2). The values were statistically significant ($p \geq 0.05$) with respect to hydration capacity (0. 33 g / grain) and swelling capacity (0.20 ml/ grain) in Kalitur and DSM black soybean genotypes respectively. The higher hydration capacity and swelling capacity of black soybean genotypes can be attributed to absorption of water by the seed coat as well as chemical composition of seed coat (Wani *et al*. 2014) [16]. Apart from this, the seed coat of DSM was de-hulled easily during milling process compared to DSb 21 indicating high imbibition, for which the hydration capacity and swelling capacity noted in the present study may be higher for DSM. The results reported for hydration capacity and swelling capacity for DSb 21 in the present study are higher than those results reported by Shridara (1997) [13]. This may be due to variation in size of grains studied and varietal differences.

Composition of soybean

The proximate composition of seeds of soybean genotypes with hull is presented in Table 3. There was significant difference ($P \geq 0.01$) in proximate composition of seeds of soybean genotype

Table 1: Physical characteristics of seeds of soybean genotypes

Genotypes	Weight (g /100 seeds)	Volume (ml/100 seeds)	Bulk density (ml)	Length (mm)	Breadth (mm)	Thickness (mm)	Diameter (mm)	Spericity/M^3
DSb 21	13.4 ± 0.10^b	10.67 ± 0.58^b	1.23 ± 0.12	6.69 ± 0.33^a	5.72 ± 0.23^b	4.29 ± 0.25^c	5.53 ± 0.12^b	0.73 ± 0.22
Kalitur	12.13 ± 1.13^b	8.67 ± 1.53^c	1.44 ± 0.38	6.48 ± 0.29^b	5.57 ± 0.26^b	4.70 ± 0.29^a	5.44 ± 0.25^a	0.80 ± 0.16
DSM	16.85 ± 0.76^a	14.33 ± 0.58^a	1.18 ± 0.04	7.26 ± 0.34^b	6.69 ± 0.27^a	5.53 ± 0.33^a	5.49 ± 0.13^b	0.88 ± 0.03
F-value	28.48	24.78	1.19	15.44	52.87	39.86	79.55	2.01
S. Em ±	0.65	0.82	0.59	0.14	0.14	0.13	0.08	0.07
C. D @ 1% level	1.58**	2.09**	NS	0.29**	0.29**	0.28**	0.17**	NS

DSb 21 - Yellow, Kalitur and DSM – black

Note: Mean ± S.D; CD - Critical Difference; S. E m ± Standard Error of mean; **Significant at 0.01 percent level; NS - Non significant; Different super scripts within a column indicate significant difference at 0.05 level by DMRT

Table 2: Functional characteristics of seeds of soybean genotypes

Genotypes	Hydration capacity (g/ grain)	Hydration index	Swelling capacity (ml/ grain)	Swelling index
DSb 21	0.17 ± 0.01^b	0.01 ± 0.00^b	0.13 ± 0.37^b	0.01 ± 0.05
Kalitur	0.33 ± 0.11^c	0.04 ± 0.63^a	0.15 ± 0.02^b	0.01 ± 0.01
DSM	0.22 ± 0.01^a	0.13 ± 0.00^b	0.20 ± 0.02^a	0.00 ± 0.00
Mean ± S.D	0.17 ± 0.40	0.06 ± 0.06	0.60 ± 0.04	0.33 ± 0.39
F-value	67.89	235.35	6.76	3.29
S. Em ±	0.00	0.00	0.03	-
C. D @ 1% level	0.00	0.00	0.06*	-

DSb 21 - Yellow, Kalitur and DSM – black

Note: Mean ± S.D; CD - Critical Difference; S. E m ± Standard Error of mean; * Significant at 0.05 per cent level; NS- Non-significant; Different super script within a column indicate significant difference at 0.05 level by DMRT

Table 3: Proximate composition of seeds of soybean genotypes

Genotypes	Moisture (%)	Fat (%)	Protein (%)	Crude fiber (%)	Ash (%)	Carbohydrates (%)	Energy (kcal/g)
DSb 21	9.97 ± 0.06[b]	18.32 ± 0.11[b]	43.63 ± 0.20[a]	4.53 ± 0.27[b]	5.68 ± 0.11[a]	18.73 ± 0.53[b]	405 ± 1.21[b]
Kalitur	12.00 ± 0.02[a]	19.76 ± 0.05[a]	40.60 ± 0.35[c]	4.46 ± 0.31[b]	5.19 ± 0.06[b]	19.88 ± 0.27[a]	420 ± 0.925[a]
DSM	8.58 ± 0.18[c]	17.86 ± 0.05[c]	42.35 ± 0.35[b]	6.30 ± 1.90[a]	5.82 ± 0.12[a]	19.60 ± 0.60[b]	408 ± 2.96[c]
F-value	647.63	458.67	728.82	2.57	48.83	4.43	25.81
S.Em ±	0.07	0.04	0.18	0.65	0.05	0.328	1.11
CD @ 1 per cent level	0.24*	0.15**	0.62**	2.25**	0.17**	0.98**	3.85

DSb 21 - Yellow, Kalitur and DSM – black

Note: Note: Mean ± S.D; CD - Critical Difference; S. E m ± Standard Error of mean; * Significant at 0.05 per cent level; **Significant at 0.01 percent level; NS - Non significant; Different super script within a column indicate significant difference at 0.05 level by DMRT

Table 4: Mineral content (of seeds of soybean genotypes

Genotypes	Calcium (mg/100 g)	Iron (ppm)
DSb 21	220 ± 1.15[b]	341 ± 1.00[a]
Kalitur	201 ± 1.52[b]	342 ± 1.00[a]
DSM	201 ± 1.00[a]	268 ± 0.01[b]
Mean SD ±	207 ± 9.81	317 ± 36.60
F-value	244.5	8.03
S. Em ±	0.72	0.47
CD @ 1% level	2.50**	1.63**

DSb 21 - Yellow, Kalitur and DSM – black

Note: Mean ± S.D; CD - Critical Difference; S. E m ± Standard error of mean ** Significant at 0.01 per cent level; NS - Non - Significant; Different super script within a column indicate significant difference at 0.05 level by DMRT

The moisture content ranged between 8.58 - 12.00 g with highest in Kalitur (12.00 g) followed by DSb 21 (9.97 g) and least moisture was found in DSM black soybean (8.58 g). The fat content varied between 17.86 - 19.76 g. The highest fat was found in Kalitur black soybean (19.76 g) followed by DSb 21(18.32) and least was found in DSM (17.86 g) and the results were found to be statistically significant ($p \geq 0.01$). The protein content ranged between 40.60 - 43.63 g. The soybean genotypes DSb 21 had significantly ($p \geq 0.01$) high protein content (43.63 g) followed by DSM (42.35 g) and least was found in Kalitur (40.60 g). The crude fiber content varied between 4.46 - 6.30 g. The highest crude fiber was found in DSM (6.30 g) followed by DSb 21 (4.53 g) and least was found in Kalitur (4.46 g). Black soybean DSM had significantly ($p \geq 0.01$) highest ash content (5.82 g) and least was found in Kalitur (5.19 g). Significantly ($p \geq 0.01$) highest carbohydrate content was found in Kalitur (19.88 g) and least was found in DSb 21 (18.73 g). The energy contents of soybean genotypes varied between 405 - 420 kcal per 100 g with highest calorific value in Kalitur (420 kcal) followed by DSM (408 kcal) and least energy was found in DSb 21 (405 kcal) and results were found to be statistically significant ($p \geq 0.01$).

Composition of grain determines the quality of the grain which differentiates it from other varieties. All foods are composed of proximate principles including moisture, fat, protein, crude fiber, ash and carbohydrate contents which perform different functions. The protein and crude fiber were higher while carbohydrate content was less in present study compared to those results reported by Sharma (2004) [9, 12] which ranged from 31.9 - 38.9 per cent, 19.7 - 21.7 per cent, 4.6 - 5.4 per cent, 21.2 - 25.0 per cent for protein, fat, fiber, carbohydrate and mineral content respectively. Furlan *et al*. (2012) reported lower protein content (34.73-36.81g) and higher oil (21.98 -23.99 g) and ash (5.66 - 6.35 g) contents for yellow soybean.

The composition of seeds also varies depending on the source of seed material, genetic and environmental factors. Drying of seeds after harvest influence composition (Grieshop *et al*. 2003) [5]. Consistently state and regional differences in protein and oil content were found in soybean grown at USA during 1986, 1987 and 1988 (Hurburgh *et al*. 1990) [6].

The calcium and iron contents of seeds of soybean genotypes with hull are presented in Table 4. The calcium content of genotypes varied significantly ($p \geq 0.01$). The calcium content of soybean ranged between 201 - 220 mg per 100 g. The highest calcium was found in DSb 21 soybean followed by Kalitur and DSM and the results were found to be statistically significant ($p \geq 0.01$). Iron content noted in soybean genotypes with hull ranged between 268 - 342 ppm. The highest iron content was found in Kalitur (342 ppm) followed by DSb 21 (341 ppm) and least was found in DSM (268 ppm) and the results varied significantly ($p \geq 0.01$).

Significant difference ($p \geq 0.01$) was observed in mineral contents viz., calcium (201 - 220 mg) and iron (268 – 342 ppm) contents of soybean genotypes. fiber, minerals such as calcium and iron.

The difference in mineral content might be due agronomical practice such as irrigation which significantly affects the concentration of macro minerals (Kresovic *et al*., 2017) [10]

Conclusion

The present study concluded that black soybean genotypes apart from having protein, fat and carbohydrate were found to be nutritionally rich in crude fiber, minerals such as calcium and iron which is help full in the human health.

Acknowledgement

With regardful memories……..

This thesis is the end of my journey in obtaining my MSc. I have not travelled in a vacuum in this journey. This thesis has been kept on track and been seen through to completion with the support and encouragement of numerous people. At the end of my thesis, it is a pleasant task to express my thanks to all those who contributed in many ways to the success of this study and made it an unforgettable experience for me I wish to express my sincere gratitude and respect to Dr. Uma N.K., Professor, Department of Food Science and Nutrition, College of Community Science, UAS, Dharwad, Chairman of my advisory committee, for her inspiring, enlightening guidance and constant encouragement and my advisory committee Dr. Kasturiba B, Professor and Head, Department of Food Science and Nutrition, CCSc, UAS, Dharwad, Dr. R. V. Koti., Professor, Department of Crop Physiology, UAS, Dharwad, and my family and my friends, ……any omission in this brief acknowledgement does not mean lack of gratitude.

References

1. Anonymous. Official methods of analysis. Association of Official Analytical Chemists, 18th edition, Washington,

D.C., 224.
2. Correa CR, Li L, Aldini G, Carini M, Chen CYO, Chun HK *et al*. Composition and stability of phytochemicals in five varieties of black soybeans (Glycine max). Food Chemistry. 2010; 123:1176-1184.
3. Fisher RA, Yuest F. Statistical Table for Biological, Agricultural and Medical Research, Oliver and Boyd, Heffner Publishing Company Edinburgh, 1963, 285.
4. Furlan ACB, Carlos ES, Marcia P, Rodrigo SL, Jose MGM, Mercedes CA *et al*. Chemical composition of tempeh from soybean cultivars specially developed for human consumption. Cienc Technol. Ailment Campinas. 2012; 32(3):613-620.
5. Grieshop MG, Kadzere TC, Clapper MG, Flickinger AF, Bauer LL, Frazier L, Fahey GCJ. Chemical and nutritional characteristics of United States soybean and soybean meals. Journal of Agricultural Food Chemistry. 2003; 51:7684-7691.
6. Hurburgh CR, Brumm TJ, Guinn JM, Hartwig RA. Protein and oil patterns in U. S. and worlds soybean markets. Journal of American Oil Chemistry Social. 1990; 67:966-973.
7. https://en.mm.wikipedia.org>wiki> Soybean.
8. Jeng TL, Shih YJ, Wu MT, Sung JM. Comparisons of flavonoids and anti-oxidative activities in seed coat, embryonic axis and cotyledon of black soybeans. Food Chemistry. 2010; 123:1112-1116.
9. Kumar V, Rani A, Dixit AK, Pratap D, Bhatnagar D. A comparative assessment of Sharma S, Saxena AK, Dhillon SK. Physico chemical and cooking quality characteristics of soybean (Glycine max). Journal of Food Science and Technology. 2004; 41(5):554-556.
10. Kresovic B, Bosko AG, Angelina T, Goran D. Yield and chemical composition of soybean seed under different irrigation regimes in the Vojvodina region. Plant Soil Environment. 2017; 63(1):34-39.
11. Sharma S, Goyal R, Barwal S. Domestic processing effects on physicochemical, nutritional and anti-nutritional attributes in soybean (Glycine max L. Merill). International Journal of Food Research. 2013; 20(6):3203-3209.
12. Sharma S, Saxena AK, Dhillon SK. Physico chemical and cooking quality characteristics of soybean (Glycine max). Journal of Food Science and Technolnology. 2004; 41(5):554-556.
13. Shridara ST, Chalapati MV. Nutritional value physical and physicochemical characteristics and cooking quality of soybean genotype Crop Research. 1997; 13(2):259-266.
14. Takahashi R, Ohmori R, Kiyose C, Momiyama Y, Ohsuzu F, Kondo K. Antioxidant activities of black and yellow soybeans against low density lipoprotein oxidation. Journal of Agricultural food chemistry. 2005; 53(11):4578-4582.
15. Vilas SW, Ukey PD, Pawar DA. Determination of physical properties of soybean at different moisture levels. International Journal of Engineering. 2012; 14(2):2081.
16. Wani IA, Sogi DS, Wani AA, Gill BS. Physical and cooking characteristics of some Indian Kidney beans (Phaseolus vulgaris L.) cultvaters. Journal of Soudi Society Agricultural Science. 2014; 0077X(14):6-9.
17. Xu B, Chang SKC. Antioxidant capacity of seed coat, dehulled bean and whole black soybeans in relation to their distributions of total phenolics, phenolic acids, anthocyanins and isoflavones. Journal of Agricultural food chemistry. 2008; 56:8365-8373.
18. Xu BJ, Yuan SH, Chang SK. Comparative analyses of phenolic composition, antioxidant capacity, and color of cool season legumes and other selected food legumes. Journal of Food Science. 2007; 72(2):S167-176.