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PROXIMATE COMPOSITION AND NUTRIENT CONTENT OF VARIOUS SELECTED VARIETIES OF SOYBEAN (*Glycine max* L.)

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Abstract

The physico-chemical characteristics of five soybean cultivars were evaluated in this study. Seed weight, moisture percentage, ash percentage, oil percentage, protein percentage, chemical constants (saponification, acid, and iodine value), fatty acid composition, and mineral composition of the seeds of five soybean genotypes and their cakes were estimated. BINA Soybean-3 had the highest seed weight (159 g) among the five varieties. The moisture level of the beans ranged from 9.06% (BARI Soybean-6) to 9.84% (BINA Soybean-3). The variety, Shohag, had the highest concentration of ash (5.20%). The oil content ranged from 14.88% in BINA Soybean-3 to 16.87% in BU Soybean-2. The maximum amount of oil cake was found in BU Soybean-2 (83.23%). The percentage of protein ranged from 38.01% (BINA Soybean-5) to 52.20% (BU Soybean-2). BINA Soybean-3 has the highest iodine number (79.65) , while BU Soybean-2 has the highest saponification value (189.9), and BINA Soybean-3 has the lowest acid value (0.90). The largest amounts of linoleic acid (54.39%), linolenic acid (9.56%), and palmitoleic acid (0.18%) were found in BU Soybean-2. The variety Shohag had the highest levels of phosphorus (0.84%), copper (29.24 ppm), calcium (0.23%), iron (86.75 ppm), and sulfur (0.09%) in terms of mineral composition. This study found that Shohag had remarkable mineral compositions, while BU Soybean-2 outperformed the other soybean varieties in terms of quality.

Keywords: Fatty acids, Mineral composition, Protein percentage, Soybean

Introduction

Soybean (*Glycine max* L.), also known as the golden miracle bean, belongs to the Leguminosae family (sub-family Papilionoidea). The crop is widely cultivated around the world for both human consumption and animal feed. Soybean is the world's most important oilseed crop and soybean seeds have an oil content of 42-45 percent and an edible oil content of 22 percent (Yaklich *et al.,* 2002). Soybeans are a healthy source of protein for diabetics because they are low in starch. Soy sauce is a common component in Asian cuisine and is a salty, dark liquid made from crushed soybeans and wheat that has been fermented with yeast in salt water for six months to a year or more. Miso, tempeh, and fermented bean paste are other fermented soy products. (Muzaiyanah *et al.,* 2020; Khan *et al.,* 2012; Hosseini *et al.,* 2002).

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With a population of over 170 million, Bangladesh consumes about 3.0 million tons of edible and non-edible fats every year. The annual needs for oils and fats are met through the importion of 90 to 92% of requirements. According to 2019 statistics, palm oil, soybean oil, and two types of rapeseed oil are currently the three main edible oils consumed in the country, with import shares of each being at a ratio of 58:37:5. Palm and soybean oils are two of the three types of oils that are imported in crude form and processed locally before being sold in refined form (Alam, 2020). Soybeans are exceptionally nutrient-dense foods. It contains about 20% oil and 40% high-quality protein, while rice, wheat, maize, and pulses contain only 7.0%, 12%, 10%, and 20-25 % respectively. Most cereals are low in essential amino acids e.g. lysine, while soybean contain abundant essential amino acids . Additionally, the soybean seed's chemical qualities can substantially impact the soymilk's flavor characteristics (Terhaag, *et al.,* 2013).

In addition to these, soybeans contain isoflavone which affects cell physiology, proliferation, growth, and maturity and also functions as a key regulators to preserve health. Soybean oil is primarily composed of polyunsaturated fatty acids (PUFAs), particularly linoleic acid (C18:2), an omega-6 (6) fatty acid that accounts for 55% of soybean oil. Soybean oil also contains omega-3 fats, which are heart-healthy fats found in salmon and sardines but the fat is less common in plant-based foods (Deol *et al.*, 2017).

Six high-yielding soybean varieties were developed by the BARI ORC in 1981, and two of those types were made available for farm-level cultivation. Since 2011, BINA has also released six soybean cultivars as Brag, Devis, Shohag, etc. BARI developed the Soybean-4, BARI Soybean-5, and BARI Soybean-6 types, and BINA developed the BINA Soybean-1, BINA Soybean-2, BINA Soybean-3, BINA Soybean-4, BINA Soybean-5, and BINA Soybean-6 varieties. In 2020, BSMRAU released the BU Soybean-2 cultivar, which has a high protein content. Hence, the general objective of this study was to assess the physical and chemical characteristics, mineral content, oil percentage, and fatty acid profiles of the collected varieties of soybean and compare the physico-chemical parameters and nutritional quality of the collected six varieties of soybean.

Materials and Methods

Five varieties of Soybean namely BINA Soybean-3, BU Soybean-2, Shohag, BINA Soybean-5, and BARI Soybean-6 were collected for the study. The seeds were from BARI, Joydebpur, Gazipur, and BINA, Mymensingh. Seeds were cleaned sun-dried and stored in a plastic container in a cool place until used for the chemical analysis.

The experiment was carried out at Central Laboratory, BINA, BAU campus, Mymensingh, Bangladesh from April 2020 to October 2020. The experiment was conducted in a Completely Randomized Design (CRD) with three replications.

Parameter of physical analysis

Determination of 1000-grain weight

The mass was determined by randomly selecting 1000 seed samples and weighing in an electronic balance of 0.00 g sensitivity.

Percent moisture content

Empty aluminum moisture dish was weighted (W 1) and a 2 g sample was taken in a moisture dish and weighted (W 2). The sample was spread evenly and placed without a lid in the oven and dried samples overnight at 100° C. The Aluminum dish was weighed after cooling (W 3). The moisture was determined from the following formula

$Moisture = W2 - W1 / W2 - W3 \times 100$

Determination of ash

The temperature of the muffle furnace was fixed to 600 ^{0}C and the crucible was heated for 1 h and transferred into a desiccator; cooled to room temperature and weighted (W1). About 2 g sample was put into the crucible weighted (W2). The sample was burned in a muffle furnace at 600oC for about 2 hrs. The crucibles were transferred into the desiccator and cooled to room temperature and weighed (W3) (Ranganna *et al.*, 1986).

% Ash = wt. of ash/wt of sample taken x100

Weight of the sample taken = W2–W1 Weight of the ash obtained = W3–W1

Chemical analysis

Estimation of oils/fats

Soybean oil was extracted by using the Soxhlet method described by Aziz *et al.*, (2018). Dried and ground soybean samples were weighed out into an extraction thimble. The weight of the thimble and sample were recorded in the laboratory workbook. The thimble was placed into the Soxhlet. 250 ml petroleum ether was added to the Soxhlet flask, then it was connected to the holder and condenser. Soxhlet flask was placed on the hot plate and distilled at low temperature (40-60oC) for 3-4 hours for each sample. After extraction, it was turned off and allowed to cool. When distillation was ceased, the extraction thimble was removed and allowed to air dry for 30-40 minutes the thimble was weighed out. The loss of weight was crude fat.

Estimation of protein

% N = (14.007) x (normality of the acid 0.02) / wt. of the sample taken (mg) x 100

Where 14.007 is the equivalent weight of nitrogen. Nitrogen percent is converted into protein by multiplying with a factor of 6.25 for cereals and pulses (AOAC, 2010).

Chemical constant

Saponification value (SPV)

Saponification value = $(B-T)\times 0.5\times 56.1 / wt.of\ o$ Here, B = ml of HCl required for each blank

T = ml of HCl required for each oil sample

Iodine value

The percent weight of I (iodine) absorbed by the oil was calculated by the following formula: Iodine number = $(B-S)\times N\times 0.127 / W \times 100$

Where, B = ml 0.1 N $Na_2S_2O_3$ required by blank

S = ml 0.1 N $Na2S2O3$ required by oil sample N = Normality of $Na_2 S_2O_3$

W = Weight of sample in grams.

Acid value

Acid value = $56.1 \times N \times V$ WHere, N = Normality of KOH

W = wt. of sample in grams.

V = Variation (Final reading – initial reading)

Estimation of fatty acid composition

The gas-liquid chromatographic method was used to determine the fatty acid content (Uppstrom and Aa, 1978).

Estimation of minerals

By using a combination diluter-dispenser, 1 ml aliquot was taken from the filtrate and 19 ml water (dilution 1) was added. The other dilutions were made in the following order. For P and K determination, 1 mL aliquot from dilution 1, 9 mL of water, and 10 mL of color reagent were mixed. It was allowed to stand for about 20 min and a reading was taken by a spectrophotometer at 680 nm for P and by using a flame photometer (Model AnA-135, OSK, Japan) at 766.5 nm for K. For S determination, 7 ml of aliquot from dilution 1, 9 ml of acid seed solution and 4 ml of turbid metric solution were mixed thoroughly. It was allowed to stand for 20 minutes and not longer than one hour. The reading was taken in a turbid meter or a colorimeter at 535 nm using a cuvette with a 2 cm light path.

For Ca and Mg determination, 1 ml aliquot from dilution 1, 9 ml of water, and 10 ml of 1 percent lanthanum solution were mixed. It was analyzed by AA procedure 700 (ANALYTIK JENA).

For Fe, Mn, and Zn determination, the original filtrate was used to analyze these elements by AA (Atomic Absorption spectrophotometer) procedure. (Sharif *et al.*, 2017).

Statistical analysis

Statistics 10 was used for the analysis of the experiment-recorded data for each character. One-way ANOVA was followed to calculate the variations of experimental treatments. The mean values for each treatment were computed, and the F variance test was used to analyze the variance of the study's features.

Results and Discussion

Physical characteristics of different varieties of soybean

The weight of 1,000 grains, the moisture content, and the ash percentage of five different soybean varieties (Table 1) were collected. It was found that seeds' weight varies based on their size and shape. The highest thousand-grain weight (159.1) belongs to BINA Soybean-3, which is followed by BU Soybean-2 (151.7). Weight-wise, BARI Soybean-6 was the lightest (115.6).

In moisture content the varieties from 9.06 to 9.84%. The two varieties of soybeans with the highest moisture content were BINA Soybean-3 (9.84%) and Shohag (9.46 %). BARI

Soybean- 6 (9.06%) and BINA Soybean-5 (9.32%) had the lowest moisture content. The current findings are supported by (Rani *et al.,* 2008; Anwar *et al.,* 2016; Kulkarni *et al.(*2019).

Considering % of ash, the variety Shohag (5.20%) got the highest value, followed by BINA Soybean-5 (4.68%) and BU Soybean-2 (4.32%). The current findings are supported by Anwar *et al.(*2016); Rani *et al.(*2008); Gupta *et al.(*2013), and Kuzniar *et al.(*2013) among others.

Table 1. Weight of 1000 seeds, moisture percentage, and Dry matter percentage of different varieties of soybean

Name of the released cultivars (Treatments)	Wt. of 1000 seeds (gm)	Moisture %	Ash %
		mean	
BINA Soybean-3	159.1a	9.84a	4.8c
BU Soybean-2	151.7b	9.71a	4.32e
Shohag	122.4c	9.46b	5.20a
BINA Soybean-5	121.7c	9.32b	4.68d
BARI Soybean-6	115.6d	9.06c	5.06b
% CV	4.25	4.26	3.42
LSD (0.05)	0.4897	0.1873	0.5031

Mean values in columns marked with the same letter(s) do not differ significantly by LSD at a 5 % level of significance.

Chemical characteristics of different varieties of soybean

Oil content

The soybean varieties with the highest oil content were BU Soybean-2 (16.87%) followed by BINA Soybean-5 (15.85%), and Shohag (15.83 %). BINA Soybean-3 has the least amount of oil % in it (14.88 %). According to Anwar *et al.* (2016) found a higher content of oil than the content of oil we found..

Oil cake

The highest oil cake was obtained in BINA Soybean-3 (85.12 %). The content of oil cake for BU Soybean-2 (83.13%), BINA Soybean-5 was the lowest (84.15 %) while Shohag had the lowest (84.15%) oil cake. Similar results were reported by Sharma *et al. (2014)* and Anwar *et al.(2016).*

Protein

The protein content of the soybean cultivars lines is presented in (Table 2). The maximum amount of protein was found in BU Soybean-2 (52.20%), followed by Shohag (40.10 %). The lowest protein level was found in BINA Soybean-5 (38.01%), which was statistically equivalent to BINA Soybean-3(38 %).

Table 2. Proximate analysis of oil content, oil cake , and protein of different varieties of soybean

Name of the released cultivars (Treatments)	Oil %	Oil cake %	Protein %
		mean	
BINA Soybean-3	14.88c	85.12a	38.29c
BU Soybean-2	16.87a	83.13c	52.20a
Shohag	15.83b	84.17b	40.10b
BINA Soybean-5	15.85b	84.15b	38.01c
BARI Soybean-6	15.42bc	84.58b	39.80b
%CV	1.85	0.91	0.68
LSD (0.05)	0.615	1.41	0.49

Mean values in columns marked with the same letter(s) do not differ significantly by LSD at a 5 % level of significance.

Chemical constant

Saponification value

The value of saponification ranged from 187.11 to 189.85 was found in different soybean varieties. The highest saponification values were found in BU Soybean-2 (189.85), which was followed by BARI Soybean-6 (188.61) and BINA Soybean-5 (189.17). The lowest amount of saponification value was found in Shohag (187.17). The values that were observed were comparable to findings reported by Anwar *et al.(* 2016)

Iodine value

The highest level of iodine value was found in BU Soybean-2 (79.65), which is statistically similar to BINA Soybean-3 (79.49) and Shohag (78.58). The lowest iodine value was found in BINA Soybean-5 (73.56). The published values of 73.02 g/100 g oil by Amos-Tautua *et al.*, (2015) support the current figures, however, the values are also lower than the values discovered by Prodhan *et al.*, (2015), Anwar et al. (2016), and (Abitogun *et al.*, 2008).

Acid value

Several varieties of soybean seeds have an acidity that ranges from 0.90 to 0.99. The BINA Soybean-5 contained the most acidic levels (0.99). The lowest value was discovered in BU Soybean-2 (0.90). The current value is supported by Belsare *et al.* (2017) who found that the acid value varied from 0.56 to 1.12 mg KOH/g. The data, however, is higher than the values published by Prodhan *et al.* (2015) and lower than those reported by Abitogun *et al.*(2008).

Table 3. Proximate analysis of Saponification value, Iodine value, and Acid value of different varieties of soybean

Name of the released cultivars (Treatments)	Saponification value (mg of KOH/gm)	Iodine value (gm of I/100gm)	Acid value (mg of KOH/gm)
		mean	
BINA Soybean-3	188.34b	79.49a	0.93bc
BU Soybean-2	189.85a	79.65a	0.90c
Shohag	187.11c	78.58b	0.94bc
BINA Soybean-5	189.17ab	73.76d	0.99a
BARI Soybean-6	188.61b	77.72c	0.97ab
% CV	0.85	0.45	3.45
LSD (0.05)	1.033	0.604	0.05

Mean values in columns marked with the same letter do not differ significantly by LSD 5% level of significance.

Saturated fatty acid composition

Palmitic acid (C16:0) was found in the highest concentrations in BINA Soybean-3 (10.82%), BU Soybean-2 (10.63%), and BARI Soybean-6 (10.62%). (10.49 %). Shohag had the lowest levels of palmitic acid (C16:0) (9.33 %). Shohag had a stearic acid (C18:0) level between 3.64 and 4.81 percent and BINA Soybean-3 (0.13 %) and BINA Soybean-5 (0.23 %) had an arachidic acid (C20:0) level between 0.13% and 0.23 %. The content of behenic acid (C22:0) in BINA Soybean- 5 was the greatest (0.87 %), followed by BARI Soybean- 6 (0.77 %), and BINA Soybean-3 had the lowest concentration (0.55 %). These results are similar to those from Martin *et al.(*2008). Reduced value was presented by Aboitogun *et al.* (2008).

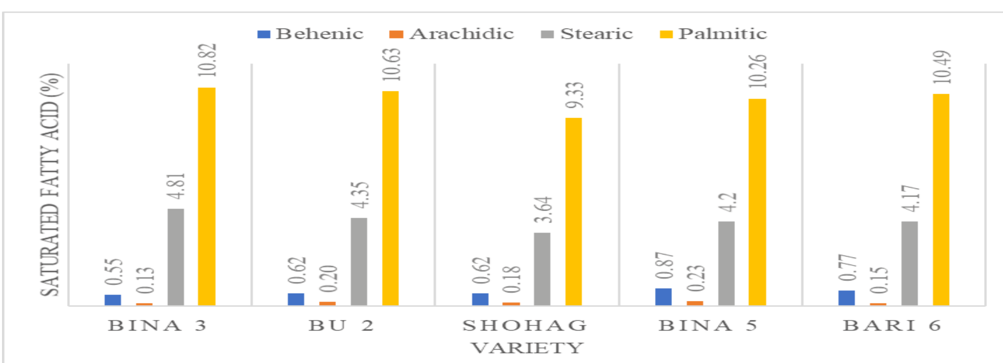

Fig. 1. Saturated fatty acid comparison of five varietiesof soybean

Unsaturated fatty acid composition

The highest concentration of palmitoleic acid (C16:1) was found in BU Soybean-2 (0.18%), followed by BINA Soybean-3 (0.13%), which is statistically equivalent to BARI Soybean-6 (0.17%). The least amount of palmitoleic acid (C16:1) was present in Shohag (0.09 %). Oleic acid (C18:1) was present in the highest concentrations in BINA Soybean-5 (30.71%) and the lowest concentrations in Shohag (16.99 %). Linoleic acid (C18:2) content varied from 44.63% to 54.39 %. The amount of linoleic acid (C18:2) in BINA Soybean-5 was the lowest and the highest in BU Soybean-2 (54.39 percent). The amount of linolenic acid (C18:3) in BARI Soybean-6 and BU Soybean-2 was significantly different (9.56%). The data described here is identical to that presented by Aboitogun *et.al.(*2008).

Mineral composition phosphorus (P)

The most phosphorus (P) concentration was found in Shohag (0.84 %), followed by BU Soybean-2 (0.81 %), and BARI Soybean-6 (0.60 %) (0.82 %). The lowest phosphorus content was found in BINA Soybean-3 (0.69 %), followed by BINA Soybean-5 (0.73 %). Rani *et al. (*2008) have reported values that are comparable to the current findings.

Potassium (K)

The soybean variety with the highest K concentration was found in BU Soybean-2 (0.77%), which was statistically equivalent to BINA Soybean-5 (0.76%) and Shohag (0.76 %). The lowest percentage was found in BINA Soybean-3 (0.69 %), followed by BINA Soybean-5 (0.76 %).

According to Ozcan *et al.* (2014), the potassium content of soybean seeds ranged from 16,375 mg/kg (raw Adasoy) to 20,357 mg/kg (sprouted A3127), which was higher than the results of the present study.

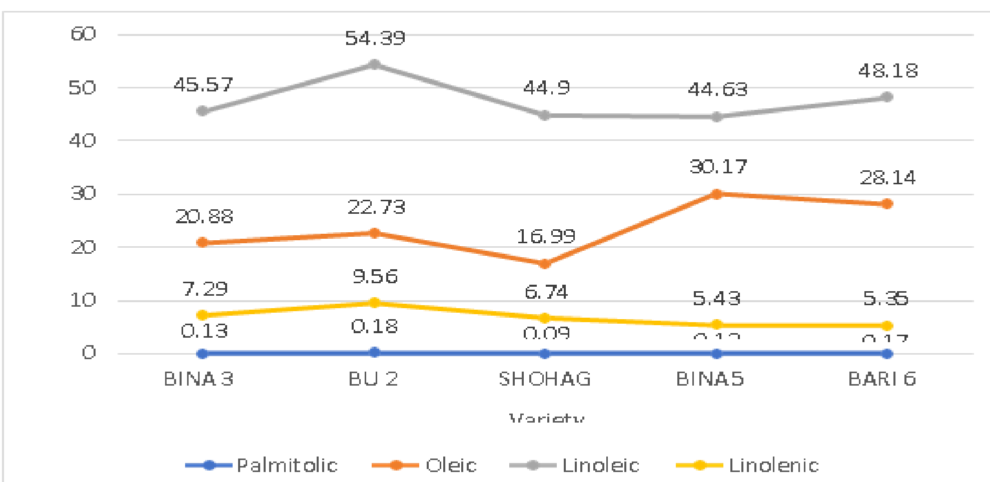

Fig. 2. Unsaturated fatty acid comparison of five soybean varieties

Magnesium (Mg)

Shohag (0.465 %), which is statistically equivalent to BINA Soybean-3 (0.43 %), had the highest content of magnesium, whereas BU Soybean-2 had the lowest concentration (0.32 %). The current value exceeds what (Etiosa *et al.,* 2018) and (Uwem *et al.*, 2017).

Calcium (Ca)

The highest calcium content was found in Shohag (0.23 %), while BINA Soybean-3 came in second (0.21 %). The lowest value was discovered in BINA Soybean-5 (0.14 %). The findings are similar to those of Rani *et al.* (2008).

Iron (Fe)

Shohag (86.75 ppm) has the greatest level of Fe, followed by BU Soybean-2 (72.42 ppm). The lowest Fe value was found in BINA Soybean-5 (56.05 ppm), which was followed by BARI Soybean-6 (68.55 ppm). Iron concentration was determined to be similar by Rani *et al.(*2008). reported higher iron concentrations than the data currently available.

Manganese (Mn)

Shohag had the second-highest level of Mn (32.05 ppm), followed by BU Soybean-2 (31.71 ppm). The lowest level was found in BINA Soybean-5 (24.03 ppm), followed by BARI Soybean-6 (29.13 ppm). The Mn concentration in soybean cultivars was approximately 0.651 (mg/100g), according to (Uwem *et al*., 2017).

Zinc (Zn)

BARI Soybean-6 (54.85 ppm), followed by BINA Soybean-3, had the highest amount of zinc found (36.12 ppm). The least amount was recorded by Shohag (23.92), followed by BU Soybean- 2 (24.52 ppm). Zinc levels range from 7.16-7.89 mg/100 g and 2.7 mg/100 g, respectively, according to (Rani *et al.,* 2008) and (Etiosa *et al.,* 2018).

Conclusion

Shohag exhibited the lowest concentration in saponification value and the highest concentration of ash, phosphorus, potassium, sulfur, magnesium, and calcium among these five soybean types. In addition, BU Soybean-2 had the lowest concentration of oil cake but the highest concentration of protein, saponification value, linoleic acid, linolenic acid, and palmitolic acid as well as mineral content such as iron, manganese, copper, and zinc. According to this study, Shohag has a unique mineral constitution. However, in terms of characteristics, BU Soybean-2 did better than the other types.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this manuscript.

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