EFFECTS OF GENOTYPES ON PHYSICO-CHEMICAL CHARACTERISTICS OF SOYBEAN (*Glycine max* L.)

BY

09-03610

DEPARTMENT OF BIOCHEMISTRY

FACULTY OF AGRICULTURE

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

DHAKA-1207

JUNE, 2016

EFFECTS OF GENOTYPES ON PHYSICO-CHEMICAL CHARACTERISTICS OF SOYBEAN (*Glycine max* L.)

Registration No. 09-03610

A Thesis
Submitted to the Faculty of Agriculture,
Sher-e-Bangla Agricultural University, Dhaka,
In partial fulfillment of the requirements
For the degree of

MASTER OF SCIENCE
IN
BIOCHEMISTRY
SEMESTER: JANUARY-JUNE, 2015

……………………………………….
(Dr. Kamal Uddin Ahmed)
Professor
Department of Biochemistry
Sher-e-Bangla Agricultural University
Supervisor

……………………………………….
(MD. Nuruddin Miah)
Professor
Department of Biochemistry
Sher-e-Bangla Agricultural University
Co-Supervisor

……………………………….
(Prof. MD. Nuruddin Miah)
Chairman
Examination Committee
Department of Biochemistry
Sher-e-Bangla Agricultural University, Dhaka

Department of Biochemistry
Sher-e-Bangla Agricultural University
Dhaka-1207, Bangladesh

Fax: +88029112649
Web site: www.sau.edu.bd

CERTIFICATE

This is to certify that the thesis entitled, **"EFFECTS OF GENOTYPES ON PHYSICO-CHEMICAL CHARACTERISTICS OF SOYBEAN (*Glycine max* L."** submitted to the Department of **Agricultural Biochemistry**, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN BIOCHEMISTRY,** embodies the result of a piece of bona fide research work carried out by **S.M. OBAIDUL HAQUE** bearing **Registration No. 09-03610** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

Dated: 18.05.2017
Place: Dhaka, Bangladesh

…………………………….
(Dr. Kamal Uddin Ahmed)
Professor
Department of Biochemistry
Sher-e-Bangla Agricultural University
Supervisor

ACKNOWLEDGEMENT

At first the author expresses his gratefulness to Almighty God who has helped him in pursuit of his education in Agriculture and for giving the strength of successful completion of this research work.

*The author is highly grateful and greatly obliged to his supervisor, **Dr. Kamal Uddin Ahmed**, Professor, Department of Biochemistry, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh for his continuous encouragement, innovative suggestions and affectionate inspiration throughout the study period.*

*With deepest emotion the author wish to express his heartfelt gratitude, indebtedness, regards sincere appreciation to his benevolent research Co-supervisor **MD. Nuruddin Miah**, Professor, Department of Biochemistry, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh for his intellectual guidance, intense supervision, affectionate feelings and continuous encouragement during the entire period of research work and for offering valuable suggestions for the improvement of the thesis writing and editing.*
Cordial thanks are extended to all respected teachers of the Department of Biochemistry, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh and the entire staff member of the Department of Biochemistry (SAU).

The author also expresses his especial thanks to his well-wishers and friends for their help and support during his work.

Finally the author expresses his heartfelt indebtedness to his beloved father and mother, brother and sisters for their sacrifice, encouragement and blessing to carry out higher study which can never be forgotten.

June, 2015 *The Author*

EFFECTS OF GENOTYPES ON PHYSICO-CHEMICAL CHARACTERISTICS OF SOYBEAN (*Glycine max* L.)

BY

Reg. No.: 09-03610

ABSTRACT

Six varieties of Soybean were analysed to evaluate the effects of genotypes on physico-chemical characteristics. Raw soybean genotypes exhibited 15.01-18.63.2% oil and palmitic (9.47-11.49%), Stearic (3.56-4.23%), Arachidic (0.10-0.43%), Behenic (0.37-0.85%) as saturated fatty acids and Palmitolic (0.05-0.26%), Oleic (11.71-30.72%), Linoleic (33.93-54.79%), Linolenic (5.28-9.46%) as unsaturated fatty acids. The major minerals were observed the various ranges namely Ca (1.23-1.29%), Mg (0.67-0.75%), K (1.12-1.38%), N (5.82-7.05%), P (5.43-7.65%), S (0.69-0.97%) among the varieties. And the minor minerals were B (16.45-17.8ppm), Cu (6.29-6.81ppm), Fe (159.8-167.6ppm), Mn (108.6-100.8ppm) and Zn (76.92-100.1ppm). In comparison to the physico-chemical characteristics, BARI Soybean-5 contained maximum amount of oil and Bangladesh Soybean-4 was the best for unsaturated fatty acids. BINA Soybean-4 was the better source of total saturated fatty acid. Most of the varieties found that the major and minor minerals were not significantly difference among the varieties.

CONTENTS

LIST OF TABLE

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Soybean (*Glycine max* L. Merrill), which is one of the most important legume crops in the world is gaining increased cultivation attention in the humid tropics (Akande *et al.,* 2007) because of its high quality protein, 85 per cent cholesterol free oil content (Malik *et al.,* 2007) and nutritional value for humans and livestock as well as its ability to maintain soil fertility (Ngalamu *et al.,* 2013). According to Rao *et al*. (2002), the crop is consumed in the form of soybean milk, soybean cheese, soybean curd, tofu and soybean sprouts, among others. It plays a significant role in boosting the immune system and general health of the human body (Murray-Kolb *et al.*, 2003) as well as serves as dietary supplement for diabetics (Azadbkht *et al.*, 2003).

Soybean posses a very high nutritional value. It contains about 20 per cent oil and 40 per cent high quality protein (as against 7.0 per cent in rice, 12 per cent in wheat, 10 per cent in maize and 20-25 per cent in other pulses). Soybean protein is rich in valuable amino acid lycine (5%) in which most ofthe cereals are deficient. In addition, it contains a good amount of minerals, salts and vitamins (thiamine and riboflavin) and its sprouting grains contain a considerable amount of Vitamin C, Vitamin A is present in the form of precursor carotene, which is converted into vitamin A in the intestine. A large number of Indian and western dishes such as bread, `chapati', milk, sweets, pastries etc., can be prepared with soybean. Wheat flour fortified with soybean flour makes good quality and more nutritious `chapati'.

Soybean oil is used for manufacturing *vanaspati* ghee and several other industrial products. Raw soybean contains a number of antinutritional factors such as trypsin inhibitors, phytic acid, saponins and phenols etc which decrease nutritive value of grain legumes and cause health problems to both human and the animals when taken in large amounts (Mikic *et al*., 2009; Sharma *et al*., 2011). Trypsin inhibitors can block either trypsin or chymotrypsin, reduce the hydrolysis of dietary protein, decrease amino acid absorption and thereby reduce digestibility (Roy *et al*., 2010). Phytic acid chelates mineral nutrients such as copper, zinc, manganese, iron and calcium thus reducing their availability (Ramakrishna *et al*., 2006). Phenols and tannins or their oxidized products can form complex with amino acid, protein, enzymes and also adversely affect their digestibility (Khandelwal *et al*., 2010). These antinutrients should be removed to improve the nutritional quality and organoleptic acceptability of legumes so that they can be effectively used as potential human food. Soybean is used for making high protein food for children. It is widely used in the industrial production of different antibiotics. Soybean builds up the soil fertility by fixing large amounts of atmospheric nitrogen through the root nodules, and also through leaf fall on the ground at maturity. It can be used as fodder; forage can be made into hay, silage etc. Its forage and cake are excellent nutritive foods for livestock and poultry (Rehenuma e*t al*.,2015).

However, soybean has long been a staple of the human diet in Asia, especially the soyfood such as soymilk or tofu (Liu, 1987). Soy protein is the most inexpensive source of high-nutritional quality protein and therefore is the world’s predominant commercially available vegetable protein.

And soybean being the richest, cheapest and easiest source of best quality proteins and fats and having a vast multiplicity of uses as food and industrial products is sometimes called a wonder crop. Soybean is one of the important crops of the world. Additionally, several putative healthbeneficial substances (e.g., isoflavone, saponin, oligosaccharide, phospholipid, polypeptide and dietary fibre) have been identified in soybeans, leading to an increased interest in and demand for soybean and soy-based products. Soymilk is a popular beverage with abundant vegetable protein in Asian countries. As a nutrient- rich beverage, soymilk consumption has sustained a growth rate of 21% per year in the U.S. (Wrick, 2003).

Moreover, the soybean seed chemical quality properties—including protein and oil content, fatty acids, isoflavones, saponins, oligosaccharide and peptides—can affect the soymilk flavour attributes significantly (Kudou *et al.*, 1991; Min, Yu, Yoo, & Martin, 2005; Terhaag, Almeida, & Benassi, 2013). Owing to soymilk's off-flavour, many efforts have been taken to improve soymilk flavour based on the selection of soybean cultivars and enhancement of the processing technology (Hildebrand & Hymowitz, 1981; Kwok *et al.*, 2002; Suppavorasatit, Lee, & Cadwallader, 2013). However, the adjustment of processing may lead to a risk of protein denaturation and nutrition destruction in soymilk (Kwok *et al.*, 2002). Therefore, it is necessary to select specific soybean cultivars suitable for soymilk processing in soybean breeding programs.

Soybean presents other chemical compounds as isoflavones that can interfere in the physiology of the cells, as in the proliferation, growth and maturity, acting as important regulators to maintain health. These compounds, as genistein and daidzein, have antioxidant properties, protecting cells of the deleterious effects of the free radicals that promote ageing (Brouns, 2002). Therefore, soybean presents antinutritional factors that limit its utilization and acceptability (Cardoso *et al.*, 2007). Among them, the Kunitz trypsin inhibitor is the most studied, because it affects the digestibility of soybean proteins. This inhibitor acts in the gastrointestinal tract reducing availability of the amino acids, limiting the nutritional value of this legume (Brune *et al.*, 2010; Konareva *et al.*, 2002).

Keeping in mind the present research work was conducted for the assessments of genotypes on Physico-Chemical characteristics of soybean with the following objectives-

1. To assess the physical and chemical characteristics, minerals content, oil percentage and fatty acid profiles of collected varieties of soybean.
2. To compare the physico-chemical parameters and nutritional quality of collected varieties of soybean.

CHAPTER II

REVIEW OF LITERATURE

Alozie *et al.* (2017) conducted a research with the soybean, melon seed and moringa seed flours at 5% substitution level to produce Soy gari, Melon seed gari and Moringa seed gari respectively. Results revealed that, fortification significantly decreased moisture (9.12±0.017% in Control to 8.14±0.04% in Soy gari) and fibre (2.73±0.04% in Control to 2.11±0.02% in Melon seed gari) in all samples except in Moringa seed gari. Protein (1.52±0.05% in Control to 7.22±0.04% in Soy gari), fat (6.34±0.29% in Control to 10.74±0.19% in Melon seed gari) and ash (1.55±0.03% in Control to 2.47±0.61% in Melon seed gari) contents were increased, while carbohydrate contents were decreased (78.74±0.242% in Control to 71.02±0.512% in Soy gari), in all samples.

Julianti *et al.* (2016) evaluated three composite flours were prepared by combining soybean flour, rice flour, potato starch, sweet potato flour, , and xanthan gum in the ratio of 30: 15: 50: 4.5: 0.5; 30: 15: 45: 9.5: 0.5; and 30: 15: 40: 14.5: 0.5, were analysed for selected physical, chemical, functional, and rheological properties. Fat, protein, ash, and crude fibre content were found to increase with increase in the ratio of soybean flour and decrease in the ratio of sweet potato flour in the mixture. The composite flours were not significantly different in water and oil absorption capacity, swelling power, and baking expansion. There was a tendency for the relative viscosities of the composite flours to increase significantly with increasing proportion of the soybean flour and decreasing proportion of sweet potato flour in the mixture. Pasting viscosity measurements of the composite flours gave maximum (peak) viscosity values ranging from 582.00–668.67 cP. The pasting analysis results indicated increased level of setback and final viscosity, pasting temperature, setback and stability ratio while peak viscosity decreased with increasing proportion of soybean flour and decreasing proportion of sweet potato flour in the mixture.

Kuswantoro *et al.* (2016) performed a study to evaluate acid-adaptive soybean genotypes that normally grown in Ultisols, may have higher yield potential when grown in optimal soil types such as associated Entisols-Inceptisols and Vertisols. A total of 10 soybean (*Glycine max* (L.) Merrill) genotypes, consisted of nine acid-adaptive soybean genotypes and one released variety (Tanggamus/G10), were grown on both locations. The check variety Tanggamus that released as acid-adaptive soybean variety showed the highest grain yield in both soil types indicating that Tanggamus is potential to be grown in Vertisols and associated Entisols-Inceptisols soil types. Shrink-swell in Vertisols might lead detrimental effect on soybean roots and caused growth and developing restriction. Consequently, grain yield in Vertisols was lower than in associated Entisols-Inceptisols. However, there were three genotypes with higher grain yield in Vertisols than in associated Entisols- Inceptisols, i.e., G2 (Tgm/Anj-833), G5 (Tgm/Anj-846) and G6 (Tgm/Anj-847).

Mohamed *et al.* (2016) evaluated the effect of two elicitors, methyl jasmonate (20μM) and sodium nitroprusside (500μM), on six soybean genotypes and to enhance the ability of susceptible genotypes to resist cotton leaf worm (*Spodoptera littoralis*) was carried out. Results showed that Giza 82 and 22 were susceptible genotypes, Giza 83 and 21 were moderate resistant genotypes and Giza 35 and 111 were resistant genotypes. Both treatments, methyl jasmonate and sodium nitroprusside, positively affected the morphological criteria, photosynthetic pigments, soluble protein, amino acids, glycolipids and phospholipids contents in shoots of all soybean genotypes. Lipid peroxidation and H_2O_2 were significantly decreased in response to both treatments. Treatment with methyl jasmonate was found to be more effective than sodium nitroprusside and enhanced the resistance of the susceptible genotypes.

Rampim *et al.* (2016) studied to evaluate the percentage of nitrogen (N) in the wheat grains, the nutrient content in leaf tissue of soybean and wheat and soybean yield due to the use of poultry deep-litter and mineral fertilizer. The experiment was conducted in Guaira, PR, in a randomized block design with two treatments and 10 repetitions. The treatments were: 3 t ha-1 of poultry deep-litter and mineral fertilizer. The N content in grain, grain yield and weight of 100 grains were evaluated in wheat crop. In turn, the nutrient contents in leaf tissue and grain yield were determined in soybean. The fertilization with poultry deep-litter did not interfere with the weight of 100 grains of wheat, but provided greater N accumulation in wheat grains, and higher yield. In soybean, poultry deep-litter manure and mineral fertilizer provided yields that did not differ each other. Regarding macronutrients, the soybean foliar analysis indicated higher N content for fertilization with poultry deep-litter while the contents of K, P, Ca and Mg remained unchanged.

Fernando *et al.* (2016) studied two N assimilation enzymes were assayed: nitrate reductase (NR) and Ni-dependent urease. Soybean plants inoculated with *Bradyrhizobium japonicum* were cultivated in soil-filled pots under two base-cation saturation (BCS) ratios (50 and 70%) and five Ni rates – 0.0; 0.1; 0.5; 1.0; and 10.0 mg dm^{-3} Ni. At flowering (R1 developmental stage), plants for each condition were evaluated for organic acids (oxalic, malonic, succinic, malic, tartaric, fumaric, oxaloacetic, citric and lactic) levels as well as the activities of urease and NR. At the end of the growth period (R7 developmental stage – grain maturity), grain N and Ni accumulations were determined. The available soil-Ni in rhizosphere extracted by DTPA increased with Ni rates, notably in BCS50. The highest concentrations of organic acid and N occurred in BCS70 and 0.5 mg dm^{-3} of Ni. There were no significant differences for urease activity taken on plants grown at BSC50 for Ni rates, except for the control treatment, while plants cultivated at soil BCS70 increased the urease activity up to 0.5 mg dm^{-3} of Ni. In addition, the highest values for urease activities were reached from the 0.5 mg dm^{-3} of Ni rate for both BCS treatments. The NR activity was not affected by any treatment indicating good biological nitrogen fixation (BNF) for all plants. The reddish color of the nodules increased with Ni rates in both BCS50 and 70, also confirms the good BNF due to Ni availability. The optimal development of soybean occurs in BCS70, but requires an extra Ni supply for the production of organic acids and for increased N-shoot and grain accumulation.

Hanafiah *et al.* (2015) analysed to determine the mechanism of adaptation and morphophysiology character of soybean genotypes to soil acidity levels. Research using randomized block design with four replications, the first factor consists of soybean varieties: Tanggamus varieties, Detam 2, Anjasmoro and Detam 1, while the second factor is the media's treatment consisted of medium acid soils and limed soil. The results showed that the low level acidity of planting medium will affect the growth and development of plants. There are different mechanisms of adaptation to acidity on soybean varieties. Avoidance mechanism is indicated by an increase in pH around the roots on Tanggamus varieties, Detam2, Anjasmoro and Detam1. Tolerant mechanism is indicated by the maturation age and high production on Tanggamus varieties .

Lei *et al.* (2015) stated soybean seed chemical quality traits (including protein content, oil content, fatty acid composition, isoflavone content, and protein subunits), soymilk chemical character (soluble solid), and soymilk sensory attributes were evaluated among 70 genotypes to determine the correlation between seed chemical quality traits and soymilk sensory attributes. Six sensory parameters (i.e., soymilk aroma, smoothness in the mouth, thickness in the mouth, sweetness, colour and appearance, and overall acceptability) and a seven-point hedonic scale for each parameter were developed. Significant positive correlations were observed between overall acceptability and the other five evaluation parameters, suggesting that overall acceptability is an ideal parameter for evaluating soymilk flavour. The soymilk sensory attributes weresignificantly positively correlated with the characteristics of the glycinin (11S)/beta-conglycinin (7S) protein ratio, soluble solid, and oil content but negatively correlated with glycitein and protein content. Ourresults indicated that soymilk sensory attributes could be improved by selecting the desirable seed chemical quality traits in practical soybean breeding programs.

Rigo *et al.* (2015) conducted a research to evaluate, three soybean cultivars, Vmax (conventional), and BR 257 and 267 (human food uses). Chemical composition was evaluated in grains with tegument (WT) and without tegument (WIT) heat treated (HT) and non-heat treated (NHT). For characterization, it was observed: humidity, proteins, lipids, minerals, nitrogen solubility index (NSI), protein dispersability index (PDI), isoflavones, Kunitz trypsin inhibitor and lipoxygenases. The heat treatment promoted reduction of the protein solubility, reduction of glucosidic and malonyl isoflavones, and of Kunitz trypsin inhibitor, in grains WIT. Lipoxygenases were also inactivated in BRS 267 and Vmax cultivars. Potassium was the mineral present in higher amount in all cultivars. BRS 267 cultivar showed the highest content of protein, but the lowest content of isoflavones. Vmax cultivar showed the highest content of lipids and isoflavones. Heat treatments, although decreasing protein solubility, are necessary for conventional soybeans to improve flavor and to reduce anti nutritional factors.

Chen *et al.* (2014) conducted a study with the sandwich ELISA for detection of trace amounts of glycinin in soybean products. We designed a soy-free mouse model to produce anti-glycinin monoclonal antibodies with high affinity and specificity. Using the monoclonal antibody as coating antibody, with the rabbit anti-glycinin polyclonal antibody as a detected antibody, the established sandwich ELISA showed high specificity for glycinin with minimum cross-reactions with other soy proteins. The practical working range of the determination was 3–200 ng/mL with detection limit of 1.63 ng/mL. The regaining of glycinin in spiked soybean samples were between 93.8% and 103.3% with relative standard deviation less than 8.3% (intra-day) and 10.5% (inter-day).

Vasconcelos *et al.* (2014) studied that constitutively expressed the AtFRO2 iron reductase gene were analyzed for leaf iron reductase activity, as well as the effect of this transgene's expression on root, leaf, pod wall, and seed mineral concentrations. High Fe supply, in combination with the constitutive expression of AtFRO2, resulted in significantly higher concentrations of different minerals in roots (K, P, Zn, Ca, Ni, Mg, and Mo), pod walls (Fe, K, P, Cu, and Ni), leaves (Fe, P, Cu, Ca, Ni, and Mg) and seeds (Fe, Zn, Cu, and Ni). Leaf and pod wall iron concentrations increased as much as 500% in transgenic plants, while seed iron concentrations only increased by 10%, suggesting that factors other than leaf and pod wall reductase activity were limiting the translocation of iron to seeds.

Mehmet and Fahad (2014) observed that free fatty acid contents of sprouted soybean oil were found between 1.26% (Adasoy) and 4.20% (Nazlıcan and Türksoy). Peroxide values (PV) of sprouted soybean oils were found between 1.52meq/kg (Adasoy) and 3.85meq/kg (A3935), while peroxide values of roasted seed oils were determined between 2.52meq/kg (Adasoy) and 4.03meq/kg (Nova). Palmitic, oleic and linoleic acids were found as major fatty acids of soybean genotypes. Oleic acid contents of samples were found between 19.07% (roasted Adasoy) and 35.31% (roasted A3935), linoleic contents of oils ranged between 42.17% (roasted Nazlican) and 54.76% (sprouted A3127). Macro and micro element contents of sprouted, oven roasted and raw (untreated) soybean seeds were determined by Inductively Coupled Plasma Atomic Emission Spectrometry. The potassium contents of soybean seeds ranged between 16,375mg/kg (raw Adasoy) and 20,357mg/kg (sprouted A3127, while phosphorus contents of seeds varied from 5427mg/kg (oven roasted Türksoy) to 7759mg/kg (sprouted Nova). The micro element contents of samples were found to be different depending on the processing procedures and soybean genotypes.

Sepanlo *et al.* (2014) experimented with 3 different soybean genotypes to evaluate the morphological and physic-chemical responses of soybean genotypes to water deficit, a field at three different irrigation regimes was carried out. Plants were grown either under optimum condition (irrigated), drought stress implemented before the flowering (pre-anthesis) and pod-filling stage (post-anthesis). Seed yield and measured morphological characters, except for number of seeds per plant and seed protein content, decreased from normal irrigation regime to water deficit stress in both flowering and pod filling growing stages. Leaf relative water content (RWC) was significantly decreased in all genotypes by water deficit at both growing stages, as well as both stressed environments had progressive fall in chemical osmolytes and chlorophyll content. With the present results, it can be concluded that drought stress retards the growth and metabolic activity of soybean genotypes. These parameters showed considerable variability under drought stress at different growth stages in soybean.

Tharise *et al.* (2014) examined the physical, chemical and functional properties of composite flour produced with cassava, rice, soybean flours, and potato starch and added with 0.5% xanthan gum. Nine blends of composite flours were prepared by homogenously mixing rice flour, cassava flour, soybean flour, and potato starch (RF:CF:SF:PS) in the proportions of 30:50:15:4.5, 30:45:20:4.5, 30:40:25:4.5, 30:45:15:9.5, 30:40:20:9.5, 30:35:25:9.5, 30:40:15:14.5, 30:35:20:14.5, 30:30:25:14.5. Composite flour produces were subjected to proximate, paste and functional properties analyses. The moisture content, fat, protein, ash and crude fiber of the composites were as follows: 9.37-12.07% db, 1.33-4.91%, 4.50-6.22%, 0.74-1.12% and 1.13-1.94% compared with wheat flour 13.32% db, 6.30%, 2.12%, 1.31% and 7.52%, respectively. There was no significant difference ($P > 0.05$) recorded for water absorption index and gelatinization temperature between nine blends of composite flours and wheat flour. Peak, set back, cooling capacity and breakdown viscocisity were: 2311.67-4423.00 cP, 1199.33-1556.33 cP, 2618.67-3415.00 cP and 992.00-2437.67 cP. The value of composite flour viscosities were higher than paste characteristics of wheat flour. The colour of composite flour showed by the L* value of chromameter were 95.71-97.10 compared with wheat flour 95.02. Hence, it was concluded that the composite flours from rice, cassava, and soybean flour, potato starch using xanthan gum had the physicochemical and functional properties which can be considered similar to wheat flour for making wheatless products. The composite flour with the proportion of rice flour 30%, cassava flour 40%, potato starch 15%, soybean flour 14.5% and xanthan gum 0.5% had the physicochemical, functional and pasting properties that comparable to those of wheat flour.

Sharma *et al.* (2014) investigated the physical characteristics and nutritional composition of some new soybean genotypes. Hundred seed weight and volume of soybean genotypes ranged from 8.7 to 11.1 g and 8.1 to 12.0 ml respectively, whereas, percent water absorption and percent volume expansion values ranged from 94.3 to 119.5% and 70.8 to 159.5% respectively. The genotypes contained % crude protein (39.4–44.4), oil (14.0–18.7), starch (4.3–6.7), total soluble sugars (5.6–7.9), reducing sugars (0.21–0.33) and sucrose (5.6–11.8). The free fatty acid and triglyceride content ranged from 31–71 mg 100 g^{-1} oil and 90.1–93.9 g 100 g^{-1} oil respectively. The antinutritional components determined include: mg g^{-1} TIA (41.5–85.0), phytate (2.3–5.6), total phenols (1.0–1.5), flavonols (0.20–0.34) and ortho-dihydroxy phenols (0.10–0.21). A significant variation for the 11S/7S ratio was observed among the 8 soybean genotypes and the values ranged from 0.70 (‘SL 768’ and ‘SL 869’) to 2.4 (‘SL 794’).

Raja *et al.* (2014) investigated with an attempt to develop processed paneer by partial addition of different levels of skimmed milk and soymilk. The control and different treatments were analyzed for physico-chemical analysis (acidity, TSS, specific gravity, ash, moisture, fat and protein) and organoleptic characteristics like (colour, flavor, taste, texture and overall acceptability). It was found that sample C has highest protein, fat and ash content.

Sharma *et al.* (2013) revealed the effects of soaking and cooking methods on physicochemical characteristics, nutrients and antinutrients in twenty soybean genotypes were studied. Batches of seeds were soaked for 18 h in distilled water, 1% citric acid and 2% sodium bicarbonate solutions at room temperature and then boiled in water. Raw soybean genotypes exhibited 36.5-43.2% protein, 20.7-22.2% oil, 2.5-8.3% total soluble sugars, 1.1-10.4% sucrose, 11.1-18.8 mg/g tannins, 14-36.2 mg/g phenols, 5.1-24.5 mg/g phytate, 30-102.5 mg/g trypsin inhibitor activity and 9.3-27 mg/g saponins. Soaking in distilled water and/or different solutions followed by cooking resulted in significant reductions in the levels of protein, oil and antinutrients and enhanced the carbohydrates in soybean seeds. Cooking of soaked seeds resulted in higher losses of antinutrients in comparison to unsoaked seeds. Among the various treatments, soaking in 1% citric acid solution followed by cooking for 30 min resulted in maximum reduction in most of the antinutrients studied.

Acuna *et al.* (2010) assessed the physicochemical characteristics and functional properties of vitabosa flour (*Mucuna deeringiana*) and soybean flour (*Glycine max*) were determined. Oil absorption capacity was higher in vitabosa. Water absorption capacity was higher in soy and it was affected by the change in the ionic strength of the medium. Emulsifying Activity (EA) decreased with increasing concentration of flour, while Emulsifying Stability (ES) showed an increased. EA and ES of flours have more ionic strength in the range between 0.0 and 0.4 M, but it is reduced afterwards with the higher concentration of NaCl. Foaming stability varied with the concentration of flour solution reaching maximum values of 39 and 33% for vitabosa and soybean, respectively at 10% flour concentration.Vitabosa had the best foaming capacity (56% to 0.6 M) compared with soybeans (47% to 0.4 M). Maximum capacity of gelation was observed in vitabosa at 10% flour concentration. Increases in ionic strength of the flour solution, at low salt concentrations (<0.4 M), improved the gelation of flours.

Yuan *et al.* (2009) performed to evaluate the acid composition, some selected physicochemical and functional properties of acidic and basic polypeptides of soy glycinin were investigated and compared. Large amount of these polypeptides were obtained by DEAE-Sepharose fast flow column chromatography. Free sulphydryl contents, surface hydrophobicity, solubility and emulsifying activities (at different pH values) were evaluated. Different polypeptides had different patterns of amino acid composition, especially contents of acidic (and basic) and hydrophobic amino acids. The free sulphydryl contents (including total and exposed) and surface hydrophobicity considerably varied with the type of polypeptides. Compared with glycinin, isoelectric point (pI) of individual polypeptides shifted towards a more acidic pH. At a given pH value (e.g. above or below pI), the solubility and emulsifying ability index of these polypeptides were closely related to their relative contents of acidic (and basic) amino acids. The results indicated that glycinin polypeptides with different amino acid character have different physicochemical and functional properties, especially solubility and emulsifying ability.

Sharma et al. (2008) performed a research with the seventy four soybean genotypes of five different groups i.e. SL, PK, DS, Bragg and Pusa were analysed for physicochemical and cooking quality. Oil correlates negatively with protein, cooking time and volume expansion after soaking. No Kokroos were found in any of the tested genotypes. Water absorption after soaking/cooking correlates positively with volume expansion. Genotypes of SL group exhibited superiority over other groups w.r.t. most of the quality traits and yield. Protein correlates negatively with yield (r = –0.16) and oil (r = –0.51).

Amuri *et al.* (2008) investigated from 2001 through 2007 in the Mississippi River Delta region of eastern Arkansas on a Calloway silt loam (fine silty, mixed, active, thermic Glossaquic Fraglossudalf). Soil bulk density increased in both CT and NT during the first three years, but at a greater rate under NT (0.12 g cm-3 yr-1) than CT (0.08 g cm-3 yr-1), followed by a decline at a similar rate in both tillage treatments. Soil pH and Mehlich-3 extractable soil Ca and Mg contents increased, while electrical conductivity decreased linearly over time when all treatments were combined. Soil organic matter (SOM) increased over time in all treatment combinations. Total C (TC) increased at a greater rate in the no burn (0.08 kg C m-2 yr-1) and high-residuelevel (0.07 kg C m-2 yr-1) than in the burn (0.05 kg C m-2 yr-1) and low-residue-level (0.05 kg C m-2 yr-1) treatments. Extractable soil P content declined linearly over time at greater rate under NT (3.3 kg P ha-1 yr-1) and high-residue-level (3.4 kg P ha-1 yr-1) than under CT (2.6 kg P ha-1 yr-1) and low-residue-level (2.4 kg P ha-1 yr-1) treatments. Soybean yield declined at a similar rate in the first three years, but increased at a similar rate over the subsequent three years in all tillage-treatment combinations.

Aide *et al.* (2008) studied with the corn and soybean nutrient accumulations were determined using tissue analysis and biomass estimates. Total soybean nutrient uptake (lbs/acre) by element are N (421), P(48), K(205), Mg(45), Ca(138), S(31), Fe(1), Mn(0.6), B(0.5), Cu(0.2), Zn(0.4). Total corn nutrient uptake (lbs/acre) by element are N (290), P(55), K(158), Mg(27), Ca(72), S(24), Fe(1.1), Mn(1), B(0.1), Cu(0.2), Zn(0.6). Based on total plant uptake, the percentages of each nutrient in the cob, stem, ear leaves, grain, tassel, shank and axial leaves are illustrated. Approximately 50% of the N is partitioned into the corn grain and 82% of the N is partitioned in the soybean grain

Liu *et al.* (2004) analysed the fourteen trace elements in soybean and its products were determined by atomic absorption spectrometry. The effects of cinefaction temperature, cinefaction time, and the concentration of HNO3 as a digestion solution were investigated in detail. The effect of the concentration of SrCl2 on the determination of Ca and Mg was also studied. The results obtained show that the soybean and its products contain higher amounts of K, Na, Ca, Mg, Fe, Cu, Zn and Mn than other elements. Fourteen trace elements in soybean and its products were determined by atomic absorption spectrometry. The effects of cinefaction temperature, cinefaction time, and the concentration of HNO3 as a digestion solution were investigated in detail. The effect of the concentration of SrCl2 on the determination of Ca and Mg was also studied. The results obtained show that the soybean and its products contain higher amounts of K, Na, Ca, Mg, Fe, Cu, Zn and Mn than other elements.

Krishna *et al.* (2003) performed a research with the seven new varieties of soybean evaluated exhibited hull content 7.31-8.51%, hardness (vertical) 5.60-7.60 kg, hardness (horizontal) 13.33-18.23 kg, bulk density 0.68-0.74 g/cc, true density 1.04-1.18 g/cc and 1000 grain weight 118.3-145.6 g. The varieties contained (%) protein 37.19-41.56, fat 18.8-22.4, fibre 3.67-4.17, ash 4.2-5.2 and carbohydrates (by difference) 17.58-22.47. Other components determined include (mg/100 g seeds) calcium 246.60-280.00, phosphorus 502.00-540.86 and iron 10.00-13.36. The phenol content was 686-747 mg/100 g soybean, whereas trypsin inhibitor activity was 21.07-25.17 TUI/mg sample.

Garcia *et al.* (1998) reported that the commercial soybean products-soybean protein isolate, soybean flour, textured soybean, whole soybeans, and soybean dairy-like products (liquid and powdered milks, shake, yogurt, and infant formulas)-have been analysed for their content in solids, ash, pH, acidity, protein, fat, phosphorus, and some metal ions (calcium, copper, iron, potassium and zinc). The differences found in the protein, phosphorus, and metal ion content and other chemical properties of these products are discussed, taking into account the procedures used to produce the above derivatives.

CHAPTER III

MATERIALS AND METHODS

3.0 Materials

Six varieties of Soybean (*Glycine max* (L.) Merrill) namely Bangladesh Soybean-4, BARI Soybean-6, Shohag, BARI Soybean-5, BINA Soybean-2 and BINA Soybean-4 were selected for the study. The seeds were collected from BARI, Joydebpur, Gazipur. Seeds were cleaned and sun-dried and stored plastic container in a cool place until used for the chemical analysis.

3.1 Brief description of selected varieties

3.1.1 Bangladesh Soybean-4

Bangladesh Soybean-4 is resistant to yellow mosaic virus (YMV) which was released in 1994. The plant height ranges from 60-65 cm. Thousand seed weight 60-70 gm. The seed is yellow with slight green color. The seed contains 40-45% protein and 21-22% oils. This variety can be grown both Kharif (Mid July) and Rabi (Mid January) seasons. Maturity period ranges from 85-95 and 120-125 days in both season respectively. The germination percentage is high. It can produce seed yield of 1.5-2.2 t/ha.

3.1.2 Shohag

Shohag is resistant to yellow mosaic virus (YMV) which was released in 1991. The plant height ranges from 50-60 cm. Hundred seed weight 11-12 gm. The seed color is bright yellow. The seed contains 40-45% protein and 21-22% oils. This variety can be grown both Kharif (Mid July) and Rabi (Mid January) seasons. Maturity period ranges from 90-100 days. It can produce seed yield of 1.5-2.0 t/ha.

3.1.3 BARI Soybean-5

BARI Soybean-5 was released in 2002. The plant height ranges from 40-60 cm. Hundred seeds weight 9-14 gm. The seed is creamy in color. The seed contains 40-45% protein and 21-22% oils. This variety can be grown both Kharif (Mid July) and Rabi (Mid January) seasons. Maturity period ranges from 90-100 days. It can produce seed yield of 1.6-2.0 t/ha.

3.1.4 BARI Soybean-6

BARI Soybean-6 is resistant to yellow mosaic virus (YMV) which was released in 2009. The plant height ranges from 50-55 cm. Hundred seed weight 11-12 gm. The seed color is creamy in color. The seed contains 42-44% protein and 20-21% oils. This variety can be grown both Kharif (Mid July) and Rabi (Mid January) seasons. Maturity period ranges from 100-110 days. It can produce seed yield of 1.8-2.10 t/ha

3.1.5 BINA Soybean-2

BINA Soybean-2 is moderately resistant to yellow mosaic virus (YMV) which is released in 2011.The plant is shorter in height, deep green leaves, hylum very clear and black color and brighter yellow seed coat color. This variety can be grown both Kharif (Mid July) and Rabi (Mid January) seasons. Maturity period ranges from 95-100 days. In can be grown in wide ranges of land and soil types from sandy to loam soils. It can produce seed yield of 2.4-2.8 t/ha. The seed contains 43.0% protein, 27.0% starch and 18.0% oils. This variety can be cultivated all over the country but more suitable for high and Charland of South and South-western regions of Bangladesh.

3.1.6 BINA Soybean-4

BINA Soybean-4 is released in 2013. The plant is shorter in height. Maturity period ranges from 110-125 days. Hundred seed weight 14 gm. Brighter yellow seed coat color. It can produce seed yield of 2.3-2.5 t/ha.

3.2 Chemical analysis

3.2.1 Estimation of oils/fats

3.2.1.1 Reagents and equipments

i. Anhydrous ethyl ether

ii. Soxhlet, flask and condenser

iii. Hot Plate

Procedure

Dried soybean sample were weighted out into an extraction thimble. Weight of thimble and sample were recorded in laboratory work book. The thimble was placed into the Soxhlet. 50-100 ml ethyl ether was added to the Soxhlet flask, then it was connected to holder and condenser. Soxhlet flask was placed on the hot plate and distilled at low temperature for 16-20 hours. 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 weighted out. The loss of weight was cured fat.

% Crude fats/oil (on a dry weight basis) =

$$\frac{\text{Wt. of thimble and sample before extraction - Wt. of thimble and sample before extraction}}{\text{Wt. of sample before extraction}} \times 100$$

The fat determined by the above procedure (Hughes, 1965) contains usual lipids including waxes pigments, certain gums and resins. A better name for these constituents would be ether soluble extract.

3.2.2 Estimation of fatty acid composition

Seed samples of Soybean were received from the Department of Biochemistry of SAU. Fatty acid composition was determined by Gas Chromatographic method (Cocks and Rede, 1996).

3.2.2.1 Preparation of Reagents

40mL of methanol were taken in 50mL conical flask. It was placed on ice water and then 10mL of H_2SO_4 acid was added in it and this solution was saved for further use.

3.2.2.2 Methyl esters preparation

Methylation of fatty acids in the oils under study was carried out according to the procedure with some modification as described by Were *et al.* (2006). The procedure adopted was under: 200mg (0.2mL) oil was taken in 50mL screw capped Pyrex glass tubes having 50cm length and 1 cm internal diameter. Then 2mL of methanolic sulphuric acid added in each tube and glass vials were put in a pure heated oven at 80^0c for 1 hour and shake after 15 mins. The glass vials taken out, cooled and 2mL of distilled water were added in each tube to stop the reaction. Then esterified fatty acid were extracted with 1mL of petroleum ether (40-60^0c) thrice. After that the ether content was evaporated and remaining oily surface was injected into Gas Chromatography for fatty acid profile.

3.3 Gas chromatography

The upper layer (1μL) was injected into a gas chromatograph (Massachusetts Model GC-Clarus 500 Perkin Elmer Incorporate, USA) equipped with a polar capillary a flame ionization detector and column ELITE-5 (30m x 0.25mm ID x 0.25μm, Perkin Elmer, USA) to obtain FA methyl ester peaks. The column temperature was 150^0c and detector temperature was 250^0c and held for 0.5 min. and increased at the rate of 10^0c/min to 250^0c. Then it held for 15 minutes and run time was 20-50 mins. Comparing the retention times with those of standards individuals peaks of FA methyl esters were identified. By individual FA composition was calculated by using the peak areas of the FA species that appear in the chromatogram as a relative percentage of the total peak areas of all the FA in the oil sample (Cock and Rede, 1966)

3.4 **Estimation of minerals**

Preparation of Reagents

a. **Reagents for P determination**

Reagent A

1. 45 gm antimony trioxide and 400mL water were mixed in 1L volumetric flask and 150mL conc. H_2SO_4 was added then it was allowed to cool.
2. Ammonium molybdate (7.5 gm) was dissolved in 300mL water
3. Cool antimony solution and molybdate solution was mixed by adding 1L of water

Reagent B

1. 1 gm gelatin was dissolved in 100 mL hot water
2. Reagent A (150mL) dissolved to 500mL water and dissolved gelatins were mixed and finally, 1 gm of ascorbic acid was dissolved with it to make volume 1 L.

b. Reagents foe Ca and Mg determination

1. 1% Lanthanum solution.

   59 gm of lanthanum oxide (La_2O_3) were added with about 500mL of water. 250mL conc. H_2SO_4 was added to dissolve the La_2O_3 slowly and cautiously. Then it was made to 5L with water.

c. Reagents for S determination

Mixed acid seed solution

65mL of HNO_3 and 250mL glacial acetic acid were added to about 500mL of water. 3mL of 1000ppm S standard solution was added and made volume to 1L with water.

3.5 Preparation of Standards

1. For convenience the Cu, Fe, Mn and Zn were prepared together in water. The high concentration for these elements was follows: 2µg Cu/mL, 10µg Fe/mL, 4µg Mn/mL, 2µg Zn/mL.
2. The P, K and N were prepared together in water with high concentration was follows : 20µg P/mL, 100µg K/mL, 40µg N/mL.
3. S was prepared in the same solution with the high concentration as follows: 20µg S/mL

4. Ca and Mg were prepared in the same solution with the high concentration as follows : 100µg Ca/mL, 40µg/mL.

d. Digestion solution

1. Nitric-perchloric solution

   Conc. Perchloric acid (100mL) was added to 500mL concentrated HNO_3 to prepare nitric-perchloric solution.

3.6 Digestion of Soybean seed sample for the determination of Ca, Mg, K, N, P, S, B, Cu, Fe, Mn and Zn.

a. Digestion Procedure

Weighted 500 gm dry seed sample and put into a 500mL boiling flask. 5mL of nitric-perchloric solution was allowed on cool hot plate and turned temperature 375^0c. It was allowed to digest for 1 hour and 30 minutes. The flask was removed from digestions chamber and was cooled and then 15mL water was added into it. The flask was agitated and heated to dissolve the ash and filter.

b. **Analytical Procedure**

By using a combination diluter-dispenser, 1mL aliquot was taken from filtrate and 19mL of water (dilution 1) was added. The other dilutions were made in the following order. For N, P and K determination, 1mL aliquot from dilution 1, 9mL of water and 10mL of color reagent were mixed together. It was allowed to stand about 20 minutes and reading was taken of spectrophotometer at 680nm.

For S determination, 7mL of aliquot from dilution 1, 9mL of acid seed solution and 4mL of turbidimetric solution were mixed together thoroughly. It was allowed to stand 200 minutes and not longer than one hour.

The reading was taken in turbid meter or in colorimeter at 535 using a cuvette with 2cm light path. For Ca and Mg determination, 1mL aliquot from dilution 1, 9mL of water and 10mL of 1% lanthanum solution were mixed together. It was analysed by AA procedure. For Fe, Mn, B and Zn determination, the original filtrate was used to analyze these elements by AA procedure.

3.7 Estimation of Protein

Generally the nitrogen content of protein is 16 % on average; thus the inverse number of this (100/16 = 6.25) is used as the factor. However, as the factor is different between samples (5.83 for flour; 5.95 for rice), the crude protein of some feeds is different from the pure protein content; crude protein is measured to be excessively small in materials of milk product origin such as casein, and excessively large in flour and soybean.

3.8 Estimation of Crude Fiber (CF)

A sample is boiled sequentially with dilute acid and then with dilute alkali, and then sequentially washed with ethanol and diethyl ether, and the residue is subtracted by its ash, and the result is defined as crude fiber. Crude fiber is primarily measured to comprehend indigestible parts in feeds, and is consisted mainly of a part of lignin, pentosan, chitin, etc., in addition to cellulose.

3.9 Statistical Analysis

The recorded date for each character from the experiments was analysed statistically to find out the variation resulting from experimental treatments using MSTAT package program. The mean for all the treatments were calculated and analysed of variance of characters under the study was performed F variance test. The mean differences were evaluated by least significance difference (LSD) test (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

Six varieties of Soybean (*Glycine max* (L.) Merrill) were taken for the determination of Physical and Chemical characteristics. The seed were stored in the store house under a suitable storage condition. The proximate composition and some other nutrients compositions of Soybean seeds are also reported.

4.1 Analytical studies of the whole seeds

The proximate composition of whole Soybean seeds of different varities are presented in different tables. The data have also been estimated on moisture free basis in order to allow for better comparison of the different fraction. The data mentioned are the average of three replication and have been presented and discussed.

4.2 Physical characteristics of different varieties of Soybean (*Glycine max* L.)

4.2.1 Oil content

The oil content of the Soybean depends on many factors like genetic factors, agro-ecological conditions including cultivation sites and crop management system etc. The oil content of different varieties were extracted by petroleum ether (40-60^0c) varied from 15.01 to 18.63% (Table). The variety BINA Soybean-4 has the lowest amount of oil (15.01%); followed by BINA Soybean- 2 (15.84%), Shohag (17.19%), Bangladesh Soybean-4 (18.22%), BARI Soybean-6 (18.46) and BARI Soybean-5 (18.63%).

The results clearly indicated that BARI Soybean-6 and BARI Soybean-5 varieties can be considered as the better source of oil.

Sharma *et al.* (2013) reported that oil content of Soybean ranges from 20.7-22.2%, which are slightly lesser than present results. On the other hand, the Pussa genotype of Soybean contained 19.1% oil (Sharma *et al.*, 2008), which was more or less similar the reported values of BARI Soybean-6 and BARI Soybean-5 varieties. Earlier studies by different authors reported percent mean protein and oil content of 39.8 and 20.5 (Krishna *et al.*, 2003) and 40.2 and 18.3 (Ramteke *et al.*, 2010) respectively in different Soybean varieties released in India. Oil content ranges from 8.3% to 27.9%, with an average of 18.1% on a 13% moisture basis in Soybean seed (Liu, 1999; Wilson, 2004).

These variation might be due to biological factor, environment factor, soil and also crop management practices. From these results it can be concluded that though BINA Soybean-2 and BINA Soybean-4 contained less amount of oil than the others varieties but all the released varieties are a good source of oil.

Table 1. Proximate analysis of Oil content of different varieties of Soybean (*Glycine max* L.)

VARIETIES	OIL (%)
Bangladesh Soybean-4	18.22 b
Shohag	17.19 c
BARI Soybean-6	18.46 ab
BARI Soybean-5	18.63 a
BINA Soybean-2	15.84 d
BINA Soybean-4	15.01 e
CV (%)	4.70
$LSD_{(0.05)}$	0.3328

4.3 Chemical characteristics of Soybean varieties

4.3.1 Fatty acid composition

Comparison of Gas chromatography results are demonstrated in Tables (2). According to the results, there was a significant difference among the varieties of Soybean in terms of their fatty acid compounds. The fatty acid compositions of saturated and unsaturated are given below:

4.3.1.1 Saturated fatty acid composition

Significantly the highest amount of palmitic acid was observed in BARI Soybean-5 (11.49%) variety; followed by BARI Soybean-6 (10.94%), Bangladesh Soybean-4 (10.71%), BINA Soybean- 2 (10.34%), Shohag (9.74%) and BINA Soybean-4 (9.47%). Lowest amount of palmitic acid content was found in BINA Soybean-4 variety. The concentration of stearic acid varied from Shohag (3.18%) to BARI Soybean-6 (4.17%), whereas arachide acid contents ranged from 0.099% to 0.433% in BINA Soybean-4 and Bangladesh Soybean-4, respectively. BARI Soybean-6 variety contained the highest amount of behenic acid; followed by Bangladesh Soybean-4 (0.78%), Shohag (0.62%) and the lowest was in BARI Soybean-5 (0.37%) variety. Gunstone (1996) found that the Soybean contained near about 14% saturated fatty acid. He observed that the typical variety of Soybean contained the amount of palmitic (10%) and stearic acid (4%).

From the present investigation, it might be suggested that all the Soybean oil seed are suitable for edible purpose as they contained significant amount of saturated fatty acids.

Table 2. Saturated Fatty acid composition of different varieties of Soybean (*Glycine max* L.)

VARIETIES	Saturated fatty acid (%)			
	Palmitic ($C_{16:0}$)	Stearic ($C_{18:0}$)	Arachidic ($C_{20:0}$)	Behenic ($C_{22:0}$)
Bangladesh Soybean-4	10.71 bc	3.557 c	0.4333 a	0.7800 ab
Shohag	9.740 d	3.180 d	0.1500 bc	0.6200 bc
BARI Soybean-6	10.94 b	4.167 a	0.2267 b	0.8533 a
BARI Soybean-5	11.49 a	3.823 b	0.1467 bc	0.3700 d
BINA Soybean-2	10.34 c	4.233 a	0.1297 c	0.5227 cd
BINA Soybean-4	9.473 d	3.727 bc	0.09967c	0.5693 c
CV (%)	6.60	14.84	8.97	15.06
$LSD_{(0.05)}$	0.3877	0.2067	0.07754	0.1779

4.3.1.2 Unsaturated fatty acid composition

There were 4 unsaturated fatty acid compounds was found during work in laboratory. The highest palmitolic acid content was observed in Bangladesh Soybean-4 (0.263%); followed by BINA Soybean- 2 (0.19%) and BARI Soybean- 6 (0.10%). Oleic acid contained highest amount in BARI Soybean-6 (30.72), followed by BARI Soybean- 5 (28.75%)and BINA Soybean-2 (20.91%).The lowest amount of oleic acid found in BINA Soybean-4 (11.71%). Maximum oleic acid content (30.4 mg 100 g^{-1} oil) was recorded in genotype ‘SL 525’ (Sharma *et al.*, 2014). The linoleic acid content varied 33.93% to 54.79%. The maximum amount of linoleic acid content was in Bangladesh Soybean-4 and minimum was BINA Soybean-4. Mizuno and Yamada (2006) observed linoleic acid (LA) content decreases contents during sprouting. And the highest amount of linolenic acid observed in Bangladesh Soybean-4(09.457%) and the lowest was BARI Soybean-6 (5.28%) varieties. Gunstone (1996) found that the Soybean contained near about 81% unsaturated fatty acid. He observed that the typical variety of Soybean contained the amount of oleic (43%), linoleic (35%) and linolenic acid (3%).

From the present study, it might be suggested that all the Soybean oil seed are suitable for edible purpose as they contained significant amount of unsaturated fatty acids.

Table 3. Unsaturated Fatty acid composition of different varieties of Soybean (*Glycine max* L.)

VARIETIES	Unsaturated fatty acid (%)			
	Palmitolic ($C_{16:1}$)	Oleic ($C_{18:1}$)	Linoleic ($C_{18:2}$)	Linolenic ($C_{18:3}$)
Bangladesh Soybean-4	0.2633 a	18.29 bc	54.79 a	9.457 a
Shohag	0.08333 c	16.99 c	54.00 a	9.243 a
BARI Soybean-6	0.1097 bc	30.72 a	44.61 b	5.283 c
BARI Soybean-5	0.09933 c	28.75 a	43.67 b	5.607 c
BINA Soybean-2	0.1867 ab	20.91 b	45.63 b	7.310 b
BINA Soybean-4	0.04633 c	11.71 d	33.93 c	6.280 bc
CV (%)	10.87	13.19	11.76	17.13
$LSD_{(0.05)}$	0.07956	3.667	5.313	1.331

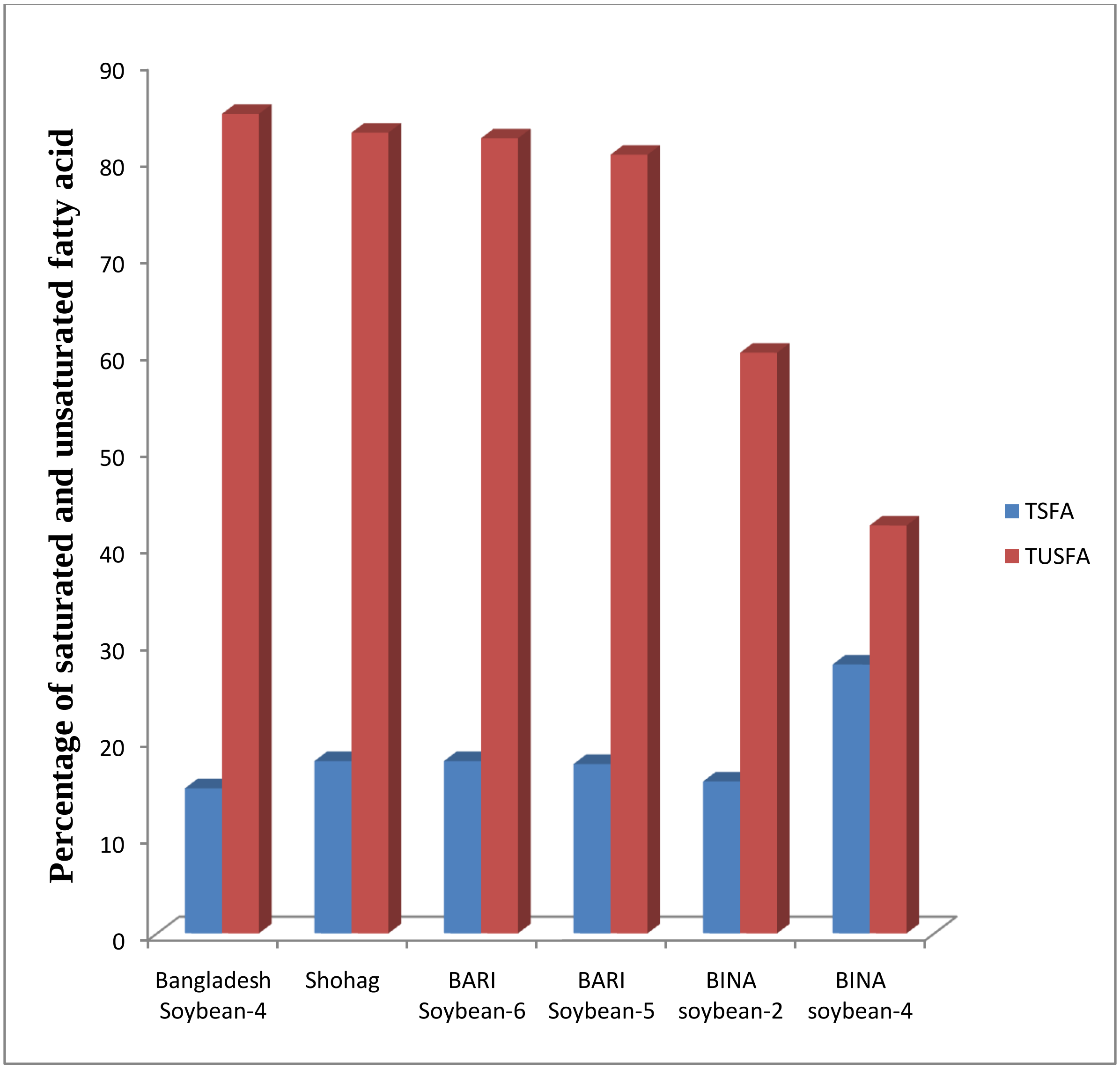

Fig. 1: Percentage of total saturated and unsaturated fatty acid of different varieties of soybean (*Glycine max* L.).

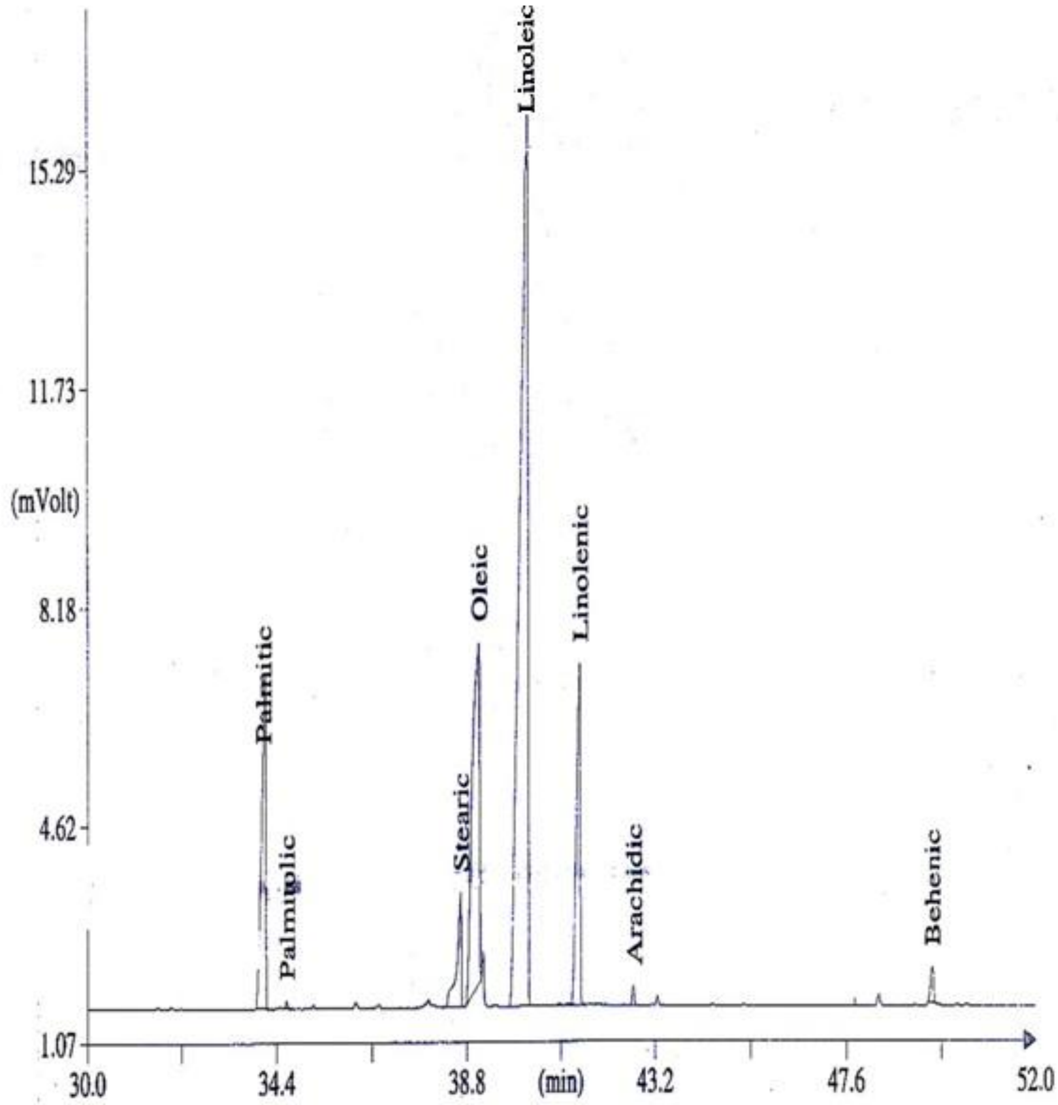

Fig. 2. Fatty Acid Composition of Bangladesh soybean-4 (*Glycine max* (L.)

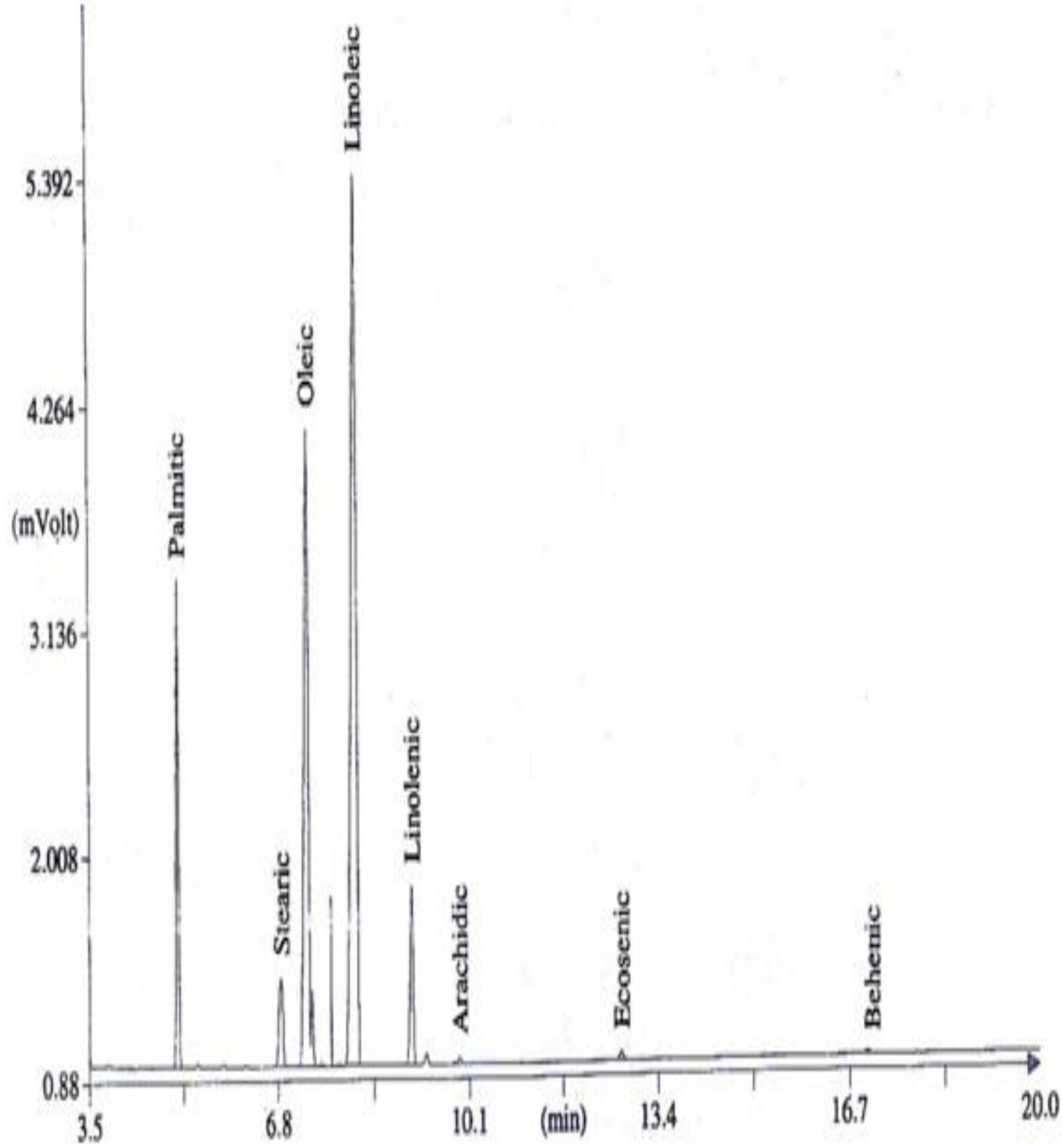

Fig. 3. Fatty acid composition of BARI soybean-6 (*Glycine max* (L.).

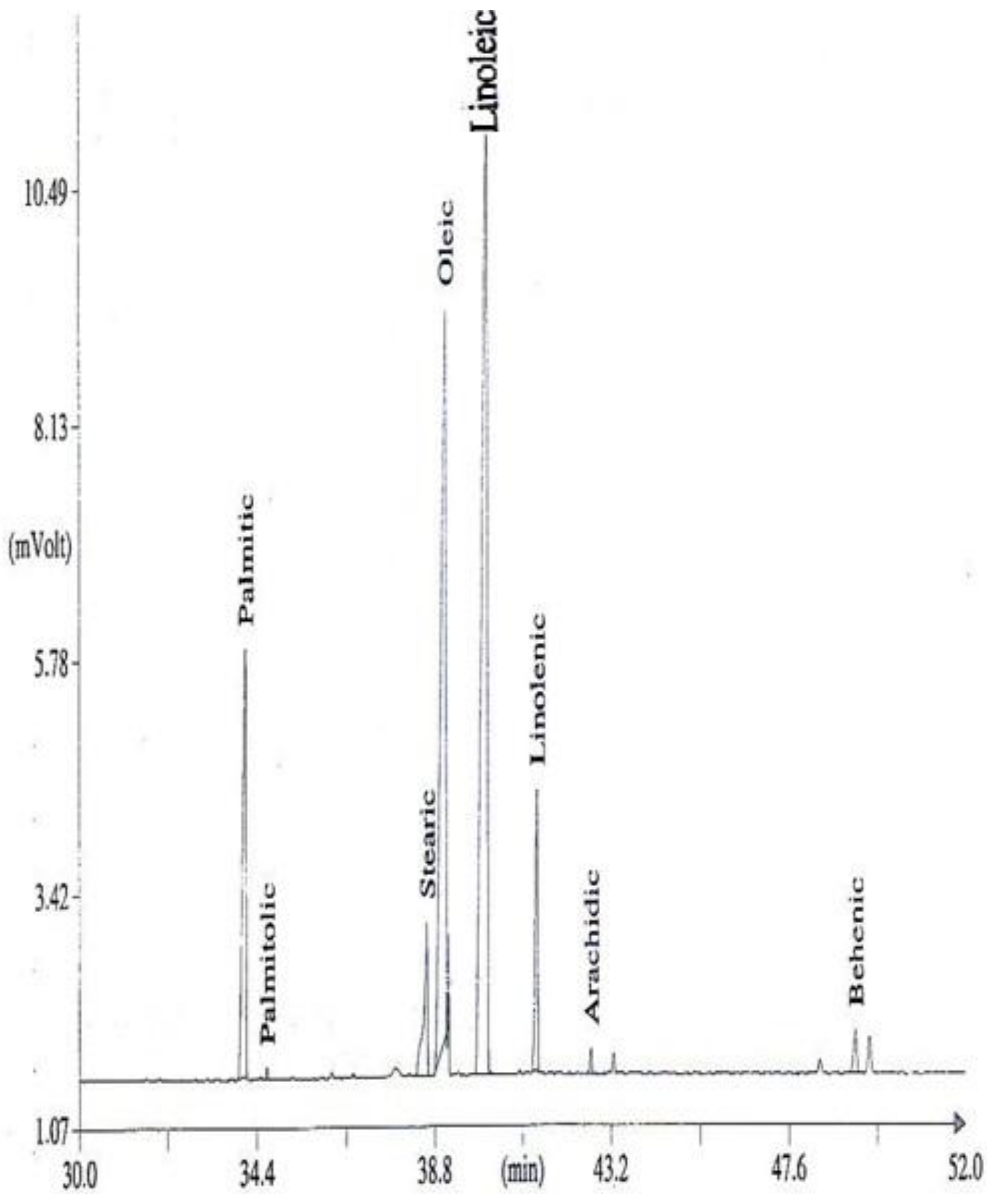

Fig. 4. Fatty acid composition of Shohag (*Glycine max* (L.)

4.4 Minerals

Different major and minors minerals were analysed in this research work. The amount of minerals content of Soybean have been illustrated in Tables.

4.4.1 Major minerals

4.4.1.1 Calcium (Ca)

Calcium (Ca) content of different varieties of Soybean ranged from 1.23 to1.29%. The highest amount of Calcium content was observed in Shohag (1.29%); followed by BINA Soybean-4 (1.283%), BARI Soybean-6 (1.28%) and BINA Soybean-2 (1.280%), respectively. The lowest amount of Calcium content was found in Bangladesh Soybean-4 (1.23%) and BARI Soybean-5 (1.26%) varieties. The average Calcium content of BRS 267 was observed as 1.5% and also 2.10% found in BRS 257 Soybean cultivars (Rigo *et al.*, 2015).

4.4.1.2 Magnesium (Mg)

Magnesium (Mg) content of different varieties of Soybean varied from 0.67 to 0.75%. The highest amount of Magnesium content was observed in Shohag (0.75%); followed by BARI Soybean-6 (0.747%), BINA Soybean-2 (0.74%) and BINA Soybean-2 (1.280%), respectively. The lowest amount of Magnesium content was found in Bangladesh Soybean-4 (0.66%) and BINA Soybean-4 (0.70%) varieties.

The present investigations were supported by Rigo *et al.* (2015) and he found that the average Mg content was 2.70% Mg and 3.20% of BRS 267 and BRS 257 genotypes of Soybean.

4.4.1.3 Potassium (K)

The highest and the lowest amount of Potassium content were observed in BINA Soybean- 2 (1.387%) and Bangladesh Soybean-4 (1.123%), respectively. And the nearest highest amount of Potassium content found in BARI Soybean-6 (1.288%) and also the lowest amount of observed in Shohag (1.20%) and BARI Soybean-6 (1.21%) varieties. And BINA Soybean -4 also contained 1.22% of Potassium. From the metal ions studied, the highest concentration is obtained for potassium (>234mg/l00g), its content in Soybean protein isolate being much lower than in whole Soybeans, Soybean flour, textured Soybean and powdered Soybean milk B (Garcia *et al.*, 1998).

Table 4. Proximate analysis of major minerals content different varieties of Soybean (*Glycine max* L.)

VARIETIES	Ca (%)	Mg (%)	K (%)
Bangladesh Soybean-4	1.233 c	0.6667 e	1.123 d
Shohag	1.290 a	0.7517 a	1.203 c
BARI Soybean-6	1.283 ab	0.7470 b	1.212 c
BARI Soybean-5	1.267 b	0.7363 c	1.288 b
BINA Soybean-2	1.280 ab	0.7400 c	1.387 a
BINA Soybean-4	1.283 ab	0.7013 d	1.220 c
CV (%)	3.17	10.98	5.42
$LSD_{(0.05)}$	0.01779	0.004358	0.03978

4.4.1.4 Nitrogen (N)

Nitrogen (N) content of different varieties of Soybean was ranged from 5.82 to7.05%. The highest amount of Nitrogen content was observed in BARI Soybean-5 (7.05%); followed by Shohag (7.04) and BINA Soybean-4 (6.18%). The lowest amount of Nitrogen content was found in Bangladesh BINA Soybean-2 (5.82%), Bangladesh Soybean-4 (5.92%) and BARI Soybean-5 (5.95%) varieties.

4.4.1.5 Phosphorus (P)

Phosphorus (P) content of different varieties of Soybean was varied from 5.82 to7.05%. The highest amount of Nitrogen content was observed in BARI Soybean-5 (7.05%); followed by Shohag (7.04) and BINA Soybean-4 (6.18%). The lowest amount of Nitrogen content was found in Bangladesh BINA Soybean-2 (5.82%) and BARI Soybean-5 (5.95%) varieties. The Soybean genotype BRS 267 and BRS 257 contained 6.07% and 5.69% Phosphorus, respectively (Rigo *et al.*, 2015).

4.4.1.6 Sulfur (S)

The highest and the lowest amount of Sulfur (S) content of different varieties of Soybean were 0.069 to 0.77%. The highest amount of Sulfur content was observed in Shohag (0.069%); followed by Bangladesh Soybean-4 (0.84%), and BINA Soybean-2 (0.82%), respectively. The lowest amount of Sulfur content was found in BARI Soybean-5 (0.77%) and the nearest lowest amount was also observed in BARI Soybean-6 (0.79%) varieties.

Table 5. Proximate analysis of major minerals content different varieties of Soybean (*Glycine max* L.)

VARIETIES	N (%)	P (%)	S (%)
Bangladesh Soybean-4	5.920 cd	5.94 cd	0.8477 b
Shohag	7.040 a	7.65 a	0.9693 a
BARI Soybean-6	7.053 a	7.13 a	0.7977 d
BARI Soybean-5	5.957 c	5.96 c	0.7767 e
BINA Soybean-2	5.823 d	5.43 d	0.8277 c
BINA Soybean-4	6.183 b	5.43 b	0.6940 f
CV (%)	2.75	7.97	12.36
$LSD_{(0.05)}$	0.09744	0.1125	0.01779

4.4.1.7 Protein

The highest and the lowest amount of protein content of different varieties of Soybean were 37.46 to 46.11%. The highest amount of Protein content was observed in Shohag (46.11%); followed by BARI Soybean-4 (44.08%), BINA Soybean-4 (38.64%) and BARI Soybean-5 (37.23%), respectively. The lowest amount of protein content was found in BINA Soybean-2 (36.38%) and the nearest lowest amount was also observed in Bangladesh Soybean-4 (37.01%) varieties.

Table 6. Proximate analysis of Protein content of different varieties of Soybean (*Glycine max* L.)

VARIETIES	PROTEIN (%)
Bangladesh Soybean-4	37.01 cd
Shohag	46.11 a
BARI Soybean-6	44.08 a
BARI Soybean-5	37.23 c
BINA Soybean-2	36.38 d
BINA Soybean-4	38.64 b
CV (%)	6.83
$LSD_{(0.05)}$	7.34

4.4.1.8 Crude Fiber (CF)

The highest and the lowest amount of crude fiber of different varieties of Soybean were 5.32 to 6.93%. The highest amount of crude fiber content was observed in Shohag (6.93%); followed by BARI Soybean-6 (6.86%), BINA Soybean-4 (6.02%), BINA Soybean-2 (5.96%) and Bangladesh Soybean-4 (5.86%), respectively. The lowest amount of crude fiber was found in BARI Soybean-5 (5.32%).

Table 7. Proximate analysis of crude fiber of different varieties of soybean (*Glycine max* L.)

VARIETIES	Crude Fiber (CF)
Bangladesh Soybean-4	5.86 bc
Shohag	6.93 a
BARI Soybean-6	6.86 a
BARI Soybean-5	5.32 c
BINA Soybean-2	5.96 b
BINA Soybean-4	6.02 b
CV (%)	6.36
$LSD_{(0.05)}$	5.43

4.5 Minor minerals

4.5.1 Boron (B)

Boron (B) content of different varieties of Soybean was ranged from 16.48 to 17.80ppm. The highest amount of Boron content was observed in Shohag (17.80ppm); followed by Bangladesh Soybean-4 (17.08ppm) and BINA Soybean-4 (17.03ppm). The lowest amount of Boron content was found in BINA Soybean-2 (16.45ppm), BARI Soybean-6 (16.48ppm) and BARI Soybean-5 (16.49ppm) varieties.

From the present study, it might be stated that all the varieties contained more or less nearest amount of Boron, so these varieties can a better source of Boron

4.5.2 Copper (Cu)

The highest and the lowest amount of Copper (Cu) content of different varieties of Soybean were 6.81 to 6.29ppm. The highest amount of Copper content was observed in BINA Soybean-4 (6.81ppm). The nearest highest amounts were also found in BARI Soybean-6 (6.79ppm), BARI Soybean-5 (6.77ppm) and BINA Soybean-2 (6.70ppm) varieties. The lowest amount of Copper content was found in Shohag (6.29ppm) and Bangladesh Soybean-4 (6.63ppm) varieties. As for metal ions, copper contents are minimal for all Soybean products (12.00 mg/100 g), its content in Soybean protein isolate being much lower than in whole Soybeans, Soybean flour, textured Soybean and powdered Soybean milk B (Garcia *et al.*, 1998)**.** The average Cu content varied from 0.03 to 0.05ppm (Hammond *et al.*, 2005)

4.5.3 Iron (Fe)

Iron (Fe) content of different varieties of Soybean was ranged from 159.8 to167.60ppm. The highest amount of Iron content was observed in BINA Soybean-2 (167.60ppm); followed by BARI Soybean-6 (166.6ppm), Shohag (166.2ppm) and BARI Soybean-5 (166.0ppm). The lowest amount of Iron content was found in Bangladesh Soybean-4 (159.8ppm) and BINA Soybean-4 (162.90ppm) varieties. The present investigations were supported by Hammond et al. (2005) and they found that the ranges of Fe content were 1-3ppm in Soybean. The average Fe content was found 48.87µg/100g on dry weight basis but in case of sprout seeds of Soybean was observed 35.29µg/g in four days (Plaza *et al.*, 2003).

From the evidence of Fe content of Soybean, it can be concluded that all the varieties contained significant amount of Fe in selected varieties of Soybean.

Table 8. Proximate analysis of minor minerals content different varieties of Soybean (*Glycine max* L.)

VARIETIES	B (ppm)	Cu (ppm)	Fe (ppm)
Bangladesh Soybean-4	17.08 b	6.630 d	159.8 e
Shohag	17.80 a	6.293 e	166.2 bc
BARI Soybean-6	16.48 c	6.790 ab	166.6 ab
BARI Soybean-5	16.49 c	6.770 b	166.0 ab
BINA Soybean-2	16.45 c	6.700 c	167.6 c
BINA Soybean-4	17.03 b	6.813 a	162.9 d
CV (%)	2.67	3.03	1.12
$LSD_{(0.05)}$	0.07956	0.03558	3.277

4.5.4 Manganese (Mn)

The maximum and the minimum amount of Manganese (Mn) content of different varieties of Soybean ranged from 100.8 to 108.60ppm. The highest amount of Manganese content was observed in BINA Soybean-4 (108.6ppm). Even the nearest highest amount also observed in BINA Soybean-2 (108.3ppm), BARI Soybean-5 (106.90ppm) and BARI Soybean-6 (106.70ppm) varieties. The lowest amount of Manganese content was found in Bangladesh Soybean-4 (100.8ppm) varieties. Plaza *et al*. (2003) found only 6.72µg/g on dry weight of seeds and also found 19.61µg/g in case of sprouts seeds of Soybean.

So, it can be concluded that all the selected varieties contained significant amount of Mn and it can be recommended that the selected varieties can be a great source of Mn from Soybean

4.5.5 Zinc (Zn)

Zinc (Zn) content of different varieties of Soybean ranged from 67.07 to 101.10ppm. The highest amount (101.10ppm) of Zinc content was observed in Shohag and BARI Soybean-5.Bangladesh Soybean-4 also contained 98.40ppm of Zinc. The lowest amount of Zinc content was found in BARI Soybean-4 (67.07) and then BINA Soybean-4 (76.92ppm) varieties. Vasconcelos *et al.* (2014) reported that the wild type of soybean contained the average concentration of Zn was 100ppm.

From the present study, it can be stated that selected varieties were contained more or less the nearest amount of Zn and also in some cases more amount of Zn in the released varieties of our country.

Table 9. Proximate analysis of minor minerals content different varieties of Soybean (*Glycine max* L.)

VARIETIES	Mn (ppm)	Zn (ppm)
Bangladesh Soybean-4	100.8 c	98.40 a
Shohag	105.7 b	100.1 a
BARI Soybean-6	106.7 ab	67.07 d
BARI Soybean-5	106.9 ab	100.1 a
BINA Soybean-2	108.3 ab	84.23 b
BINA Soybean-4	108.6 a	76.92 c
CV (%)	1.76	1.48
$LSD_{(0.05)}$	2.503	2.304

CHAPTER V

SUMMARY AND CONCLUSION

Soybean is an important crop that provides food for both humans and animals. The crop is a source of income for farmers, a source of protein and a prospective export crop. Therefore, this study evaluated soybean genotypes or varieties on varying physico-chemical characteristics of Soybean in Bangladesh. This included establishing farmers' preferences for soybean genotypes and determining the profitability and nutritional properties of soybean genotypes in our country as well as for the international consumers. The physical, chemical and functional properties of the soybean seeds were determined for the assessments of physic-chemical properties of Soybean varieties.

However, the highest amount of oil content varieties were Bangladesh Soybean-4, Shohag, BARI Soybean-5 and also BARI Soybean-6. These varieties contained significant amount of oil than BINA Soybean-2 and BINA Soybean-3. Most of the selected varieties found that they have the considerable amount of saturated and unsaturated fatty acids. They contained significant amount of palmitic and stearic acid. Arachidic and behenic acids also found in the selected varieties. The considerable amount of oleic, linoleic and also linolenic was found in these varieties. The selected varieties also contained palmitolic acid. From the results, the significant amount of unsaturated fatty acids were observed than the saturated fatty acids.

Moreover, the major minerals were observed and found that the concentration of NPK and Ca were found abundantly. And Mg and S were found slightly lower amount than the proportion of NPK. In case of minor minerals the selected varieties were observed and found that they also contained the B, Cu, Fe, Mn and Zn. Even the minor minerals were found significantly compare to the proportion of the major minerals. A better understanding of the forces driving aggregation and the parameters that affect physic-chemical properties provides useful information for Soybean varieties and quality control monitoring during production. During the statistical analysis, the present study shows that the estimated coefficients of determination indicated a predominantly genetic origin of the genotypic differences in the traits. The genetic variability was maintained in the superior genotypes, which can be used to assess the physic-chemical properties.

The most preferred soybean varieties among the six varieties the BARI Soybean-5, BARI Soybean-5 and also Bangladesh Soybean-4 are the best source of oil from the soybean. In case of fatty acids and minerals, all the selected varieties are more or less contained nearest amount of saturated and unsaturated fatty acids as well the minerals. Finally, it can be concluded that the existing varieties of Soybean might be the great source of crude oil, fatty acids and also minerals of our country.

RECOMMENDATION

- From the experiment we can recommend that BARI Soybean-5, BARI Soybean-6, Shohag and also Bangladesh Soybean are the best among the varieties.
- Further analysis of different Soybean varieties should be done to know content the nutrient.
- Nutritional analysis is also important for the breeders to evolve more nutrients rich in Soybean varieties.
- Chemical composition and nutritional traits suggests the future strategy for the nutritionist, health advisors and also dieticians as to how to make best use of the released Soybean varieties.

REFERENCES

Acuña, S.P.C., González, J.H.G., Torres, I.D.A. (2010). Physicochemical characteristics and functional properties of vitabosa (*mucuna deeringiana*) and soybean (*glycine max*). Ciênc. Tecnol. Aliment., Campinas **32**(1): 98-105

Aide, M.T., Ellis, W.,Mueller, W., Braden, I., Hermann, N. (2008). Corn and Soybean Nutrient Accumulations Grown on a Controlled Drainage/Irrigation System. Department of Agriculture, Southeast MO State University.

Akande, S. R., Owolade, v and Ayanwole, J. A. (2007). Field evaluation of soybean varieties at Ilorin in the southern guinea savanna ecology of Nigeria. *African Journal of Agricultural Research* **2**(8):356-359.

Alozie, Y.E., Ekerette, N.N. (2017). Proximate Compositions, Physicochemical and Sensory Properties of Gari Fortified with Soybean, Melon Seed and Moringa Seed Flours. *International Journal of Nutrition and Food Sciences.* **6**(2):105-110.

Amuri, N., Kristofor, Brye, R., Gbur, E.E., Popp, J. and Chen, P. (2008). Soil property and soybean yield trends in response to alternative wheat residue management practices in a wheat-soybean, double-crop production system in eastern Arkansas. *J. Integr. Biosci.*, **6**(1):64-86.

Azadbakht, L., R. Shakerhosseini, S. Atabak, M. Jamshidian, Y. Mehrabi and A. Esmaill- Zadeh (2003). Beneficiary effects of dietary soy protein on lowering plasma levels of lipid and improving kidney function in type II diabetes with nephropathy. *European Journal of Clinical*Nutrition**57**:1292–1294.

Brouns, F. (2002). Soybean isoflavones: a new and promising ingredient for the health foods sector. *Food Research International* **35** (2-3):187-193

Brown, S. (2006). The effect of environment on seed composition of tofu and natto soybean cultivars. Ms thesis.

Brune, M.F.S.S., Pinto, M.O., Peluzio, M.C.G., Moreira, M.A., and Barros, E. G.(2010). Biochemical and nutritional evaluation of a free soybean line Kunitz trypsin inhibitor and lectins. *Food Science and Technology* **30**(3): 657-663

Cardoso, L. R., Oliveira, M. G. A., Mendes, F. Q. (2007). Protease activity inhibitors in soybeans genetically improved strains. *Nutrition* **18**(1):19-26

Chen, J., Wang, J., Song, P., Ma, X. (2014). Determination of glycinin in soybean and soybean products using a sandwich enzyme-linked immunosorbent assay. *Food Chemistry* **162**: 27–33

Fernando, G. , Macedo, D., Joana, Bresolin, D., Elcio, F., Santos, F.F. , Wilson, T. Lopes, S., Joe, Polacco, C. and Lavres, J. (2016).Nickel Availability in Soil as Influenced by Liming and Its Role in Soybean Nitrogen Metabolism. *Front Plant Sci.*,**7**: 1358.

Garcia, M.C., Marina, M.L., Labordab, F. and Terre, M. (1998). Chemical characterization of products. *Food Chemistry* **62**(3):325-331

Gomez, A.K. and Gomez, A.A. (1984). Statistical Procedures for Agricultural Research. 2nd Edn. John Wiley and Sons. New York. p325

Gunstone, F. (1996). Fatty Acid and Lipid Chemistry; Blackie: London.

Hammond, E. G., Johnson, L.A., Caiping, S., Tong, W., and Pamela, J.W. (2005). Soybean Oil. Bailey's Industrial Oil And Fat Products, Sixth Edition, Six Volume Set.

Hanafiah, D.S., Alida, L. and Asmarlaili (2015). Effect of soil acidity on some soybean varities. *Journal of Biodiversity and Environmental Sciences* **6**(4):43-48

Hany, A.E. (2011). Soybean and Nutrition. Janeza Trdine 9, 51000 Rijeka, Croatia

Hildebrand, D. F., & Hymowitz, T. (1981). Two soybean genotypes lacking lipoxygenase-1. *Journal of the American Oil Chemists' Society* **58**:583–586.

Julianti, E., Rusmarilin, H., Ridwansyah and Yusraini, E. (2016). Effect of Soybean Flour on Physico-chemical, Functional, and Rheological Properties of Composite Flour from Rice, Sweet Potato, and Potato. *Tropical Life Sciences Research,* **27**(1): 133–138

Khandelwal, S., Udipi, S. A. and Ghugre, P. 2010. Polyphenols and tannins in Indian pulses: Effect of soaking, germination and pressure cooking. *Food Research Internationa*l **43:** 526-530

Konareva, A.V., Anisimovab, I. N. (2002). Serine proteinase inhibitors in the compositae: distribution, polymorphism and properties. *Phytochemistry* **59**: 279-291.

Krishna, A., Singh, G., Kumar, D., Agarwal, K. (2003). Physico-chemical characteristics of some new varieties of soybean. *J Food Sci Technol.* **40**:490–492.

Krishna, G. Singh, Kumar, D. and Agrawal, K. (2003). *Physico-chemical characteristics of some new varieties of soybean*. *Journal of Food Science and Technology -Mysore-* **40**(5):490-492

Kudou, S., Fleury, Y., Welti, D., Magnolato, D., Uchida, T., Kitamura, K., et al. (1991). Malonyl isoflavone glycosides in soybean seeds [Glycine max (L.) Merill]. *Agricultural and Biological Chemistry* **55**:2227–2233.

Kuswantoro, H. (2016). Response of Acid-Adaptive Soybean Genotypes Grown in Associated Entisols-Inceptisols and Vertisols Soil Types. *International Journal of Soil Science* **10** (4): 195-202

Kwok, K. C., Liang, H. H., & Niranjan, K. (2002). Optimizing conditions for thermal processes of soy milk. *Journal of Agricultural and Food Chemistry* **50**:4834–4838.

Lei, M., Bin, L., Fenxia, H., Yan, S., Wang, L., Junming, S. (2015). Evaluation of the chemical quality traits of soybean seeds, as related to sensory attributes of soymilk. *Food Chemistry* **173**:694–701

Liu, K. and Markakis, P. (1987). Effect of maturity and processing on the trypsin inhibitor and oligosaccharides of soybeans. *Journal of Food Science and Technology* **52**: 222-225

Liu, L.L.,Tian. Y. and Liu, X. (2012). Physico-chemical Properties and Characterization of Nano-Crystalline Soybean Dregs Cellulose. *FOOD SCIENCE*, **33**(9): 41-46.

Liu, Y.M., Wang, H., Liu, Y.F., Zhao, Y.M., Zhan, B.H. (2004). Determination of 14 trace elements in soybean and its products by atomic absorption spectrometry. *PubMed.*, **24**(11):1454-7.

Malik, M. F. A., M. Ashraf, A. S. Qureshi and A. Ghafoor (2007). Assessment of genetic variability, correlation and path analyses for yield and its components in soybean Pakistan. *Journal of Botany* **42**(2):971-976

Mehmet, M.Ö. and Fahad, A.J. (2014). Effect of sprouting and roasting processes on some physico-chemical properties and mineral contents of soybean seed and oils. *Food Chemistry* 154:337-342

Mikic, A., Peric, V., Dordevic, V., Srebric, M. and Mihailovic, V. 2009. Antinutritional factors in some grain legumes. *Biotechnology in Animal Husbandry* **25**(5-6): 1181-1188.

Min, S., Yu, Y., Yoo, S., & Martin, S. S. (2005). Effect of soybean varieties and growing locations on the flavor of soymilk. Journal of Food Science, 70, C1–C7.

Mizuno, T., Yamada, K. (2006). Proximate composition, fatty acid composition and free amino acid composition of sprouts. *J. Integr. Study Diet. Habits.,* **16**: 369-375.

Mohamed, H., Haleem, A., Mohammed, M and Mogazy, A.M. (2016). Effects Of Plant Defense Elicitors On Soybean (*Glycine Max* L.) Growth, Photosynthetic Pigments, Osmolyts And Lipid Components In Response To Cotton Worm (*Spodoptera Littoralis*) Infestation. *Bangladesh J. Bot.,* **45**(3): 597-604

Murray-Kolb, L. E., R. Welch, E. C. Theil, and Beard, J. L. (2003). Women with low iron stores absorb iron from soybeans. *The American Journal of Clinical Nutrition* **77:** 180–184.

Ngalamu, T., M. Ashraf and S. Meseka (2013). Soybean (Glycine max L) genotype and environment interaction effect on yield and other related traits. *American Journal of Experimental Agriculture* **3**(4):977-987. http://dx.doi.org/10.9734/AJEA/2013/5069

Raja, J., Punoo, H.A. and Farooq A.M. (2014). Comparative Study of Soy Paneer Prepared from Soymilk, Blends of Soymilk and Skimmed Milk. *Journal of Food Processing & Technology* **5**:301

Ramakrishna, V., Rani, P. J. and Rao, P. R. 2006. AntiNutritional factors during germination in Indian bean (Dolichos lablab L.) seeds. *World Journal of Dairy and Food Sciences* 1: 6-11.

Rampim, L., Lima, P.R., Lana, M.D.C., Rosset, J.S., Sarto, M.V.M., Borsoi, A., Mattei, D., Molin, P.V.D., Ohland, T. (2016). Poultry Deep-Litter And Mineral Fertilizer As A Source Of N-P-K In The Culture of Wheat and Soybean. *Gl. Sci Technol.*, **9**(3):163 – 171

Ramteke, R., Kumarm, V., Murlidharan, P., Agarwal, D.K. (2010). Study on genetic variability and traits interrelationship among released soybean varieties in India [*Glycine max* (L.) Merrill] Elect. *J Plant Breeding.*, **1**:1483–1487.

Rao, M.S.S., B.G. Mullinix, Rangappa, M. Cebert, E., Bhagsari, A.S., Sapra, V.T., Joshi, J. M. and Dadson, R.B. (2002). Genotype x Environmental Interactions and yield stability of food grade soybean genotypes. *Agronomy Journal* **94**: pp 72-80. http://dx.doi.org/10.2134/agronj2002.0072

Rehenuma, T., Saiful Islam, A.F.M., Rahman, M.M., Fakhrul, I.M. (2015) Morpho-Physiological Features and Yield Attributes of Soybean Genotypes in Acid Soil. Res. J. Agric. & Biol. Sci., ***11**(1): 11-20*

Rigo, A.A., Dahmer, A.M., Steffens, C. and Steffens, J. (2015). Characterization of Soybean Cultivars Genetically Improved for Human Consumption. *International Journal of Food Engineering* **1**(1): 1-7

Roy, F., Boye, J. I. and Simpson, B. K. 2010. Bioactive proteins and peptides in pulse crops: Pea, chickpea and lentil. *Food Research International* 43: 432-442.

Sepanlo, N., Talebi, R., Rokhzadi, A., Mohammadi, H. (2014). Morphological and physiological behavior in soybean (Glycine max) genotypes to drought stress implemented at pre- and post-anthesis stages. *Acta Biologica Szegediensis*., **58**(2):109-113

Sharma, S., Goyal, R. and Barwal, S. (2013). Domestic processing effects on physicochemical, nutritional and anti-nutritional attributes in soybean (*Glycine max* L. Merill). *International Food Research Journal* **20**(6): 3203-3209

Sharma, S., Kaur, M., Goyal, R. and Gill, B. S. (2011). Physical characteristics and nutritional composition of some new soybean (*Glycine max* (L.) Merrill) genotypes, *Journal of Food Science and Technology*. DOI 10.1007/s13197-011-0517- 7.

Sharma, S., Saxena, A. K., Gill, B. S. and Dhillon, S. K. (2008). Identification of soybean [Glycine max (L.) Merrill] genotypes with superior quality traits and their correlations with oil and protein. *Indian J. Genet.,* **68**(3): 265-268

Sharma, S., Kaur, M., Goyal, R. and Gill, B. S. (2014). Physical characteristics and nutritional composition of some new soybean (*Glycine max* (L.) Merrill) genotypes. *J. Food Sci. Tech.*, **51**(3): 551–557.

Suppavorasatit, I., Lee, S. Y., & Cadwallader, K. R. (2013). Effect of enzymatic protein deamidation on protein solubility and flavor binding properties of soymilk. *Journal of Food Science* **78**, C1–C7.

Terhaag, M. M., Almeida, M. B., & Benassi, M. D. T. (2013). Soymilk plain beverages: Correlation between acceptability and physical and chemical characteristics. *Food Science and Technology (Campinas)*, **33**:387–394.

Tharise, N.,Julianti, E. and Nurminah, M. (2014). Evaluation of physico-chemical and functional properties of composite flour from cassava, rice, potato, soybean and xanthan gum as alternative of wheat flour. *International Food Research Journal* **21**(4): 1641-1649

Vasconcelos, M.W., Thomas, E., Clemente and Grusak, M.A. (2014). Evaluation of constitutive iron reductase (*AtFRO2*) expression on mineral accumulation and distribution in soybean (*Glycine max*. L). Front. Plant Sci.,https://doi.org/10.3389/fpls.2014.00112

Wrick,K. (2003)The U.S. market – an update and outlook. Nutraceuticals World, **22**:36–40

Yuan, D.B. Yang , X.Q., Tang, C.H., Zheng, Z.X., Wei-Min, Ahmad, I., Yin, S.W. (2009). Physicochemical and functional properties of acidic and basic polypeptides of soy glycinin. *Food Research International* **42**(5–6):700–706