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

BY

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DEPARTMENT OF BIOCHEMISTRY

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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 **MOHAMMAD HAFIZUR RAHMAN** bearing **Registration No. 10-04196** 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
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ABSTRACT

Six varieties of Soybean were analysed to evaluate the effects of genotypes on physico-chemical characteristics. Raw soybean genotypes exhibited oil content (13.32- 17.17%) and palmitic (7.40- 10.89%), stearic (2.52- 3.78%), arachidic (0.07- 0.43%), behenic (0.31- 0.62%) as saturated fatty acids and palmitolic (0.05-0.13%), oleic (7.13-29.05%), linoleic (26.49-165.4%), linolenic (4.84-8.96%) as unsaturated fatty acids. The major minerals were observed the various ranges namely Ca (1.23-1.97%), Mg (0.66-0.77%), K (1.19-1.48%), N (5.99-6.80%), P (0.73-0.94%), S (0.26-0.33%) among the varieties. And the minor minerals were B (13.56-17.40ppm), Cu (6.36-6.88ppm), Fe (106.7-162.8ppm), Mn (68.27-103.1ppm) and Zn (98.32-65.95ppm). In comparison to the physico-chemical characteristics, Shohag contained maximum amount of oil and Bangladesh Soybean-4 was the best for total percentage of unsaturated fatty acids, whereas Shohag was the good source of total saturated fatty acid. Most of the varieties found that the major and minor minerals were more or less significantly difference among the varieties.

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CHAPTER I
INTRODUCTION

Being one of the most important cash oil crops*,* soybean [*Glycine max* (L.) Merrill] is widely planted. Soybean is a legume increasingly consumed for economical and nutritional reasons (Steinke, 1992; Henley *et al.,* 1993; Garcia *et al.,* 1997a; Garcia *et al.,* 1997b). In fact, soybean products are an important low-cost source of proteins, minerals, phosphorus and vitamins. Furthermore, soybean products play an important role in health (Messina and Barnes, 1991; Messina, 1995; Sirtori *et al.,* 1995). The intake of soybean is not only suitable for people with allergenic reactions caused by animal milk, but it is also recommended to prevent heart disease, obesity, hypercholesterolemia, cancer, diabetes, kidney disease, and osteoporosis. These reasons have promoted the recent appearance of numerous products derived from soybean such as soybean flour, textured soybean, soybean dairy-like products, meat, bakery products prepared with soybean etc., in order to facilitate its consumption and to improve its flavour (Wang and Ascheri, 1991; Ishii and Yamagucho, 1992; Ladodo and Borovik, 1992). However, there is not much information about the nutritional value of soybean once it has been transformed into one of these products.

Soybeans have become one of the strategic commodities after rice and corn. Domestic soybean demand continues to increase, but domestic soybean production has not been able to offset demand growth. Efforts to improve the production of national soybean could be pursued with three approaches: increased productivity, the increased intensity cropping and the expansion of acreage land cropping into sub optimal. Sub optimal land covering dry land, tidal land and rainfed land. The problems faced in soybean cultivation in dry land among others are less fertile land, drought because the rainfall erratic, the use of local varieties (not superior varieties), weeds, disorder pests and plant diseases (Arsyad *et al*. 2007; Rachman *et al*. 2007). According to Sopandie, 2006; Akande *et al.*,2007), the development of plants on marginal land (sub optimal) very requires an understanding of the mechanism that role in increasing the potential outcome (with potential yield) and adaptation plants against various abiotic environmental stresses.

Moreover, soybean protein is a typical raw material used for the production of imitational products, such as cheese-like products with similar tastes and textures. Traditionally fermented cheese is produced with milk protein, which is concentrated and fermented by lactic acid bacteria or fungi, and has been developed in western countries, providing indigenous flavor, taste and textural properties (Kim and Shin, 1971). Generally, various cheeses are classified based on the region of production, raw materials used and aging method. Fermented cheese has superior nutritional and storage properties and is a popular representative fermented food in western regions (Yang, 2009). Soybean contains approx 40-45% protein and 18-22% oil (Goyal *et al*., 2012) and is a rich source of vitamins and minerals. 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; Azadbakht *et al.,* 2003).

However, Soybean is one of the protein source most used in the world. However, its organoleptic characteristics are not well accepted for human consumption (Chen and Buss, 2004). Therefore, the development of soybean cultivars more suitable for food utilization is important to attend the demand of the niche market that requires special cultivars with better quality characteristics (Carrão-Panizzi *et al.,* 2012). The soybean protein is the only vegetal protein that contains all the essential amino acids that support growth and maintenance of an organism, according to the World Health Organization (Carrão-Panizzi and Silva, 2011). Solubility of the soybean proteins is also an important property, because it defines the adequate utilization of in food processing. Functional properties, as foaming, emulsification and gelification, are affected by the protein solubility (Villalva, 2008; Mcklem, 2002; Fennema *et al.*, 2010).

In order to perform the research, the experiment has been undertaken with the following objectives-

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

CHAPTER I I

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.

Antony *et al.* (2016) proved that the percentage of phospholipids in oil and lecithin is decreased by 1.02% and 8.08%, respectively under saline cultivation. The phospholipids of the lecithin were qualitatively identified by thin-layer chromatography (TLC) and high performance of liquid chromatography (HPLC). The Rf values for phosphatidyl-ethanolamine (PE), phosphatidyl-serine (PS), phosphatidyl-inositol (PI) and phosphatidyl-choline (PC) of samples were well related to the standard. HPLC spectrum is well resolved and the retention time (RT) is correlated the standard with high precision. Quantisation of phospholipids shows a variation in the average percentage of PC, PI, PS and PE as 17.925, 9.125, 5.9, 15.1 for saline cultivation and 22.25, 12.025, 8.525, 18.975 for non-saline cultivation. Average decrease in the percentage in saline cultivation is due to the total salinity and ionic (Na+Cl-) stress of water.

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.

Rampim *et al.* (2016) evaluated 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.

Kuswantoro *et al.* (2016) performed a research with 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. A randomized complete blocks design with three replications was applied in this study. Results showed that interaction between the genotypes and the environments was found on five characters of seven observed characters. 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 (20 μM) and sodium nitroprusside (500 μM), 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.

Buta and Emire (2015) studied the effects of fermentation on quality protein maize (QPM) and soybean blends with respect to the nutritional quality including physico-chemical and functional properties; microbiological and sensory analyses, minerals and antinutrients composition. Quality protein maize-soybean blend flours were fermented for 24 and 48 hrs by natural and controlled fermentations. In contrary concentration of tannins and phytate were reduced significantly due to the fermentation process. Micronutrients increment in (mg/100 g) for P, Fe and Zn was 32.57 to 61.9; 3.98 to 7.20 and 2.61 to 4.21; respectively were revealed. Fermentation significantly ($p<0.05$) decreased the antinutrients which resulted a significant increase in micronutrients. Microbiological result revealed significant reduction of undesirable coliform count and increment of LAB with increase in fermentation time. Sensory quality result showed that gruel prepared from the fermented blended flours at 24 hrs of fermentation time and <250 μm particle size was found acceptable.

Mudlagiri *et al.* (2015) showed that applications of Cu, Zn, B and Mo increased three unrolled trifoliate leaves Cu, Zn, B by 26.5%, 13.8%, 113% and Mo increased to 179 mg/kg, respectively in the leaves. Also, the application of "Cu, Zn, B and Mo increased Cu, Zn, B by 55.5%, 8.2%, 28.6% and Mo increased to 202 mg/kg" respectively in soybean seeds. Application of Mn had no direct effect on increasing Mn either in leaves or in seeds, however, Mn and Mn + CA treatment affected other mineral contents. Application of Cu, Zn, Mo, B and CA increased macro-nutrients K, N, P, Mg, and S. Irrespective of the applications, the nutrient increase trend in seed was Na > Fe > Zn > Mn > B > Cu > Mo. However, Mo application resulted in the following seed nutrient accumulation pattern: Na > Mo > Fe > Zn > Mn > B > Cu. This may suggest that Mo had higher mobility to seeds than other micro-nutrients. Combination of soil application of Mo + CA increased Mo in leaves at V3 stage; however, Mo + CA soil application during pod-filling stage had no significant effects on Mo accumulation in seeds. The current research showed that some micro-nutrient application with the chelating agent CA could increase seed nutrients. Since these results are conducted under greenhouse experiments, further research under field conditions is needed before conclusive recommendations are made.

Keino *et al.* (2015) observed interveinal leaf yellowing in Mg omission and N addition and dark green leaves in P omission. Nutrients omission resulted in their significantly low concentration in plant tissues than the complete treatment. Significantly ($P \leq 0.05$) lower shoot dry weights (SDWs) than the complete treatment were obtained in different treatments; omission of K and Mg in Masaba and Shikhulu, Mg in Khwisero, K in Butere and, P, Mg and K in Butula. Nitrogen significantly improved SDWs in soils from Kakamega and Butula. Liming significantly raised soil pH by 9, 13 and 11% from 4.65, 4.91 and 4.99 in soils from Masaba, Butere and Butula respectively and soybean SDWs in soils from Butere. The results show that, poor soybean growth was due to K, Mg and P limitation and low pH in some soils. The results also signify necessity of application of small quantities of N for initial soybean use.

Rigo *et al.* (2015) evaluated 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.

Tharise *et al.* (2014) examined with 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.

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.

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’).

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.

Hossain and Mazen (2010) conducted to produce biodiesel from waste oils to reduce the waste and pollutions. Several important variables such as volumetric ratio, catalyst types and concentration were selected to obtain a high quality biodiesel fuel with the specification of American Standard for Biodiesel Testing Materials (ASTM D 6751) and European Norm (EN 14214). The highest biodiesel yield was obtained (68.5%) under conditions of 3:1 oil-to-methanol molar ratio, 0.5% NaOH catalyst at 55º C reaction temperature and 250 rpm stirring speed. The results showed that biodiesel production from different oil to methanol molar ratio, catalyst types and concentrations exhibited considerable differences. Biodiesel yield was higher in NaOH than in KOH while used 0.5% as catalyst and the highest yield was obtained having 1% NaOH compared to 0.5 and 1.5% NaOH.. There was little difference in viscosity, acid value and chemical elements (Fe, Mg, Ca, Na, P etc.) at different parameters. The research investigated that biodiesel could be obtained under optimum conditions and catalyst concentrations from completely waste oil which considered as recycled of waste cooking oil.

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.

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-1 and BINA Soybean-3 were selected for the study. The seeds were collected from the Department of Biochemistry of SAU (Sher-e-Bangla Agricultural University). 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 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

3.1.3 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.

3.1.4 BARI Soybean-5

BARI Soybean-5 was released in 2002. The plant height ranges from 40-60 cm. Hundred seed 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.

3.1.5 BINA Soybean-1

BINA Soybean-1 is moderately resistant to yellow mosaic virus (YMV) and tolerant to stem rot disease released in 2011.The plant is shorter in height, deep green leaflet and light yellow seed coat color. This variety can be grown both Kharif (Mid July) and Rabi (Mid January) seasons. Maturity period ranges from 105-110 days. In can be grown in wide ranges of land and soil types from sandy to loam soils. It can produce seed yield of 3.0-3.3 t/ha. The seed contains 44.5% protein, 27.0% starch and 19.0% 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-3

BINA Soybean-3 is released in 2013. The plant height ranges from 71.6-71.8cm. Maturity period ranges from 109-116 days. Brighter yellow seed coat color. It is resistant to yellow mosaic virus (YMV) and collar rot diseases. 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) =

Wt. of thimble and sample before extraction-Wt. of thimble and sample before extraction
--x 100
Wt. of sample before extraction

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^{0}c) 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^{0}c and detector temperature was 250^{0}c and held for 0.5 min. and increased at the rate of 10^{0}c/min to 250^{0}c. Then it held for 15 mins 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 400 mL water were mixed in 1L volumetric flask and 150 mL conc. H_2SO_4 was added then it was allowed to cool.
2. Ammonium molybdate (7.5gm) 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 100mL 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 for Ca and Mg P 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 foe S determination

Mixed acid seed solution

65 mL of HNO_3 and 250 mL glacial acetic acid were added to about 500 mL of water. 3 mL of 1000 ppm S standard solutionwas 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 : 2 µg Cu/mL, 10µg Fe/mL, 4µg Mn/mL, 2 µg Zn/mL.
2. The P, K and N were prepared together in water with high concentration was follows : 20µg P/mL, 100µg K/mL, 40 µg N/mL.

3. S was prepared in the same solution with the high concentration as follows: 20 μg S/mL
4. Ca and Mg were prepared in the same solution with the high concentration as follows : 100μg Ca/mL, 40μg Mg/mL

d. Digestion solution

1. Nitric-perchloric solution

Conc. Perchloric acid (100 mL) was added to 5oo mL 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 500 mL boiling flask. 5 mL 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 15 mL 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, 1 mL aliquot was taken from filtrate and 19 mL of water (dilution 1) was added. The other dilutions were made in the following order. For N, P and K determination, 1 mL aliquot from dilution 1, 9 mL of water and 10 mL of color reagent were mixed together. It was allowed to stand about 20 minutes and reading was taken of spectrophotometer at 680 nm.

For S determination, 7 mL of aliquot from dilution 1, 9 mL of acid seed solution and 4 mL 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 2 cm light path. For Ca and Mg determination, 1 mL aliquot from dilution 1, 9 mL of water and 10 mL 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 bt F variance tes. The mean difference 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

There are many factors are involved in oil content of soybean such as-genetic factors, agro-ecological conditions including cultivation sites and crop management system etc. And it also varied form variety to variety.. The oil content of different varieties were extracted by petroleum ether (40-60^{0}c) varied from 13.32 to 17.17% (Table). Highest amount of oil content variety was Shohag (17.17%); followed by Bangladesh Soybena-4 (17.09%), BARI soybean-5 (16.86%) and BARI soybean-6 (16.44%). The variety BINA Soybean-3 has the lowest amount of oil (13.32%) and then BINA Soybean-1 (15.83%). In case of Bragg genotype contained 20.6% of oil (Sharma *et al.*, 2008). The two natto cultivars had average oil contents of 17.4 and 16.2%, respectively (Brown, 2006). The maximum and minimum content of oil ranged 20.7-22.2% (Sharma *et al.*, 2013). The results clearly indicated that the two varieties Shohag and Bangladesh Soybena-4 can be considered as the better source of oil. Even BARI soybean-5 and BARI soybean-6 can be used as a good source of oil. Genotypes 'SL 688' and 'SL 869' recorded the maximum (18.7%) and minimum (14.0%) amount of oil respectively. 'SL 869' and 'SL 831' contained significantly lower oil content as compared to other genotypes (Sharma *et al.*, 2014). These variation might be due to biological factor, environment factor, soil and also crop management practices.

From the present investigation, it can be decided that all the selected varieties of Soybean in our country can be a better source of oil from Soybean.

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

VARIETIES	OIL (%)
Bangladesh Soybean-4	17.09 a
BARI Soybean-6	16.44 b
Shohag	17.17 a
BARI Soybean-5	16.86 ab
BINA Soybean-1	15.83 c
BINA Soybean-3	13.32 d
CV (%)	12.19

4.3 Chemical characteristics of Soybean varieties

4.3.1 Fatty acid composition

Comparison of Gas chromatography results are demonstrated in Table..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 (10.89%) variety; followed by Shohag (10.23%) and Bangladesh Soybean-4 (10.71%), BINA soybean- 2 (10.34%), Shohag (9.74%) and Bangladesh soybean-4 (9.63%). The lowest amount of palmitic acid content was found in BINA soybean-3 (7.40%) variety. The concentration of stearic cid varied from Shohag (3.78%) to BARI Soybean-6 (2.52%), whereas arachide acid contents ranged from 0.426% to 0.073% in Shohag and BINA soybean-3, respectively. Bangladesh Soybean-4 variety contained the highest (0.616%) amount of behenic acid; followed by BARI Soybean-6 (0.55%), BARI Soybean-5 (0.54%) and BINA Soybean-3 (0.33%) 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%). Mizuno and Yamada (2006) observed slight increases in palmitic and stearic acid contents during sprouting.

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	9.630 abc	3.170 bc	0.1113 bc	0.6167 a
BARI Soybean-6	8.677 cd	2.523 d	0.1530 b	0.5567 b
Shohag	10.23 ab	3.783 a	0.4263 a	0.3927 c
BARI Soybean-5	10.89 a	3.153 bc	0.1490 b	0.5400 b
BINA soybean-1	9.283 bc	3.637 ab	0.09970bc	0.3067 e
BINA soybean-3	7.400 d	2.993 cd	0.07367c	0.3383 d
CV (%)	17.42	29.46	132.94	94.51

4.3.1.2 Unsaturated fatty acid composition

There were 4 unsaturated fatty acid compounds found during work in laboratory. BINA Soybean-1 contained highest amount (0.132%) of palmitolic acid; followed by Shohag (0.093%). The lowest amount of this acid found in BARI Soybean-5 (0.052%). Oleic acid contained highest amount in BARI soybean- 5 (29.05%) and Shohag (29.05%). Maximum oleic acid content (30.4 mg 100 g^{-1} oil) was recorded in genotype 'SL 525'. (Sharma *et al.*, 2014). The lowest amount of oleic acid found in BINA Soybean-3 (7.13%). Mizuno and Yamada (2006) observed slight increases in oleic acid contents during sprouting.

The linoleic acid content varied 26.49 to 165.42%. The maximum amount of linoleic acid content was in Shohag and the minimum was BINA Soybean-3. And the highest amount of linolenic acid observed in BARI Soybean-6 (09.457%) and the lowest was BARI Soybean-5 (4.87%) varieties. Mizuno and Yamada (2006) observed linolenic acid (ALA) decreases contents during sprouting. 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/saturated fatty acid.

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	0.0693 c	17.43 bc	52.91 b	8.960 a
BARI Soybean-6	0.09367 b	16.06 c	52.71 b	8.863 a
Shohag	0.09833 b	29.05 a	165.4 a	4.847 d
BARI Soybean-5	0.05200 c	29.05 a	41.78 d	4.877 d
BINA soybean-1	0.1327 a	18.22 b	44.54 c	7.903 b
BINA soybean-3	0.06200 c	7.133 d	26.49 e	6.993 c
CV (%)	102.46%	11.46	134.14	15.26

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

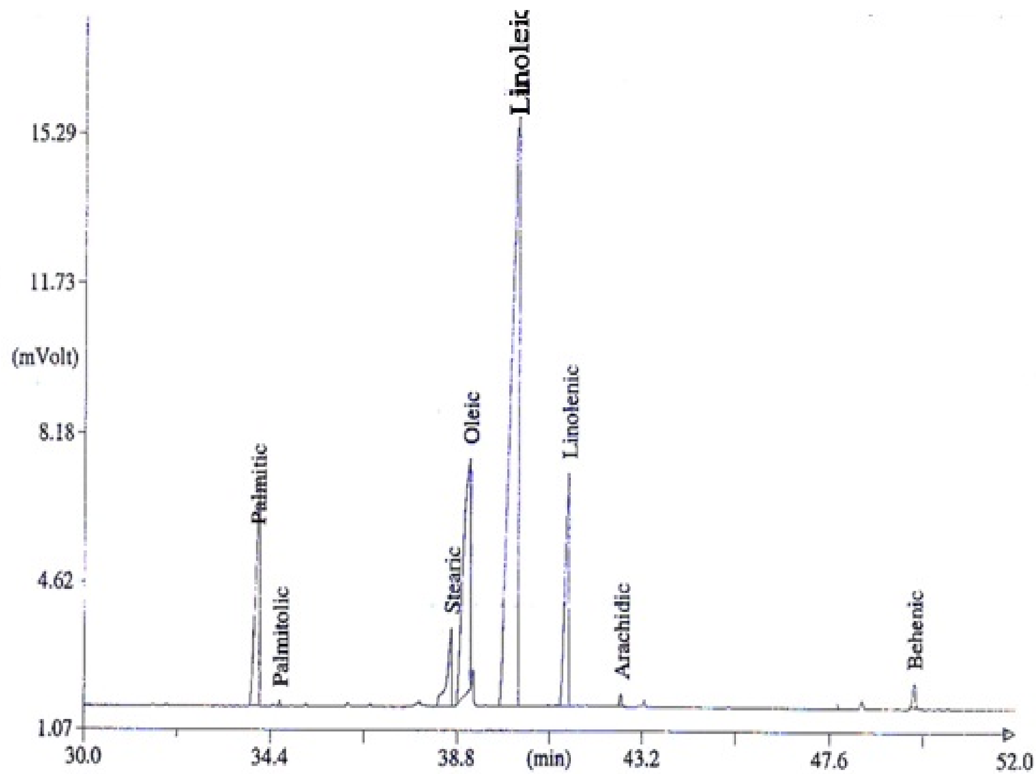

Fig. 2. Fatty Acid Composition of Bangladesh Soybean-4 (*Glycine max* (L.)

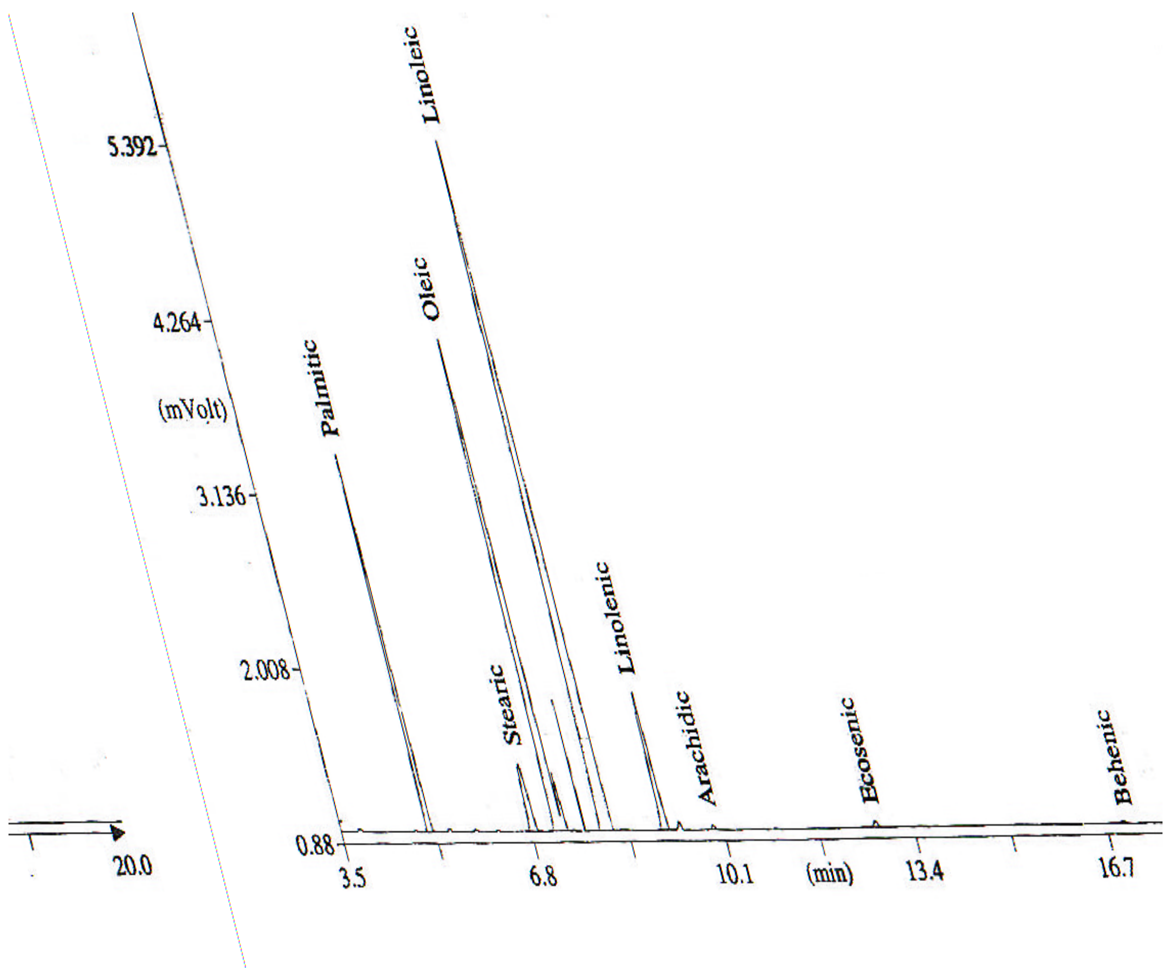

Fig. 3. Fatty Acid Composition of BARI Soybean-6 (*Glycine max* (L.)

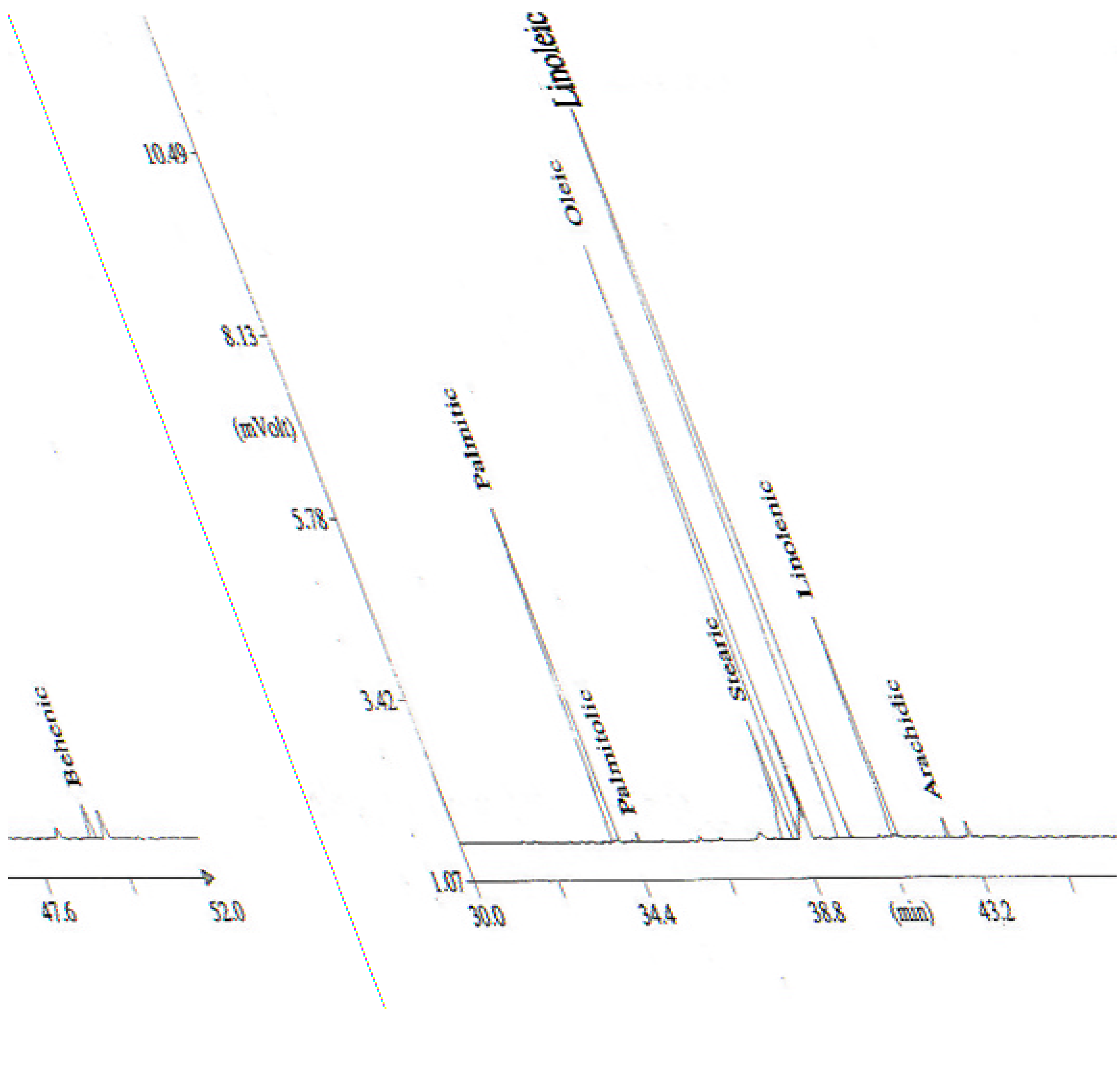

Fig. 4. Fatty Acid Composition of Shohag (*Glycine max* (L.)

4.4 Minerals

Different major and minor minerals were analysed in this research work. The amount of minerals content of soybean have been illustrated in Table.

4.4.1 Major minerals

4.4.1.1 Calcium (Ca)

Calcium (Ca) content of different varieties of soybean ranged from 1.23 to 1.303%. The highest amount of Calcium content was observed in BARI Soybean-6 (1.303%); followed by BINA soybean-1 (1.297%), Shohag (1.297%), BARI Soybean-5 (1.29%) and BINA soybean-3 (1.283%), respectively. The lowest amount of Calcium content was found in Bangladesh Soybean-4 (1.23. The average Calcium content (2.62%) was found in Soybean cultivars (Hany, 2011).

From the present investigation, though the selected varieties contained less amount of Ca than the varieties of Croatia but it might be alternative source of Ca in our country.

4.4.1.2 Magnesium (Mg)

Magnesium (Mg) content of different varieties of soybean varied from 0.66 to 0.77%. The highest amount of Magnesium content was observed in BINA Soybean-1 (0.77%); followed by BARI soybean-6 (0.759%), Shohag (0.754%), respectively. The lowest amount of Magnesium content was found in Bangladesh Soybean-4 (0.66%) and BARI Soybean-5 (0.70%) varieties. Hanny (2011) found that the average Mg content of soybean cultivars was 2.80%.

4.4.1.3 Potassium (K)

The highest and the lowest amount of Potassium content were observed in BARI Soybean-6 (1.483%) and Bangladesh Soybean-4 (1.19%), respectively. And the nearest highest amount of Potassium content found in BARI Soybean-5 (1.37%) and BINA Soybean-3 (1.31%). The nearest lowest amount of Potassium observed in BARI Soybean-6 (1.23%) and Shohag (1.24%) varieties. Hany (2011) found that the average K content of soybean was 5.8%. 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	1.230 c	0.6647 e	1.195 d
BARI Soybean-6	1.303 a	0.7593 b	1.237 cd
Shohag	1.297 ab	0.7547 bc	1.249 cd
BARI Soybean-5	1.290 ab	0.7487 d	1.376 b
BINA soybean-1	1.297 ab	0.7707 a	1.483 a
BINA soybean-3	1.283 b	0.7507 cd	1.313 bc
CV (%)	2.61	9.24	11.25

4.4.1.4 Nitrogen (N)

Nitrogen (N) content of different varieties of soybean was ranged from 5.99 to 6.807 7.05%. The highest amount of Nitrogen content was observed in BARI Soybean-6 (6.807%); followed by Shohag (6.73%) and BINA soybean-1 (6.25%). The lowest amount of Nitrogen content was found in BARI soybean-5 (5.99%).The nearest amount of Nitrogen found in Bangladesh soybean-4 (6.14%) and BINA Soybean-3 (6.24%) varieties.

4.4.1.5 Phosphorus (P)

Phosphorus (P) content of different varieties of soybean was varied from 0.72 to 0.949%. The highest amount of Nitrogen content was observed in BARI Soybean-6 (0.949%); followed by Shohag (0.84%), BINA soybean-1 (0.83%) and Bangladesh soybean-4 (0.82%). The lowest amount of Nitrogen content was found in BINA soybean-3 (0.72%) and BARI Soybean-5 (0.79%) varieties.

4.4.1.6 Sulfur (S)

The highest and the lowest amount of Sulfur (S) content of different varieties of soybean were 0.32 to 0.26%. The highest amount of Sulfur content was observed in BARI Soybean-5 (0.32%); followed by BINA soybean-1 (0.31%), BINA soybean-3 (0.308%) and Shohag (0.30%), respectively. The lowest amount of Sulfur content was found in BARI Soybean-6 (0.26%) and the nearest lowest amount was also observed in Bangladesh Soybean-4 (0.28%) varieties.

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

VARIETIES	N (%)	P (%)	S (%)
Bangladesh Soybean-4	6.143 bc	0.8240 bc	0.2857 c
BARI Soybean-6	6.807 a	0.9493 a	0.2640 d
Shohag	6.737 a	0.8453 b	0.3020 bc
BARI Soybean-5	5.993 c	0.7930 bc	0.3263 a
BINA soybean-1	6.250 b	0.8370 b	0.3170 ab
BINA soybean-3	6.243 b	0.7253 c	0.3080 ab
CV (%)	6.57	6.83	11.54

4.4.1.7 Protein

The highest and the lowest amount of protein content of different varieties of Soybean were 37.46 to 41.5%. The highest amount of Protein content was observed in Bangladesh Soybean-6 (41.5%); followed by Shohag (41.06%), BINA Soybean-1 (39.06%) and BINA Soybean-3 (39.02%), respectively. The lowest amount of protein content was found in BARI Soybean-5 (37.46%) and the nearest lowest amount was also observed in BARI Soybean-4 (38.37%) varieties

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

VARIETIES	Protein
Bangladesh Soybean-4	38.37 bc
BARI Soybean-6	41.5 a
Shohag	41.06 a
BARI Soybean-5	37.46 c

BINA soybean-1	39.06 b
BINA soybean-3	39.02 b
CV (%)	7.32

4.4.1.8 Crude Fiber (CF)

The highest and the lowest amount of crude fiber of different varieties of Soybean were 5.46 to 6.28%. The highest amount of crude fiber content was observed in Shohag (6.28%); followed by Bangladesh Soybean-6 (6.27%), BINA Soybean-3 (6.02%) and BINA Soybean-1 (5.96%), respectively. The lowest amount of crude fiber was found in BARI Soybean-5 (5.46%) and the nearest lowest amount was also observed in Bangladesh Soybean-4 (5.86%) varieties

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
BARI Soybean-6	6.27 a
Shohag	6.28 a

BARI Soybean-5	5.46 c
BINA soybean-1	5.96 b
BINA soybean-3	6.02 b
CV (%)	6.36

4.5 Minor minerals

4.5.1 Boron (B)

Boron (B) content of different varieties of soybean was ranged from 13.56 to 17.40ppm. The highest amount of Boron content was observed in BARI Soybean-6 (17.40ppm); followed by BINA soybean-3 (18.88ppm), Shohag (16.88ppm), and BINA soybean-1 (16.34ppm). The lowest amount of Boron content was found in Bangladesh soybean-4 (13.56ppm) and BARI soybean-5 contained 6.29ppm of Boron.

4.5.2 Copper (Cu)

The highest and the lowest amount of Copper (Cu) content of different varieties of soybean were 6.88 to 6.36ppm. The highest amount of Copper content was observed in BARI Soybean-5 (6.88ppm). The nearest highest amount were also found in Shohag (6.86ppm) and BINA soybean-3 (6.81ppm) varieties. The lowest amount of Copper content was found in BARI Soybean-6 (6.36ppm) and BINA soybean-1 (6.51ppm) varieties. The

BRS 267 and BRS257 genotypes contained 0.016 and 0.015ppm of Cu (Rigo *et al.*, 2015). As for metal ions, copper contents are minimal for all soybean products (12.00 mg/100g), 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).

4.5.3 Iron (Fe)

Iron (Fe) content of different varieties of soybean was ranged from 106.7 to162.80ppm. The highest amount of Iron content was observed in BARI Soybean-5 (162.80ppm); followed by BINA soybean-1 (156.90ppm) and BINA soybean-3 (151.50ppm. The lowest amount of Iron content was found in Bangladesh soybean-4 (106.70ppm) and BARI Soybean-6 (151.30ppm) varieties. The Fe content was found as the ranges from 1-3 ppm (Hammond *et al.*, 2005).

From the present study, it can be concluded that that the selected varieties contained the higher amount of Fe. So these varieties can be a better source of Fe in our country.

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	13.56 d	6.613 c	106.7 d
BARI Soybean-6	17.40 a	6.367 e	141.1 c
Shohag	16.88 b	6.860 ab	151.3 b
BARI Soybean-5	16.29 c	6.883 a	162.8 a
BINA soybean-1	16.34 c	6.517 d	156.9 ab
BINA soybean-3	16.88 b	6.813 b	151.5 b
CV (%)	3.14	2.83	2.47

4.5.4 Manganese (Mn)

The maximum and the minimum amount of Manganese (Mn) content of different varieties of soybean ranged from 68.27 to 103.10ppm. The highest amount of Manganese content was observed in Shohag (103.10ppm); followed by BARI Soybean-5 (97.46ppm), BINA soybean-1 (94.47ppm). Even the nearest highest amount also observed in BINA soybean-1 (94.47ppm). The lowest amount of Manganese content was found in Bangladesh soybean-4 (68.27ppm) and BINA soybean-3 (89.37ppm) varieties. The average Mn content was found 0.022 and 0.029ppm in BRS 267 and BRS257, respectively (Rigo *et al.*, 2015).

So, the he present investigation showed that the selected varieties of Soybean contained significant amount of Mn and these varieties can a great source of Mn in our country.

4.5.5 Zinc (Zn)

Zinc (Zn) content of different varieties of soybean ranged from 65.95 to 98.32ppm. The highest amount (98.32ppm) of Zinc content was observed in

Shohag and BARI Soybean-6 (97.71ppm). Even BARI Soybean-6 also contained 95.65ppm of Zinc. The lowest amount of Zinc content was found in Bangladesh soybean-4 (65.95ppm) and then BINA soybean-1 (84.17ppm) varieties. The average Zn content (76ppm) in Soybean was observed by Vasconcelos *et al.* (2014) in United States of America.

From the present study, it can be concluded that the selected varieties our country contained higher amount of Zn from USA. So, the selected varieties can a great source of Zn in 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	68.27 d	65.95 e
BARI Soybean-6	90.43 c	97.71 ab
Shohag	103.1 a	98.32 a
BARI Soybean-5	97.46 b	95.65 b
BINA soybean-1	94.47 bc	84.17 d
BINA soybean-3	89.37 c	87.38 c
CV (%)	3.23	2.19

CHAPTER V

SUMMARY AND CONCLUSION

Soybean are an important traditional crude oil containing vegetable foods in the world. Soybean as well as the soybean sprouts have high nutritional value and are easy to produce. Optimum consumption of sprouts can provide the recommended dietary allowance of protein, vitamins, amino acids and isoflavones. Due to these benefits, there is steady demand for soybean sprouts in the market. The production systems for soybeans in our country are generally characterized by use of non certified and non certified seeds obtained from local markets. Major constraints to soybean production are lack of improved seeds, drought, pests and diseases in both regions. Fortunately, Bangladesh released some varieties which are produced significant amount of yield against the stress and also resistant to yellow mosaic virus (YMV).

The highest amount of oil content varieties were Shohag, Bangladesh Soybean-4, Shohag, BARI Soybean-5 and also BARI Soybean-6, accordingly. BINA Soybean-1 and BINA Soybean-3 also contained nearest amount of oil. 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.

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. Statistically, 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.

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. 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. The information presented in this investigation about the physic-chemicals properties for the selected varieties of Soybean will be helpful for breeders and farmers, especially in variety selection and improvement.

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.

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