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Original Article

Physicochemical Characters of Oilseed from Selected Groundnut Genotypes

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ABSTRACT: Three varieties of groundnut seed were studied to evaluate their physicochemical characteristics such as seed weight, moisture, ash, carbohydrate, protein, fat, total energy, and minerals composition of oil and oil cake. Among the varieties the highest grain weight was found in BARI Chenabadam-7 (127.90 g) and the lowest thousand grain weight was found in BARI Chenabadam-8 (100.20 g). The moisture content was highest amount in case of BARI Chenabadam-9 (4.20 %); whereas BARI Chenabadam-7 (3.70 %) exhibited the lowest moisture content. The variety of BARI Chenabadam-9 contained significantly highest amount of oil (49.51 %) including 9.60 % of ash also highest in value, but the BARI Chenabadam-8 variety contained lowest amount of oil (49.15 %). In the study of protein amount largest quantity was obtained from BARI Chenabadam-8 (34.50 %) and the smallest quantity was obtained from BARI Chenabadam-9 (29.85 %). BARI Chenabadam-7 contained highest amount of carbohydrate (7.74 %), whereas BARI Chenabadam-8 contained the lowest amount of carbohydrate (2.55 %). Highest amount of Ca (2.58 %) Mg (0.73 %), N (5.52 %) and Fe (147.50 %) were in BARI Chenabadam-9 and only the amount of Zn (66.90 %) and Cu (14.04 %) were highest in value for BARI Chenabadam-8 and BARI Chenabadam-7 respectfully. BARI Chenabadam-8 sustained largest amount (18.41 %) of total saturated fatty acid (TSFA) and BARI Chenabadam-9 was responsible for the lowest (11.74 %). BARI Chenabadam-9 was also accounted for the highest content of total unsaturated fatty acid (TUSFA) (94.21 %), on the other hand BARI Chenabadam-8 was lowest (83.44 %) in amount for this parameter. But BARI Chenabadam-8 showed the highest saponification value (183.4) and lowest saponification value was obtained from BARI Chenabadam-9 (179.50). No uric acid was found in the varieties of groundnut. The result of this work confirms that the groundnut varieties seed would be of good quality and might be used for food production. The knowledge of this study could be utilized for various food formulations and for breeding selection purpose.

Keywords: *Groundnut, BARI Chenabadam, Grain Weight, Mineral Content, Fatty Acid, Saponification Value, Oil Content, and Iodine Value.*

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INTRODUCTION

Oilseed crops have occupied an important place in human nutrition as they remain the major sources of calories and proteins for a large proportion of the world population. Oilseeds are those seeds that contain considerably large amounts of oil. The most commonly known oilseeds (conventional oil seeds) are

groundnut, soybean, palm kernel, cotton seed, olive, sunflower seed, rapeseed, sesame seed, linseed, safflower seed, etc[1, 2]. Generally, oils and fats from seeds and nuts constitute an essential parts of man's diet. The chief importance of the vegetable oils lies in their food value. Vegetable oils derived from plant seeds have been playing vital roles to provide comfort in human lives in various aspects; they are essential in meeting global nutritional demands and are utilized for many foods and other industrial purposes[3]. In a balanced diet for human health 20-25 % of calories should come from fats and oils. Herbal oils are the main sources of fats and fat-soluble vitamins, which have a substantial role in the human diet[4]. After cereals, oily seeds are the second food sources throughout the world, whose oil is of rich fatty acid types[5].

Groundnut or peanut (*Arachishypogaea*), is a species in the legume family fabaceae, native to South America, Mexico and Central America[6]. Groundnuts have been known to man as an important food crop for many centuries. However, they acquired economic importance only 130 years ago and even as late as 60 years ago in the developed and developing countries[7]. China, India and USA are the main producers of groundnuts to the rest of the world[8]. In Bangladesh, groundnut (*Arachishypogaea L*) is the 2nd important oil seed crop next to mustard (*Brassica spp.)* on the basis of annual production, and it stands 3rd next to sesame (*Sesamumindicum L.*) on the basis of acreage among the major oil crops. Groundnut is grown mainly for its oil, protein, plant residue and seed cake. Being a legume crop, groundnut seed contain 44-56 % oil and 22-30 % protein on a dry seed basis and is a rich source of minerals (phosphorus, calcium, magnesium and potassium) and vitamins (E, K and B group)[9]. The nutritive value of food is high as the groundnut is affordable and serves as good source of oil and protein[10]. Groundnut oil is composed of mixed glycerides and contains a high proportion of unsaturated fatty acids, particularly oleic (50-65 %) and linoleic (18-30 %)[11]. Nuts are a good source of oil containing higher unsaturated fatty acids (UFAs) to saturated fatty acids (SFAs) ratio. Groundnut cake, a by-product of oil extraction, is an excellent livestock feed because of its high protein content. The haulms are excellent high protein hay for horses and ruminant livestock. The cake contains 45-60 % protein, 22-30 % carbohydrate, 3.8-7.5 % crude fiber, and 4-6 % minerals[12]. The oil of groundnut is one of the most important vegetable oil in regions where other oily vegetables cannot grow up[13, 14]. In our country fried or roasted groundnut is popular snacks.

The uses of groundnut are diverse; all parts of the plant can be used. The nut (kernel) is a rich source of edible oil; groundnut oil is used primarily for cooking, manufacture of margarine, shortening and soaps. Seeds are consumed directly either raw or roasted, chopped in confectioneries, or ground into peanut butter. Nonfood products such as soaps, medicines, cosmetics, pharmaceuticals, emulsions for insect control, lubricants and fuel for diesel engines can be made from groundnut.

In folk medicine, groundnut is used for aphrodisiac purposes, inflammation, cholecystosis, nephritis and decoagulant. In China the nuts are considered demulcent, pectoral, and peptic, the oil aperients and emollient, taken internally in milk for treating gonorrhoea, externally for treating rheumatism. In Zimbabwe the peanut is used in folk remedies for plantar warts. Haemostatic and vasoconstrictor activity are reported[15]. The alcoholic extract is said to affect isolated smooth muscles and frog hearts like acetylcholine. The alcoholic lipoid fraction of the seed is said to prevent haemophiliac tendencies and for the treatment of some blood disorders (mucorrhagia and arthritic haemorrhages) in haemophilia.

Oilseeds are critically needed in many developing countries where protein-energy malnutrition remains a major health hazard, especially among children. The protein quantity and quality, caloric value, and overall nutrient content of oilseeds are quite good. Some oil seed cultivars viz. BARI Chinabadam-7, BARI Chinabadam-8 and BARI Chinabadam-9 are widely cultivated throughout the country. If the nutritional status of oil seed is known, their consumption and multipurpose uses will be increased. The characteristics of oils from different sources depend mainly on their compositions and no oil from a single source can be suitable for all purposes thus the study of their constituents is important. Hence the physicochemical properties of these popular selected varieties was undertaken to ensure their nutritional status. The main purpose of our present study is to determine the oil content, protein, carbohydrate and minerals content of different genotypes groundnut seed.

MATERIAL AND METODS

***Materials and Measurement*:** The experiment was carried out at the Biochemistry laboratory of the Department of Biochemistry, Sher-*e*-Bangla Agricultural University, Dhaka, Bangladesh and Post Harves Technology Division BARI Joydebpur, Gazipur, Bangladesh. Three varieties of groundnut (*Arachishypogaea*) namely BARI Chenabadam-7 (Shells are round and medium in size, and seeds are light brown in color), BARI-Chenabadam-8 (shells are smooth and whitish in color and soft in nature and seeds are reddish brown in color) and BARI Chenabadam-9 (shells surface is slightly rough and shell's vine and sub vine are prominent and seeds are light brown in color) were collected from the Oilseeds Research Centre of BARI, Gazipur, Bangladesh. After cleaning seeds were sun dried and stored into plastic container in a cool place until used for the chemical analysis. The nutritive value of a food-grain is indicated by its composition shown by chemical analysis. The degree to which the chemical analysis indicates the nutritive value is dependent on the constituents determined. All the chemicals used were collected from Merck (Germany), Wako Pure Chemicals Industries Ltd. and JHD (China). These chemicals were used analytical and spectroscopic grade without further purification.

Determination of Physical Properties of Groundnut Varieties

Grain Weight: Grain weight was determined by randomly selecting thousand seed sample weighted by electric balance (KEY: JY-2003; China).

Moisture: Moisture content of groundnut sample was determined by a thermostat controlled oven. Empty aluminum moisture dish was weighted (W_1) and 2.5 g sample was taken in a moisture dish and weighted (W_2). The sample was spread evenly and placed without lid in oven and dried samples overnight at 100 ^oC temperature. The dishes were transferred to desiccators to cool. Aluminum dish was weighed after cooling (W_3). The percentage of the dry mater was then calculated by the following formula.

$$\% \text{ Moisture} = \frac{(W_2 - W_3)}{(W_2 - W_1)} \times 100$$

Determination of Ash: The samples were ignited at 600 ^oC temperature by muffle furnace (Nebertherm: Mod-L9/11/c6; Germany) to burn off all organic material. The inorganic material which does not volatilize at that temperature is called ash. The temperature of the muffle furnace was fixed to 600 ^oC and crucible was heated for 1h and transferred into desiccators; cooled them to room temperature and weighted (W_1). About 2 g sample was put into the crucible weighted (W_2). The sample was burned in a muffle furnace at 600 ^oC for about 2 h. The crucibles were transferred into the desiccator and cooled them to room temperature and weighted (W_3). It was done immediately to prevent moisture absorption. The incineration repeated until constant weight was obtained. The percentage of the ash was then calculated by the following formula[16].

$$\% \text{ Ash} = \frac{(W_3 - W_1)}{(W_2 - W_1)} \times 100$$

$W_2 - W_1$ = Weight of the Sample Taken
$W_3 - W_1$ = Weight of the Ash Obtained

Determination of Chemical Constant of Groundnut Varieties

Estimation of Fatty Acid Composition: Fatty acid composition was determined by gas-liquid chromatographic method[17]. About 12 mg of oil or equivalent amount of oil seeds was taken (seed was crushed in an oil paper and then transferred into a test tube). The sample was extracted and transesterified at the same time with 5 ml ethylated reagent (petroleum ether/0.02M sodium hydroxide in ethanol) and shacked. The samples were kept for overnight at room temperature. 10 ml salt solution (80 g NaCl and 3 g sodium hydrogen sulphate in 1 liter water) was added and shaked. As soon as the two layers were separated, the benzene phase was transferred to small test tubes. A Philips PU 4500 chromatograph instrument was used with flame ionization detector (FID). A glass column (1.5m x 4mm) was packed with BDS. With this column the injection post, column, and detector temperature was set at 220 ^oC, 185 ^oC, and 240 ^oC, respectively. Nitrogen flow (used as career gas) rate was 22 ml/min, the injection volume was 2 µl. Peak areas were measured with an electronic digital integrator (Shinadzu C-R6A chromatopac).

Saponification Value: At first, 2 g fat was taken in 250 ml round bottom flask and 25 ml, 0.5 N alcoholic potassium hydroxide solution added in same flask. The flask was fitted with a long air condenser and heated solution at reflux temperature about 30 minutes. Finally, the flask was cooled and added 1 ml of 1 % phenolphthalein solution and titrated with the excess of the alkali against standard 0.5 N HCl acid. At the same time and under similar conditions carried out a blank titration without fat (25 ml, 0.5 N same alcoholic KOH solution was taken in another round bottom flask and heated in a similar way and titrated, against 0.5 N acid). 1 ml of 0.5 N HCl acid was equivalent to 0.02805 g of KOH.

$$\text{Saponification value} = \frac{(b\text{-}a) \times 0.02805 \times 1000}{\text{Wt. of substance in g}}$$

Where
a = mL of 0.5 N acid required in sample solution titration
b = mL of 0.5 N acid required in blank solution titration

Iodine Value: 5 g of oil or fat was taken into 200 ml a glass stoppard bottle. 5 ml of CCl_4 was added to dissolve this oil after 25 ml of Wij's solution was added and to allow it at least 1 hour in a dark place. Then 5 ml of 10 % potassium iodide solution and 50 ml water were added to each bottle and titrated against 0.1 N $Na_2S_2O_3$ using starch solution as the indicator, near the end point of titration the color of solution became pale yellow. Blue color was disappeared which indicates the end point. At the same time and under similar conditions carried out a blank titration without oil or fat.

$$\text{Iodine value} = \frac{100}{\text{Wt. of oil}} \times 0.0127 \times (v_1\text{-}v_2)$$

Where
a = mL of 0.1 N $Na_2S_2O_3$ used in blank titration
b = mL of 0.1 N $Na_2S_2O_3$ used in the case of oil titration

Estimation of Carbohydrate: Total carbohydrate estimation method was described by Raghuramulu *et al*. 2003[18]. The content of the available carbohydrate was determined by the following equation:

$$\text{Carbohydrate} = 100\text{- [(Moisture + Protein + Ash + Oil/Fats) g/100g]}$$

Chemical Analyses

Estimation of Oils/Fats: The oil content was determined by the ether soluble extract method. Dried sample was weighed out into an extraction thimble. Weight of thimble and sample were recorded in laboratory book. The thimble was placed into the soxhlet. 100 ml ethyl ether was added to the soxhlet flask then it was connected to holder and condenser. Soxhlet flask was placed on hot plate and distilled at low temperature for 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 40 minutes the thimble was weighed out. The loss of weight was cured fat. The fat determined by the above procedure contains usual lipids including waxes pigments, certain gums and resins[19]. A better name for these constituents would be "ether soluble extract."

$$\text{\% Crude fats/Oil (on a dry weight basis)} = \frac{\text{Wt. of thimble \& sample before extraction - Wt. of thimble \& sample after}}{\text{Weight of sample before extraction}} \times 100$$

Estimation of Total Protein Content by Microkjeldhal Method: The protein content of food stuff is obtained by estimating the nitrogen content of the material and multiplying the nitrogen value by 5.5 (according to the fact that nitrogen constitutes on average 18 % of a protein molecule). The estimation of nitrogen is done by Kjeldhal method[20] which depends upon the fact that organic nitrogen when digested at 380 ^oC temperature with sulphuric acid in the presence of catalyst selenium oxide, mercury or copper sulfate is converted into ammonium sulphate[20]. Ammonia liberated by making the solution alkaline is distilled into a known volume of a standard acid which is then back titrated.

A known quantity of the finely ground sample (100 mg) weighted out in an Mkj digestion flask. About 2 g digestion mixture (100 g of potassium suphate (K_2SO_4) was thoroughly mixed with 20 g of copper sulfate ($CuSO_4.5H_2O$) and 2.5 g selenium dioxide (SeO_2) was added with it) was added with it 2 ml of concentrated sulphuric acid was dispensed into the flask. Then it was digested for about 2 hrs at 380 ^oC temperature in Mkj digestion set and was cooled the clear digest. The digest was dissolved in minimum amount of distilled water and carefully transferred to an Mkj distillation set 60 %, 10 ml of NaOH solution

was added and distilled it. The distillate was collected for 5 min into 4 %, 5 ml boric acid containing 2 drops of mixed indicator (methyl red and bromocresol green) in a 50 ml conical flask, till the color of solution was changed. The distillate was titrated against a standard 0.02 N HCl acid and noted the titer value:

$$N\,\% = \frac{(14.007) \times (\text{Normality of the Acid, } 0.02) \times (\text{Titer Volume})}{\text{Weight of Sample (mg)}} \times 100$$

Where 14.007 is the equivalent weight of nitrogen.

Nitrogen % is converted into protein by multiplying with a factor 5.5 for cereals and pulses:

$$\text{Crude Protein (\%)} = \%\ N \times 5.5$$

Estimation of Minerals

Mineral content was determined using Absorption Spectrophotometer.

Reagent for Ca and Mg Determination: 1% lanthanum solution: 59 g of lanthanum oxide (La_2O_3) were added with about 50 ml of water. Slowly and cautiously, 250 ml conc. HCl was added to dissolve the La_2O_3. It was made to 5 liters with water.

Preparation of Standards Solution: For convenience the Cu, Fe and Zn were prepared together in water. The high concentration for these elements was as follows: 2 µg Cu/ml, 10 µg Fe/ml, 4 µg, and 2 µg Zn/ml. Ca and Mg were prepared in the same solution with high concentrations as follows; 100 µg Ca/ml, 40 µg Mg/ml.

***Digestion Solution*:** Nitric-perchloric solution. Conc. perchloric acid (100 ml) was added to 500 ml concentrated HNO_3 to prepare nitric-perchloric solution.

Digestion of Oil seed Cake for Determination of Ca, Mg, Fe and Zn

Digestion Procedure: Weighted 500 g dry seed sample and put into a 50 ml boiling flask. 5 ml of nitric-perchloric solution was allowed on cool hot plate and turned temperature to 375 ^oC. It was allowed to digest for 1 hour and 30 minutes. The flask was removed from digestion chamber and was cooled and 15 ml water was added. The flask was agitated and heated to dissolve the ash and filter.

Analytical Procedure: By using a combination diluter-dispenser, 1 ml aliquot was taken from filtrate and 19 ml water (dilution 1) was added. The other dilutions were made in the following order. For P, K and Na 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 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 analyzed by absorption spectrophotometer. For Fe, Mn and Zn determination, the original filtrate was used to analyze these elements by absorption spectrophotometer.

Estimation of Energy

The chemical energy content of food ingredients is usually expressed in terms of heat units (since all forms of energy are convertible into heat energy). The gross food energy was estimated by multiplying the crude protein, crude fat, and total carbohydrate by at water factors 4, 9, and 4 respectively[21, 22].

Statistical Analysis

The recorded data for each character from the experiments was analyzed statistically to find out the variation resulting from experimental treatments using MSTAT package program. The mean for all the treatments were calculated and analysis of variance of characters under the study was performed by F variance test. The mean differences were evaluated by least significance difference test.

RESULTS AND DISCUSSION

Three varieties of groundnut seed were collected for the determination of physical and chemical characteristics.

Physical Characteristics of Groundnut Varieties

***Grain Weight**:* Weight of thousand grains of different released varieties of groundnut has been compared in Table-1. Seed weight varied with their size and shape. BARI Chenabadam-7 seed size is higher than the other two varieties of Chenabadam. Seed weights were determined at 13 % moisture level. Among different groundnut varieties highest thousand grain weights was found in BARI Chenabadam-7 (127.90 g), followed by BARI Chenabadam-6 (117.6 g), BARI Chenabadam-8 (100.20 g). Our present studies groundnut seed weight are consistent with the results reported by Chowdhury *et al*. (2010), who found that thousand groundnut seed weight varies from128.30 g to 66.76 g among different Bangladeshi groundnut verieties[23].

Table 1. Weight of 1000 seeds and moisture of different varies of groundnut oilseed varieties.

Name of the Varieties (Treatments)	Weight of 1000 Seeds (at 13% Moisture Level) (gm)	Moisture (%)
BARI Chenabadam-7	127.90 a	3.70 c
BARI Chenabadam-8	100.20 c	4.00 b
BARI Chenabadam-9	117.60 b	4.20 a
LSD $_{(0.05)}$	3.463	0.1897
CV (%)	1.33 %	2.18 %

Figure in a column followed by a common letter do not differ significantly at 5% level by DMRT

Moisture: Seeds have moisture content of above 18 % gets heating, is attacked by molds and insects. The moisture content of different released varieties of groundnut varieties moisture content was ranged from 3.70 % to 4.20 % (Table-1). The results of the moisture content were significantly lower than Ingale *et al.*, (2011) reported groundnut seed contains 5.53 % moisture[24]. Chowdhury *et al.*, (2015) found the range of moisture content of groundnut seed of 1.130 to 5.120 among different Bangladeshi groundnut varieties[25].

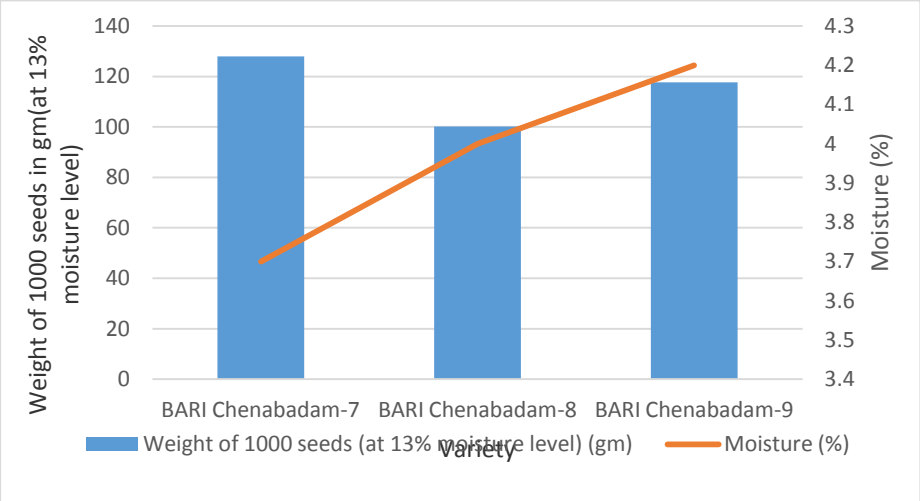

Figure 1. Relation between weight of 1000 seeds in gm (at 13 % moisture level) and moisture of different varieties of groundnut oilseed.

Oil Content: The oil content of different varieties of groundnut varied from 49.51 % to 49.15 % (Table 2). Groundnut varieties contain significantly higher amount of oil as compared to other oil seed varieties. Groundnut variety BARI Chenabadam-9 contained highest amount of 49.51 % of oil followed by BARI Chenabadan-7 (49.35 %), BARI Chenabadam-8 (49.15 %). The results clearly indicated that groundnut variety can be considered as better source of oil. Our present studies values of oil content of groundnut seed were supported by the reported values of Chowdhury *et al.*, (2015) and Asibuo *et al.*, (2008)[25, 26]. Chowdhury *et al.* (2015) found that percentage of oil content range from 50.76 % to 49.20 % whereas Asibuo *et al.*, (2008) found 49.70 %[25, 26]. These variations might be due to biological factor, environmental factor, soil and crop management practices.

Oil Cake: Oil cake/meals are used for various purposes. Oil cake is a nutritious food items for cattle and fish. It is also used as a good organic fertilizer and ingredient of composts. The BARI Chenabadam-8 contained significantly highest amount of oil cake (50.85 %), followed by BARI Chenabadam-7 (50.65 %) and BARI Chenabadam-9 (50.49 %) (Table 2). The present studies values of groundnut oil cake were supported by the reported values of Chowdhury *et al.*, (2014) and Appelqvist *et al.*, (1992)[27, 28]. Chowdhury *et al.*, (2014) found that percentage of oil cake range from 58.14 to 59.95 %[27].

Table 2. Proximate analysis of oil content, oil cake and dry wt. of cake of the different oilseed varieties.

Name of the Varieties (Treatments)	Oil Content (%)	Oil Cake (%)	Dry Wt. of Cake (%)
BARI Chenabadam-7	49.35 a	50.65 d	46.95 d
BARI Chenabadam-8	49.15 b	50.85 c	46.85 d
BARI Chenabadam-9	49.51 a	50.49 d	46.29 e
LSD $_{(0.05)}$	0.2041	0.2041	0.4025
CV (%)	0.37 %	0.36 %	0.76 %

Figure in a column followed by a common letter do not differ significantly at 5% level by DMRT

Dry Weight of Cake: Dry cakes are used to evaluate the content of different nutrient which are essential for our poultry feed, organic fertilizer and other various purposes. The highest value was obtained from BARI Chenabadam-7 (46.95 %), followed by Chenabadam-8 (46.85 %) and Chenabadam-9 (46.29 %) (Table 2).

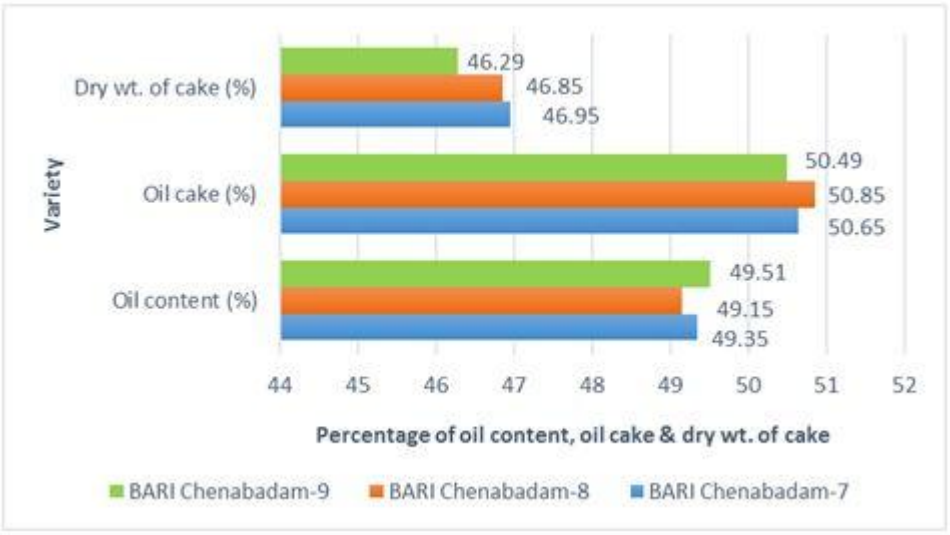

Figure 2. Relation between oil content, oil cake, and dry wt. of cake of different groundnut oilseed varieties.

Chemical Characteristics of Groundnut Varieties
Chemical Constant of Oil

Saponification Value: Saponification value of oil/fats refers to the number of mg of KOH required to saponify one gram of fats/oil. It is inversely proportionate to the molecular weight or chain length of the fatty acids present in the fats/oil. The range of saponification values have been presented in Table-3. The highest saponification value groundnut variety was found in BARI Chenabadam-8 (183.40), the lowest value was found in BARI Chenabadam-9 (179.50) and BARI Chenabadam-7 was found 182.00. These values are supported by Chowdhury *et al.*, (2014)[27]. Our present studies saponification values found in groundnut varieties are lower than the reported values of Khan *et al*. (2013), Martin *et al*., (1995) and Richet *et al*. (1987)[29- 31]. The present saponification values of groundnut varieties were approximately similar as Nkafamiya *et al.*, (2010) who found the range of saponification values from 179.50 ± 0.36 to 184.30 ± 0.20 in case of refined oil[32].

Iodine Value: Iodine value is defined as grams of iodine absorbed by 100 g fats/oil. It helps to estimate the degree of unsaturation. The iodine values of different varieties of groundnut varieties have been presented in Figure-3. Groundnut varieties have significantly higher iodine value than other oilseed varieties. The highest amount of iodine value were observed in BARI Chenabadam-9 (106.40), followed by BARI Chenabadam-7 (104.10), whereas the lowest iodine value was found in BARI Chenabadam-8 (101.30). The observed values were supported by the reported values of Chowdhury *et al*., (2015)[25]; Chowdhury *et al.*, *(*2014)[27]; Khan *et al*., (2013)[29]; Martin *et al*., (1995)[30]; and Richet *et al*., (1987)[31].

Table 3. Chemical constant of oil of different groundnut oilseed varieties.

Name of the Varieties (Treatment)	Saponification Value	Iodine Value
BARI Chenabadam-7	182.00 a	104.10 ab
BARI Chenabadam-8	183.40 a	101.30 b
BARI Chenabadam-9	179.50 b	106.40 a
LSD $_{(0.05)}$	2.236	2.890
CV (%)	1.09 %	2.46 %

Figure in a column followed by a common letter do not differ significantly at 5 % level by DMRT

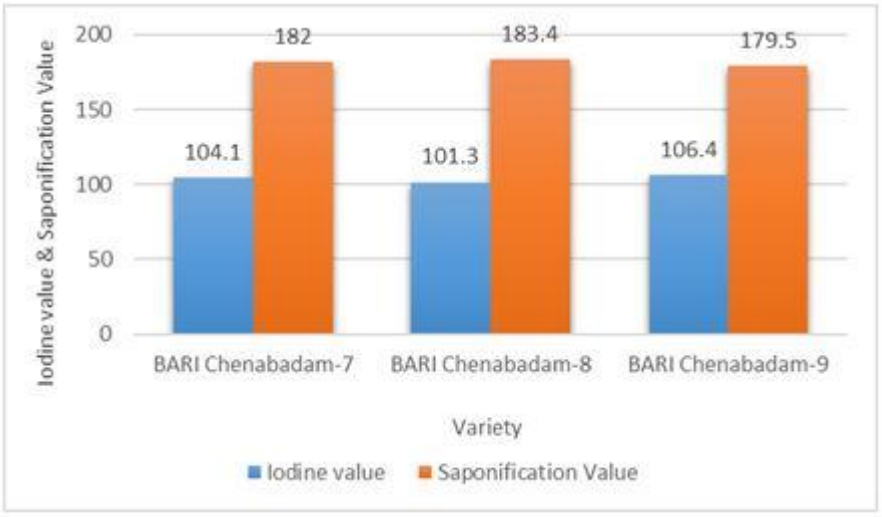

Figure 3. Saponification value and iodine value of oil of the different groundnut oilseed varieties.

Fatty Acid Composition: There was a significant difference between the studied of groundnut varieties in terms of their fatty acid composition (Table 4). Significantly the highest amount of palmitic acid was observed in BARI Chenabadam-8 (13.98 %); followed by BARI Chenabadam-7 (11.16%). Lowest amount of palmitic acid content was observed in BARI Chenabadam-9 (8.71 %). Highest amount of stearic acid content found in BARI Chenabadam-7 (2.79 %) and the lowest amount found in BARI Chenabadam-9 (2.41 %). BARI Chenabadam-6 contained the highest amount (62.94 %) of oleic acid followed by BARI Chenabadam-7 (60.76 %), BARI Chenabadam-8 (45.07 %). Highest amount of arachidic acid was found in BARI Chenabadam-8 (1.91 %); whereas lowest amount found in BARI Chenabadam-7 (0.42 %). Highest amount of linoleic acid contained was found in BARI Chenabadam-8 (36.10 %) which was significantly highest among all the varieties and lowest amount (13.49 %) was found BARI Chenabadam-7 (29.90 %). The linoleic acid content is important from the stand point of utilization of oil for food products. Differences were found between the varieties of groundnut and other oilseed in respect of linoleic acid and erucic acid content. Other oilseed varieties contained significant amount of erucic acid, whereas groundnut varieties contained no erucic acid. The concentration of linoleic acid varied from 0.240 % to 2.27 %. Analytical data indicated that the highest amount of total saturated fatty acid (TSFA) contained in BARI Chenabadam-8 (18.41 %) and the lowest amount contained BARI Chenabadam-9 (11.74 %). Highest amount of total unsaturated fatty acid (TUSFA) contained in BARI Chenabadam-9 (94.21 %) and lowest amount contained in BARI Chenabadam-8 (83.44%). The highest amount of gross energy found from BARI Chenabadam-7 (595.70 kcal/g; while lowest amount of gross energy recorded from BARI Chenabadam-8 (590.5 kcal/g). From the present data, it might be suggested that the groundnut oil seeds are suitable for edible purpose as they contained higher amount of protein, oil, and gross energy. Ingale *et al.*, (2011) reported that the major saturated fatty acid in groundnut seed oil was palmitic acid (6.20 %); the main unsaturated fatty acids were oleic acid (16.28 %), and linoleic acid (16.35 %)[24]. According to Chowdhury

et al., (2015) the range of total saturated fatty acid (TSFA) and unsaturated fatty acid among different Bangladeshi groundnut varieties are 10.92 % to 17.47 % and 81.13 % to 94.81 %[25].

Table 4. Fatty acid composition of the different groundnut oilseed varieties.

Name of the Varieties (Treatments)	Percentage of Fatty Acids						
	Saturated Fatty Acid (SFA)			Unsaturated Fatty Acid (USFA)			
	Palmitic Acid ($C_{16:0}$)	Stearic Acid ($C_{18:0}$)	Arachidc Acid ($C_{20:0}$)	Oleic Acid ($C_{18:1}$)	Linoleic Acid ($C_{18:2}$)	Linolenic Acid ($C_{18:3}$)	Erucic Acid ($C_{22:1}$)
BARI Chenabadam-7	11.16 b	2.79 a	0.42 c	60.76 b	29.90 c	0.24 c	0.00 a
BARI Chenabadam-8	13.98 a	2.52 b	1.91 a	45.07 c	36.10 a	2.27 a	0.00 a
BARI Chenabadam-9	8.71 c	2.41 c	0.62 b	62.94 a	30.17 b	1.10 b	0.00 a
LSD $_{(0.05)}$	2.984	0.2213	0.9152	11.03	3.965	1.153	0
CV (%)	23.37 %	7.60 %	82.24 %	17.33 %	10.93 %	84.68 %	0

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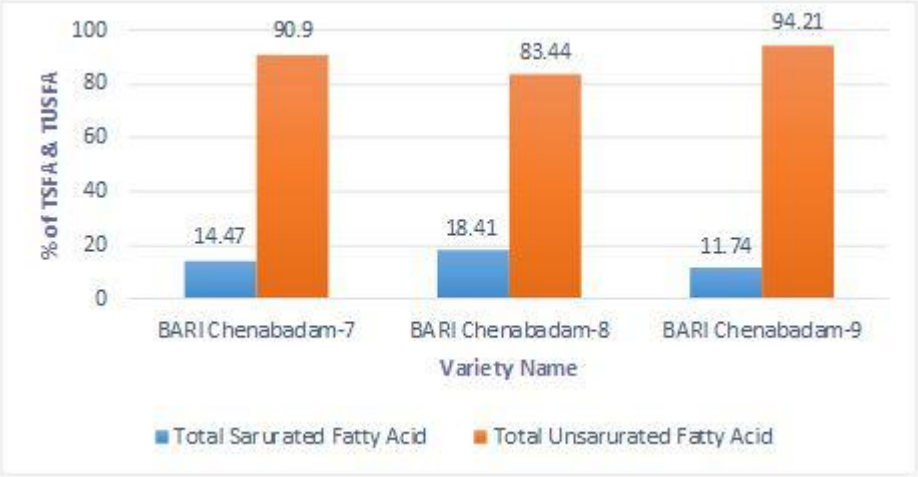

Figure 4. Percentage of total saturated and unsaturated fatty acid of oil of the different groundnut varieties of oilseed.

Analysis of Oil Cake

After extraction of oil the seeds gave the defatted cakes of varying amounts. The results of cake analysis were presented in Table 5.

Ash: Ash content of different released varieties of groundnut varieties were ranged from 9.06 % to 9.80 % (Table 5). BARI Chenabadam-8 contained the highest amount of ash (9.80 %) followed by BARI Chenabadam-6 (9.60 %), BARI Chenabadam-7 (9.06 %). Our studies values of groundnut verities were supported by the reported values of Chowdhury *et al.*, (2015) but significantly higher than the reported values of Abdulrazak *et al.*, (2014) and Ayoola *et al.*, (2012)[25, 33, 34].

Protein: Protein is the major nutrient components of different varieties groundnut. Protein content is genetically controlled. It is also influenced by nitrogen fertilizer application and agronomies practices. Significantly highest amount of protein was obtained from BARI Chenabadam-8 (34.50 %) and the lowest amount of protein content found in BARI Chenabadam-7 (30.15 %) (Table 5). These results are lower than those reported by many other authors Prapakornwiriya and Diosady (2004) determined the protein percentage from 45.0-34.0 and Sengupta *et al.*, (2003) revealed that protein content of her studies were ranges from 44.2-44.7 %[35, 36]. However these results are higher than the reported value of Ingale *et al.*, (2011); Asibuo *et al.*, (2008), and Ayoola *et al.*, (2012)[24, 26, 34].

Table 5. Proximate analysis of protein, ash, and carbohydrate content of the different oilseed varieties (dry weight basis).

Name of the Varieties (Treatments)	Ash (%)	Protein (%)	Carbohydrate (%)
BARI Chenabadam-7	9.06 e	30.15 b	7.74 c
BARI Chenabadam-8	9.80 d	34.15 a	2.55 d
BARI Chenabadam-9	9.60 d	29.85 b	6.84 c
LSD $_{(0.05)}$	0.4332	2.717	3.138
CV (%)	4.04 %	7.65 %	48.57 %

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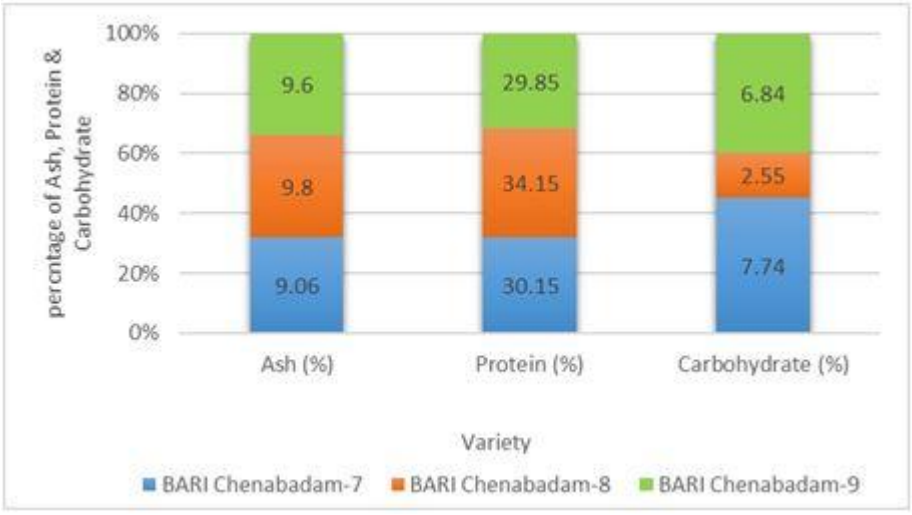

Figure 5. Proximate analysis of protein, ash, and carbohydrate content of the different oilseed varieties.

Carbohydrate: Carbohydrate content of different released varieties of oil seed were determined moisture on free basis. The data have been presented in Table 5. The amount of carbohydrate contained found in BARI Chenabadam-8, BARI Chenabadam-9, and BARI Chenabadam-7 were 2.55 %, 6.85 %, and 7.74 % respectively. Our studies carbohydrate content are slightly lower than the reported values of Ingale *et al.*, (2011); Ayoola *et al.*, (2012); Bachheti *et al.*, (2012) and Gopalan *et al.*, (1981)[24, 34, 37, 38]. It was observed that the groundnut varieties contain significantly lower amount of carbohydrates than the other oilseed varieties.

Proximate Analysis of Minerals Content of the Different Oilseed Varieties: Different major and minor minerals were analyzed in this work. The amounts of major minerals content of groundnut have been illustrated in Table 6.

In case of calcium content of different released varieties of groundnut was ranged from 2.58 % to 1.00 % (Table 6). Significantly highest amount of calcium (Ca) content was observed in BARI Chenabadam-9 (2.58 %), followed by BARI Chenabadam-8 (2.50 %), and BARI Chenabadam-7 (2.403 %); these varieties are statistically similar in respect to calcium content. The present investigations were supported by reported value of Chowdhury *et al.*, (2015); Bachheti *et al.*, (2012); Sarker *et al.*, (2015); Arif *et al.*, (2012); Josefson (1988) and Pathak *et al.*, (1973)[25, 37, 39-42].

Magnesium is the major minerals for human nutrition. Magnesium content of different released varieties of oil seed have been presented in Table 6. There is no significant variation in magnesium content among the varieties. Magnesium content of different varieties was ranged from 0.72 % to 0.730 %. The present investigations were supported by reported value of Chowdhury *et al.*, (2015); Bachheti *et al.*, (2012); Sarker *et al.*, (2015); Arif *et al.*, (2012); Josefson (1988) and Pathak *et al.* (1973)[25, 37, 39-,42].

Percentage of nitrogen is influenced by nitrogen fertilizer application and agronomies practices. Significantly highest amount of content was obtained from BARI Chenabadam-8 (5.52 %) the Lowest amount of protein content found in BARI Chenabadam-7 (4.78 %) (Table 6). The present values are more or less similar with the reported values of Chowdhury *et al.*, (2010); Chowdhury *et al.*, (2015); Sarker *et al.*, (2015); and Mirza *et al.* (1998)[23, 25, 39, 43]. However these results are lower than those reported by

many other authors. This might be due to the nitrogen fertilizer application, ecology, and agronomics practices.

Copper contained of different varieties of groundnut were ranged from 10.51-14.04 ppm (Table 6). Statistically similar amount of Cu content observed in BARI Chenabadam-7 (14.04 ppm), BARI Chenabadam-8 (11.10 ppm), and BARI Chenabadam-9(10.51 ppm). The present investigations were supported by reported value of Sarker *et al*., (2015); Arif *et al*., (2012); Bachheti *et al.*, (2012); Josefson (1988); and Pathak *et al.*, (1973)[39- 42].

Iron contained of different varieties of groundnut was ranged from 99.80 ppm to 147.50 ppm (Table 6). Significantly highest amount of Fe contained was observed in BARI Chenabadam-9 (147.50 ppm) which was followed by BARI Chenabadam-8 (131.00 ppm). These might be influenced the different levels of Fe in soil, fertilizer, and variation among the varieties. However our studies results were supported by the reported values of Chowdhury *et al.*, (2015)[25].

The zinc content of different varieties of groundnut was ranges from 47.94 to 66.90 ppm in Table 6. Significantly highest amount of Zn contained was found in BARI Chenabadam-8 (66.90 ppm) which was followed BARI Chenabadam-7 (51.48 ppm). The lowest amount was found in BARI Chenabadam-6 (47.94 ppm). The present studies values were supported by the reported value of Chowdhury *et al*., (2015); Bachheti *et al.*, (2012); and Josefson (1988)[25, 37, 41].

Table 6. Proximate analysis of minerals content of the different oilseed varieties.

Name of the Varieties (Treatments)	Ca (%)	Mg (%)	N (%)	Cu (ppm)	Fe (ppm)	Zn (ppm)
BARI Chenabadam-7	2.40 c	0.73 a	4.78 c	14.04 a	99.80 c	51.48 b
BARI Chenabadam-8	2.50 b	0.72 b	4.82 b	11.10 b	131.00 b	66.90 a
BARI Chenabadam-9	2.58 a	0.73 a	5.52 a	10.51 c	147.50 a	47.94 c
LSD $_{(0.05)}$	0.1021	0.0065	0.4709	2.140	27.41	11.41
CV (%)	3.62 %	0.76 %	8.26 %	15.91 %	19.21 %	18.18 %

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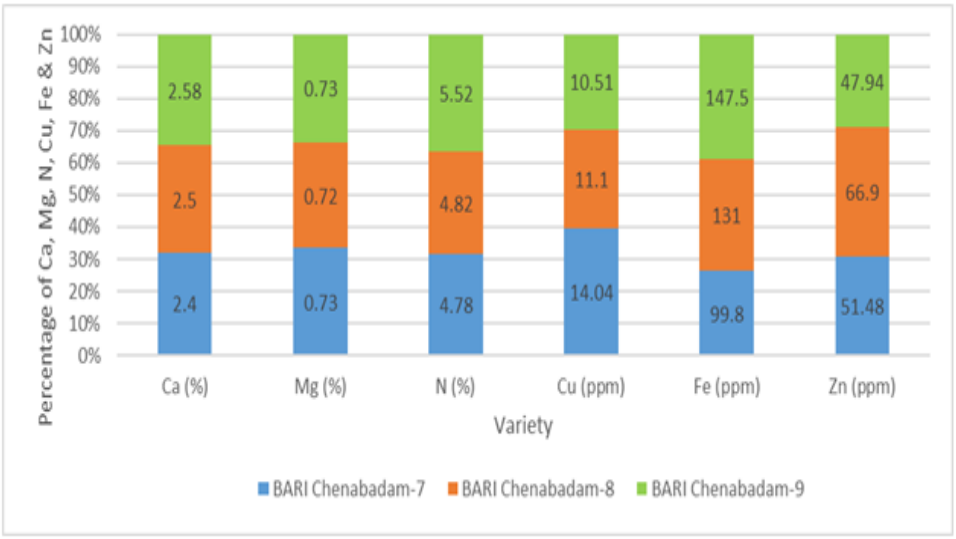

Figure 6. Comparison amongst mineral content of the different oilseed varieties.

Gross Energy

Energy from carbohydrate of groundnut varieties varied significantly due to different varieties (Table-7). Significantly the highest amount of energy from carbohydrate found in BARI Chenabadam-7 (30.96 kcal/g), followed by BARI Chenabadam-9 (27.3 kcal/g), and BARI Chenabadam-8 (10.20 kcal/g). The highest energy from protein observed from BARI Chenabadam-8 (138.00 kca/g); whereas the lowest amount of energy (119.40 kcal/g) from protein observed from BARI Chenabadam-9. The highest amount of energy from fat was observed in BARI

Chenabadam-9 (445.60 kcal/g), significantly same amount of energy obtained from BARI Chenabadam-8 (442.40 kcal/g). The study found that gross energy of different varieties of groundnut ranged from 590.5 kcal/g to 595.70 kcal/g. The highest amount of gross energy found from BARI Chenabadam-8 (595.70 kcal/g); while lowest amount of gross energy recorded from BARI Chenabadam-8 (590.5 kcal/g). The current value supported by the reported value of Chowdhury *et al*., (2015); Hossain *et al.*, (2015)[25, 44].

Table 7. Proximate analysis of Gross energy from carbohydrates, proteins, and oils of the different varieties of oilseed.

Name of the Varieties (Treatments)	Energy from Carbohydrate (kcal/g)	Energy from Protein (kcal/g)	Energy from Oil (kcal/g)	Total Energy (kcal/g)
BARI Chenabadam-7	30.96 c	120.60 b	444.10 b	595.7 a
BARI Chenabadam-8	10.20 d	138.00 a	442.40 a	590.5 c
BARI Chenabadam-9	27.3 c	119.40 b	445.60 a	592.3 b
LSD $_{(0.05)}$	12.53	11.78	1.812	1.016
CV (%)	48.56 %	8.26 %	0.36 %	0.45 %

Figure in a column followed by a common letter do not differ significantly at 5 % level by DMRT

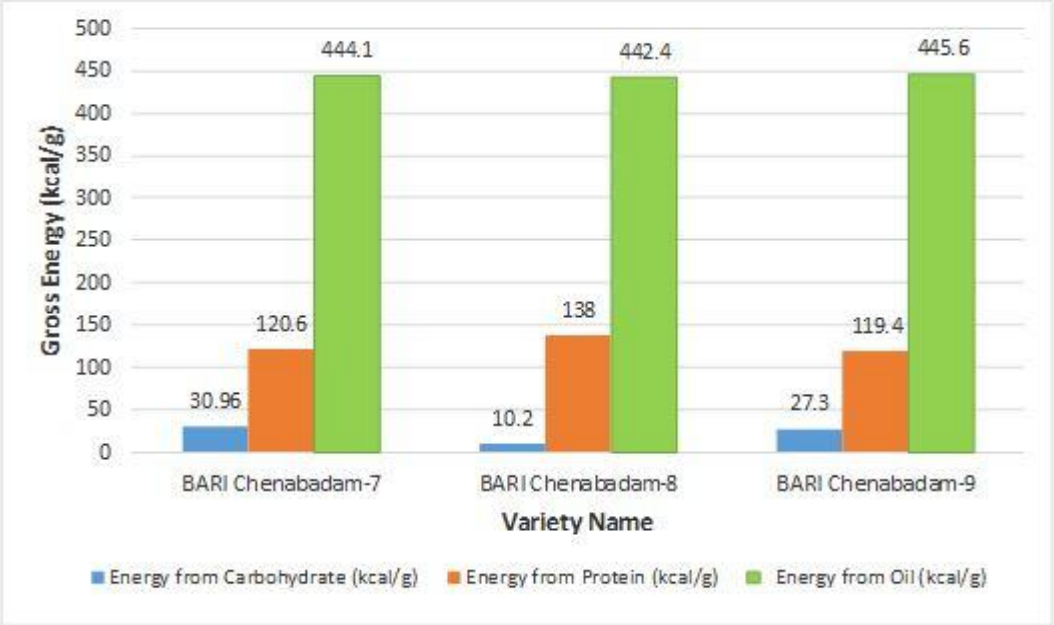

Figure 7. Gross Energy of the different oilseed varieties.

CONCLUSION

The physicochemical characteristics of three varieties of groundnut oilseed were analyzed. Among groundnut varieties BARI Chenabadam-8 was contained highest amount of Protein, Zn, saponification value, palmatic acid, arachidic acid, linoleic acid, oil cake content, ash content and highest amount of total saturated fatty acid (TSFA). Highest amount of oil content, moisture, iodine value, Ca, Mg, N, Fe, total unsaturated fatty acid (TUSFA) were found from BARI Chenabadam-9. BARI Chenabadam-7 contained highest amount of carbohydrate, grain weight, dry weight, stearic acid, Cu and total gross energy. The absence of erucic acid was observed in all groundnut varieties. So, the observation indicates that BARI Chenabadam-8 is the most appealing candidate amongst three varieties of oil seed. We hope that, our present findings will contribute to the national health economy and pharmaceutical sector by providing the information of the nutrient values of the groundnuts to the peasants and mass people.

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