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# Chemical Composition of *Kalimatar*, a Locally Grown Strain of Faba Bean (*Vicia faba* L.)

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**Abstract:** The chemical composition (major constituents, protein solubility profile, macro- and micro-nutrients, fat characterizing parameters and fatty acids profile) of cotyledon of *Kalimatar* (a local strain of faba bean) was investigated to assess its nutritive quality. Exotic counterpart of this local land race (*Vicia faba* L.) was also included in this study to compare their nutritive quality. A little variation in nutrient contents between these two varieties was found. The local faba bean cotyledon contained 27.67% crude protein, 3.12% crude fat, 2.48% crude fibre, 5.67% ash, 4.97% total sugar and 45% starch. On the other hand, exotic faba bean cotyledon contained 27.17% crude protein, 3.29% crude fat, 1.12% crude fibre, 5.46% ash, 4.15% total sugar and 46.16% starch. The protein fraction also varied between these varieties; globulin was followed by albumin and glutelin and accounted for 79.32 and 75.30%, 6.56 and 6.47% and 5.17% and 5.87% in local and exotic varieties, respectively. Prolamin content was negligible, which accounted for 0.59 and 0.60% in local and exotic cotyledon, respectively. Essential minerals (macro- and micronutrients), such as, calcium (Ca), magnesium (Mg), potassium (K), phosphorus (P), sulphur (S), boron (B), copper (Cu), iron (Fe), manganese (Mn) and zinc (Zn) contents were considerably different from each other between these varieties. Local faba bean cotyledon contained 0.07% Ca, 0.18% Mg, 1.73% K, 0.88% P, 0.04% S, 6.37 ppm B, 15.13 ppm Cu, 63.25 ppm Fe, 10.33 ppm Mn and 30.45 ppm Zn. On the contrary, exotic faba bean cotyledon contained 0.05% Ca, 0.15% Mg, 1.52% K, 0.86% P, 0.03% S, 5.39 ppm B, 13.59 ppm Cu, 61.68 ppm Fe, 9.67 ppm Mn and 32.41 ppm Zn. Oil characterizing parameters of these two varieties were more or less similar. Oil content, saponification number and iodine value of local and exotic faba bean varieties were respectively 1.36 and 1.33%, 192.61 and 109.90 and 190.39 and 107.63. Among the fatty acids analyzed, linoleic acid was found to be rich in this legume which accounted for 60.75 and 54.03% in local and exotic faba bean cotyledon, respectively. The second highest fatty acid was linolenic acid (14.30 and 21.10%) followed by palmitic acid (11.59 and 9.73%) in local and exotic faba bean cotyledon, respectively. This study shows that both the cotyledons are rich in protein, reducing sugar, starch, K, Fe and linoleic acid content. This study also reveals that local land race of faba bean is comparatively better in nutrients content than its exotic counterpart.

**Key words:** Chemical composition, proteins, lipids, minerals, fatty acids

## INTRODUCTION

Faba bean (*Vicia faba* L.), commonly named as Broad bean, Horse bean, Windsor bean, Tick bean (small types), taxonomically belongs to the Section Faba of the Genus Vicia under Papilionaceae of Leguminosae. Four subspecies of this bean, namely, *minor*, *equina*, *major* and *paucijuga* (Cubero, 1973) are found with variable seed-shape, size and color. Faba bean derives its utility as a protein rich crop. Average protein content as found in the literature is about 27-28% but genotypes with 35% or higher protein content are also available (Witcombe and Drskine, 1984; McPhee and Muehlbauer, 2002). In addition, faba bean contains little percentage of oil but it provides higher amount (88.6%) of polyunsaturated essential fatty acids (Duke, 1981). Moreover, faba bean contains appreciable amount of essential minerals (Sammour, 1985). One land race of faba bean, locally named *Kalimatar*, has been cultivated in Bangladesh for quite a long time.

*Kalimatar* is so named because of its black (meaning *kalo*) seed coat. It belongs to the *minor* subspecies of *Vicia faba*. This crop is cultivated sporadically across Bangladesh and it has got a few advantages to farmers from the view points of crop production. It requires minimum tillage or is sown directly in low-lying areas (Biswas, 1988) with minimum inputs in winter season. Compared to the traditional legumes, *Kalimatar* is more pest resistant as it is locally adaptive. Farmers of our country are choosing this legume owing to its erect plant type. As a result, its cultivation is extending in Bangladesh.

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Bangladesh, like many other developing countries of the third world, is confronted with serious problems of protein-calorie-malnutrition. Two consecutive National Nutrition Surveys in Bangladesh (Ahmad *et al*., 1977; Ahmad and Hossain, 1983) give poignant revelation to the fact that average Bangladeshi diet is grossly inadequate in terms of energy, protein and micronutrients. Protein deficiency is a severe problem; 77% of the population is suffering from insufficient protein intake (Ministry of Health and Family Planning, 1992). Micronutrients such as iron, calcium and magnesium are limited in our diet. Anemia is another nutritional catastrophe in Bangladesh; about 70% women and children, nearly 80% of the pregnant women and 60% of men have anemia mostly due to effective iron deficiency (Ahmad and Hossain, 1983).

The increasing demand for protein for human and animal consumption and the high price of animal protein such as meat and fish have resulted in increased demand of legumes as a source of dietary protein and calorie. However, the conventional legumes grown in our country viz. lentil (*Lens culinaris)*, grass pea (*Lathyrus sativus*), green gram (*Vigna radiata*), field pea (*Pisum sativum*), blackgram (*Vigna mungo*), lablab bean (*Lablab niger*) etc. can only supply a fraction of the country's total requirement of proteins. Because, the seed size of these legumes is very small and therefore, the yield is quite low. In this regard we have to find some other legumes which should be of large seeded and obviously high yielding. From this point of view, *Kalimatar* may occupy an important position in the field of nutrition in Bangladesh.

Experimental findings have evidenced that haemato-biochemical parameters (Mortuza *et al*., 1997) and weight in different organs (Mortuza and Newaz, 2001) of rats are almost remained unaffected in feeding trials with *Kalimatar* seeds. However, the nutritive information of *kalimatar* is scanty because of limited research on this legume. Considering this point of view, we carried out proximate composition analysis (moisture, dry matter, protein, fat, ash, fiber, NFE, total sugar, reducing sugar and starch), mineral (Ca, Mg, K, P, S, B, Cu, Fe Mn and Zn) contents, the protein solubility profile and the fat composition of this legume. We also compared the data of this local legume with that of its exotic counterpart. This study gives a first hand idea of this seed legume.

## MATERIALS AND METHODS

**Materials:** The seeds of two faba bean varieties were used; one was local, deep black seeded variety locally called Kalimatar" and another was exotic, brown colored. Exotic faba bean seeds [ICARDA (International Center for Agricultural Research in the Dry Areas) origin] were collected from the Department of Genetics and Plant Breeding, Bangladesh Agricultural University (BAU), Mymensingh and local faba bean seeds were collected from Savar bazaar in Dhaka district. The seeds were sun dried, cleaned and dehusked; cotyledons were ground by micro-grinder (CYCLOTEC 1093 sample mill, Tecator, Sweden) in the Department of Animal Science, BAU, Mymensingh and stored in airtight plastic container until required for analysis.

**Proximate analysis:** The proximate composition was carried out in triplicate for moisture, protein (N × 5.5, Mosse, 1990), fat, crude fibre and ash contents of cotyledons according to Official Methods of Agricultural Chemists (AOAC, 1965). Nitrogen free extract was calculated by difference. Total sugar was determined by the method of Kent-Jones and Amons (1967).

**Protein solubility profile determination:** Fine powdered cotyledons were first made fat free using alcohol. Then this defated flour was used for protein fractionation according to Landry and Moareaux (1970) scheme (Table 1). All the analysis was performed in duplicate and the mean values were reported.

**Mineral estimation:** Ca, Mg, P, S, K and B were determined by Hunter method (Hunter, 1984) and Cu, Fe, Mn and Zn by wet oxidation methods as described by Jackson (1973). All the analysis was performed in duplicate and the mean values were reported.

**Fat characterization:** The percent oil content, saponification number and iodine value were estimated by the method of Chopra and Kanwar (1986) and fatty acid profile was investigated by the method of Uppstrom and Johansson (1978). All the analysis was performed in duplicate and the mean values were recorded.

Table 1: Landry-Moareaux (1970) scheme of fraction sequences

| Fractions | Solvent | Protein class | Extraction time (min) |
|---|---|---|---|
| I | Water | Albumins | 60, 30, 30 |
| II | 0.05 M NaCl | Globulins | 30, 30, 30 |
| III | 70 % isopropanol | Prolamin | 30, 30, 30 |
| IV | 70 % isopropanol+0.6% 2-ME | Cross-linked prolamin | 30, 30, 30 |
| V | Borate buffer (pH 10)+0.6% 2-ME | Glutelin-like | 30, 30, 30 |
| VI | Borate buffer (pH 10)+2-ME+0.5% SDS | Glutelin | 30, 30, 30 |
| VII | 0.1 N NaOH | Residue | 30, 30, 30 |

2-ME = 2-mercaptoethanol, 0.05 M Borate buffer = Borate, NaOH with 0.5 M NaCl, SDS = Sodium dodecyl sulphate

## RESULTS AND DISCUSSION

**Proximate composition:** The proximate composition of cotyledons of two faba bean (local and exotic) varieties was nearly similar (Table 2). The moisture content of local and exotic faba bean were 11.01 and 11.23%, respectively. The percent of moisture is influenced by many factors such as storage condition, cultivar, environmental and agronomical factors etc. The dry matter content of local cotyledon was 88.99% while that of exotic was 88.77%. Crude protein content of local and exotic faba bean varieties were 27.67 and 27.17%, respectively. These values are still lower compared with the previous report (Semenyuk *et al*., 1989; Rubio *et al*., 1990) because of using different N to protein conversion factor. The common conversion factor for protein estimation is 6.25 that has been derived from the assumption that protein contains 16% nitrogen. In fact, different proteins vary in nitrogen content due to their presence of different proportion of individual amino acids. The assessment of real amount of total protein also becomes difficult due to the presence of high amount of non-protein nitrogen, especially in plants. The conventional nitrogen to protein (N:P) conversion value (6.25) never valid in plant material as it has been successively emphasized by several authors (Sosulski and Holt, 1980; Smith, 1987; Mosse, 1990). A conversion factor 5.5, experimentally found out for average plant total proteins (Mosse, 1990), was used in this study for determination of total protein. Thus the protein values obtained for faba bean here are lower than those in literature based on conversion factor 6.25. Faba bean can be used as protein supplement to cereal based foods or can provide a good protein source to produce weaning foods of high nutritive value. Awsthi and Taredon (1988) stated that faba bean contained high protein value as well as low fat content which could make them suitable for use as a low cost source of protein. The crude fat content of these bean varieties was almost similar. Local variety contained 3.12% crude fat while the exotic one contained 3.29%. The values of crude fat are in agreement with results found in literature (Aykroyd and Doughty, 1964). The higher crude fibre was found in local faba bean (2.48%) compared to exotic one (1.11%). Crude fibre plays an important role in human and animal nutrition. The ash (minerals) content of local and exotic faba bean was almost similar (5.67 and 5.46% in local and exotic, respectively). These values are comparable to those found in previous work (Semenyuk *et al*., 1989; Rubio *et al*., 1990). In the present study, it was found that local faba bean cotyledons contained 50.05% NFE, 4.97% total sugar and 45% starch whereas, exotic faba bean cotyledons contained 51.73% NFE, 5.11% total sugar and 46.16% starch. Proximate composition analysis shows that the seeds of local and exotic faba bean are rich source of protein and carbohydrate. Their high NFE indicates good calorific value of these faba bean seeds.

Table 2: Biochemical composition of local and exotic faba bean cotyledon on dry basis

| Nutrients (%) | Local | Exotic |
|---|---|---|
| Moisture | 11.01 | 11.23 |
| Dry matter (DM) | 88.99 | 88.77 |
| Crude protein (Nx5.5) | 27.67 | 27.17 |
| Crude fat | 3.12 | 3.29 |
| Crude fibre | 2.48 | 1.12 |
| Ash | 5.67 | 5.46 |
| NFE | 50.05 | 51.73 |
| Total sugar | 4.97 | 4.15 |
| Starch | 45.00 | 46.16 |

NFE = Nitrogen Free Extract

**Protein solubility profile:** Seed proteins have been classified into five major groups based on their solubility (Osborne and Brewer, 1977). These include water soluble albumins, salt soluble globulins, alcohol soluble prolamins, alkali soluble glutelins and residue (insoluble) proteins. In the present study, quantitative distribution of nitrogen was determined according to Landry-Moareaux scheme. Both local and exotic defated faba bean cotyledons were used for protein fractionation. The results of protein fractions are presented as percent of nitrogen extracted (Table 3). It was observed that the highest protein fraction of both faba bean cotyledons was globulin. The globulin content was 79.32 and 75.30% in local and exotic faba bean cotyledons, respectively. Local faba bean contained relatively higher amount of globulin than the exotic one. However, the results are in agreement with those of El-Fiel *et al*. (2002) and Gukova and Brazhinkova (1971). Globulin generally constitutes the largest fraction in legume seed protein. This fraction is the variable part of protein and is genetically controlled

Table 3: Distribution of nitrogen (%) of local and exotic faba bean cotyledon after Landry-Moareaux scheme

| Protein fraction | Local | Exotic |
|---|---|---|
| Total nitrogen (TN) | 5.03 | 4.94 |
| Albumin nitrogen | 0.33 | 0.32 |
| Albumin nitrogen of total nitrogen | 6.56 | 6.47 |
| Globulin nitrogen | 3.99 | 3.72 |
| Globulin nitrogen of total nitrogen | 79.32 | 75.30 |
| Cross-linked prolamin nitrogen | 0.02 | 0.02 |
| Cross-linked prolamin nitrogen of total nitrogen | 0.39 | 0.40 |
| Prolamin nitrogen | 0.03 | 0.03 |
| Prolamin nitrogen of total nitrogen | 0.59 | 0.60 |
| Glutelin like nitrogen | 0.10 | 0.16 |
| Glutelin like nitrogen of total nitrogen | 1.99 | 3.23 |
| Glutelin nitrogen | 0.26 | 0.29 |
| Glutelin nitrogen of total nitrogen | 5.17 | 5.87 |
| Non-extractable nitrogen | 0.30 | 0.40 |
| Non-extractable nitrogen of total nitrogen | 5.95 | 8.09 |

(Cubero, 1984). Globulin supplies high levels of sulphur amino acids (Nelson, 1969). Albumin contents were almost similar (6.56% in local and 6.47% in exotic faba bean cotyledon). Cross-linked prolamin (0.39% in local cotyledons and 0.40% in exotic cotyledons) and prolamin (0.59% in local cotyledons and 0.60% in exotic cotyledons) were negligible. In the recorded data, it was found that glutelin like and true glutelin were 1.99, 3.23, 5.17 and 5.87% in local and exotic faba bean cotyledons, respectively. Similar results were observed by Gukova and Brazhinkova (1971). In the present study, it was observed that non-extractable nitrogen was 5.95% in local while that of exotic was 8.09%. These values are in partial agreement with Moniem *et al.* (1997). It was observed in both faba bean varieties that the sequences of protein fraction is globulin>albumin> glutelin> prolamin.

**Mineral composition:** At least fourteen mineral elements (macro- and micro-nutrients) are essential for human body processes, each of which has its specific role to play (Doris, 1984). Faba bean contains appreciable amount of essential minerals (Sammour, 1985). In this study, six macronutients (Fe, Zn, Cu, Mn, B and K) and four micronutients (Ca, Mg, P and S) contents of local and exotic faba bean cotyledon were studied (Table 4). Among the macronutrients studied, K content was the highest for both varieties and varied between 1.73 and 1.52% in local and exotic faba bean varieties, respectively. Among other macronutrients, Ca, Mg, P and S content varied between 0.07 and 0.05%, 0.18 and 0.15%, 0.88 and 0.86% and 0.04 and 0.03%, respectively for local and exotic varieties. Among the micronutrients studied, Fe content was the highest for both varieties and varied between 63.25 and 61.68 ppm in local and exotic faba bean varieties, respectively. Among other micronutrients, B, Cu, Mn and Zn content varied between 6.37 and 5.39, 15.13 and 13.59, 10.33 and 9.67 and 30.45 and 32.41 ppm, respectively for local and exotic varieties. These values are comparable to those found in other work (Sammour, 1985; Keyoel *et al.*, 1986; Karamanos *et al.*, 1994). In general, faba beans are not good source of Ca and S. The mineral composition of faba bean cotyledons may vary largely due to variation of genotypes, type of seeds, seed size, stock location, and/or environmental condition (Karamanos *et al.*, 1994).

**Fat characterization:** Faba bean is one of the most important legumes/pulse crops that provides higher amount (88.6%) of essential polyunsaturated fatty acids (Duke, 1981) which are good for health, decrease obesity, help to prevent blood coagulation and thus control heart disease. In the present study, oil percentage, saponification number and iodine value of *Kalimatar* and exotic faba bean were determined (Table 5). Results revealed that the mentioned parameters for fat characterization were almost similar for these two varieties. Oil content and saponification number in local and exotic faba bean varieties were 1.36 and 1.33% and 192.61 and 190.39, respectively. Iodine value indicates the unsaturation of oil and fats, which is important from the nutritional view point. Iodine value of local variety was relatively higher (109.90) than that of its exotic counterpart (107.63). This indicates that oil of local variety is more unsaturated than that of exotic one, which is again reflected by higher linoleic acid content of local variety (60.75%) compared with that of exotic counterpart (54.03%). Grela and Gunther (1995) reported almost similar level of linoleic acid in soybean oil. The second major fatty acid in both varieties was linolenic acid (14.30 and 21.10% in local and exotic, respectively). Grela and Gunther (1995) reported the similar values in *Phaseolus coccineus* (kidney bean) and *Phaseolus vulgaris* (common bean) and these values are also in partial agreement with Schettino *et al.* (1985). In the present investigation, oleic acid content in local cotyledons was 12.73% and in exotic cotyledons was 14.85%. In this study, among the saturated fatty acid it was observed that both faba bean contained significant amount of palmitic acid (11.59 and 9.73% in local and exotic, respectively). The local faba bean cotyledons contained negligible amount of stearic acid (0.60%) while the exotic faba bean cotyledons contained negligible amount of lauric acid (0.25%).

Legumes in general are a good source of protein for human especially when vegetable-based diet is the major food source. Faba bean is a rich food for the presence of proteins, essential minerals and carbohydrates in it. These major constituents of seeds are stored in cotyledon. Considerable information regarding the nutritive values of faba bean is available (Baratt, 1982; Semenyuk *et al.*, 1989; Rubio *et al.*, 1990; McPhee and Muehlbauer, 2002).

Table 4: Macro- and micro-nutrient content of local and exotic faba bean cotyledon on dry basis

| | Macronutrient (%) | | | | | Micronutrient (ppm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sample | Ca | Mg | K | P | S | B | Cu | Fe | Mn | Zn |
| Local | 0.07 | 0.18 | 1.73 | 0.88 | 0.04 | 6.37 | 15.13 | 63.25 | 10.33 | 30.45 |
| Exotic | 0.05 | 0.15 | 1.52 | 0.86 | 0.03 | 5.39 | 13.59 | 61.68 | 9.67 | 32.41 |

Table 5: Oil content (%), saponification number, iodine value and fatty acid composition (%) of local and exotic faba bean cotyledon

| Parameters | Local | Exotic |
|---|---|---|
| Oil content | 1.36 | 1.33 |
| Saponification number | 192.61 | 190.39 |
| Iodine value | 109.90 | 107.63 |
| Palmitic acid | 11.59 | 9.73 |
| Oleic acid | 12.73 | 14.85 |
| Linoleic acid | 60.75 | 54.03 |
| Linolenic acid | 14.30 | 21.10 |

However, data regarding the nutritional value of *kalimatar* are lacking. Chemical composition analysis is useful to give the first hand idea about the nutritive value of the material under examination.

Chemical composition analysis shows that both faba seeds are rich in protein and starch content (27.67, 27.17, 45 and 46.16% in local and exotic cotyledon, respectively). High NFE (56.13 and 58.33% in local and exotic cotyledon, respectively) content of the flour indicates good calorific value of this legume. Among the various protein fractions, globulin content was the highest (79.32% in local and 75.30% in exotic). Cross-linked prolamin (0.39% in local and 0.40% in exotic) and true prolamin (0.59% in local and 0.60% in exotic) were negligible. Non-extractable N was 5.25% in local while 8.09% in exotic faba bean cotyledons. Mineral content analysis indicates that both faba bean cotyledons are outstandingly rich in potassium (1.73% in local and 1.52% in exotic) while poor in calcium (0.07% in local and 0.05% in exotic) and sulphur (0.04% in local and 0.03% in exotic) content. On the other hand, in respect of micro-nutrient content both faba bean seeds are rich source of iron (69.30 ppm in local and 66.47 ppm in exotic). Zinc content was found to be moderate; local faba cotyledons contained 33.45 ppm zinc while the exotic cotyledons contained 36.29 ppm. Mineral content analysis shows that local faba bean is fairly good source of all essential mineral content.

Fat characterizing parameters were almost similar for these two varieties. However, saponification number of local variety was relatively higher (192.61) than that of exotic one (190.39). Iodine value of local variety was also relatively higher (109.90) than that of exotic one (107.63). This indicates that oil of local variety is more unsaturated than that of exotic one, which is again reflected by higher linoleic acid content of local variety (60.75%) compared with that of exotic counterpart (54.03%). This study not only shows that *Kalimatar* contains, in addition to protein, a substantial amount of various nutrients, such as, minerals, fatty acids and carbohydrate, but also reveals that this local land race is little better in nutrients content compared with its exotic counterpart.

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## REFERENCES

Ahmad, K., M.M. Huda and P.C. Nath, 1977. Nutrition Survey of Rural Bangladesh, 1975-1976. Institute of Nutrition and food Science. University of Dhaka, Bangladesh.

Ahmad, K. and N. Hossain, 1983. The Nutrition of rural Bangladesh, 1981-1982 1st Edn. Institute of Nutrition and Food Science. University of Dhaka, Bangladesh.

AOAC, 1965. Official Methods of Analysis. Association of Official Analytical Chemist, Washngton DC., U.S.A.

Awsthi, C.P. and P.K. Taredon, 1988. Biochemical composition of some conventional leafy vegetables. Narendra Deva J. Agril., 3: 161-164.

Aykroyd, W.R. and J. Doughty, 1964. legumes in human nutrition. FAO Nutritional Studies. No. 19, FAO, Rome.

Baratt, D.H., 1982. Chemical composition of mature seed from different cultivars and lines of *Vicia faba* L. J. Sci. Food Agric., 33: 603-608.

Biswas, B.K., 1988. Genotype and Environmental interaction in faba bean. M. Sc. thesis in Genetics and Plant Breeding, Bangladesh Agricultural University, Mymensingh.

Chopra, S.L. and J.S. Kanwar, 1986. The Analysis of Agricultural Materials Analytical Agricl. Chem., pp: 396-399.

Cubero, J.I., 1973. Evolutionary trends in *Vicia faba* L. Theor. Applied Genet., 43: 59-65.

Cubero, J.I., 1984. Problems and Prospectives in breeding for protein content in *Vicia faba*. FABIS., No. 9: 1-9.

Doris, M.C.N., 1984. Potassium regulation. In: Food nutrition and diet therapy, pp: 272-276.

Duke, J.A., 1981. Handbook of legumes of world economic importance. Plenum Press, New York, pp: 199-265.

El-Fiel, H.E.A., A.H. El-Tinay and E.A.E. Elsheikh, 2002. Effect of nutritional status of faba bean (*Vicia faba* L.) on protein solubility profiles. Food Chem., 76: 219-223.

Grela, E.R. and K.D. Gunther, 1995. Fatty acid composition and tocopherol content of some legume seeds. Anim. Feed Sci. Technol., 52: 325-331.

Gukova, M.M. and T.S. Brazhinkova, 1971. Protein metabolism in germinating seeds of vetch and peas. Izvestiya Timiryzevski Sel'skhozyaistvemnoi Akademii., 4: 104-112. [Cited from FCA 1972, 25(2): 296].

Hunter, A.H., 1984. Soil fertility analytical service in Bangladesh Consultancy Report Bangladesh Agricultural Research Project- Phase II. BARC, Dhaka, Bangladesh.

Jackson, M.L., 1973. Soil and Chemical Analysis, pp: 106-190.

Karamanos, A.J., G. Papadopoulos, C.E. Avgoulus and P. Papastylianou, 1994. Chemical composition of seeds of 11 field-grown faba bean cultivars in two cultivation periods. FABIS. Newslett., 34/35: 39-47.

Kent-Jones, D.W. and A.J. Amons, 1967. Modern cereal chemistry. London Food Trade Press Ltd. 7 Garrick street, W.C. 2, 6th Edn, pp: 558-563.

Keyoel, F., A. Wunsch and H. Scheler, 1986. Field bean constituents and influences on them of genotype and environment. J. Agron. Crop. Sci., 156: 67-72.

Landry, J. and Moaureaux, 1970. Heterogenecity of the glutelins of maize grain: selective extraction of comparison in amino acids of the three fractions isolated (in French). Bull. Soc. Chem. Biol., 52: 1021-1037.

McPhee, K.E. and F.J. Muehlbauer, 2002. Improving the nutritional value of cool season food legumes. J. Crop Pro., 5: 191-211.

Ministry of Health and Family Planning, 1992. Bangladesh Country Paper International Conference of Nutrition, Rome. Government of the People's Republic of Bangladesh.

Moniem, A.O., El. Khalifa, E. Babiker, H.M. Abdullahi and D. Eltinay, 1997. Amino acid composition and protein fraction of faba bean. FABIS. Newslett., 40: 36-37.

Mortuza, M.G., N. Newaz, M.A. Islam and P.K. Roy, 1997. Haemato-biochemical parameters of rats fed on faba bean (*Vicia faba* L.). Progressive Agric., 8: 5-8.

Mortuza, M.G. and N. Newaz, 2001. Faecal moisture content, intestinal length and organ weight of rats fed on faba bean seeds. Pak. J. Biol. Sci., 4: 1279-1280.

Mosse, J., 1990. Nitrogen to protein conversion factor for ten cereals and six legumes for oilseeds. J. Agric. Food Chem., 38: 18-24.

Nelson, D.E., 1969. Genetic modification of protein quality in plants. Adv. Agron. 21:171-194

Osborne, J.C. and H.B. Brewer, 1977. The plasma protein. Adv. Protein Chem., 31: 253. [Cited from Harper's Review of Biochemistry. 18th Edn., pp: 31-39.

Rubio, L.A., A. Brenes and M. Castano, 1990. The utilization of raw and autoclaved faba beans (*Vicia faba* L. var. *minor*) and faba bean fractions in diets for growing broiler chickens. Br. J. Nutr., 63: 419-430.

Sammour, R.H., 1985. Chemical constituents and electrophoresis of seed proteins of some species of *Vicia*. FABIS. Newslett., 18: 30-32.

Schettino, O., F.D.E. Simione, E. Ramudo and R. Antonone, 1985. Fatty acid in *Vicia faba* seeds: nutritional consideration and possible clinical implications. Rvistta/holiana delle sontamze grasse, 62: 257-259.

Semenyuk, V.F., S.A. Vrublevskaya, N.A. Shcherebatyuk and A.M. Broeiko, 1989. Biochemical compositon of anatomical parts of the seed of some field bean cultivars. Nauchnye Doklady Vysshei Shkoly. Biologicheskie Nauki, 6: 83-87. [Cited from FBA (1981) 11(2): Abst. 196].

Smith, D.B., 1987. Determination of Protein Content of Seeds in Breeding Programs. In: Protein evaluation in cereals and legumes. Pattakou, V., (Ed.) CEC Rep. EUR 1404 EN; CEC: Luxembourg, pp: 21-31.

Sosulski, F.W. and N.W. Holt, 1980. Amino acid composition and nitrogen-to-protein factors for grain legumes. Can. J. Plant Sci., 60: 1327-1331.

Uppstrom, B. and S.A. Johansson, 1978. Methods for determination of fatty acids adapted to breeding program. Proceedings, 5th International Rapeseed Conference, June 12-16, 1978, Malmo, Sweden, pp: 140-144.

Witcombe, T.R. and W. Drskine, 1984. Genetics resources and their explanation of chickpeas, faba beans and lentils. Ed. Martinus Nijhoff/W. Junk Pub. ICARDA, Syria.