Bangladesh J. Bot. **38**(1): 93-97, 2009 (June)

CHEMICAL COMPOSITION AND FUNCTIONAL PROPERTIES OF *VICIA FABA* L. FROM BANGLADESH

MD. GOLAM MORTUZA[1], MD. ABDUL HANNAN[1] AND JASON TC TZEN[*]

Graduate Institute of Biotechnology, National Chung-Hsing University, Taichung, Taiwan

Key words: Vicia faba, Chemical composition, Functional properties, Legumes, Bangladesh

Abstract

Seed-cotyledons of *Vicia faba* L. an unconventional legume from Bangladesh were analyzed for chemical composition and protein functionality to assess its potential usage as an alternative source of protein. Proximate component in per cent were crude protein 30.57, crude fat 3.22, crude fibre 2.73, ash 3.61 and carbohydrate 59.87. With the exception of methionine plus cystine, the essential amino acids in the seed-cotyledons were present at concentrations equal to or greater than those commonly recommended. Least gelation concentration, water and fat absorption capacities were 8.00, 83.86 and 79.43%, respectively. Foaming capacity and foaming stability were 57.19 and 29.78%, respectively. With respect to its nutritive composition and functionality, the pulse appeared to be a potential source of nutrient.

Introduction

Legumes with high protein content, energy values, vitamin and mineral content, have been recognized as 'meat of poor people' (Bello-Perez *et al*. 2007). The increasing global protein consumption and high prices for meat and fish have led to the demand for new food protein sources, particularly from plants. Intensive efforts to find alternative sources of proteins from unconventional legumes have been conducted worldwide (Prakash and Misra 1987, Laurena *et al*. 1991, Iyayi *et al*. 2006) and have met with some success.

Nonetheless, the conventional legumes grown in Bangladesh, such as, lentil (*Lens culinaris*), grass pea (*Lathyrus sativus*), pea (*Pisum sativum*), black gram (*Vigna mungo*) and green gram (*Vigna radiata*) could not keep pace with the demand, which has led to the search for unconventional plant seeds like faba bean/broad bean or Kalimatar in Bengali (*Vicia faba* L.) as food protein and carbohydrate (Mortuza 1996).

Although no data are available on the production and yearly consumption of this legume, it is grown on a small scale in the southern part of Tangail, the western part of Gazipur, Manikganj, Rangpur and Rajbari districts of Bangladesh, for commercial purposes. The acceptability of legumes in food-industry depends on their nutritive values and more importantly on their functional properties (Pour-El 1981). In this study, the possibility of using the faba bean as a source in the manufactured foodstuffs by analyzing its proximate composition, amino acid profile and functional properties have been evaluated.

Materials and Methods

The *Vicia faba* L. seeds collected from Karatia bazar in Tangail, Bangladesh were sun dried, cleaned and stored in airtight polythene bags until analysis. The seeds were first broken by hammer, dehulled and made into flour by micro-grinder (A-10 Analytical mill, Tekmar, Staufen, Germany). Finally the flour was passed through a 60-mesh sieve and used for the chemical analyses and functional characteristics.

[*]Corresponding author: <TCTZEN@dragon.nchu.edu.tw> <gmortuza2003@yahoo.com>. [1]Department of Biochemistry, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh.

Chemical analysis: The crude protein (Kjeldahl N × 6.25), crude fat (solvent extraction), crude fibre, ash and moisture were determined according to the AOAC methods (AOAC 2000). Total carbohydrate content and energy value were calculated following Muller and Tobin (1980) and Narasinga *et al.* (1989), respectively. The total amino acid composition was analyzed in the Food Industry Research and Development Institute, Hsinchu, Taiwan. The essential amino acid (EAA) score was calculated as follows:

$$\text{EAA} = \frac{\text{g of EAA in 100 g test protein} \times 100}{\text{g of EAA in 100 g FAO/WHO ref pattern}}$$

Determination of functional properties: Least gelation concentration (LGC) was determined according to Coffman and Garcia (1977) as modified by Sathe *et al.* (1982). Suspensions of flour at concentrations of 2, 4, 6, 8, 10, 12, 14, 16 and 18% (w/v) were prepared in test tubes with distilled water to a final volume of 5 ml. After thorough mixing, the tubes were heated in a boiling water bath for 1 h and then cooled under running tap water. They were further cooled in a 4° C refrigerator for 2 h. LGC was the flour concentration at which the sample did not fall or slip in an inverted test tube.

Water absorption capacity (WAC) was measured using a modification of the centrifugation technique of Janicki and Walczak (1954). Fat absorption capacity (FAC) was assessed by the procedure of Lin *et al.* (1974) as modified by Gruener and Ismond (1997). Foaming capacity (FC) and Foaming stability (FS) were evaluated according to the method of Gruener and Ismond (1997) with some modifications.

Statistical analysis: In all experiments three replicates were used. Data were subjected to analysis of variance (ANOVA), and statistical comparisons between treatments were made by the Tukey honest significant difference (HSD) test using SPSS version 12.0 software for Windows (SPSS Inc. Chicago, IL, USA).

Results and Discussion

Proximate analyses: Chemical analyses of faba bean revealed that the protein content (30.57%) was higher than those of commonly consumed legumes (Table 1) and some beans grown in other regions of the world once mentioned as underutilized but currently receiving research attention (Carmona-Garcia *et al.* 2007, Coelho *et al.* 2007, Rajeev *et al.* 2008). Similar high protein content was reported for some faba beans (*Vicia faba* L.) grown in Egypt and Canada (El-Sayed *et al.* 1986, Sosulski and McCurdy 1987). The notably high level of protein in this little-known legume underscores its importance as a potential protein source.

Table 1. Chemical composition (%) of flour from *V. faba* L. and comparison with faba bean reported by Sosulski and McCurdy 1987*. n = 3, ± standard error.

Sample	Crude protein	Crude fat	Crude fibre	Ash	Carbohydrate
Studied faba bean	30.57 ± 0.32	3.22 ± 0.12	2.73 ± 0.12	3.61 ± 0.11	59.87
Faba bean*	29.2	1.4	1.6	2.6	-

The crude fat (3.22%) and fibre (2.73%) in the faba bean were higher than those in faba bean grown in Canada (Sosulski and McCurdy 1987). Yet the crude fat content does not qualify this faba bean as an oil-rich legume, especially when compared with groundnut and soybean (Narasinga *et al.* 1989). Although the fibre level found in faba bean does not fulfill the human

requirement of 2.2 - 2.3g fibre/100 kcal diet (Kanwar *et al.* 1997), it may be a relatively desirable character.

The ash content (3.61%) of faba bean was higher than that of faba bean grown in Canada (Sosulski and McCurdy 1987) but similar to those of faba beans grown in Egypt (El-Sayed *et al.* 1986). This difference might be attributed to characteristics of the soil in different locations (Bello-Perez *et al.* 2007).

The carbohydrate content of faba bean (59.87%) was much higher than those of groundnut and soybean (Narasinga *et al.* 1989) and similar to those of other legumes (Bello-Perez *et al.* 2007). The faba been seeds exhibited high energy value (1631.55 kJ/100g sample), which was much higher in comparison with conventional legumes (Narasinga *et al.* 1989).

Amino acid patterns: Faba bean has methionine/cystine as the only limiting amino acid for 2-5-year-old children (Table 2). All other essential amino acids meet the children's needs, although the contents of most of them are lower than those for hen egg. Again the essential amino acids profile of faba bean flour, except lower methionine/cystine and higher lysine content, is well

Table 2. Amino acid composition (g/100g protein), essential amino acid (EAA) score, total EAA (TEAA) and limiting amino acid (LAA) of studied faba bean compared with soyabean, faba bean and hen egg (FAO/WHO/UNU 1985).

Amino acid	Total protein	EAA score	Soya-bean[a]	Faba bean [b]	Hen egg[c]	Requirement [d]	
						2-5 yr	10-12 yr
EAA							
Val	4.46	127.43	4.59	4.9	6.6	3.5	2.5
Ile	4.07	145.35	4.62	4.6	5.4	2.8	2.8
Leu	7.48	113.33	7.72	8.3	8.6	6.6	4.4
Lys	6.70	115.52	6.08	6.4	7.0	5.8	4.4
Cys	1.10	54.80	1.70	0.9	5.7	2.5	2.2
Met	0.27		1.22	0.8			
Phe	4.18	119.68	4.84	4.8	9.3	6.3	2.2
Tyr	3.36		3.39	3.5			
Thr	3.41	100.20	3.76	3.4	4.7	3.4	2.8
His	2.95	155.26	2.50	2.8	2.2	1.9	1.9
TEAA	37.98		40.42	40.4		32.8	
LAA	Met+Cys						
Non-EAA							
Ala	3.99		4.23	4.2			
Asp	12.33		11.3	11.5			
Arg	11.83		7.13	10.1			
Glu	17.64		16.9	18.9			
Gly	4.12		4.01	4.3			
Pro	4.15		4.86	4.5			
Ser	4.83		5.67	5.1			

[a] Vasconcelos (1997); [b] Sosulski and McCurdy (1987); [c] FAO/WHO/UNU (1985). [d]Patterns of amino acid requirements for children age groups.

comparable to that of soybean (Vasconcelos *et al.* 1997). In agreement with the previous findings for legumes for non-essential amino acids (Laurena *et al.* 1991, Mohan *et al.* 1995), high levels of glutamic and aspartic acid were observed in the faba bean. However, in contrast to the arginine level reported for the above-mentioned legumes, a very high level of arginine was observed in faba bean.

Relatively low level of methionine/cystine is a common deficiency in legumes (Laurena *et al*. 1991). This problem however can be overcome by complementing the diet with cereal proteins in which sulphur-amino acids are relatively high. Interestingly, faba bean was found to contain, in contrast to cereals, a high level of lysine and also of arginine, which may complement the low level of those in cereals.

Functional properties: The LGC, WAC and FAC values of flour from faba bean was 8.00, 83.86 and 79.43%, respectively (Table 3). The ability of protein to form gels that provide a structural matrix for holding water, flavors and sugars is useful in new foodstuff development, thereby providing an added dimension to protein functionality. The low LGC value indicates that faba bean has a greater ability to form gel than other seed flours (Sathe *et al*. 1982, Oshodi and Adeladun 1993, Kaur and Singh 2007) and thus may be an asset of faba bean for the production of curd, pudding or as an additive to other gel-forming materials in food products. WAC is considered an essential function of protein in viscous foods such as soups, gravies, doughs, and baked products. The WAC value of faba bean is comparable to those of many beans (Sosulski and McCurdy 1987, Oshodi and Adeladun 1993) and thus faba bean flour may be useful in these food formulations. FAC is important because oil acts as a flavor retainer and improves the mouth feel of foods. The FAC value of faba bean is comparable to those of several beans (Lin *et al*. 1974, Sosulski and McCurdy 1987, Oshodi and Adeladun 1993) and thus faba bean flour has flavor retaining ability similar to these legumes.

Table 3. Functional properties of flour from faba bean cotyledons and comperison with faba bean reported by Sosulski and McCurdy 1987*.

Sample	LGC	WAC	FAC	FC	FS (after 2 h)
Studied faba bean	8.0 ± 0	83.86 ± 1.17	79.43 ± 1.36	57.19 ± 1.5	29.78 ± 1.45
Faba bean*	-	72	47	-	-

LGC, Least gelation concentration; WAC, Water absorption capacity; FAC, Fat absorption capacity; FC, Foaming capacity; FS, Foaming stability and comparison with faba bean. n = 3, ± standard error.

Foaming capacity (FC) and foaming stability (FS) are important properties in food products such as breads, cakes, crackers, meringues, ice creams and several other bakery items to maintain their texture and structure during or after processing. The FC (57.10%) and FS (29.78%) values of bread faba flour (Table 3), are higher than those of other beans (Lin *et al*. 1974, Oshodi and Ekperigin 1989). After 16 h standing at room temperature (25 °C), the foams did not collapse completely indicating good foam stability. Therefore, faba bean flour may be useful in these food products.

Acknowledgments

The authors gratefully acknowledge financial support from the Islamic Development Bank (IDB), Jeddah, Saudi Arabia.

References

AOAC. 2000. Official Methods of the Association of Official Analytical Chemists. S Williams, AOAC. Washington DC.

Bello-Perez, L.A., S.G. Sayago-Ayerdi, C.E. Chavez-Murillo, E. Agama-Acevedo and J. Tovar. 2007. Proximal composition and *in vitro d*igestibility of starch in lima bean (*Phaseolus lunatus*) varieties. J. Sci. Food Agric. **87**: 2570-2575.

Carmona-Garcia, R., P. Osorio-Diaz, E. Agama-Acevedo, J. Tovar and L.A. Bello-Perez. 2007. Composition and effect of soaking on starch digestibility of *Phaseolus vulgaris* (L.) cv. 'Mayocoba'. Int. J. Food Sci. Technol. **42**: 296–302.

Coelho, C.M.M., C.M. Bellato, J.C.P. Santos, E.M.M. Ortega and S.M. Tsai. 2007. Effect of phytate and storage conditions on the development of the 'hard-to-cook' phenomenon in common beans. J. Sci. Food Agric. **87**: 1237–1243.

Coffman, C.W. and V.V. Garcia. 1977. Functional properties and amino acid contents of a protein isolate from mung bean flour. J. Food Technol. **12**: 473-484.

El-Refai, A.A., H.M. Harras, K.M. El-Nemr and M.A. Noaman. 1988. Chemical and technological studies on faba bean seeds. I. Effect of storage on some physical and chemical properties. Food Chem. **29**: 27-39.

El-Sayed, M.A., A. Adel-Shehata, A.R. El-Mahdy, M.M. Youssef. 1986. Extractability and functional properties of some legume proteins isolated by three different methods. J. Sci. Food Agric. **37**: 553-559.

FAO/WHO/UNU. 1985. Energy and Protein Requirements. FAO/WHO/UNU Technical Report Series No. 724, WHO, Geneva.

Gruener, L. and M.A.H. Ismond. 1997. Effects of acetylation and succinylation on the physicochemical properties of the canola 12S globulin. Food Chem. **60**: 513-520.

Iyayi, E.A., H. Kluth and M. Rodehutscord. 2006. Chemical composition, antinutritional constituents, precaecal crude protein and amino acid digestibility in three unconventional tropical legumes in broilers. J. Sci. Food Agric. **86**: 2166-2171.

Janicki, N.A. and J. Walczak. 1954. Wateriness of meat and methods of its determination. Adv. Food Res. **10**: 355- 463.

Kaur, M. and N.A. Singh. 2007. Comparison between the properties of seed, starch, flour and protein separated from chemically hardened and normal kidney beans. J. Sci. Food Agric. **87**: 729-737.

Laurena, A.C., F.M. Rodriguez, N.G. Sabino, A.F. Zamora and E.M.T. Mendoza. 1991. Amino acid composition, relative nutritive value and in vitro protein digestibility of several Philippine indigenous legumes. Plant Foods Human Nutr. **41**: 59-68.

Lin, M.J.Y., E.S. Humbert and F.W. Sosulski. 1974. Certain functional properties of sunflower meal products. J. Food Sci. **39**: 368-370.

Mortuza, M.G. 1996. Biological effects of faba bean (*Vicia faba* L.) in rats. M.S. thesis in Biochemistry, Bangladesh Agricultural University, Mymensingh.

Muller, H.G. and G. Tobin. 1980. Nutrition and Food Processing. London: Croom Helm.

Narasinga, R.B.S., Y.G. Deosthale and K.C. Pant. 1989. Nutritive value of Indian foods. Hyderabad, India: Indian Council of Medical Research, National Institute of Nutrition.

Oshodi, A.A. and M.O.A. Adeladun. 1993. Proximate composition, some nutritionally valuable minerals and functional properties of three varieties of lima bean (*Phaseolus lunatus* L.) flour. Int. J. Food Sci. Nutr. **43**: 181-185.

Oshodi, A.A. and M.M. Ekperigin. 1989. Functional properties of pigeon pea (*Cajanus cajan*) flour. Food Chem. **34**: 187–191.

Pour-El, A. 1981. Protein functionality: classification, definition, and methodology. In: Protein Functionality in Foods (ed by JP Cherry) pp.1-5. American Chemical Society Symposium Series147. Washington DC.

Rajeev, B., R. Kandikere, K.R. Sridhar and S. Seena. 2008. Nutritional quality evaluation of velvet bean seeds (*Mucuna pruriens*) exposed to gamma irradiation. Int. J. Food Sci. Nutr. **59**(4): 261-278.

Sathe, S.K., S.S. Deshpande and D.K. Salunkhe. 1982. Functional properties of lupin seeds (*Lupinus mutabilis*) proteins and protein concentrates. J. Food Sci. **47**: 491-497.

Sosulski, F.W. and A.R. McCurdy. 1987. Functionality of flours, protein fractions and isolates from field peas and faba bean. J. Food Sci. **52**: 1010-1014.

Vasconcelos, I.M., E.A. Siebra, A.A.B. Maia, R.A. Moreira, A.F. Neto, G.J.A. Campelo and J.T.A. Oliveira. 1997. Composition, toxic and antinutritional factors of newly developed cultivars of Brazilian soybean (*Glycine max*). J. Sci. Food Agric. **75**: 419-426.

(Manuscript received on 10 April, 2009; revised on 24 May, 2009)