ISSN NO. 2320-5407

Journal homepage: http://www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH

RESEARCH ARTICLE

NUTRITIONAL COMPOSITION AND ANTI NUTRIENTS OF TWO FABA BEAN (Vicia faba L.) LINES

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Manuscript Info

Manuscript History:

Received: 26 October 2014
Final Accepted: 17 November 2014
Published Online: December 2014

Key words:
Faba bean, protein fraction, protein digestibility, anti nutritional factor, mineral

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Abstract

The present study was carried out to investigate the proximate composition, mineral content, protein fractions, in vitro protein digestibility, and antinutritional factors (polyphenol,tannin, and phytic acid contents)of two newly developed faba bean (Vicia faba L.) seed flours (Hud-line 1 and Base line 11. Significant ($p < 0.05$) variations existed between two introduced lines with respect to their crude protein, ash, and carbohydrate. Both seed flour samples contained considerable amounts of P, Ca, Mg, K, Na, and Fe which made them potentials for future food supplements. No significant ($p < 0.05$) differences was observed in Fe content. Significant ($p < 0.05$) differences were observed in all protein fractions. Bas- line have significantly ($p < 0.05$) higher protein digestibility with lower tannin, polyphenol, and phytic acid contents compared to hud-line 11.

Introduction

It's at present acknowledged that food proteins are not only source of constructive and energetic compound such as amino acids but may also play bioactive role and/or can be a precursors of biologically active peptides physiological functions. In this context plant protein and their derived proteins hydrolysates are increasingly being used as an alternative to protein from animal sources in human nutrition (Kostyra, 1996). Grain legumes are important sources of food proteins. In many regions of the world, legume seeds are the unique protein supply in the diet.

Faba beans (Vicia faba L.) though are less consumed in western countries as human food, it is considered as one of the main sources of cheap protein and energy in Africa, parts of Asia and Latin America, where most people cannot afford meat sources of protein (Duc, 1997; Haciseferogullari et al., 2003).Similarly, faba bean in the Middle East region, is consumed mostly as dried seed while, a little portions is consumed as fresh kernel. The crop is also becoming increasingly important in Saudi diets due to the high lysine content of the seed, which encourages the use of faba bean as a protein supplement for cereals (El-Fiel et al., 2002; Alghamdi, 2003). Proteins in legume seeds represent from about 20% (dry weight) in pea and beans up to 38–40% in soybean and lupin (Guéguen and Cerletti, 1994) (Derbyshire, 1976). Therefore legume seeds are among the richest food sources of proteins and amino acids for human and animal nutrition. Traditionally, the classification of storage proteins is based on their solubility properties: albumins are soluble in water, globulins are soluble in salt water solutions and prolamins are soluble in ethanol/water solutions (Osborne,1924).

The latter ones are most prominent in cereal seeds. This old classification scheme still has an operative validity, especially in relation to the techno/functional properties of these proteins. The most abundant class of storage proteins in grain legumes are the globulins. They are generally classified as 7S and 11S globulins according to their sedimentation coefficients (S). The 7S and 11S globulins of pea are named vicilin and legumin, respectively, so that the corresponding proteins of other seeds are often indicated as vicilin- and leguminlike globulins. From the nutritional viewpoint, all legume storage proteins are relatively low in sulphur-containing amino acids, methionine, cysteine and tryptophan, but the amounts of another essential amino acid, lysine, are much greater than in cereal grains Rockland Radke (1981) (Ampe et al, 1986) . Therefore, with respect to lysine and sulphur amino acid contents, legume and cereal proteins are nutritionally complementary. Generally, legumes have been reported to have low nutritive value because of low amounts of sulfur-containing amino acids, low protein digestibility and the presence of anti-nutritional factors. Legumes are usually cooked before being used in the human diet. This improves the protein quality by destruction or inactivation of the heat labile anti-nutritional factors (Chau et al., 1997; Vijayakumari et al., 1998). However, cooking causes considerable losses in soluble solids, especially vitamins and minerals (Barampama and Simard, 1995). This experimental study was therefore carried out to determine the chemical composition, mineral profile, protein quality attributes, in vitro protein digestibility,and anti -nutritional factors such as tannin content, phytic acid and polyphenols contents of new lines of faba bean

2.1. Material**:** Two newly introduced faba bean lines were brought from Department of Crop Production, Faculty of Agriculture, and University of Khartoum. The seed were carefully cleaned and freed from broken and extraneous matters. The seeds were milled into fine flour to pass a 0.4mm mesh size screen

2.2. Methods:

2.2.1. Chemical analysis: Moisture content, crude protein (N x 6.25), ether extract, crude fiber and ash were determined according to AOAC (2000), while carbohydrate was calculated by subtraction.

2.2.2. Determination of Minerals: Minerals were extracted from samples by dry ashing methods described by Chapman and Pratt (1982). Iron content was determined by using Atomic Absorption Spectrophotometer (Shimadzum AA6806) while phosphorus content was determined by using spectrophotometer (Champan and Pratt, 1982). Sodium and potassium was determined by using flame photometer according to AOAC (2003). Calcium and magnesium were determined by titration method as described by Chapman and partt (1982).

2.2.3. Determination of Protein Fractionation: The Mendel-Osborne (1924) scheme for protein fractionation was used in this study.

2.2.4. Determination of aninutritional Factors**:** Phytic acid was determined according to the method of Wheeler and Ferrel(1971). Tannins were determined by method described by Price et al. Polyphenolics present in faba bean seed were estimated using the Prussian blue assay, as described by Price and Butler (1977).

2.2.5. Determination of In Vitro Protein Digestibility**:** In vitro protein digestibility of samples was measured according to the method developed by Saunders et al. (1973).

2.2.6. Statistical Analysis: Data generated were subjected to SAS. T-student test was performed to test the significance between samples for each parameter as reported by steel et al. (1997).

3. Results and discussion:

3.1. Proximate analyses: Chemical compositions of newly introduced two faba bean seeds are presented in Table 1. No significant ($P > 0.05$) differences in moisture, fat, fiber, ash contents were observed while significant ($P > 0.05$) differences was observed in total protein and carbohydrate. Chemical analyses of newly introduced faba bean lines revealed that the protein contents (31.13% and 33.77%) was higher than those of commonly consumed legumes 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) and faba beans grown in Sudia Arabia (Algamdi, 2009). The notably high level of protein in this little known legume underscores its importance as a potential protein source. The crude fat (1.45%-1.76%) and fibre (8.06%-8.47) in the faba bean were higher than those in faba bean reported by Balla (2004). 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%- 4.10%) of faba bean was higher than that of faba bean reported by Abusin (2007) 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 (44.16%-47.3%) 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)

4.2 Mineral Content: Mineral contents of seeds are presented in Table 2. Calcium, potassium, magnesium, sodium, phosphorus and iron content were analyzed for both faba bean lines. Calcium content for Hud-Line I was found to be 392.03mg/100g, which was significantly higher ($p \leq 0.05$) than the value 163.70mg/100g obtained for Bas-Line II. The value of Hud line I was higher than the range of 173 to 191mg/100g reported by El Tinay et al., (1988), but lower than the range of 422.92 to 427.17mg/100g recorded by Balla (2004). Potassium content for Bas-Line II was found to be 1025.70mg/100g, which was significantly higher ($p \leq 0.05$) than the value of 975.41mg/100g for Hud-Line I. These values were higher than the value 649mg/100g reported by Khalil (2001), but lower than the range of 1079 to 1182mg/100g and 1030.66 to 1037.45mg/100g reported by El Tinay et al., (1989) and Balla (2004) respectively. Magnesium content for Hud-Line I was found to be 222.90mg/100g, while for Bas-Line II it was 225.72mg/100g. There is no significant difference between the magnesium content of the two inbred lines. These results were lower than the range of 255.32 to 288.58mg/100g reported by Balla (2004), but higher than the range of 180 to 196mg/100g reported by El Tinay et al., (1989). The sodium content of Hud-Line I was found to be 30.49mg/100g, while for Bas-Line II it was 25.85mg/100g. The values of sodium content for two inbred lines were varied significantly ($p \leq 0.05$). The values obtained were simillarly within the range of 26.6 to 35.94mg/100g reported by Balla (2004), but lower than the range of 32.5 to 38.1mg/100g reported by El Tinay et al., (1989). Phosphorus content for Hud-Line I was found to be 178.23 mg/100g, which was significantly ($p \leq 0.05$) lower than the value of 198.61 mg/100g for Bas-Line II. These values were lower than the range of 309 to 342 mg/100g reported by El Tinay et al, (1989). Iron content for Hud-Line I was found to be 5.25mg/100g, while for Bas-Line II it was 6.25mg/100g. There is no significant difference between the iron content of the two inbred lines. The values of Hud-line I and Bas-line II were similarly within the range of 5.97 to 6.47mg/100g reported by Balla (2004), but lower than the range of 6.9 to 8.6mg/100g reported by El Tinay et al., (1989).

3.3. Protein fractionation: The sequential extraction of the faba bean seed protein, determined on the basis of differences in solubility allowed for easy separation of the Osborne fractions as follow in table 3. Globulin is the major storage protein in legume seeds, where legume seeds contain two major types of globulin, vicilin-type and legumins. It's clear in this study that glutelins and globulins make up 75% and 79% of total protein of the tested seeds. Globulin, the predominant fraction for faba bean genotypes tested, ranged from 57.0% in Hud-Line I 1 and 60.57% in Bas-Line II 1. The prolamin fraction was the lowest 3.16% in Hud-Line I and 3.57% in Bas-Line II 1. Results obtained were comparable with Oouji et al (2010) who explained that the globulins and glutelins are the major protein fractions of faba bean and disagreed with Previous researchers (shastry and john, 1991) who reported albumin and globulins are the major storage plant protein as varying between 50% and 75% of the total seed protein content. The Bas-Line II 1 have relatively the highest protein and prolamin contents, indicating that the increase in protein content in faba bean genotypes is attributable mainly to higher levels of the prolamin fraction (Algamdi ,2009).

3.4.Anti- nutritional factors contents**:** The anti nutritional factors contents of tested seeds are presented in Table 4.The mean polyphenol content of faba bean samples ranged from 225.15 to 230.23mg/100g. Inbred line Hud-line I contain polyphenol in level which was significantly ($p \leq 0.05$) higher than that found in Bas-line II. The levels of polyphenol in both inbred lines, under study, were lower than the range of 231.77 to 331.16 mg/100g and 322.08 to 338.64mg/100g reported by Abusin (2007), A/Rahman et al., (2005), and also lower than 322.08 mg/100g reported by Balla (2004). For cultivar Hud-Line I tannin content was found to be 37.11mg/100g, while for Bas-Line II it was 30.99mg/100g. There is a significant ($p \leq 0.05$) difference between the two inbred lines. The values were lower than the range of 70 to 1120mg/100g reported by Abusin (2007), but higher than the range of 5.37 to 28.79 mg/100g reported by Shimelis and Rakshit (2007). Phytic acid contains six phosphorus atoms per molecule. It is a substantial phosphorus resource for the germinating seed. The phosphorus of phytic acid binds iron, zinc, calcium and magnesium causing deficiencies of these minerals in monogastric animals and humans Nwokolo and Bragg (1977) Wolters et al (1993). Phytic acid also decreases the availability of proteins in nutrition. The high phytic acid content of seeds can be decreased by using phytase enzymes in feed Urbano et al (2007). The mean phytic acid contents of faba bean samples under study ranged from 186.08 to 192.71mg/100g. Inbred line Hud-line I has the highest value, while Bas-line II has the lowest value (Table 4). Data for phytic acid content of the two inbred lines were higher than the range of 153.44 to 183.65mg/100g reported by Abusin (2007), but lower than the range of 247.07 to 259.21 mg/100g, 291.51 to 298.91 mg/100g reported by Abdul Rahim (2004) and A/Rahman et al., (2005), and also lower than 291.15 mg/100g reported by Balla (2004).

In Vitro Protein Digestibility (IVPD): The protein digestibility is determined to provide the most satisfactory indication of seed utilization (FAO/WHO/UNV, 1985).The result of in vitro protein digestibility (IVPD) is shown in Table (5). The mean IVPD of Hud-Line I and Bas-Line II was 74.97% and 76.51% respectively. There is a significant difference ($p \leq 0.05$) between the two inbred lines. Both values were within the range of 73.56% to 79.33%, 68.62% to 75.09% and 66.2- to 80.1% reported by Abusin (2007), Abdel Rahim (2004) and El Sheikh et al., (2000) respectively, lower than the range of 89.0% to 93.8% reported by Siddig (1999), but higher than 70.8% as reported by Alonso et al., (2000).

Finally it could be concluded that, The Bas-line II inbred line showed relatively increased level in ash , protein, and mineral compared to Hud-line I inbred line. The developed inbred lines contained very high levels of albumin which reflect protein quality of developed inbred lines with low levels of tannin relatively good levels of an in vitro protein digestibility. Also these seed flour may be used in food enrichment to compensate the shortage of certain amino acids with regarding removing of antinutritional factors or avoiding use these proteins, when affect the mineral content of the food which added to it.

Table (1): Proximate Composition of Two Inbred Lines of Faba Bean

Inbred lines	Moisture (%)	Protein (%)	Oil (%)	Fibre (%)	Ash (%)	Carbohydrates (%)
Hud-Line I	8.13^{a} (±0.11)	31.13^{b} (±0.06)	1.76^{a} (±0.25)	8.06^{a} (±0.22)	3.67^{b} (±0.13)	47.25^{a} (±0.29)
Bas-Line II	8.05^{a} (±0.28)	33.77^{a} (±0.07)	1.45^{a} (±0.23)	8.47^{a} (±0.38)	4.10^{a} (±0.10)	44.16^{b} (±0.12)

-Each value is an average of three replicates expressed on dry weight base.
-Value are mean±SD.
-Means not sharing a common superscript letter a column are significantly different at ($p \leq 0.05$).

Table (2): Minerals Content (mg/100g) of Two Inbred Lines of Faba Bean

Inbred lines	Ca	K	Mg	Na	P	Fe
Hud-Line I	392.03^{a} (±2.91)	975.4^{b} (±1.76)	222.90^{a} (±1.74)	30.49^{a} (±1.59)	178.23^{b} (±1.99)	5.25^{a} (±0.29)
Bas-Line II	163.70^{b} (±3.90)	1025.7^{a} (±1.87)	225.72^{a} (±1.73)	25.85^{b} (±1.38)	198.61^{a} (±2.57)	6.25^{a} (±0.66)

-Each value is an average of three replicates expressed on dry weight basis.
-Value are mean±SD.
-Means not sharing a common superscript letter a column are significantly different at ($p \leq 0.05$).

Table (3): Protein Fractions of Two Inbred Lines of Faba Bean

Inbred lines	Albumin (%)	Globulin (%)	Proalmin (%)	Glutelin (%)	Insoluble (%)
Hud-Line I	57.00[b] (±0.17)	19.11[a] (±0.10)	3.16[b] (±0.19)	17.71[a] (±0.44)	3.01[a] (±0.34)
Bas-Line II	60.57[a] (±0.29)	18.69[b] (±0.05)	3.76[a] (±0.13)	13.83[b] (±0.56)	2.91[a] (±0.41)

-Each value is an average of three replicates expressed on dry weight basis.
-Value are mean±SD.
-Means not sharing a common superscript letter a column are significantly different at ($p \leq 0.05$).

Table (4): In Vitro Protein Digestibility (IVPD) of Two Inbred Lines

Inbred lines	IVPD %
Hud-Line I	74.97[b] (±0.57)
Bas-Line II	76.51[a] (±0.08)

-Each value is an average of three replicates expressed on dry weight basis.
-Value are mean±SD.
-Means not sharing a common superscript letter a column are significantly different at ($p \leq 0.05$).

Table (5): Anti-Nutritional Factors (mg/100g) of Two Faba Bean Inbred Lines

Inbred lines	Tannins	Phytic acid	Polyphenols
Hud-Line I	37.11[a] (±0.17)	192.71[a] (±0.10)	230.23[a] (±0.93)
Bas-Line II	30.99[b] (±0.22)	186.08[b] (±0.15)	225.15[b] (±0.21)

-Each value is an average of three replicates expressed on dry weight basis.
-Value are mean±SD.
-Means not sharing a common superscript letter a column are significantly different at ($p \leq 0.05$).

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