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Effect of Egyptian cooking methods of faba beans on its nutritive value, dietary protein utilization and iron deficiency anemia 1. The role of main technological pretreatments

A.A. BAKR

Food Science and Technology Department, Faculty of Agriculture, El-Menofiya University, Shibin El-Kom, A.R. Egypt

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Abstract. In order to study the effects of main technological pretreatments practised for preparing Egyptian faba bean products, i.e. decortication as well as soaking and germination followed by dehulling on the nutritional value, series of experiments were carried out. Such pretreatments had a significant effect on the changes in the chemical composition of faba beans. The proportion of the removed hulls reached generally about 14%. Data revealed also pronounced improvements on the nutritive value as a result of all studied pretreatments, especially germination being the most effective. Chemical scoring of all determined essential amino acids was >60, except methionine and cystine showed the lowest score (<20). Germinated seeds had the highest chemical score for the restricting amino acids beside the lowest GDR value [Grams consumed of product to cover the daily requirements for adult man in protein (63 g) and in energy (2900 kcal)]. All pretreatments caused a significant decrease in the antinutritional factors, especially soaking followed by dehulling, whereas decortication led to a significant increase in phytic acid content.

Introduction

Faba bean (*Vicia faba*) is a cheap and valuable potential source of good quality protein, and it is consumed in large quantities in Middle East countries. In Egypt faba bean constitutes 79.6% of the total production of pulses [1], and it is used to prepare the four most popular Egyptian dishes, namely Medammis (stewed beans), Falafel (deep fried dough), Bissara (poured paste) and Nabet Soup (boiled germinated beans). However, there are several investigations indicating that faba beans contain several chemical compounds such as polyphenols (tannins), trypsin inhibitors, amylase inhibitors, phytic acid, vicine and convicine, which reduce protein quality [2, 3]. In general, when faba bean dishes are prepared for consumption they are usually subjected to some pretreatments, i.e. dehulling, soaking and/or germination. Accordingly, this work was undertaken to study the effect of these primary processes on the extent of changes in the antinutritional factors and some other nutritive value indices of faba beans.

Materials and methods

Materials. Faba beans (*Vicia faba*) var. Giza – 2, the most common variety in Egypt, were obtained from the Agricultural Authority (Seed Department), Shibin El-Kom, Egypt. The seeds were carefully freed from husks, and other foreign materials.

Decortication of seeds. The whole faba beans were mechanically decorticated with a P.R.L., 'Mini Dehuller'. Dehulled seeds and seed coats were weighed separately and the hull percentage was calculated.

Soaking of seeds. The whole faba beans were soaked in distilled water (1:5, w/v) for 12 hours at room temperature ($\sim$ 25 °C). At the end of the soaking period, the beans were removed and decorticated manually. The cotyledons and hulls were then disintegrated with a wearing blender, then dried at 50 °C for 18 hours in an electric air draught oven.

Germination procedure. Three lot samples of the whole faba beans were first steeped for 12 hours in distilled water (1:5 w/v) at room temperature ($\sim$ 25 °C) then transferred to moistened cotton layers and allowed to germinate in the dark at room temperature for 3 days. During germination, the cotton layers were kept always moistened with distilled water. Germinated beans were frozen for 12 hours to terminate the germination process. After thawing, the samples were manually decorticated and the separated cotyledons and hulls were disintegrated and dried as mentioned before.

Preparation of samples

The whole seeds and their dried cotyledons and hulls after soaking and germination followed by dehulling were ground to pass through a 70 mesh sieve, packed into air-tight jars and kept at 4 °C until analysis.

Analytical methods. True protein: The total nitrogen (TN) content of each sample was determined in triplicates by the Kjeldahl method [4]. Non-protein nitrogen (NPN) was determined in triplicates according to the method of Bhatty [5] using 13% trichloroacetic acid (TCA) to precipitate proteins. Protein nitrogen (TN-NPN) was multiplied by a conversion factor of 5.85 as recommended by Murray et al. [6] to obtain true protein. Crude ether extract, crude fiber and total ash were determined according to the AOAC methods [4]. Reducing sugars were determined in 70% ethanol extract by the method of Dubois et al. [7]. Total soluble carbohydrates were calculated by difference.

Amino acid assay. Amino acids (AA) other than cystine, methionine and tryptophan were determined in the acid hydrolysates according to the method

of Moore et al. [8], using a Beckman Amino Acid Analyzer (Model 121 M). The analysis of methionine, cystine and tryptophan was accomplished by microbiological assay [9].

Amino acid score. Amino acid score (AAS) was calculated for essential amino acids using FAO/WHO/UNU reference protein 'Whole egg protein' [10].

$$\text{AAS} = \frac{\text{Concentration of essential amino acid in tested protein}}{\text{Concentration of essential amino acid in FAO/WHO/UNU pattern}} \times 100$$

AAS value, less than 100 indicates deficiency in considered amino acid. The acid which showed highest deficiency (lowest AAS) was called limiting amino acid (LAA).

Chemical score of protein. Values for the essential AA were converted to protein scores to obtain an estimate of the protein quality. Protein scores are based on the distribution of the individual essential AA compared to the essential AA as related to ideal egg protein [10].

Antinutritional factors. Trypsin inhibitor was extracted and determined as described by Chavan and Heigaard [11]. Total tannin content was determined according to the AOAC methods [4]. Furthermore, phytic acid content was determined according to the method of Wheeler and Ferrel [12].

Statistical analysis. Data were subjected to analysis of variance and the least significant difference (LSD) was calculated to allow comparison between the average values of the factors studied [13].

Results and discussion

Chemical composition and the proportion of removed hulls. The proximate chemical composition of the whole faba beans as influenced by dehulling as well as soaking and germination followed by dehulling and the proportion of hulls removed are presented in Table 1.

The true protein content of whole beans was 27.3% and the dehulling as well as soaking and germination followed by dehulling increased it significantly ($p \leqslant 0.01$) by 4.0, 1.5 and 5.1%, respectively. This increase in true protein may be attributed to the low protein content of the hulls, besides the leaching out and the break down of some dry matter during both soaking and germination processes [6]. Dehulling as well as soaking and germination followed by dehulling had no effect on the crude fat content of faba beans, where its values were constant (1.3%). Reducing sugars suffered from a significant reduction as a consequence of these pretreatments. The whole beans had 9.4% crude fiber and the dehulling process led to a significant decrease in its original value by about 88%. The soaking or germination processes followed by dehulling

Table 1. Chemical composition and the removed hulls (%) of whole faba beans as influenced by dehulling as well as by soaking and germination followed by dehulling (means of triplicates on air dry weight basis)

Constituents	Faba beans				LSD	
	Whole	Dehulled	Soaked and dehulled	Germinated and dehulled	$p \leqslant 0.05$	$p \leqslant 0.01$
Protein (N% × 5.85)	31.4	31.9	31.8	32.2	0.8	1.1
Non-protein nitrogen	0.7	0.6	0.7	0.6	N.S.*	N.S.
True protein	27.3	28.4	27.7	28.7	0.5	0.7
Crude ether extract	1.3	1.3	1.3	1.3	N.S.	N.S.
Reducing sugars (as glucose)	7.6	6.2	5.7	5.2	0.3	0.4
Crude fiber	9.4	1.1	1.1	1.1	0.1	0.2
Total soluble carbohydrates	54.3	62.2	62.5	61.6	0.1	0.2
Total ash	3.6	3.5	3.3	3.8	0.1	0.1
Removed hulls (%)	–	13.8	13.7	13.8	N.S.	N.S.

*N.S. = Not significant.

showed no further effect on the crude fiber content. Total soluble carbohydrates which were calculated by difference increased apparently as a result of the dehulling as well as soaking and germination followed by dehulling. While the dehulling and soaking for 12 hours, followed by dehulling of faba beans, resulted in a significant decrease in total ash, the germinated seeds exhibited highly significant increase in the content of ash (3.8%). This reduction in total ash of dehulled and soaked followed by dehulling faba beans could be attributed to the lower ash content in the removed hulls and the loss of water-soluble ash during soaking. Subsequent losses of dry matter other than ash led to the increase in the total ash content of the germinated seeds. These results are partially in agreement with those obtained by Hsu et al. [14]. The proportion of the removed hulls reached generally about 14%, without any significant differences between treatments.

Amino acid composition. The AA composition of whole, dehulled, as well as soaked and germinated faba beans followed by dehulling is presented in Table 2. The AA composition of whole beans was similar to that reported by Kaldy [13]. Dehulling of seeds increased the total AA content per 16 g N by

Table 2. Amino acid composition (gm/16 gm N) of whole faba beans as influenced by dehulling as well as soaking and germination followed by dehulling (means of triplicates)

Amino acid	Faba beans				LSD at 5%
	Whole	Dehulled	Soaked and dehulled	Germinated and dehulled	
Alanine	4.9	5.2	4.8	5.1	0.3
Arginine	7.9	8.2	8.0	8.3	N.S.
Aspartic acid	13.5	13.8	13.6	14.2	N.S.
Cystine	0.7	0.8	0.7	0.7	N.S.
Glutamic acid	19.0	19.8	19.8	19.9	N.S.
Glycine	4.9	5.1	4.9	5.0	N.S.
Histidine	2.5	2.6	2.5	2.6	N.S.
Isoleucine	5.1	5.3	5.2	5.4	N.S.
Leucine	7.7	8.0	7.7	8.0	N.S.
Lysine	6.1	6.3	6.1	6.4	N.S.
Methionine	0.7	0.7	0.6	0.7	N.S.
Phenylalanine	4.0	4.1	4.0	4.2	N.S.
Proline	4.2	4.4	4.3	4.5	N.S.
Serine	5.9	6.1	5.9	6.2	0.2
Threonine	4.7	4.9	4.5	4.9	N.S.
Tryptophan	1.7	1.8	1.7	1.8	N.S.
Tyrosine	2.5	2.6	2.4	2.5	N.S.
Valine	5.1	5.3	5.1	5.3	N.S.
Total	101.1	105.0	101.8	105.8	–
Relative retention %	100	103.9	100.7	104.6	–

Table 3. Some nutritive value indices of whole faba beans as influenced by dehulling as well as soaking and germination followed by dehulling

Essential amino acids	Pretreatments	gm/16 gm N						AAS				
		Whole egg	Whole beans	Dehulled beans	Soaked beans and dehulled	Germinated beans and dehulled	LSD at 5%	Whole beans	Dehulled beans	Soaked beans and dehulled	Germinated beans and dehulled	LSD at 5%
Isoleucine		5.4	5.1	5.3	5.2	5.4	N.S.	94	98	96	100	N.S.
Leucine		8.6	7.7	8.0	7.7	8.0	N.S.	90	93	90	93	N.S.
Lysine		7.0	6.1	6.3	6.1	6.4	N.S.	87	90	87	91	N.S.
Threonine		4.7	4.7	4.9	4.5	4.9	N.S.	100	104	96	104	N.S.
Tryptophan		1.7	1.7	1.8	1.7	1.8	N.S.	100	106	100	106	N.S.
Valine		6.6	5.1	5.3	5.1	5.3	N.S.	77	80	77	80	N.S.
Histidine		2.3	2.5	2.6	2.5	2.6	N.S.	109	113	109	113	N.S.
Methionine + Cystine*		5.7	1.4	1.5	1.3	1.4	N.S.	25*	26	23	25	N.S.
Phenylalanine + Tyrosine		9.3	6.5	6.7	6.4	6.8	N.S.	70	72	69	73	N.S.
Chemical score		100	–	–	–	–		24.6	26.3	22.8	24.6	

Table 3 (Continued)

Essential amino acids	USRDR (G)	G.D.R.					P.S./150				
		Whole beans	Dehulled beans	Soaked beans and dehulled	Germinated beans and dehulled	LSD at 5%	Whole beans	Dehulled beans	Soaked beans and dehulled	Germinated beans and dehulled	LSD at 5%
Isoleucine	0.819	48.2	45.5	45.5	43.1	3.2	311.2	329.7	329.7	348.0	11.7
Leucine	1.197	46.0	44.3	46.0	42.8	0.2	326.1	338.6	326.1	350.5	N.S.
Lysine	1.008	50.4	48.0	48.0	45.8	2.8	297.6	312.5	312.5	327.5	14.2
Threonine	0.567	35.4	33.4	37.8	33.4	N.S.	423.7	449.1	396.8	449.1	8.5
Tryptophan	0.315	52.5	52.5	52.5	52.5	N.S.	285.7	285.7	285.7	285.7	N.S.
Valine	0.819	48.2	45.5	48.2	45.5	1.8	311.2	329.7	311.2	329.7	N.S.
Histidine	1.008	126.0	112.0	112.0	112.0	N.S.	119.0	133.9	133.9	133.9	5.6
Methionine + Cystine*	1.071	214.2	214.2	267.8	214.2	10.6	70.0	70.0	56.0	70.0	3.2
Phenylalanine + Tyrosine	1.197	54.4	52.0	54.4	52.0	N.S.	275.7	288.5	275.7	288.5	4.8
Chemical score	–	–	–	–	–		–	–	–	–	

AAS = Amino acid score.
USRDA = United State Recommended Daily Allowances.
GDR = Grams consumed of product to cover the daily requirements for adult man in protein (63 gm) and in energy (2900 Kcal).
PS/150 = Satisfaction of the daily requirements of the adult man when 150 (one can content) grams are consumed of product.
*Restricting amino acid.

about 4% over that of the whole faba beans. This increase may be attributed to a different AA pattern of the hulls. On the other hand, when faba beans were soaked for 12 hours followed by dehulling only a slight increase (0.7%) in the content of total AA of the cotyledons was observed. This may be due to the effect of the interaction between the dehulling and the leaching out of amino acids during the soaking process ($\sim$ 3%). Moreover, a further significant increase in total AA content was noticed after 72 h of germination followed by dehulling. This increase in AA may be due to the processes as in the dehulled beans. All technological pretreatments had no significant ($p \leqslant 0.05$) effect on the content of the individual AA, except on that of both alanine and serine. These results coincide partially with those of Kaldy [13] and Hsu et al. [14].

Some nutritive value indices. All AAS for the individual essential AA are > 60, except methionine + cystine, which showed lowest AAS (< 30) (Table 3). Therefore, they are the limiting AA in the proteins of these investigated samples. It was also noticed that germination improved the protein quality of faba beans, where the germinated and dehulled seeds had the highest AAS. GDR values have been calculated regarded a parameter for the nutritional value, for adult human requirements and expresses the daily amount of food needed to meet the daily requirements of protein and energy. Values of GDR are inversely related to the protein content. The percent satisfaction of daily requirements for the adult human consuming 150 g (PS/150) of faba beans as related directly to the amino acid content in these treated faba bean samples and depends on the factors affecting the AA content. It is clear from the previously mentioned results that, protein from faba bean seeds appear to be reasonably well balanced with respect to the essential AA, except the sulphur containing AA particularly methionine. Consequently, germinated seeds had the highest nutritive value as they had the lowest GDR and the highest PS/150 for the restricting AA.

Antinutritional factors. Changes in certain chemical and biological antinutritional factors such as tannins, phytic acid and trypsin inhibitor of faba beans as affected by some technological pretreatments are illustrated in Figure 1. Dehulling of faba beans led to a significant ($p \leqslant 0.05$) decrease in tannins content, since the seed coats had more than 85% of the tannins present in the seeds [15]. A further reduction in tannin content was also noticed after 12 hours of soaking followed by dehulling. This may be due to the double effect of both soaking and dehulling processes, which tends to confirm the results obtained by Panda et al. [16]. The loss of tannins from the whole beans after 3 days of germination was similar, which agrees with results reported by Udayasekhara Rao and Deosthale [17], demonstrating that the loss of tannins from the whole beans during the first 3 days of germination was essentially due to leaching out by seed coats rather than by enzymatic degredation. In contrast dehulling of faba beans caused a significant ($p \leqslant 0.05$) increase in phytic acid content, which can be attributed to the localization of phytic acid in cotyledons [3]. However, soaking for 12 h followed by dehulling decreased signifi-

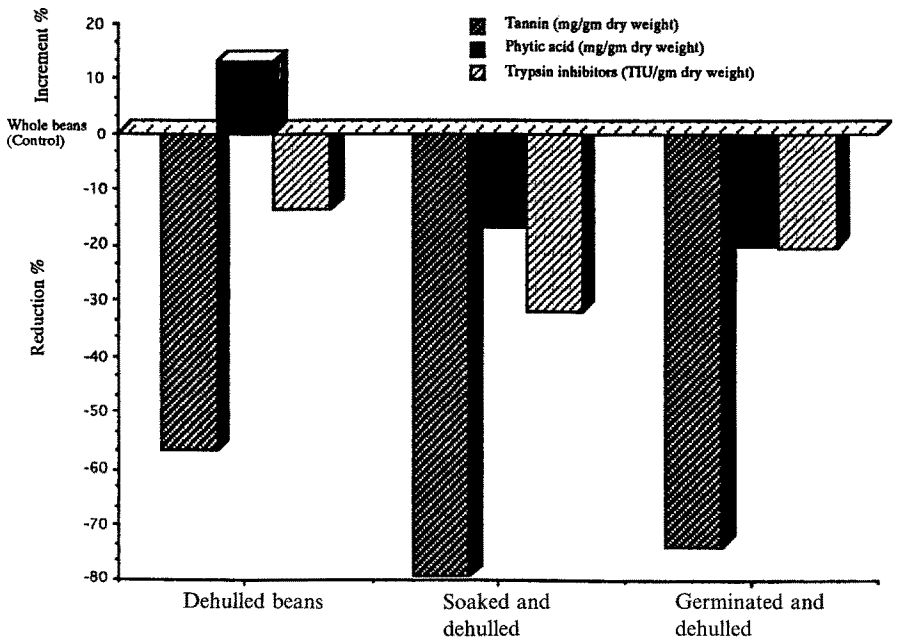

Fig. 1. Changes as % in some antinutritional factors content of raw faba beans as influenced by dehulling as well as soaking and germination followed by dehulling.

cantly ($p \leqslant 0.05$) the phytic acid content. Germination followed by dehulling decreased also significantly ($p \leqslant 0.05$) the phytic acid content, which agrees with results reported by Tabekhia and Luh [18], demonstrating that the first 2 days of germination represents a latent period during which the phytase activity was not prevalent. After 72 hours of germination the decrease in phytic acid was more more rapid. Furthermore, all three pretreatments tested lowered the trypsin inhibitor compared to whole faba beans.

Conclusions

Our results confirm that soaking and germination of faba bean seeds followed by dehulling are effective ways for inactivating trypsin inhibitors and removing of significant proportions of polyphenols and oligosaccharides, which means that these primary processes improve the nutritive value of faba beans with regard to their positive effects on the chemical scoring of all essential amino acids, except methionine and cystine.

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