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# Comparative studies on some leguminous protein sources and soybean proteins

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With 6 tables

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A considerable amount of work has been carried out on the nutritive value of leguminous seeds and about their potential success as protein supplement in human nutrition (*Liener* 1966, *Jose* 1968 and *Kakade* and *Evans* 1966).

Broad bean is one of the legumes most widely consumed in Egypt providing nearly two-thirds of total supplies of protein with lentils coming next in order of importance (*Morcos* 1966). Some reports have been published concerning its carbohydrate, protein and amino acid contents (*Hegazi* and *Salem* 1973) and the effect of its supplementation with lysine in bread based diet (*Hussein* et al. 1974).

Soybean proteins received extensive attention as an excellent protein source that could be added to foods to improve their protein values (*Mizrahi* et al. 1967, and *Parthasarathy* et al. 1964). In Egypt this valuable protein source is virtually unknown where the need of protein is the greatest.

The object of the present work was to investigate the protein quality of broad bean and kidney bean compared with that of soybean protein which are widely used and play an important role in the planning of a well-balanced and nutritionally adequate diet for people of Egypt.

## Experimental

*Sampling*

Different varieties of soybeans (*Clark* and *Hampton*), broad beans (Giza 1) and kidney beans (Giza 3), were given from the Ministry of Agriculture de-

Tab. 1. Composition of experimental diets used.

| Ingredients g % | Soybean Hampton | Soybean Clark | Broad bean | Kidney bean | Casein diet. | Nonprotein diet. |
|---|---|---|---|---|---|---|
| Wt. taken | 25.6 | 23.3 | 35.8 | 57.1 | 10.9 | – |
| Maize starch | 40.9 | 42.4 | 24.6 | 3.0 | 40.6 | 50.0 |
| Potato starch | – | – | – | – | – | 10.0 |
| Fat | 8.5 | 9.3 | 14.6 | 14.9 | 15.0 | 15.0 |
| Glucose | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 |
| Vitamin mixture | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| Salt mixture | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| Methionine | – | – | – | – | 0.5 | – |
| Total | 100 | 100 | 100 | 100 | 92,0 | 100 |

partment of plant breeding. The samples were finely ground and subjected for chemical analysis.

*Methods*

The moisture, fat, nitrogen, ash and iron contents were determined by the methods adopted by the A.O.A.C. (1965). Estimation of calcium and phosphorus as described by *Stuffins* (1967). Determination of total sugars and the starch contents was followed according to the method of *Clegg* (1956). The amino acid contents were determined as described by *Hegazi* and *Salem* (1972).

The net protein utilization was determined on weanling hooded rats according to the method of *Miller* and *Bender* (1955). The digestibility coefficient and the biological value were calculated.

*Autoclaving*

The raw beans were autoclaved at 100 °C for one hour under press of 15 lb./sq. and followed by air drying at 60 °C.

## Results

The chemical analysis of broad bean, kidney bean and soybean are shown in tab. 2. From the results tabulated it is seen that soybean (Clark variety) is the most rich source for protein, fat, total ash, calcium and iron contents compared with broad bean and kidney bean.

Tab. 2. Chemical composition of soybean, broad beans and kidney beans (g/100g).

| Constituents g % | Soybean Hampton | Soybean Clark | Broad beans | Kidney beans |
|---|---|---|---|---|
| Moisture | 5.4 | 5.5 | 10.1 | 11.8 |
| Crude protein | 39.0 | 40.2 | 27.5 | 20.6 |
| Fat | 24.5 | 23.4 | 1.2 | 1.7 |
| Total carbohydrate | 20.1 | 20.3 | 46.5 | 56.7 |
| Ash | 6.1 | 6.4 | 3.5 | 4.1 |
| Crude fibre | 5.2 | 5.1 | 6.9 | 4.7 |
| Calcium mg/100 g | 224 | 273 | 215 | 80 |
| Phosphorus mg/100 g | 657 | 609 | 899 | 633 |
| Iron mg/100 g | 18 | 12 | 4.5 | 4.8 |

Tab. 3 shows the amino acid pattern of the three leguminous seeds. Soybean proteins were superior for the values of lysine, arginine and phenylalanine as well a thyrosine while kidney bean proteins contain higher amonuts of threonine, valine, phenylalanine, leucine and isoleucine compared with broad bean and soybean proteins. Although the three protein sources are poor sources for cystine, methionine and tryptophan, it is apparent that soybean proteins contain relatively higher amounts from these amino acids when compared with those of broad bean and kidney bean.

The changes in the concentrations of lysine, cystine, methionine and tryptophan due to autoclaving of soybean, broad bean and kidney bean are shown in tab. 4. From the results it is evident that a remarkable change in the concentration of these amino acids had occurred. Methionine content of the three seeds was highly reduced by 22, 23 and 28% respec-

Tab. 3. Amino acids pattern of soybean (*Hampton* and *Clark*), broad beans (Giza 1) and kidney beans (Giza 3) (mg/gN)*.

| Amino acid | Soybean | | Broad bean | Kidney bean |
|---|---|---|---|---|
| | Hampton | Clark | | |
| Lysine | 368 | 389 | 375 | 357 |
| Histidine | 171 | 165 | 148 | 154 |
| Arginine | 445 | 437 | 340 | 345 |
| Threonine | 209 | 217 | 224 | 269 |
| Valine | 272 | 283 | 336 | 338 |
| Tyrosine | 256 | 264 | 246 | 242 |
| Phenylalanine | 319 | 315 | 273 | 317 |
| Leucine + Isoleucine | 635 | 647 | 805 | 853 |
| Cystine | 79 | 82 | 53 | 64 |
| Methionine | 72 | 72 | 39 | 72 |
| Tryptophan | 68 | 69 | 67 | 58 |
| Serine | 288 | 297 | 332 | 262 |
| Glycine | 321 | 329 | 322 | 206 |
| Alanine | 239 | 253 | 219 | 248 |
| Aspartic acid | 708 | 723 | 523 | 678 |
| Glutamic acid | 937 | 952 | 1019 | 812 |

* mean of 5 samples

Tab. 4. Effect of heat treatment on the concentrations of lysine, methionine, cystine and tryptophan components of soybean, broad beans and kidney beans (mg/gN).

| Amino acid | Soybean (Clark) | | Broad bean | | Kidney bean | |
|---|---|---|---|---|---|---|
| | Raw | Treated | Raw | Treated | Raw | Treated |
| Lysine | 389 | 323 | 375 | 332 | 357 | 312 |
| Methionine | 72 | 56 | 39 | 28 | 64 | 49 |
| Cystine | 79 | 61 | 53 | 47 | 72 | 58 |
| Tryptophan | 69 | 65 | 67 | 65 | 64 | 57 |

Tab. 5. Net protein utilization (N.P.U.) Digestibility coefficient (D.) and Biological value (B.V.) of soybean, broad beans and kidney beans (%)*.

| Diets | Digestibility coefficient % | Biological value % | Net protein utilization % |
|---|---|---|---|
| Soybean (Hampton) | 84.17 | 73.45 | 61.82 |
| Soybean (Clark) | 83.18 | 72.28 | 60.12 |
| Broad bean | 73.26 | 57.26 | 41.79 |
| Kidney bean | 83.79 | 66.45 | 55.68 |
| Casein | 94.82 | 74.48 | 70.62 |
| Soybean raw | – ve | – ve | – ve |
| Kidney bean raw | – ve | – ve | – ve |

* mean of 3 assays

tively followed by cystine 22, 19 and 11 % and lysine which showed a reduction by 17, 12 and 11 %. The tryptophan content was more stable to heat treatment and lost 4.5, 11 and 4 % of its value in the three seeds respectively. These results indicate that the amino acid contents of soybean and kidney beans were more highly affected by the heat treatment than those of the broad beans.

The net protein utilization, digestibility coefficient and biological value of the three leguminous seeds are summarized in tab. 5. It is apparent from the results obtained that soybean had a higher N.P.U. value (61.82) compared with that of kidney beans (55.68 %) and broad beans which showed the lowest value (41.79 %). The N.P.U. of soybean was the nearest value to that of casein (70.62).

## Discussion

The concentration of the essential amino acids is the important factor in determining the biological value of proteins. On comparing the amounts of these amino acids in soybean, broad bean and kidney bean proteins with both the provisional amino acid pattern recommended by the FAO for consumption and that of the egg (tab. 6), it is apparent that most of the essential amino acids are existing in optimal amounts with the exception of tryptophan, methionine and cystine which showed deficiencies. It could be shown that soybean furnished 70 % more of phenylalanine as well as 40 % more of lysine and 20 % more of threonine and leucine than that of the provisional amino acid pattern.

*Kakade* and *Evans* (1965) observed the improvement in the nutritive value of navy bean when they were heat-treated. They explained that the beneficial effect of heat on the nutritive value of navy bean could be attributed to the destruction of the heat-labile trypsin inhibitor and to the changes (denaturation) in the protein molecule. *Lea* and *Hannan* (1950) attributed the destruction of the amino acids caused by the heat treatment to be due to the interaction between the free amino acid groups and the reducing carbohydrates. Such losses were observed in the amounts of

Tab. 6. Amino acids pattern of soybean, broad beans and kidney beans as compared to F.A.O. provisional pattern and egg (mg/gN).

| Amino acid | F.A.O. pattern | Egg | Soybean Hampton | Soybean Clark | Broad bean | Kidney bean |
|---|---|---|---|---|---|---|
| Isoleucine + leucine | 576 | 993 | 653 | 647 | 809 | 853 |
| Lysine | 270 | 396 | 368 | 389 | 375 | 357 |
| Phenylalanine | 180 | 368 | 319 | 315 | 273 | 317 |
| Tyrosine | 180 | 274 | 256 | 264 | 246 | 242 |
| Methionine + Cystine | 270 | 342 | 151 | 154 | 92 | 136 |
| Threonine | 180 | 310 | 209 | 217 | 224 | 269 |
| Tryptophan | 90 | 106 | 68 | 69 | 67 | 58 |
| Valine | 270 | 460 | 272 | 283 | 336 | 338 |
| Total | 2016 | 3249 | 2278 | 2338 | 2422 | 2570 |

methionine, cystine, lysine and tryptophan contents of soybean, kidney bean and broad bean, indicating that soybean proteins were more highly affected by the heat treatment than those of the broad bean. These observations were confirmed by *Liener* (1958) and *Kakade* and *Evans* (1965). They reported that lysine, methionine, cystine and tryptophan were decreased by autoclaving.

The data obtained from rat feeding experiments indicate the extremely low values of the N.P.U. and the digestibility coefficient for the broad bean and kidney bean diets compared with soybean. This could be attributed to the deficiency of the sulphur amino acids and to the effect of heat treatment. Broad bean was the most poor source for methionine and cystine, and their amounts just cover one third of the respective minimal daily requirement of these amino acids (tab. 6).

Considering this comparison it is apparent that soybean protein had a good protein quality superior to that of kidney bean and broad bean.

*Summary*

The nutrient contents as well as the amino acid pattern of broad bean, kidney bean and soybean were determined. The levels of most of the amino acids were also estimated. Heat treatment of the leguminous seeds caused a noticeable reduction in the levels of methionine, cystine, lysine and tryptophan.

Animal experiments showed high figures for digestibility, biological value and net protein utilization for the soybean diet whereas the broad bean and kidney beans gave lower values of these measurement compared with soybean.

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