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PROTEIN QUALITY IMPROVEMENT

Improvement in the Protein Efficiency of Soybean Concentrates and Isolates by Heat Treatment

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Protein efficiency values were determined for three soybean concentrates (approximately 60% protein) and four soybean isolates (approximately 90% protein) before and after mild heat treatment. Values for the unheated samples were 0.34 to 1.91, as compared to 2.44 (81% of the casein control) for a processed soybean flour. Mild heat treatment improved the protein efficiency values to 2.02 to 2.29, except for one, which remained low (1.46). The latter isolate contained appreciable cysteic acid apparently from destruction of cystine. Addition of methionine hydroxy analog to this isolate markedly improved its protein value. The findings indicate that soy isolates and concentrates may contain inherently good protein, but often require mild heat treatment to bring out maximal protein value. This must be considered in assessment of nutritive value and in use of these materials in nutritional products.

SOYBEANS are a very valuable protein source for many nutritional products designed for human and animal use. Soybean flour must be properly heat treated to achieve maximal nutritional value, although excess heat can be detrimental (*1–3, 9, 15*). The improvement in the nutritional quality of soybean protein resulting from mild heat treatment is due partly to the destruction of trypsin inhibitor(s) (*8, 10, 15*) and partly to modification of the protein permitting more complete digestibility and utilization of the growth-limiting sulfur amino acids (*3, 10*).

There is increasing interest in the use of soybean concentrates and isolates in place of soybean flour in nutritional products because of the many technological advantages relating to taste, texture, and other characteristics (*6, 13*). Successful use of such special preparations also depends to a great extent on their nutritional qualities. Three soybean concentrates (approximately 60% protein) and four isolates (approximately 90% protein) were studied to evaluate their protein qualities and to determine whether they had received adequate heat treatment in manufacture to promote maximal protein quality, and whether processing had reduced their potential protein quality. The results of these experiments are presented.

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Experimental

The soybean protein preparations were obtained from Archer Daniels Midland Co., Central Soya Co., Hercules Powder Co., and Ralston-Purina Co. The conditions of manufacture were not divulged by the companies. Methionine, cystine, and tryptophan content of several of the soybean preparations were determined by microbiological assay with *Leuconostoc mesenteroides* (*5*), and the other amino acids (and cysteic acid) by ion exchange chromatography (*11, 14*) using a Beckman-Spinco Model X120 amino acid analyzer. Values for methionine by the latter method were similar to those found microbiologically.

Each sample was tested in rat studies as received, and again after heat treatment, in which the soybean samples were spread in a thin layer (approximately 1/2 inch) in flat pans and exposed to live steam at 105° C. in the autoclave for 30 minutes. The materials were then dried in an oven at 100° C. for 1 hour. In all experiments, groups of 10 male weanling rats each (McCollum-Wisconsin strain) with an average initial weight of approximately 50 grams were selected on the basis of body weight and litter. The animals were individually housed in metal, screen-bottomed cages in an air conditioned animal room.

The general composition of the diets is shown in Table I. In all experiments, food and water were offered *ad libitum* and their intakes recorded; the animals were weighed each week. After 4 weeks, the protein efficiency value was calculated for each animal, and an average value and standard deviations were determined.

Results and Discussion

The protein efficiencies for the unheated and heated soybean concentrates

Table I. Composition of Diets

Ingredients	Amount, %
Protein source	To give 10% protein
Corn oil	To give 10% fat[a]
Vitamin mixture[b]	0.35
Mineral mixture[c]	4.0
Nonnutritive fiber	4.0
DL-α-Tocopherol acetate	0.005
Oleum Percomorphum[b]	0.015
Amidex[d]	To 100

[a] Including fat supplied by protein source.
[b] Sarett and Snipper (*12*) with ascorbic acid omitted from the vitamin mixture. Vitamins A and D added as Oleum Percomorphum.
[c] Jones and Foster (*7*) with 10 p.p.m. F added as NaF.
[d] Amidex brand corn starch (partially hydrolyzed), Corn Products Refining Co., New York, N. Y.

Table II. Protein Efficiency Values of Soybean Concentrates and Soybean Isolates before and after Heat Treatment

Protein Source	Protein,[a] %	Protein Efficiency: Grams Gain per Gram Protein Intake, Unheated	Protein Efficiency: Grams Gain per Gram Protein Intake, Heated	Casein Standard, %, Unheated	Casein Standard, %, Heated
Casein, ANRC	91.2	3.00 ± 0.24[b]	...	100	..
Soybean flour	43.4	2.44 ± 0.36	2.39 ± 0.27[b]	81	80
Soybean concentrate A	52.9	0.34 ± 0.55	2.06 ± 0.33	12	69
Soybean concentrate B	57.1	1.37 ± 0.36	2.10 ± 0.19	46	70
Soybean concentrate C	64.8	1.86 ± 0.38	2.02 ± 0.33	63	67
Soybean isolate I	90.2	1.36 ± 0.23	1.46 ± 0.32	45	49
Soybean isolate II	88.6	1.41 ± 0.31	2.27 ± 0.21	44	76
Soybean isolate III	85.7	1.77 ± 0.23	2.29 ± 0.17	59	73
Soybean isolate IV	87.5	1.91 ± 0.26	2.11 ± 0.26	64	70
Soybean isolate I + 0.7% methionine hydroxy analog	90.9	...	2.24 ± 0.22	...	75

[a] Protein content (N × 6.25) on as is basis. [b] Mean ± standard deviations.

Table III. Essential Amino Acid Content of Soybean Isolates and Soybean Flour

Grams per 100 grams protein

Amino Acid	Soybean Isolate I	Soybean Isolate II	Soybean Isolate III	Soybean Flour
Methionine	1.1	1.1	1.3	1.4
Cystine	0.8	1.2	1.1	1.0
Methionine + cystine	1.9	2.3	2.4	2.4
Cysteic acid	0.5[a]	...[b]	...[b]	...[b]
Threonine	3.3	3.8	3.6	3.8
Valine	4.5	4.8	5.1	4.5
Isoleucine	4.6	4.7	4.6	4.4
Leucine	7.5	7.9	7.7	7.2
Phenylalanine	5.3	5.1	5.2	4.5
Lysine	6.0	5.9	6.5	5.9
Histidine	2.4	2.3	2.7	2.4
Arginine	8.0	7.0	7.5	6.4
Tryptophan	1.0	1.3	...	...

[a] Equivalent to 0.36 gram cystine.
[b] Cysteic acid content less than 0.05 gram.

and soybean isolates are given in Table II. The values for the unheated materials showed marked variation in nutritional quality. However, after heat treatment, the values for all of the concentrates and three of the isolates approached the values for soybean flour. The protein efficiency for one isolate was still quite low after heat treatment. These data suggest that there are marked differences in manufacturing processes for soybean concentrates and isolates, that losses in nutritional value in processing may be quite large, and that heat treatment is not optimal in most cases. Huge (*6*) reported that the nutritional value of a soy isolate (Promine, Central Soya Co.) was not significantly improved by heat treatment, and therefore suggested that in the manufacture of the isolate, most of the inhibitors in the soybeans were removed. The present demonstration of improvement of nutritional value of soy isolates by heat suggests that inhibitors may not be completely removed, or that heat permits better utilization of the isolate protein.

Sulfur amino acids (methionine and cystine) are the growth-limiting amino acids in soybean protein (*1*, *4*). The concentrations of the essential amino acids in three soybean isolates showed little difference from values for soybean flour, except for sulfur amino acids (Table III). [The amino acid analyses were in close agreement with those reported by Huge (*6*) for a soybean concentrate and a soybean isolate.] The low value of sulfur amino acids in isolate I was apparently due to the conversion of cystine to cysteic acid during processing (Table III), and this probably accounts for the poor nutritional quality of this isolate, even after heat treatment. When methionine hydroxy analog (equivalent to methionine) was added to heat-treated isolate I at a level of 0.7 gram per 100 grams protein, the protein efficiency was improved from 1.46 to 2.24 (Table II).

The determination of the sulfur amino acids in soybean proteins is useful to estimate the potential nutritional value of soybean products when properly heated. However, sulfur amino acid values alone do not reflect protein quality, since they give no indication of amino acid availability. The data from these studies show the importance of heat treatment of soybean concentrates and isolates as well as of soybean flour when evaluating their nutritional quality. Consideration should be given to the amount of heat employed in the manufacturing of nutritional products containing soybean to ensure maximal protein quality.

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