Nutritional Value and Economic Aspects of Fortification of Foods of Plant Origin with Soy Protein

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ABSTRACT

The protein requirements of children and adults are reviewed in comparison with the protein qualities of several foods with and without added soy. The economic considerations greatly favor soy containing foods for equivalent nutrition.

INTRODUCTION

The biological value of the protein consumed depends upon the quantity and proportions of the essential amino acids. As long as the food is of animal origin, the essential amino acids are present in quantities that approach the ratios necessary for protein formation in humans; most of the essential amino acids can be found in plant materials important as protein sources but usually only in smaller quantities than necessary.

Since the body building value of a protein is characterized by the essential amino acid present in the least quantity, the nutritive value of the plant proteins is generally less than that of the animal protein. Production costs, on the contrary, are much higher for animal proteins than for plant proteins. Therefore, even in economically developed countries, a deficiency can arise in biologically effective proteins, in addition to a deficiency in sufficient energy content and total protein content, mostly with consumers of lower incomes. The detrimental influence of such a deficiency on humans is well known, especially in relation to the functioning of the nervous system. It also is known that this effect first shows itself in children. Other biological processes also are interfered with, as for example, vitamin C management, where the demands for this vitamin can be increased many times. The quantities of complete protein necessary/day for man are illustrated in Table I, based upon data from the World Health Organization (WHO).

For practical calculations, the Food and Agriculture Organization (FAO) threonine formula which includes the ratio of the desired quantity of the essential amino acids to threonine may be used appropriately (Table II).

TABLE I

Requirements for Complete Protein

Age in years	g/kg wt/day
1-3 child	0.88
4-6 child	0.81
7-9 child	0.77
10-12 child	0.72
13-15 child	0.70
16-19 child	0.64
Adult[a]	0.59

[a]For pregnant women, add 6g, for nursing women add 15g or more.

TABLE II

Food and Agriculture Organization Threonine Formula

Optimum ratio of amino acids	
Threonine	1.0
Lysine	1.5
Sulfur containing	0.8
Valine	1.5
Isoleucine	1.5
Leucine	1.7
Phenylalanine	1.0

NUTRITIONAL AND ECONOMICAL ASPECTS OF SOY PROTEIN

There have been experiments where the optimum amino acid requirement is higher than the stated norm; there are also cases where a greater consumption, particularly in the case of methionine, cystine, phenylalanine, and tryptophan, was found to be injurious. The first, which, due to the narrowness of the norm, is related to observation, supports our efforts to guarantee a supply of essential amino acids. The latter, fear of overuse, refers to excessive cases of chemical supplementation of individual amino acids and not to the fortification attained by the addition of soy protein, which approaches the composition of the complete natural sources.

Along with the protein content of the raw materials, it should be noted that, after cooking, drying, etc., the essential amino acids, especially threonine, valine, and phenylalanine, substantially are decreased and, in the case of the sulfur containing ones, are depleted seriously.

Table III shows the nutritive value of the individual animal and plant protein sources as determined by methods used most often.

In Table III, column two contains the amino acids determined quantitatively by a chemical method, values which are retained with methods based upon the limiting amino acid principle. Column four contains the index of protein nutritive values based upon quantitatively charac-

TABLE III

Nutritive Value of the Protein of a Few Foods

Food	Chemically determined	Egg = limiting amino acid	Net protein utilization	Biological value
Egg	1.0	—	1.0	1.0
Beef	0.80	Sulfur containing	0.80	0.74
Fish	0.75	Tryptophan	0.83	0.85
Cow's milk	0.60	Sulfur containing	0.75	0.85
White bread	0.37	Lysine	0.49	0.54
Potato puree	0.52	Leucine	0.55	0.68
Rice	0.75	Lysine	0.57	0.70
Maize	0.45	Tryptophan	0.55	0.54

TABLE IV

Cost of Complete Protein in Protein Sources

Food	Relative price of 100 g pure material Forint	Biologically complete protein Percent content	Cost, forint
Chicken	4.52	16.81	25.65
Pork	3.90	13.77	27.82
Beef	3.80	16.00	23.67
Fish	4.00	15.00	26.34
Cheese (½ fat, ½ hard)	4.10	23.10	16.93
Cows' milk	0.50	2.62	18.97
Beans (dry)	2.00	11.60	16.67
Flour (white)	0.46	7.00	5.81
Soy protein isolate	6.60	73.60	8.91

TABLE V

Change of the Protein Content of Vegetables with Addition of 5% Soy Protein Concentrate and Cost

Vegetable	Percent protein content without fortification	Percent protein content with fortification	Complete protein content without fortification	Complete protein content with fortification	Cost of fortification forint/100 g food
Paprika stuffed with vegetables in tomato sauce	1.0	4.25	0.6	3.0	0.25
Stuffed paprika (Hungarian type)	4.1	7.35	3.15	5.6	0.25
Stuffed cabbage (Hungarian type)	2.3	5.55	1.6	4.0	0.25
Letscho with rice fatty	1.5	4.75	0.8	3.3	0.25

terized animal studies, the net protein utilization. In column five, values are shown which were determined by microbiological methods using test organisms.

Beside the nutritive value of the protein content of the individual foods, the economic side of the question is especially important; as is the cost of the complete protein content of the protein source. In Table IV, the price of 100 g biologically complete protein is shown in our most important protein sources, with the actual use calculated, so that in the products mentioned, the value of other constituents (fat, carbohydrates) are deducted. From the data, we can understand the economic sense of partial replacement of animal protein sources and the suitability of protein restoration of plant sources by valuable soy protein.

This explanation also is supported by our dietary habits–we eat much which contains only small quantities of essential amino acids–bread, pasta, potatoes, various vegetables, etc.

The soybean protein concentrate and isolate proposed for fortification are corresponding essential amino acid sources which contain leucine and phenylalanine in excess (based upon FAO threonine formula) and are, therefore, suitable for the fortification of the plant foods mentioned, because the quantity of amino acids which limit the biological value can be decreased.

For the present, soy protein in Hungary is used only with products as a partial substitution of meat or liver to improve the texture and emulsify the fat. This practice is important for broad use in other countries.

To guarantee a complete protein supply, the fortification of several products of plant origin is necessary. First of all, the fortification of vegetables, foods containing little meat, and pasta is expedient, in addition to baked goods eaten by children and teenagers. Fortification studies with canned vegetables and baked goods have begun.

It is extremely interesting to note that, according to a current Soviet publication, studies with soy hydrolysates for protein fortification of a few canned vegetables have been carried out there. Chopped tomato paprika preserves, eggplant conserves, vegetable ragouts, and various sauces have been fortified with 1-2% hydrolysate and in a few cases with 0.1% methionine (1).

It is absolutely essential in the future to fortify vegetable conserves, such as letscho with rice, paprika (sakuska), or eggplant stuffed with vegetables, and stuffed vegetables which are prepared with relatively little meat, such as stuffed paprika, stuffed sauerkraut, and stuffed cabbage, with soy protein.

The data for the formation of the protein content and cost of fortification are shown in Table V.

With fatty letscho with low protein content (it is often eaten by itself as a second course) after a fortification of 4% protein concentrate, instead of the original 1.5%, 6.1% protein content and the content of complete protein increase at the same time to 4.1%, which is a significant quantity with consumption of the selected portion, whose cost is only 0.20 forint/100 g.

At the same time, the texture of the product is improved. The corresponding structurally formed soy protein concentrate used (granulated from barley size up to hazelnut size according to choice) gives the impression of ground meat, not only in structure, but also in color (for example, by use of promosoy 1G, 2G, and 3G TST/UU in three sizes in natural color and 1G, 2G, and 3G TSP/UC in three sizes in caramel color).

The water uptake of the soy protein concentrate is 200%, therefore 1 kg product corresponds in wt and protein content to 3 kg lean meat.

Soy protein fortification also is significant in baked goods, which is proven by broad foreign use. Based upon studies by the Institute for Technology and Professional Education in Nagykoros I see the necessity for use in rolls intended for school children in our country. According to plan, 5% textrol, a specially prepared soy flour, will be added to flour and thus the total protein content of 9.4%. Respectively, a complete protein content of 5% in the roll is fortified to 12.2% or 8.2%.

In two rolls (108 g) the pupil therefore receives 9 g complete protein which itself covers one-fourth—one-third of the daily requirement. The lysine excess of the soy protein profitably supplements the amino acid limiting the biological value of the protein content, thus increasing the biological value of the original protein.

Experiments have been started for the fortification with soy protein of many pastas eaten by children.

On the basis of foreign experiences and initial results of our own studies, the use of soy protein products in the Hungarian food industry appears to have a future.

REFERENCES

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