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CURRENT TOPICS IN NUTRITION

IMPROVING PLANT PROTEINS FOR HUMAN NEEDS (1977-1980)

A Scientific Review

&

An Annotated Bibliography

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IMPROVING PLANT PROTEINS FOR HUMAN NEEDS -

A. REVIEW

Protein malnutrition continues to stand out as the most serious of the nutritional deficiencies in many of the developing countries of the world. This situation is attributed to the over-dependence on starchy roots and cereals for the nutritional needs of the people in these areas, for socio-economic reasons. Cereals are not only low in protein content, but also lack the essential amino acid, lysine. Most of the common legume grains are also deficient in the sulfur amino acids, methionine and cystein; making plant proteins in their various individual forms inadequate to support normal growth and development. Since plants are known to contribute approximately 80% of the world's food proteins, the solution to the protein malnutrition problem must therefore rest on the improvement of plant proteins for human needs.

In this regard, current research on the subject continues to widen in scope to embrace all possible areas that could lead to an improvement in both the quality and quantity of proteins in plant foods. During the past three years, much attention has been focused on methods of altering the pattern of amino acids in plant proteins by mixing plant foods together, germination and/or fermentation, and induction of genetic changes in plants to incorporate larger amounts of limiting amino acids. The possibility of introducing unconventional cereals, legume grains and leaf protein sources in food formulations, was also explored.

The findings of various workers have been able to establish levels and processing techniques for different oil-seeds and luggumes that could improve the protein quality in cereals by complementation, without adverse effects on the functional and organoleptic properties for the intended food uses. Ayres et al (1977) investigated the role of peanut flour as a fortifier in a variety of foods, while three separate works by Bressani et al (1977, 1978 and 1979) examined the effects of supplementing corn with whole soybeans on the nutritional, chemical and rheological properties of common maize foods. The use of a combination of different oil seeds and legumes in fortifying maize flour based diets to give maximum complementation of the limiting amino acids in both cereals and legumes was suggested (Ekpenyong et al, 1977; Green et al, 1977).

The need for using non-conventional species of legume grains (Molina et al, 1977), cereals (Inglett, 1977) and plant leaves (Nagy et al, 1978) for protein has been emphasised. Production of protein concentrates and /or isolates from these sources for use in food formulations was suggested.

Germination and fermentation to improve the amino acid pattern in cereals attracted a great deal of attention during the last three years. Marked increases in the lysine content, relative nutritive value and vitamins have been reported for various germinated and fermented cereals (Finney P. L., 1977; Hamad and Fields, 1979; Hasim and Fields, 1979; and Wang and Fields, 1978). Pomeranz et al (1977) also reported an improvement in the baking properties of germinated soy/wheat blends. In addition sprouting was found to increase digestibility coefficient and reduce trypsin inhibitor activity in some legumes (El Hag et al, 1978).

Genetic and agronomic practices to develop grains with improved protein quantity and quality continue to be investigated as a feasible means for solving the protein malnutrition problem. The current status of breeding for protein quality in corn was reviewed by Deutscher (1977), while evidence of high-lysine gene sources in barley derived from spontaneous and induced mutations was reported by Eggum (1977).

An Annotated Bibliography

1977 to 1980

1. Adambi, A.O. and Potter, N.N. 1978.
Properties of Ogi powders made from normal, fortified and opaque-2 corn. J. Food Sci. 43 : 1571.

Compositional, nutritional, organoleptic and storage properties of Ogi powders made from normal corn, corn plus lysine and tryptophan, opaque-2 corn were determined. Although processing did not affect the protein content of the corn, the total available lysine content was significantly reduced. The products were found to be organoleptically stable for at least twelve weeks at 30°C but decreased protein efficienty ratio (PER) values indicated a decline in nutritive value. Fortification with lysine and other amino acids was recommended.

2. Ayres, J.L. and Davenport, B.L. 1977.
Peanut protein: A versatile food ingredient.
J. Am. Oil Chem. Soc. 54 : 109A.

The use of peanut flour in a variety of food products as a replacement for animal source of protein is evaluated. In addition to blending well with cereal flours to yeild products with excellent flavor, texture and color, preprocessed and solvent extracted edible peanut flour was found to be capable of providing good moisture and fat characteristics in ground meats. In bakery product, the authors recommend peanut flour at 20% levels to provide protein supplementation without the astringent flavor characteristic of other oilseed flours.

3. Bockwalter, G.N. 1977
Corn-based foods used in food aid programs: Stability characteristics A review, J. Food Sci. 42 : 1421.

Storage stability of corn-based foods for aid programs (prepared by combining soybean and other protein supplements with yellow corn was investigated as a function of processing, formulation, packaging and distribution under various climatic conditions. Careful control of cooking was found to be necessary in inactivating hydrolytic and oxidative enzymes that could cause deterioration. Overcooking is reported to be capable of reducing storage stability. Other factors include inadequate processing of the germ and other protein supplements, absence of non-reducing sweetness, and high moisture levels.

4. Bressani, R. , Braham, J.E., Elias, L.G., Cuevas, R. and Molina, M.R. 1978. Protein quality of a whole corn/whole soybean mixture processed by simple extrusion cooker. J. Food Sci. 43 : 1563.

The study was carried out to determine the effects of extrusion with a Brady Extruder, on 70:30 corn: soybean blend. The results indicated that it is preferable to use flour with intermediate or coarse particle size with addition of water up to 17%. Application of heat prior to extrusion yields a product of greater specific volume, high water retention and lower trypsin inhibitor activity as well as improving the protein quality of the product.

5. Bressani, R., Elias, G.L., and Braham, J.E. 1977. Improvement of the protein quality of corn with soybean protein. In "Nutritional improvemamt of food and feed proteins." Friedman M. (ed.) Advances in experimental medicine and biology (vol.105 Prenum Press, New York.

The need for supplementing corn with its limiting amino acids is emphasised; and the levels of fortification of lime-treated corn with whole soybean without affecting the functional and organoleptic properties for the intended food uses, are presented. 15 parts of whole soy bean or 8 parts soybean derived products to 85-92 parts of corn was found by the authors to have no significant changes in the rheological or organoleptic characteristics of tortillas prepared thereof.

6. Bressani, R., Braham, J.E., Elias, L.G. and Rubio, M. 1979 Further studies on the enrichment of lime-treated corn with whole soybeans. J. Food Sci. 44 : 1707.

The effect of supplementing corn with whole soybeans on the chemical composition, presence of antiphysiological substances and protein quality of tortillas was studied. Although addition of whole soybeans to corn increased total protein and fat content, both the protein efficiency ratio (PER) and weight data suggest an optimum soybean level between 8 and 12%. No further improvement in PER was observed at soybean levels above 12%. Cooking for 30 minutes in the home process was found to effectively inactivate antiphysiological factors independent of lime concentration.

7. Cherry, J.P. and Simmons, J.G. 1977
Potential for improving conttonseed quality by genetic and agronomic practises. In "Nutritional Improvement of food and feed proteins". Friedman, M. (ed.). Advances in experimental medicine and biology (vol. 105) Prenum Press, New York.

Extended studies on the evaluation of cottonseed composition were used to develop a data base on composition of various cottonseed cultivars. The data suggest that breeding and agronomic practices could be used to alter cottonseed composition for human needs.

8. Deutscher, D. 1977.
The current status of breeding for protein quality in corn. In "Nutritional improvement of food and feed proteins". Friedman, M. (ed.). Advances in experimental medicine and biology (vol.105) Prenum Press, New York.

The advances so far attained by plant breeders in their efforts to develop maize with improved protein quantity and quality were reviewed. Utilisation of mutant genes that improve protein quality was also examined. The areas of interest that are currently being investigated include utilisation of the opaque-2 gene; utilisation of modifier genes to alter the phenotypic expression of the opaque-2 gene; utilisation of endosperm double-mutants; and taking advantage of the naturally occuring variation in maize for protein and lysine levels.

9. Eggum, B.O. 1977.
Protein quality of induced high lysine mutants in barley. In "Nutritional improvement of food and feed proteins". Friedman, M. (ed.). Advances in exp. med. bio. (vol. 105) Prenum Press, New York.

The paper reviews research efforts in chemical and biological evaluation of some of the high-lysine barley cultivars. Evidence of high-lysine gene sources in barley derived from spontaneous and induced mutations has been presented by the author.

10. Ekpenyong, T.E., Fetuga, B.L. and Oyenuga, V.A. 1977
Fortification of maize flour based diets with blends of Cashewnut meal, African locust bean meal and sesame oil meal.
J. Sci. Food Agric. 28 : 710.

The paper reports a preliminary study on the potentials of cashewnut meal (a source found to be superior to soybean meal), sesame oil meal and African locust bean meal (a source which provides high amounts of lysine but which on its own is incapable of supporting weight gains in rats). When used in different proportions to fortify maize flour, some of the blends were found to have higher growth promoting ability, protein efficiency ratio (PER), Net Protein Utilisation (NPU), Net Protein Retention (NPR) and Biological Value (BV) than for some commercially available baby foods.

11. El-Hag, N., Haard, N.F., and Morse, R.E. 1978.
Influence of sprouting on the digestibility coefficient, trypsin inhibitor and globulin proteins of red kidney beans.
J. Food Sci. 43 : 1874.

The influence of sprouting on the protein digestibility of raw and cooked kidney beans and on the trypsin inhibitor activity was evaluated. Sprouting of the beans resulted in a marked increase in digestibility coefficient of both raw and cooked beans, reduced trypsin inhibitor activity by approximately 50%, and decreased globulin E protein fraction by about one-third. The globulin fraction from bean sprouts had improved digestibility, compared to the globulins from intact beans.

12. Finney, P.L. 1977
Potential for the use of germinated wheat and soybeans to enhance human nutrition. In "Nutritional improvement of food and feed proteins. Friedman, M. (ed.) Adv. Expt. Med. Bio. (vol. 105) Prenum Press, New York.

Germination was found by the author to be capable of increasing many of the nutrients or food functional properties in wheat kernel, including vitamins, lysine and tryptophen. Levels of vitamins and of protein efficiency of soybeans were also enhanced by germination.

13. Green, J.R., Lawhon, J.T., Cater C.M. and Mattil, K.F. 1977.
Utilisation of whole undefatted glandless cottonseed kernels and soybeans to protein-fortify corn tortillas.
J. Food Sci. 42 : 790

A procedure for preparing and incorporating blends of undefatted glandless conttonseed kernels and soybeans with corn to improve the protein content is described. A maximum increase in protein content of 18% was achieved in the fortified corn tortillas by the developed technique without any detectable objectionable factor.

14. Hamad, A.M. and Fields, M.L. 1979
Evaluation of the protein quality and available lysine of germinated and fermented cereals. J. Food Sci. 44 : 456

The effects of two separate procedures - germination and fermentation - upon the amino acids balance of selected cereals were studied. The percent relative nutritive value (RNV) for wheat, barley and rice increased significantly after germination. A significant increase in available lysine was also observed in germinated wheat, barley, oats and rice. Natural lactic acid fermentation was found to have similar effects in improving the protein quality of cereals. The % RNV and available lysine content increased significantly in fermented wheat, barley, rice, millet and maize.

15. Hamad, A.M. and Fields, M.L. 1979.
Nutritional and sensory evaluation of bread made from fermented wheat meal and corn chips made from fermented corn meal.
J. Food Sci. 44 : 1514.

Significant improvements in the relative nutritive value, lysine, isoleucine and riboflavin contents of both fermented wheat meal and fermented corn meal is reported. Even though there was a decline in the % relative nutritive value, lysine and isoleucine in bread and chips made from fermented wheat meal and fermented corn meal respectively, these properties were significantly higher than in the corresponding controls (i.e. bread and chips from non-fermented meals). The bread and chips from the fermented meals were also scored acceptable by consumer taste panel.

16. Hasin, N.B. and Fields, M.L. 1979
Germination and Relative Nutritive Value of corn meal and Corn chips. J. Food Sci. 44 : 936.

Germination as a means of improving both the amino acid balance and vitamin content in corn is reported. Microbiological assay showed a significant increase in niacin and riboflavin in corn meal made from germinated corn. Similar increase in Relative Nutritive Value (RNV) was also observed. Processing the germinated corn meal into chips decrease the levels of vitamins and % RNV but these values are still higher than in control chips made from ungerminated corn.

17. Hofsten, B. 1979.
Legume sprouts as a source of protein and other nutrients.
J. Am. Oil Chem. Soc. 56 : 382.

Changes which take place during germination which are of nutritional significance are described. Although the amino acid profile does not change dramatically, the chemical score of the seed is never decreased during sprout formation, and it is sometimes increased. Trypsin inhibitors do not disappear during sprout formation but at least some lectins are degraded. In addition, sprouts contain significantly higher levels of vitamins than the dry seed.

18. Hsu, D., Leung, H.K. Finney, P.L. and Morad, M.M. 1980
Effect of germination on nutritive value and baking properties of dry peas, lentils, and faba beans. J. Food Sci. 45 : 87

The bread baking properties of wheat flour blends fortified with germinated and un-germinated peas, lentils and faba beans were compared; and the effect of germination on the changes in ascorbic acid, riboflavin and amino acid composition of the legumes was determined. Marked increase in ascorbic acid was observed during germination but the authors found little change in the amino acid contents after 4-day germination period. Germination also adversely affected the baking properties of peas and lentils but not faba beans.

19. Inglett, G.E. 1977
Food proteins fron unconventional cereals.
Food Tech. 31 (5) : 180

The paper reviews the major cereals of the world which were at one time wild ancestors, and reports their properties, utilisation and contribution to feeding the world of the future. Self-propagating wild grasses, teosinte (Zea mexicana) and Tripsacum (ssp. L.) are reported to have genetic similarities to maize; including similarities between their seed proteins in proportion and amino acid content. High lysine maize, barley and sorghum are considered unconventional because they are not found in common market place. But these high protein varieties continue to be propagated and evaluated for use in improving their protein quality for human needs.

20. Johnson, V.A. and Mattern, P.J. 1977
Improvement of wheat protein quality and quantity by breeding.
In "Nutritional improvement of food and feed proteins" Friedman, M. (ed.) Adv. Expt. Med. Bio. (vol. 105) Prenum Press, New York.

Progress in improving the quantity and quality of protein in the grain of wheat was reviewed. Genes for high protein have been demonstrated to effectively increase protein content of wheat in many different production environments. A high protein hard red winter variety developed in Nebraska is reported to be the result of elevated NO_3 reductase activity, increased N-absorption by the roots, and more complete translocation of N to the grain.

21. Juneja, P.K., Kawatra, B.L. and Bajaj, S. 1980.
Nutritive value of triticale and the effects of its supplementation to wheat and Bengal Gram (cicer arietinum) flour.
J. Food Sci. 45 : 328

The effect of adding bengal gram (cicer arietinum) flour to triticale and wheat flour mixture, in solving the problem of stickiness and enhancing the protein quality as well as protein quantity of chapati (unleavened bread) was investigated. The results showed higher protein efficiency ratio (PER) value, plasma protein, and plasma lysine content for a

40:40:20 blend of wheat flour, triticale flour and bengal gram flour than other test diets prepared with the flours singly or in other blend ratios.

22. Labanauskas, C.K., Bingham, F.T. and Cerda, A. 1978.
Free and protein amino acids and nutrient concentrations in wheat as affected by phosporus nutrition at various salinity levels plant and Soil 49 : 581.

The effects of phosphorus nutrition under various salinity levels on the protein, amino acids, and nutrients in mature wheat grains were studied. The results indicate that increasing levels of phosphorus in the nutrient solutions tend to decrease the grain yield, nitrogen, chlorine, glutamic acid, proline, leucine, glycine and serine. The sum of all protein amino acids in the grains also decreases as concentration of phosphorus is increased in the nutrient solution. Similar results were obtained with increased levels of salinity.

23. Martz, E.T. 1977
Methods for improving cereal protein quality. In "Nutritional improvement of food and feed proteins". Friedman, M. (ed.) Adv. Expt. Med. Bio. (vol. 105) Prenum Press, New York.

Three methods for improving cereal protein quality are discussed. Supplementation with limiting essential amino acids and with protein concentrates high in those amino acids were mentioned as older methods while the most recent method is the replacement of the normal cereal grain with its high lysine mutant counterpart. Corn, barley, and sorghum are now available in high lysine forms.

24. Molina, M.R., Bressani, R. and Elias, L.G. 1977.
Non conventional legume grains as protein sources.
Food Tech. 31 (5) : 188.

The need for using nonconventional species of legume grains in supplementing commonly used cereals in developing countries of the world to overcome the protein malnutrition problems, is emphasised. Lack of popularity of a great number of known legumes is attributed to regional dietetic habits that do not include them as part of the common diet.

The paper therefore advocates for the production of protein concentrates and/or isolates from the beans for use in food formulations and also use of the beans or their flours in the formulation of conventional processed food products as a means to increase their utilisation as a protein source.

25. Nagy, S., Telek, L., Hall N.T. and Berry, R.E. 1978
Potential food uses for protein from tropical and subtropical plant leaves. J. Agric. Food Chem. 26 : 1016.

The potential usefulness of tropical and subtropical leaves as a source of supplemental protein is discussed. The protein contents of 60 leaves and potential protein values of grasses and aquatic plants are compared. In addition, the preparation, composition, nutritional value, and flavor acceptability of several leaf protein fractions are discussed. From their findings, the authors concluded that leaf proteins are abundant protein source that could be seriously considered for use in developing countries to prevent massive starvation. It is further suggested that more research should be directed toward improving leaf protein concentrates for human consumption.

26. Platt, S.G. and Bassham, J.A. 1977
Photosynthesis and increased production of protein. In "Nutritional improvement of food and feed proteins" Friedman, M . (ed.) Adv. Expt. Med. Bio. (vol. 105) Prenum Press, New York.

The authors investigated the effect of CO_2 concentration on alfalfa photosynthetic metabolism, and the action of ammonia in the regulation of leaf carbon metabolism. Their results support the contention that alfalfa productivity can be increased by an environment of elevated CO_2. Also, ammonia was found to be capable of increasing the production of amino acids at the expense of sucrose production. Increased plant productivity can therefore be achieved through regulation of carbon flow during photosynthesis so as to increase protein production relative to that of other plant constituents.

27. Pomeranz, Y., Shogren, M.D. and Finney, K.F., 1977
Flour from germinate soybeans in high protein bread.
J. Food Sci. 42 : 824.

Germination of soybeans used in the fortification of wheat flour for high-protein bread was proposed as a means of overcoming the adverse effects of high level soy fortification on bread quality. Bread baked from 90g wheat flour and 10g germinated soy product in the presence of 0.50g sodium stearoyl lactylate or 0.55g sucrose palmitate with 3g vegetable shortening was found to be consumer acceptable with regard to loaf volume, crumb color, freshness retention, taste and flavor.

28. Pyadchikov, V.G. 1978
Improvement of cereal proteins and their evaluation.
Uluchshenie zernovykh belkor i ikh otsenka (Book) Moscow, USSR.

A world-wide range collection of mutants was studied with the aim of cultivating new varieties and hybrids with improved quality and protein contents. Topics covered in the book include the protein problem and ways of dealing with it; cereal proteins; nutritional value of proteins and methods of biological evaluation; maize, barley; wheat; and triticale.

29. Sawar, G. Sosulski, F.W. and Bell, J.M. 1977.
Nutritional evaluation of oilseeds and legumes as protein supplements to cereals. In "Nutritional improvement of food and feed proteins" Friedman, M. (ed. Adv. Expt. Med. Bio. (vol. 105)

The authors present an evaluation of the nutritive value of oilseeds (repressed, mustard, sunflower, safflower, flax) and legumes (field pea, field bean, lentil, bread bean, fababean) as protein supplements to cereals (wheat and rice). Results of rat trials revealed that the adjusted protein efficiency ratio, PER, for rapeseed meal was higher than those of fababean, field pea and soybean meal. Supplementation with methionine (0.2%) resulted in improved PER for fababean, fieldpea, and soybean meal. Blending of legumes and oilseeds with wheat flour (PER=28) gave high PER value (60 - 85).

30. Wang, D.Y. and Fields, M.L. 1978.
Germination of corn and sorghum in the home to improve nutritive Value. J. Food Sci. 43 :1113.

The conditions of time and temperature of germination necessary to produce the highest relative nutritive value (RNV) in corn and sorghum were presented. Germinated seeds of both cereals increased in % relative nutritive value and levels of lysine, methionine, and tryptophan when compared to nongerminated seeds. The highest RNV for corn occured after 4 days at 25°C, 2 days at 30°C and 3 days at 35°C. For sorghum, highest RNV was attained when the seeds were germinated for 5 days at 25°C, 6 days at 30°C and 3 days at 35°C.

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