Future Developments in Soy Protein Research and Technology

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ABSTRACT

The many successful and desirable uses of soy products have been recounted in the talks during the past three days. We will attempt to emphasize: (A.) That practically every natural food can be improved in its adaptation to food for man. This includes milk. Improvement may be made by deleting certain undesirable factors such as flavors, odor, or anti-nutritional factors. We will attempt to point out that many of these undesirable factors have been recognized and either eliminated or reduced to insignificance. We also will point out that further improvement may be made by enhancing functional and nutritional characteristics; (B.) That acceptance of soybean products as desired food constituents can result in further improvement in both yield and quality of the basic product as well as of the flours, concentrates, and isolates, which in turn may result in more economical production and processing costs; (C.) That the best progress is accomplished by those who recognize the inherent problems in the products and who are honestly willing to do something about them. It is the responsibility of every processor of food products, in the U.S. and elsewhere, to produce food products worthy of the quality of the raw product from which they are produced. This is particularly true of soybeans. The observance of all these factors will result in a real contribution to the food industry throughout the world.

INTRODUCTION

Soy protein products–flour and grits, concentrates and isolates–have found increasing acceptance in U.S. food products. Although precise figures for the production or use of these types of products are not available, Hammonds and Call (1) have estimated that 121 million lb of soy flour and grits, 33 million lb of soy concentrate and 38 million lb of soy isolates were utilized in food products in 1969. Melnychyn (2) estimated that 325 to 500 million lb of soy flour and grits, 25 to 30 million lb of a soy concentrate, and 35 to 40 million lb of soy isolates were produced in the U.S. in 1971. The protein content of the flour and grits falls within the 50-60% protein equivalent range, the concentrates above 70%, and the isolates above 90%. Nitrogen times 6.25 is used as the conversion factor in all these values. Production estimates for this year are ca. 450 to 600 million lb of flour and grits, 60 million lb of the concentrates and 40 million lb of the isolates.

The present food situation, particularly with reference to the price and scarcity of meats, has greatly increased the acceptance of soy protein products so that drastic increases will be expected in the use of these types of materials during the coming year. Other oilseed proteins, such as those from the cottonseed and the peanut, also contribute to the food supply, but to a much lesser extent than the soy protein, at least for the present.

Although the production, marketing, and use of the soy products has attained some degree of maturity, there are still skeptics who insist that the soy protein products are a substitute for something more desirable and frequently classify them as poor substitutes. A much greater proportion of the food industry and of the consuming public, particularly those who have used and consumed the products, feel that this is a desirable foodstuff. Therefore, there must be a change in attitude from that of marketing a commodity to that of providing foodstuffs which fulfill a need and are sought after. This change in philosophy is essential to the recognition of any foodstuff as a product in its own right rather than being considered a substitute or a poor alternate.

ACCEPTABILITY OF SOY PRODUCTS THROUGH FLAVOR AND COLOR

Experiences gained through volume usage of the soy products over a period of years have pointed to several opportunities for improvement in both nutrition and in acceptability of soy products in the future. In some parts of the world, particularly in the western world, there is a strong objection to the beany flavor associated with soybeans and with many of the other food legumes. This was of real and practical importance to those in Western Europe who consumed certain types of soy flour and beans after World War II when marked aversion to the beany flavor was developed. A tremendous amount of work has been done to remove this flavor from the soy product with varying degrees of success. In some cases, some of the flavor returns with rehydration or further heating. However, with the basic work being done on the fundamental aspects of flavor, there is no doubt that this problem will become insignificant even in those foods completely bland in flavor. A companion problem has been flatulence. This problem also has been under intensive study and does not seem to be serious in concentrates and isolates. More work needs to be done with the flours and grits, particularly when they are used in fairly large proportions in the food.

The consensus at a recent oilseed conference (2) was that blandness and flavor were the first requirements for protein ingredients in foods. This suggests that the most desirable characteristic would be flavor enhancement but that lacking this characteristic, it should at least not detract from the desirability of the flavor of the product in which it was to be used. The second most important characteristic was color. Here again desirable colors would be preferred, but at least no undesirable color should be apparent. However, the importance and the applicability of flavor and color depends upon the ultimate usage. These characteristics are emphasized to permit the broadest possible usage, since neither flavor nor color is essential when the protein ingredient is to be used in highly colored or highly flavored end products.

FUNCTIONAL CHARACTERISTICS OF SOY PROTEIN

In addition to flavor and color, several functional characteristics have been discussed extensively in the food industry although there seem to be no satisfactory definitions or methods of evaluating these properties. There is a distinct need for more information on the compatibility of each of the types of protein products with the balance of the formula with which they are to be used. And, conversely, the food producer must study the characteristics of the particular formulation he has in mind before evaluating the specific protein supplement he wishes to use.

One of the problems in the effective use of the soy protein products and other new products has been the lack of imagination in adapting these products to the formulation or in adapting the formulation to the product. Products with different characteristics often require different techniques in handling. Some attention has been paid to the possible coprecipitation of proteins which could result in products with completely different characteristics, particularly in regard to nutritive value. This technique could be used to alter amino acid patterns, to provide variations in solubility characteristics, and, to meet certain possible requirements not met by any one protein source. Frequently adaptability and innovation are rewarded with a more desirable end product.

It should be emphasized that protein products prepared from the soybean are not pure proteins. It probably would not be desirable to use pure proteins as far as the food industry is concerned. However, this does offer opportunities to utilize information on identification of protein sub-units, sequences of sub-units, molecular weights, and other fundamental information. If the demand should become sufficiently sophisticated it may become practical to provide fractions of the soy protein to fulfill specific requirements. Certainly each degree of refinement will increase costs but equally certainly these more sophisticated procedures of extraction would provide a range of proteins which would meet a much broader spectrum of requirements and characteristics. Since a computer is used in evaluating many of our foods, more definitive information must be provided to fit into computer programs. In research programs ahead, it will be necessary to obtain more fundamental information on both the physical and chemical characteristics of protein products. This applies not only to chemical characteristics but to nutritional properties as well.

It is generally recognized that when soybean protein is fed as the sole source the first limiting amino acid is methionine. This limitation becomes more distinct in the isolates and to a lesser extent in the concentrates as compared with the intact soy protein. Supplementation of the soy isolates with methionine usually results in an increased biological efficiency of the protein as expressed by any of the standard methods. When these proteins are supplemented with methionine, protein efficiency ratios as high as, or higher than, that of casein may be obtained. The primary deterrents to the addition of methionine, now that it has been recognized as a permissible additive, is the off-flavor that is introduced with this addition. This flavor is not readily apparent in the more highly flavored foods and should cause no problem in that type of product. However, in the blandly flavored products means must be developed of masking or avoiding this flavor.

While a methionine deficiency is indicated when protein quality is measured by our conventional methods, there is still a serious question as to whether the addition of methionine is needed in the normal human diet. Excellent results as measured by growth rate, blood albumin, and other criteria for good development of children, have been obtained when a soy isolate provided the sole source of protein in liquid form for children. A critical evaluation of the real needs of the human for the essential amino acids is sorely needed, not only for this purpose but for general nutritional information. It should be recognized that there is a distinct possibility that the soy proteins, when fed with our common cereals which are somewhat higher in methionine, may pose no problem as far as methionine is concerned, but at the same time we should recognize that the possibility may exist.

In this connection, the computer already has been a tremendous help in highlighting the fact that a protein with what we consider the most desirable amino acid profile, i.e. one which has all the amino acids in the proper proportions as far as we know them to meet the human requirement, is usually not a satisfactory supplement to improve the nutritional adequacy of the food we are attempting to fortify. The exception, of course, is when we want to introduce a quantity of protein rather than to correct amino acid imbalances. With this information, it may be entirely possible to tailor the soy protein product to most effectively meet the needs, both nutritional and physical, of the food product.

Another major function of the soy protein products may be to extend certain high protein foods which may be in limited supply. Certain types of cheese products in which soy protein has been used to augment the volume of the product while maintaining a high protein value have been made and marketed. This permits the price of the product to be reduced to make it more readily available for a broader range of customer usage. With present consumer attitudes toward food prices, cost reductions will be a distinct service to the consuming public, and in addition, product availability would be increased. Another example of this type of usage was the introduction of the addition of soy to hamburger during periods of short supply of beef during last summer. This product was well received by the consuming public, both from the standpoint of price and of desirability of the end product. The technology is available and additional technology will certainly be developed to extend this type of usage and make it possible to introduce the soy protein extenders in many other food items.

TECHNOLOGY AND THE SOYBEAN

Technology is another of the areas of opportunity in the development of soybean products which must be developed to reduce the costs of the fractions of the soybean that are to be used for direct human consumption. Obviously one of the means of reducing costs of soy products produced for human consumption is to upgrade the value of the by-products. How much do we actually know about the structure of the cell walls and of the hull of the seed? It will be necessary to characterize these tissues in detail before they can be utilized to the utmost advantage. This lack of information also handicaps some other products, such as yeast and bacterial products produced from petroleum hydrocarbons or other similar substrates. It is possible that proper enzymic digestion may improve the value of these products.

The spectacular increases in the market prices of raw soybeans in the last two seasons have made savings in cost of the end product of much less magnitude and consequently of less incentive to the food industry than before that time. Therefore, it is much more important now than ever that in marketing the true values of the soy products be emphasized rather than depending too heavily upon price of product.

In the U.S. another significant cost is the disposal of the effluent from the processing plants. There is a real need for the development of processes for the production of concentrates and isolates which will result in less loss through the effluent with the attendant costs of handling those waste products under the emphasis that we now have on pollution and contamination of the environment. We need to develop a technology to recover and recycle water from the large volumes of effluent from soy protein isolation plants. This would accomplish two objectives—it would reduce pollution and it would improve the recovery of additional proteins, carbohydrates, and other nutrients.

The property of providing texture is one of the desired attributes of the soy protein products. At present, texturization of our soy products is achieved largely by two methods, either by extrusion or by spinning. It is possible that technology may be borrowed from such industries as the dairy industry when textures of a sort may be achieved without the additional processing step. If we, in the soybean industry, are to borrow terminology such as the term "whey" from the dairy industry, perhaps we might borrow some of the processing technology as well.

Thus it seems to me that the relationship of water activity to the texture and functional characteristics of the protein product, including the effects of processing procedures, should be a profitable area of study. This is a relatively new area of science, but it is a promising one. Many of these relationships and effects were described in a recent symposium conducted at the 32nd annual meeting of the Institute of Food Technology (3).

Soybeans have been developed in the U.S. largely as an oil-producing seed with the protein part of the seed used for animal feed. While this crop was imported from the Far East originally, production has increased to the point that 70-73% of the world's production of soybeans occurs in the U.S. Much has been accomplished in the genetic improvement of the soybean as a crop, but there is still much to be done. Yields of seed were increased, but for the last several years those yields have plateaued between 27.3 and ca. 28.2 bushels/acre on the average in the U.S. However, this cannot be contributed only to genetic constraints by any means. Proof of this lies in the fact that when yield contests are conducted with small acreages, the contest winners usually produce from ca. 85 to more than 100 bushels of soybeans/acre. Therefore, we do have the genetic potential to increase production of soybeans/unit of land and, subsequently, to decrease the cost of production and the cost of the product on the market. The question of constraints on production of all food legumes is one which must be solved and which was the subject of a recent conference in Brazil. It is well recognized that the food legumes, including the soybean, do not respond to cultural practices as well as our cereal grains, including corn. This then becomes a problem to be solved by the use of many disciplines.

The possible improvements are not limited to greater yield/unit of land. In the past the soybean processors have completely confused the plant breeders and geneticists by vacillating between requests for increased oil in the seed or increased protein depending upon the relative price of oil or the protein commodities on the market. If we really want varieties of soybeans that will produce higher yields of edible protein products, there must be a firm commitment to the need for such products. By far the most convincing argument in this respect is the acceptance and demand for these types of products in food chains. As a corollary to this, emphasis may be placed on eliminating some of the desirable factors in soybeans by genetic means instead of by processing. I am referring to such factors as the anti-trypsin factor, the hemagglutinins and urease, all of which are reduced to insignificance by proper processing at the present time, but which may be subject to control by genetic means.

REFERENCES

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