Oilseed Proteins. Present Utilization Patterns[1]

M. D. WILDING, Research and Development Center, Swift & Company, Oak Brook, Illinois

Introduction

This review will be centered around the present utilization patterns of soy protein. It should be emphasized that many of the same principles are common to other oilseed proteins that will be utilized in the coming years.

Perhaps the most dramatic success story in U.S. Agriculture has been the development of the soybean and its major food and non-food uses. Historically, the soybean is indigenous to China and one of the oldest crops grown by man. As A. A. Horwath has said, "The Chinese nation exists today because of the use of the soybean as a food." It might also be predicted that the future of our own nation along with many other peoples of the world will depend upon the technological food developments from vegetable protein sources of which the soybean will play a major role.

Soybean production has had phenomenal growth during the past four decades. In 1926 the total production of soybeans in the United States was less than 5 million bushels. The 1968 crop exceeded a billion bushels and represents a 200-fold increase in just over four decades (1). Another comparison of interest is made by noting that more protein is produced from soybeans than from any other crop. Also, they return a greater export value to the United States than any other crop.

We could discuss at length the critical protein food needs that lay before us as the projected world population doubles in the next 35 years. Let us turn our attention to some of the approaches that have been taken here in the United States to shorten the protein food chain as contrasted to the conventional animal body route.

Discussion

Figure 1 shows the relative efficiencies of protein conversion from some of our major protein sources. The time has now come as predicted by H. W. Miller in 1943, that our chief interest in the soybean is in its value as a human food. As noted there is a great difference in the cost per pound of protein from various sources because protein conversions per acre are much greater with soybean than other conventional protein sources.

The following summarizes a number of distinct advantages of soy as a protein food. The first of these is a large amount of protein that can be grown per acre of farmland. The cost per pound of protein produced is quite low compared to other protein sources. Both of these facts would be unimportant if the soy protein were poor in quality. As will be discussed later the quality of soy protein is very good and has a particular advantage as a supplement to the protein of cereal crops. Finally, of course, a food is not a food unless it has some desirable qualities that cause a person to want to eat it. Fortunately, it has been found that soy protein has functional properties that make it possible to develop textural characteristics in this protein source.

By far, the largest group of protein raw materials now used is 50% soybean meal, flour and related forms. They are the raw materials from which most of the other food types are derived. Of course, some of these require further processing. Presently the major portion goes into animal feeds. After oil is extracted and the solvent removed by low heat or vacuum, a protein retaining its functional properties is produced. This flour or flake form then becomes a base material for further extraction of protein for soy isolates to be used either as a protein powder, or to be spun in fibers for the development of texture. This flour can be processed directly into textured products.

Before we get into the details of each of these protein categories, Table I shows the estimated production and pricing structure of these three major groups of soy protein (2).

Table II shows the estimated use of soy flour projected to 1969 (2). Large percentage usage of this flour in various food products is limited because of inherent flavor properties that exist from the defatted bean. Thus, additional processing steps are necessary in order to expand the volume usage of soy protein in existing and new food products.

It should be mentioned that one should not underestimate the textural properties of foods in either U.S. or world feeding programs. Importance of texture can be illustrated by comparing a cooked beef steak with the same piece of cooked meat ground to a puree in a blender. The flavor, color, or nutritive value has not changed but there is vast difference in eating quality. The difference exists mainly in the textural properties of the two foods. This principle should not be forgotten when relating our challenge to our foreign or domestic feeding programs.

Soy protein concentrates (3) are prepared by extracting defatted soybean meal with suitable polar solvents that will remove the more soluble carbohydrates but retain the protein. For example, if a 50% protein soybean meal is extracted with 70% alcohol, very little protein is solubilized while most of the carbohydrates, flavor and color bodies are removed.

The soy protein concentrates have several important funtional advantages in food products (4). When used as a component in food products, such as, meat loaf, hamburger patties and meat balls, they help to retain the moisture, juices and fat during cooking because of their good absorptive properties. Further, where the ground meat items are being manufactured on a commercial production basis, the incorporation of soy protein concentrates improves the machineability of these items. The soy protein concentrates represent a relatively low cost source of good protein supplement.

In our experience, the flavor acceptance of these products can be evaluated more accurately in the finished product than as a raw material by itself. It is a matter of finding the right product compatibility. From a commercial point of view, the most important characteristic of the bread, doughnuts and rolls made with 15% soy protein concentrates is they have met with good consumer acceptance. A leading university has evaluated this bread and found it to be the most acceptable of the several bread types tested by a panel of seven women. From a scientific point of view, it is much more interesting to consider what the conclusion of only 15% of soy protein concentrate has done to the nutritional quality of overall

[1] Presented at the AOCS-AACC Joint Protein Short Course, French Lick, Indiana, July 13–16, 1969.

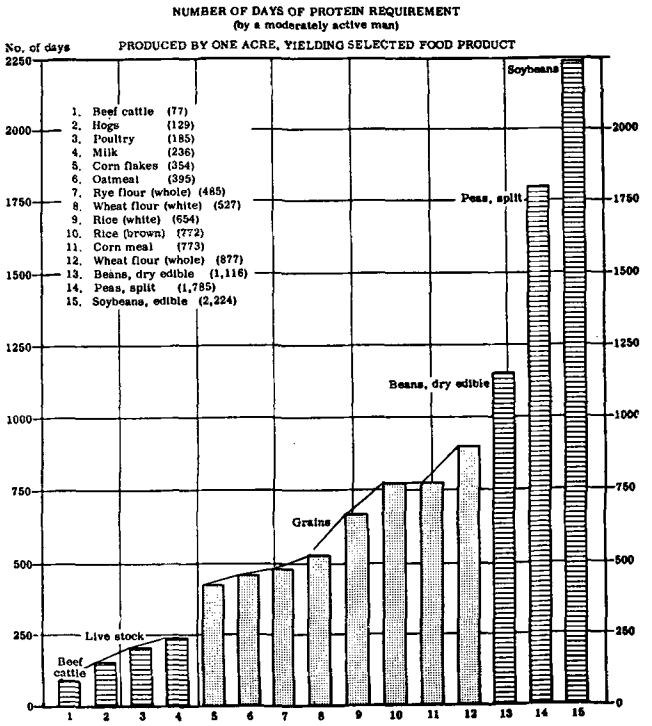

FIG. 1. Relative efficiency of protein conversion per acre of land from various protein sources.

protein of the bread. This relationship has been shown by Dr. Rice in the nutrition section.

While we as scientists may be impressed by dramatic nutritional data, we have to be practical minded and realize the hard cold facts that the average consumer does not buy foods on the basis of nutritional quality. Rather, she buys for texture, flavor and functional characteristics that are often of distinct advantage. They do not, however, have the type of textural properties that characterize popular protein foods, such as, beef, poultry and fish. Consequently, considerable research attention has been directed toward producing soy protein products that have the fibrous texture usually associated with animal products.

The first significant breakthrough was made in 1947 by R. A. Boyer, who made an edible fiber by a process similar to that used for textile fibers. The following outline describes briefly the process for making these fibers and food products from these fibers (5).

Defatted flakes and flour are extracted and purified to a pure protein. This pure protein is dispersed in alkali and then precipitated at the isoelectric point in a bath by drawing it away continuously from the face of the spinnerets to form tiny microfilaments (10/100 in. diameter). These fibrils are combined with such standard, edible items as wheat gluten, egg albumin, vegetable or animal fats, flavors and colors. The mixture is then cooked, which sets up and binds the protein fibers together. The resultant products are used as refrigerated, frozen, canned or shelf stable products. These products are the type that are being produced commercially by General Mills, Worthington Foods and Ralston Purina. Some highly sophisticated

TABLE I

Estimated Production and Price of Various Soy Proteins (2)

Soy proteins	Production million lbs.	Price cents/lb.
Soy flour and grits	120–126	7–8
Soy concentrates	19–33	18–26
Soy isolates	24–38	35–45

TABLE II

Estimated Use of Soy Flour—1969 (2)

Soy flour	Million lbs.
Domestic use	
Baked goods	57
Meat products	35
Soy beverage	11.5
Dry cereals and baby foods	7
Enzyme active flours	7
Brewers flakes	3.5
Pasta and macaroni products	1
Miscellaneous	6–11
Commercial exports	11
U.S. Government (for CSM)	100

engineered meat-like items are now being produced on a pilot or semi-plant scale by these companies. Recently, General Mills announced plans to build a multimillion dollar plant to manufacture these fabricated engineered foods (6). Some of these products have very desirable flavors and textures. They appear to have excellent consumer acceptance. Their rapid penetration into the U.S. and more specially the foreign market has been limited primarily because the process is quite involved, resulting in a comparatively costly finished product. This fact is significant as we consider the lower purchasing power of the people in the world who need protein most. Another point of scientific importance is that a fractionation of protein occurs to some extent to not only reduce the yield of protein, but it changes the amino acid balance in the protein which apparently reduces the protein quality. This lowering of protein quality can be corrected, however, by addition of certain amino acids back into the fabricated food product.

Considering the above limitations, at least two U.S. companies have taken the approach of producing textured soy products more directly from soy flours or grits or both. While details of the processes used cannot be disclosed, they are much more economical than the process for making food products via the spun fiber route.

Several products representing this class of materials are being produced commercially at the present time; the consumer response has been very gratifying.

The physical properties of the textured soy proteins made by one of these more direct processes is shown in Table III. These products when hydrated have textural properties closely simulating the chewability of ground meat products. It is important to add that in addition to these functional advantages, the textured soy proteins have excellent nutritional qualities quite comparable to meat and other animal protein sources.

The flavor of the textured soy protein products is particularly important. The basic material has a slight toasted flavor. These products have been stored for as much as a year at room temperature with no development of adverse flavors. Because of their low moisture content, they are not susceptible to microbiological deterioration (7). Because these products do

TABLE III

Physical Properties and Functional Advantages of Textured Soy Protein

Properties	Advantages
Texture	Crunchy when dry Fibrous and chewy when hydrated Particle retention of integrity during cooking and retorting
Color	Light tan, or colored to meet specific need
Flavor	Slight toast Flavoring incorporated to specific needs Compatible with most food products
Hydration	Hydration to three times its dry weight Increases retention of natural flavors, juices and moisture

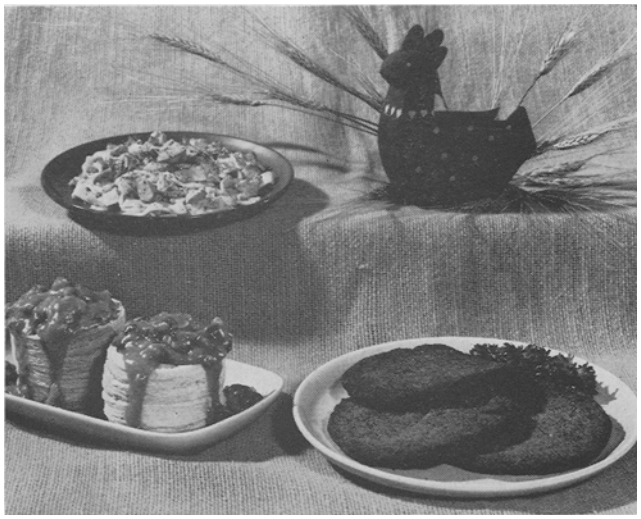

FIG. 2. Textured soy protein used as textured protein in a dry casserole mix (upper left), hydrated mix (lower left), processed with chicken meat into a pattie (lower right).

FIG. 3. Processed soy protein used as a replacement for non-fat dry milk solids in various bakery items.

have a very mild initial flavor and good flavor stability, their flavors can be modified to resemble many different types of flavors that have been used successfully on soy products (8).

We can talk about nutritional, physical and chemical properties of these new food products, but "the proof of the pudding is in the eating." A food is not a food until some person has put it into their mouth, chewed it and swallowed it. It cannot be considered commercially successful until a substantial number of people will come back and repeat this process over and over again. In our experience thus far, the textured soy protein food products are going to pass these tests. Several product applications are typified by use of these textured products in foods shown in Figure 2. They will illustrate the many more uses that have been found by other people in commercial products. A dry mix (9) is used in which the higher protein or meat-like portion is a textured soy protein. These products can be made up as chicken ala king, chile with beans, Spanish rice, etc. It is made simply by heating the dry mix as shown for about 5 min. This product has had good consumer acceptance when used at relatively high levels.

In the development of an imitation bacon-like product we wanted to get some estimation of its consumer acceptance and the correlation of our own laboratory testing facilities of the average public as measured by a facility at the Museum of Science & Industry (10). Results of both panels indicate that there was a 2–1 preference of the fabricated imitation bacon-like product compared to prefried crumbled bacon. This development merely highlights what can and is being done in simulating acceptance in food products from oilseed protein sources.

A wide variety of applications in ground meat products have been made, such as, chili or sloppy joe type formulations. It should be emphasized again that all of the above products, and many like them, have been evaluated both by expert flavor panels and by consumer panels from various national origins. Our criteria for evaluation has been contrasting them to the natural or customary food concept. The response of these panels as judgements for the population have been extremely encouraging.

Another product concept that we can quickly mention illustrates a different type of texture, color and flavor variation made from soy—that of a vegetable spread. This product is made to resemble peanut butter in color, texture and flavor. We were asked by AID to make an economical protein and calorie product for overseas feeding. Two slices of wheat bread, spread with this new soy vegetable spread served with a glass of reconstituted skim milk powder twice a day would approximate a child's minimum daily requirements. From a practical point of view, the product is quite acceptable as a food, in addition to being quite well balanced nutritionally.

One of the great stimuli to the development of these new protein sources is the increased pricing structure between the conventional protein for food and the vegetable proteins. Another area other than the textured meat area is in imitation dairy products. Recent work in our own laboratory has demonstrated the utility of a new product from a combination of soy flour and cheese whey to replace non-fat dry milk solids. While many excellent bakery products can be formulated with this new product as shown in Figure 3, its performance has been comparable to milk solids in most applications from meat emulsions to imitation ice cream. This kind of development merely illustrates the kind of application that can be made of oilseed proteins to simulate the conventional products.

Another large protein usage area that is developing is in the fluid beverage area. In Brazil, Coca-Cola has introduced a chocolate flavor beverage, "Saci." Monsanto is making an oilseed protein drink called "Puma" in British Guiana. In Hong Kong a soy milk called "Vitasoy" is being sold with good commercial success.

In our own country the sale of filled milk is paving the way for a completely non-dairy beverage referred to as imitation milk. We are confident that oilseed proteins will be a major source for this new technological challenge. There are many problems to solve among which are nutritional equivalence, proper viscosity properties and complete flavor acceptance. We have adequate evidence in the past that it is near impossible to legislate against progress in areas of obvious challenge and opportunities even though there may be some temporary restrictions. If these challenges are met, many changes could occur that would alter the type of products we see at the consumer level.

Major efforts are now under way to bring solutions

to these new potential developments.

There are many new oilseed proteins that are used in products such as bakery items that have different protein content than the typical flour, concentrate or isolate. Each of these items are designed to perform a definite functional purpose to improve the existing food.

There are many reasons why our present technological know-how is not being used in more uses of oilseed proteins. Some of these reasons will be given by other speakers. Some of the problems result because those people who need protein the most can least afford to pay for it.

Thus, we can except in the future an entire family of products that will vary in protein composition, functionality and flavor characteristics. We believe that this new technology is just in its infancy and that our present utilization patterns are but symbols of what is to come.

REFERENCES

1. Pellet, K., Soybean Dig. (Blue Book Issue) *28*, 44 (1968).
2. Eley, C. P., USDA ERS-388, August 1968 (Reprinted from the Marketing & Transportation Situation, August 1968).
3. Milleville, H. P., Food Process. *24*(No. 11), 109 (1963).
4. Pietraszek, G., Nat. Provisioner *151*(No. 19), 16 (1963).
5. Thulin, W. W., and S. Kuramoto, Food Technol. *21*(No. 2), 64 (1967).
6. Pellet, K., Soybean Dig. *29*(No. 9), 40 (1969).
7. McCormick, R., Food Prod. Develop. *1*(No. 1), 35 (1967).
8. Martin, R. E., and D. V. LeClair, Food Eng. *39*(No. 4), 66 (1967).
9. Milleville, A. P., Food Process. *28*(Nov. 7), 48 (1967).
10. Dethmers, E. E., Food Prod. Develop. *2*(No. 5), 23 (1968).

[Received July 27, 1970]