

Soybeans For Food Uses

by Dr. Frank T. Orthoefer and Keshun Liu

Soybeans are an increasingly important agricultural commodity with global production around 113.0 million metric tons between 1993-1994. Major production countries include the United States, Brazil, China, Argentina, and India (figure 1). Soybean utilization is distinctly different between the West and East. In the West, the majority of soybeans are crushed for oil and meal, whereas in the East, a substantial portion are used directly for a variety of non-fermented and fermented soy foods. Although oil from crushed soybeans is almost entirely for food application, soy meal is mainly served as animal feed.

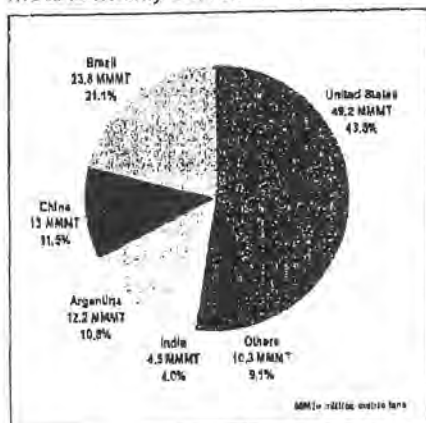


Figure 1: Estimated world soybean production by major producing countries for 1993-1994. Total * 13 million metric tons.

Because of this difference in soy utilization, two different type of soybeans have emerged: oil beans and food beans. This is particularly true in the US soy market where about 15% of soybean production, about 7.4 million MT, is exported to such Oriental countries as Japan, South Korea and Taiwan. The oil beans include all the commonly produced varieties. Their major quality factors are oil, protein, fiber, and foreign material content. Food beans, on the

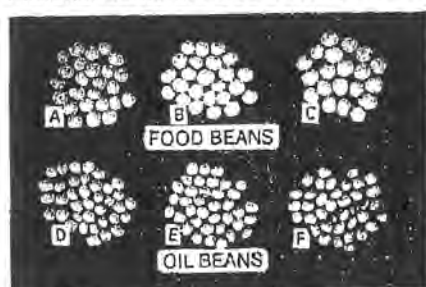


Figure 2: Oil beans and food beans.

other hand, are those beans that have a distinctly different appearance (figure 2). The differences include larger seed size, higher protein content, clear to buff-colored hilum, improved seed integrity, and higher seed grade. These features make them especially suited for direct soy food preparation. Large seeds removed by scalping of oil beans are not included as food soybeans.

Although food-grade soybeans are mainly used for making traditional soy foods, they are also adaptable to the preparation of Western soy protein ingredients. The use of food beans has resulted in an upgrade of soy foods as well as soy protein ingredients.

Traditional Soy Foods

In the Orient, traditionally, soybeans have been prepared into a variety of foods generally classified as non-fermented and fermented. The non-fermented products include soy milk, tofu, toasted soybeans and powders, bean sprouts, and yuba. The fermented soy foods include soy sauce, tempeh, natto, and miso.

(a) Soy milk

Soy milk is a water extract of soybeans. It resembles cow's milk not only in appearance (see page 2) but also in chemical composition. Thus, it is especially attractive to those who may be allergic to or have difficulties digesting dairy milk.

Soy milk has been prepared for centuries by simply soaking soybeans overnight, followed by wet grinding, coarse filtration, and boiling. Soy milk has been consumed throughout Eastern Asia similarly to dairy milk in the West. Since its introduction to the western world earlier this century, soy milk has gained increasing popularity. As a result, modern technology has been applied for large scale production of soy milk. Figure 3 shows a flow chart of an industrial process. Because food beans have a white cotyledon, clear hilum, and high protein content, soy milk made from

these beans has a whiter color, less beany flavor, and higher protein content as compared with that from oil beans.

(b) Tofu

Just as soy milk resembles dairy milk, tofu is very similar to cheese in appearance, texture, and chemical composition. In the Far East, tofu is the most popular soybean food. In the West, tofu is gaining in popularity.

Basically, tofu is a water-extracted and salt-precipitated soy protein. Tofu requires the preparation of soy milk followed by coagulation of the soy protein. The coagulants commonly used are magnesium chloride, calcium chloride, calcium sulfate, and glucono-d-lactone. By controlling the amount of coagulants and pressure applied during molding, the texture of the tofu may be varied from extra firm, firm, soft, to silken. These products can be seen in grocery stores in almost every continent. The quality of tofu depends mainly on quality of raw beans. Tofu made from food beans exhibits a high yield, higher protein content, whiter color, and less beany flavor.

Tofu is an inexpensive, high protein and high calcium food with no cholesterol. It can be served as a meat or cheese substitute. Because it has a bland taste and porous texture, tofu can be prepared with virtually any other food. Most popularly, it is served in soups or separate dishes cooked with meat and/

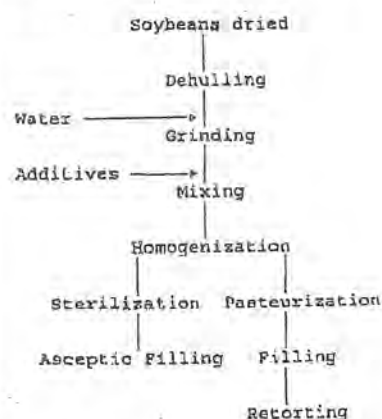


Figure 3: Flow sheet for an industrial soy milk process.

or vegetables. It can also be seasoned and served without further cooking. In the West, tofu-based ingredients have emerged. Together with soy-based ice cream and yoghurt, they are referred to as the new generation of soy foods.

(c) **Toasted whole soybeans and full-fat soy flour**
Toasted whole soybeans are used as snacks similar to roasted nuts or as a seasoning having a nut-like flavor and texture. The toasted flour is often used in rice recipes or for the preparation of flavored bakery snacks. The toasted powder may be mixed with plastic fats and sugar to be used as a filling or as a coating for confectionery and bakery products. Toasted soy snacks or nuts are prepared by initially soaking in water then deep frying. The larger sized food beans may be dry toasted directly without soaking or deep frying.

Since the soybean is the starting material and nothing is added or taken away in the production of toasted soybeans and full-fat soy flour, the quality of these products largely depends on the quality of the raw beans. Therefore, proper selection of the beans used to produce these products is essential. Because of their improved appearance and integrity, food beans deliver better products with less beany flavor.

(d) **Soybean sprouts**
Soybean sprouts are prepared by initially soaking the beans followed by germination in shallow trays in dark rooms with an intermittent water spray for cooling. The fully germinated soybeans with sprouts of about 5 cm are washed and dehulled. The sprouts are eaten as a cooked vegetable.

(e) **Yuba**
Yuba, a delicacy in China and Japan, is a soy milk film. It contains high protein as well as high lipid content. When soy milk is heated to boiling in a flat, shallow, open pan and maintained at a temperature just below boiling, a film forms at the surface just as with heated cow's milk. The film is lifted off with a long, thin stick and then dried to make sheets or flakes. Once dried, it becomes brittle. Before cooking, it must be softened by rehydration. The film can be used in soups as a meat substitute or as an edible wrapping for other foods.

(f) **Soy sauce**
Soy sauce is a fermented soy product used as a seasoning. It is prepared by mixing cooked soy meal with wheat and fermenting with a culture of *Aspergillus oryzae* in a salt brine. The protein is degraded during fermentation to amino acids and the carbohydrates to sugars and acids. The sauce has a meaty, savory flavor.

(g) **Tempeh**
Tempeh is a savory Indonesian food. It is prepared first by presoaking, boiling, and dehulling soybeans followed by fermenting with a starter culture of *Rhizopus oligosporus* for one to two days. Freshly prepared tempeh looks like a cake tightly bound by the mold mycelium and has a yeasty odor. When sliced and deep fat fried, it has a nutty flavor and pleasant aroma.

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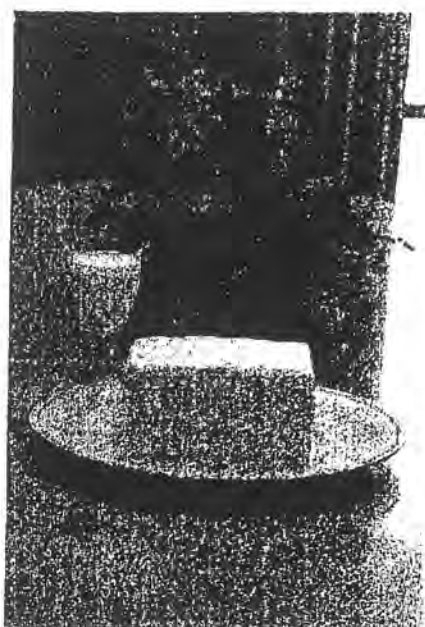
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Tofu is very similar to cheese in appearance, texture and chemical composition.
Photos & Tables: Riceland Foods

(h) Natto

Natto is a Japanese fermented soy food prepared by a bacterial fermentation. Soybeans are soaked, inoculated with *Bacillus natto*, packed into polyethylene bags, and incubated at 40°C for about 20 hours. The product is matured at refrigerator temperatures for one to two days. Natto has a musty flavor and slimy appearance.

(i) Miso

Miso is similar to soy sauce except that cooked whole beans are mixed with steamed rice. Fermentation occurs after

salt and limited water addition. The aged product is a dark paste with a characteristic flavor that is also used as a seasoning.

Soy Protein Ingredients

The major soy based food ingredients are soy (a) grits and flours (b) protein concentrates, and (c) isolates. Mostly, they are incorporated into foods as a functional ingredient or nutritional supplement such as in bakery, dairy, confectionery, and meat products. Generally, they perform different functional roles from water binding to fat binding to building a desirable texture. Flavor contributed by the soy food ingredient is almost always undesirable.

(a) Soy grits and flour

Soy grits and flours, generally prepared from extracted meal, can vary from full-fat, enzyme active, or lecithinated products. The grits and flours vary mainly in the particle size and protein solubility. Grits are prepared by coarse grinding and flours by fine grinding.

(b) Soy protein concentrates

The soybean protein concentrates are prepared by washing the soluble carbohydrates, mainly sucrose, stachyose, and raffinose, from the defatted soybean meal. The product is soy protein concentrate with 70% protein (N x 6.25). The processing methods utilized include hot water washing, isoelectric extraction, or aqueous-alcohol extraction. Soy con-

centrates have lighter color, less flavor, and are generally more functional than flours and grits.

(c) Soy protein isolates

The isolates are almost pure soy proteins (90% protein). Both the water soluble carbohydrates and insoluble polysaccharides are separated from the protein by using a high pH extraction followed by isoelectric precipitation. The precipitated protein is usually neutralized and spray dried. The functional properties of the protein isolates are the highest of the soy ingredients.

Soy Nutrition

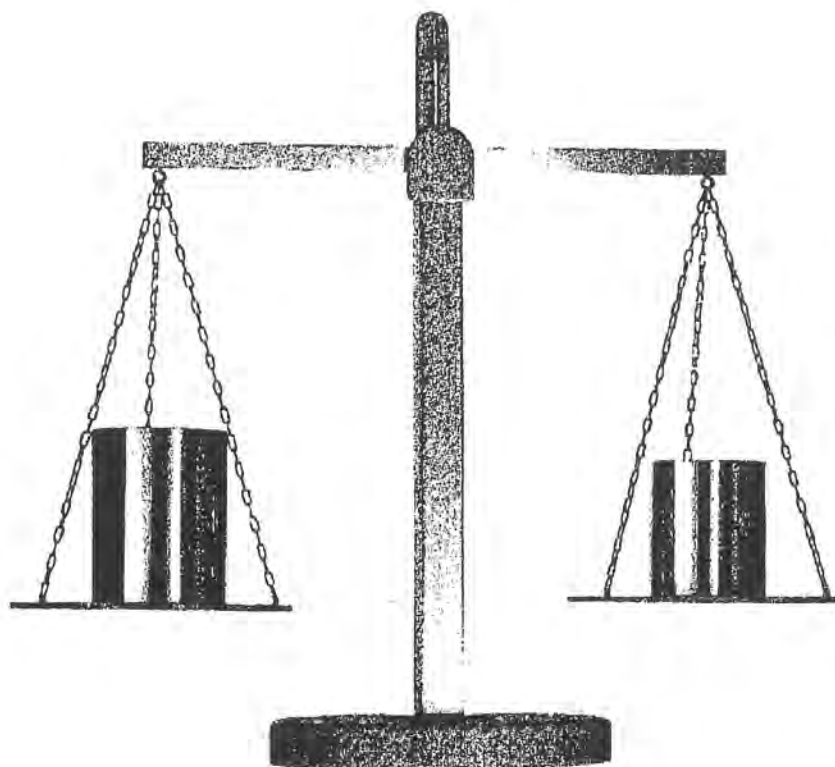
On a dry weight basis, soybeans contain approximately 40% protein, 20% crude oil, 35% carbohydrates, and 5% ash, although these values vary with varieties and growing conditions. Soybeans and soy products are an excellent source of not only protein and oil, but also dietary fiber and minerals. Table 1 shows nutrient contents of some common soy foods per serving.

(a) Soy protein

Raw soy meal is known to cause growth retardation when fed to rats. The raw soy protein is not only poorly digested but also contains natural toxicants. Trypsin inhibitors and hemagglutinin are the two main toxicants. Fortunately, many of the natural toxicants are readily inactivated upon moist heating. This explains why heat treatment improves the nutritional values of soy proteins.

Table 1: Composition of various soyfoods (4)

| Soyfood | Calories | Protein (g) | Fat (g) | Carbohydrate (g) | Crude Fiber (g) | Calcium (mg) | Iron (mg) | Zinc (mg) | Thiamine (mg) | Riboflavin (mg) | Niacin (mg) | Vitamin B6 (mg) | Folate (mg) |
|----------------------------------|----------|-------------|---------|------------------|-----------------|--------------|-----------|-----------|---------------|-----------------|-------------|-----------------|-------------|
| Soybeans, dry roasted, 1/2 cup | 367 | 34.0 | 18.60 | 28.1 | 4.60 | 232 | 3.4 | 4.10 | 0.40 | 0.70 | 0.90 | 0.190 | 175.90 |
| Soy flour, defatted, 1/2 cup | 165 | 23.5 | 0.30 | 19.2 | 2.10 | 120 | 4.6 | 1.20 | 0.40 | 0.10 | 1.30 | 0.290 | 152.70 |
| Soy protein concentrate, 1 ounce | 93 | 16.3 | 0.13 | 8.7 | 1.10 | 102 | 3.0 | 1.20 | 0.90 | 0.04 | 0.20 | 0.040 | 85.20 |
| Soy protein isolate, 1 ounce | 95 | 22.6 | 0.95 | 2.1 | 0.07 | 50 | 4.0 | 1.10 | 0.05 | 0.03 | 0.40 | N/A | 49.30 |
| Soy milk, 1/2 cup | 165 | 3.3 | 2.30 | 2.2 | 0.92 | 5 | 0.7 | 0.10 | 0.19 | 0.08 | 0.16 | 0.049 | 1.80 |
| Miso, 1/2 cup | 284 | 16.3 | 8.40 | 38.6 | 3.40 | 92 | 3.8 | 4.60 | 0.13 | 0.35 | 1.19 | 0.297 | 45.60 |
| Natto, 1/2 cup | 187 | 15.6 | 9.70 | 12.6 | 1.40 | 181 | 7.6 | 2.67 | 0.14 | 0.17 | 0.00 | N/A | N/A |
| Tofu, regular, raw, 1/4 block | 88 | 9.4 | 5.60 | 2.2 | 0.83 | 122 | 6.2 | 0.93 | 0.90 | 0.06 | 0.23 | 0.080 | 0.06 |



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Almost all soy foods and soy ingredients undergo heat treatment during their preparation or application. Studies have shown that when properly heated, soy protein is essentially equivalent in nutritional quality to animal proteins such as eggs, milk, and meat. One drawback with soy protein is its deficiency of methionine, a sulfur-containing amino acid. Many soy-based products are often fortified with methionine, particularly for infant formulas. Since cereal proteins contain sufficient methionine but lack lysine, a food containing both soy ingredients and a cereal becomes complementary for these amino acids.

In addition, new studies have shown that soy protein helps to reduce serum cholesterol levels. The reduction likely occurs by changing insulin and thyroid hormone production.

(b) Fat and calories

Soy oil contains less than 15% saturated fatty acids and about 50% linoleic acid, an essential fatty acid (Table 2). Linolenic acid, an omega-3 fatty acid, is present at about 8% of the total fatty acids. Omega-3 fatty acids are known to reduce the incidence of heart disease.

Soy-based food contains a relatively low fat content (Table 1). Compared with meat and dairy products, there are considerable savings in total calories, calories from fat, total saturated fat, and cholesterol.

(c) Phytochemicals

Besides their high value in general nutrition, soybeans are becoming recognized as a storehouse of phytochemicals. Phytochemicals consist of a diverse group of plant substances which have been shown to affect human health as much as vitamins and minerals. Many of them have anti-cancer effects or help to prevent other diseases. In

fact, discovery of these plant components and their relation to our health may change how the nutritional value of a food is assessed.

Of the fourteen phytochemicals, seven are present in soybeans. They are phytates, isoflavones, carotenoids, coumarins, triterpenes, lignans, and phenolic acids. Phytochemicals in soybeans may explain their beneficial effect on our health. For example, phytates, together with soy fiber, may play an inhibitory role in colon cancer. Phenolic acids may inhibit cancer through its antioxidant activity. Isoflavones present in soy, mainly genistein, are similar to the female sex hormone, estrogen. The isoflavones compete with estrogen in binding sites similar to antiestrogens and may prevent the development of breast cancer. In addition, protease inhibitors present in soybeans have been shown to reduce breast, skin, bladder, and other cancers in laboratory studies.

Food Bean Market

The worldwide market for soybeans for soy food preparation is estimated at about one million metric tons. In Japan alone about 830 thousand metric tons of soybeans are used for preparing soy foods (figure 4). In the US, it is about 50 thousand metric tons. Major markets exist in Korea, China (including Taiwan and Hong Kong), Singapore, Malaysia, and Thailand.

The market for food beans carries a premium price. Producers receive 5-20% above the base price. The premium is often a trade-off in yield or other agroeconomic characteristics of these beans.

There is a steadily increasing demand for food beans. This demand has been driven by the consumers' desire for improved quality and manufacturers' requests for better soy food yield. The healthy image of soy foods is also a factor. Further improvement in varieties suitable for food beans is expected as the relationship between raw soybeans and quality of soy foods is identified. Already, varieties with higher protein, less beany flavor, larger seed size,

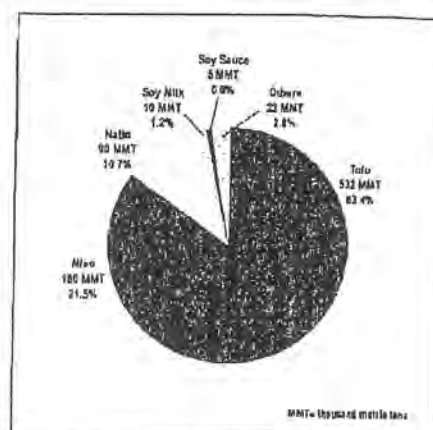


Figure 4: Estimated market for food soybeans in Japan for preparing various soyfoods (5). Total is 830 thousand metric tons.

better seed integrity, and improved color and appearance have been bred.

Summary

Two types of soybeans are being produced. The traditional oil bean continues to be used for oil extraction and meal preparation whereas food soybeans are adapted to direct food uses, including traditional soy foods as well as soy protein ingredients. Because of their apparent advantages in appearance, composition, and functionality, food beans offer an opportunity to improve yield, texture, flavor, appearance, and nutritional values of soy foods and soy-based products. Moreover, the recent research showing that soy-based foods can help prevent and treat heart disease and cancer should increase food use of soybeans.

Key No. 37571

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Table 2: Major Fatty Acid Composition of Common Soybean Oil

| Fatty Acid | Relative % |
|------------|------------|
| Palmitic | 10.6 |
| Stearic | 4.1 |
| Oleic | 23.4 |
| Linoleic | 53.2 |
| Linolenic | 7.8 |