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SOYBEANS AS HUMAN FOOD

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Abstract

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Unprocessed and simply processed soybeans used as human food and the pattern of soybean consumption and production are reviewed country by country. Traditional soybean foods used have been limited to the Orient where soybean foods are eaten by everyone—young and old, rich and poor. The kinds of soybean foods people in the Orient like, the ways to prepare such foods, and the manner of consuming them are deeply imbedded in their culture. Preparation and use of these traditional soybean foods are described. In recent years, various approaches have been taken to incorporate soybeans into native diets of countries that do not traditionally use soybeans as foods. These studies indicate that soy flour may be the most versatile product. A village process for making soy flour is discussed.

Although soybeans are grown in small areas throughout the world, soybean production is concentrated in three countries: The United States, Brazil, and China. World food consumption of soybeans, however, is low; most of the soybeans produced are used for oil and feeds. Even in China and Japan, which consume significant amounts of soybean foods, the percentage of soybeans used as food is only 15 and 22 percent, respectively. In the past years, the United States has distributed cereal-soy blends to be used as food to many countries.

Key Words:

Soybeans, production, consumption, simple processing, economics, fermentation, soybean foods, Asia, Africa, Europe, Latin America, North America, oriental soybean foods, traditional soybean foods.

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Soybeans as Human Food—Unprocessed and Simply Processed

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L. C. Wang, C. W. Hesseltine, E. B. Bagley

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Preface

Inadequate diets in many developing countries (DC) have contributed to their population's high mortality, poor mental as well as physical growth, and general deterioration in the quality of life. In turn, the economic growth of these countries is inhibited. Thus, the lack of nutritious foods is a basic link in a cycle of poverty and primitive existence.

To provide low-cost and highly nutritious foods for DC, the U.S. State Department's Agency for International Development (AID) supports the approach of introducing soybeans for human consumption. Accordingly, a project was initiated to promote soybeans as a food staple among the rural poor in selected DC and to develop methods for introducing unprocessed or simply processed soybeans as a direct food for low-income segments of the population of other DC. This review on the use of unprocessed and simply processed soybeans as human food is a part of that project. Its primary purpose is to reveal the state of the art of soybean food uses and the pattern of soybean consumption around the world. Barriers affecting the use of soybeans as food are also identified.

This study was done on contract AID AG/TAB-225-12-76.

Contents

Introduction, 1
Soybean food uses in Asia, 2
China, 3
Soaking dry soybeans, 3
Tou chiang (soybean milk), 3
Tou fu (soybean curd), 5
Processed tou fu products, 7
Tou fu pi (protein-lipid films), 8
Huang tou ya (soybean sprouts), 9
Whole soybeans, 10
Fermented soybean foods, 10
Production and consumption, 11
Japan, 11
Tofu (soybean curd), 11
Kinugoshi tofu, 13
Processed tofu products, 14
Yuba (protein-lipid film), 14
Soybean milk, 15
Go (ground soybean mash), 15
Daizu no mayashi (soybean sprouts), 15
Whole soybeans, 15
Fermented soybean foods, 15
Production and consumption, 15
Korea, 16
Tubu (soybean curd), 16
Processed tubu product, 16
Soybean sprouts, 16
Whole soybeans, 16
Soybean flour, 16
Fermented soybean food, 17
Production and consumption, 17
Indonesia, 17
Tahu or tahoo (soybean curd), 17
Bubuk kedele (soybean powder), 17
Tempe kedele, 17
Tempe gembus, 18
Oncom tahu, 18
Other soybean products, 19
Food mixtures, 19
Production and consumption, 19
Thailand, 20
Philippines, 20
Soybean sprouts, 21
Soybean coffee, 21
Soybean cake, 21
Soybean milk, 21
Tou fu and processed tou fu products, 21
Production and consumption, 21
Burma, 21
India, 22
Malaysia, 22
Nepal, 23
Singapore, 23
Sri Lanka (Ceylon), 23
Vietnam, 24
Middle East, 24
References—Soybean food uses in Asia, 24
Soybean food uses in Africa, 26
Ethiopia, 26
Injera, 27
Wots and allichas, 27
Kitta, 27
Dabbo, 27
Dabokolo, 27
Porridge, 27
Kenya, 27
Morocco, 27
Nigeria, 28
Whole soybeans, 28
Soybean paste, 28
Corn-soy mixtures (soy-ogi), 28
Tanzania, 29
Uganda, 29
Production, 29
References—Soybean food uses in Africa, 30
Soybean food uses in Europe and U.S.S.R., 30
Soybean food uses in Latin America, 30
Argentina, 30
Bolivia, 31
Brazil, 31
Chile, 32
Colombia, 32
Ecuador, 33
Guyana, 33
Paraguay, 33
Peru, 34
Uruguay, 34
Venezuela, 34
Mexico, 34
New village process, 35
Commercial developments, 36
Honduras, 37
Costa Rica, 37
Panama, 37
Dominican Republic, 37
Jamaica, 38

Haiti, 38
Trinidad, 38
References—Soybean food uses in Latin America, 39
Soybean food uses in North America, 39
United States, 39
Canada, 41
References—soybean food uses in North America, 41
Soybean food uses in Australia, 41
Summary of soybean food uses, 41
Traditional soybean foods, 41
Soybean milk, 41
Soybean curd and processed soybean curd products, 42
Protein-lipid film, 42
Soybean sprouts, 42
Tempe (Tempeh), 42
Green soybeans, 42
Boiled soybeans, 42
Roasted soybeans, 42
Soybean flour, 42
Soy sauce, 42
Fermented soybean paste, 43
Fermented whole soybeans, 43
Natto, 43
Fermented soybean curd, 43
Experimental soybean foods, 43
Whole soybeans, 43
Soybean paste, 43
Soy flour, 43
Soy beverage, 43
Production and consumption, 43
Simple village process for processing whole soybeans, 46
Equipment, 46
Process, 46
Sanitation requirements, 50
Quality of product, 50
Evaluation of product in formulas and procedures for family and institutional use in developing countries, 51
NRRC village process, 51
Industrial production and selling prices of edible soybean protein products, 52
Barriers to accepting and using soybeans in food, 52
Availability, 52
Cultural and social factors, 52
Texture, 53
Flavor, 53
Nutrition and food safety, 53
Technology development, 53
Technology transfer, 53

Metric Conversion Factors

1 inch .....2.5 centimeters, 25 millimeters
1 teaspoon .....5 milliliters
1 tablespoon .....15 milliliters

1 ounce (fluid) .....30 milliliters
1 cup .....0.24 liter, 237 milliliters
1 gallon .....3.8 liters

1 ounce .....28 grams
1 pound .....0.45 kilogram, 454 grams
1 ton .....0.9 metric ton

1 acre .....0.4 hectare
F .....(9/5 C) + 32

Soybeans as Human Food—Unprocessed and Simply Processed

H. L. Wang, G. C. Mustakas, W. J. Wolf, L. C. Wang, C. W. Hesseltine, and E. B. Bagley[1]

Introduction

The soybean, a native of China, is perhaps one of the world's oldest crops. No one knows how long ago man started to cultivate soybeans. Ancient Chinese literature reveals that soybeans were cultivated and highly valued as a food long before written records were kept, and, for many centuries, their cultivation was confined to oriental countries. On a small scale, soybeans were grown in Europe as early as the 1700's and in the United States in the 1800's. Not until the 1930's did the United States begin to produce soybeans as a commercial crop and, since then, this phenomenal growth is history. The United States leads the world in soybean production with 41,406,000 metric tons (t) in 1975. China, the chief soybean-producing country in Asia, produced only 10,000,000 t that same year.

Traditionally, soybeans have been used in the Orient as food. To a great extent, they have provided all the oriental population with needed protein since ancient times. In the United States and Europe, soybeans were used as a forage crop through the 19th century. Since then, soybeans have become valued as a source of edible and industrial oil and as defatted meal for animal feeds. But soybeans have never been well accepted as food by the people of Western countries.

Soybeans are scarcely known to people in many areas of the world. They know nothing about methods used to cook soybeans, and those who do find the flavor peculiar to their taste.

Some people outside of the Orient have the idea that soybeans are not suitable for human food. Undoubtedly, cultural traditions dictate food customs, but the inherent aversion of people to anything new also curbs the popularity of soybeans.

Problems in using soybeans for foods include antinutritional and flatus factors, beany flavor, disagreeable taste, and cooking difficulty. These problems are not really unique to soybeans but, rather, are common to many beans and other pulses consumed around the world. Because of the high fat and low carbohydrate content, lack of starch, and compact texture, soybeans do not cook as soft nor as readily as many other beans. However, when cooked properly, soybeans do not require much longer cooking time than other beans to be palatable. Therefore, with some education and promotion, the public may find that soybeans, as food, could be included in diets the same as other beans.

Cooking soybeans is a fine art in the Orient. Elaborate fermentation methods, as well as many other simple processes, produce a variety of fresh, dried, and fermented products. The majority of products are made at home or in family-operated shops, and preparation methods are usually kept as a family secret. Consequently, these products, and the simple technology of making them, are not widely known or adopted outside the oriental population. In recent years, major cities in the Orient have become industrialized, but the fine household art of making soybean food products remains

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active in small towns, as well as in other areas around the globe to which people from the Orient have emigrated. Today, millions of oriental people still enjoy and rely on soybean foods prepared by methods developed many centuries ago.

Because of the increasing awareness of the nutritional value of soybeans and the shortage or nonexistence of animal protein in many areas of the world, soybeans are being used in ever-increasing amounts in a variety of food products and perhaps by more people than ever. This literature survey attempts to reveal the state of the art of worldwide use of soybeans as food. Emphasis here will be on unprocessed and simply processed soybean foods used in the home and in the village processes.

The survey, which was mainly derived from the files of Northern Regional Research Center (NRRC) scientists, covers existing literature as well as information obtained from contacts with scientists from various countries, institutes, industries, and voluntary agencies; visits to other countries; and firsthand know-how. To supplement and update this information, a literature search was made in AGRIOLA (Agriculture On-Line Access) from the Science and Education Administration's Technical Information Systems data base using subject key words as well as key words of voluntary agencies and international organizations, and letters were sent to individuals, Government agencies, and educational institutions of concerned countries.

Sources of information on soybean production are many: Foreign Agriculture Service (FAS) and Economics Statistics, and Cooperatives Service (ESCS) of USDA; Food and Agriculture Organization of the United Nations (FAO), International Soybean Program at the University of Illinois (INTSOY), American Soybean Association (ASA), and responses from the individual countries. However, production figures from different sources often do not agree, and in some instances, the difference is severalfold.

Two main sources of information are available on soybean consumption: national food balance sheets and dietary surveys. However, in many food balance sheets as well as dietary surveys, edible beans are reported in the category "pulses, nuts, and seeds," "pulses," or "dry seeds." This indicates, perhaps, that soybeans or any other beans cited, are insignificant in those countries. Dietary surveys often cover only limited groups, not always representative of countries as a whole. The data on production and consumption, therefore, are less complete and less accurate. These data, however, may point out the extent of production and consumption of soybeans in a given country.

Soybean Food Uses in Asia

Soybean foods are common in the Asian countries, but they are most popular in China, Japan, Korea, and perhaps Indonesia. Because of China's long history, the Chinese have had a great influence on the use of soybean foods. As a result, many soybean foods from different countries are similar, but the details in preparing and serving such foods may vary. Some soybean foods are still unique to one particular area or country.

In Asia, all soybeans are classified as edible. To make the beans as palatable as possible, many methods of preparation have been devised. Not only are soybeans cooked whole, but they are processed to make such products as soybean milk, soybean curd, soybean sprouts, soybean protein and oil film, soybean flour, soy sauce, bean paste, soybean cheese, tempeh, natto, and fermented black beans. Some of these products are flavoring agents and others are staples. Many soybean foods are simply prepared while others are prepared by complex fermentation processes. However, all these foods are versatile and can be served in endless ways.

Information for this study was gathered from many sources and variations in the procedures of making and serving any one food frequently occur, even in the same country. Therefore, only some of the relatively simple and fundamentally sound processes with significant variations and adaptations will be presented.

China

Soaking dry soybeans

Regardless of the process used and the end product desired, the first and most important step in making soybean foods from dry soybeans in the Orient is to soak the beans thoroughly. The soaking process has long been believed to reduce the cooking time as well as to increase the wholesomeness of the product. A general description of this process follows.

Beans are first rinsed several times with fresh water and rubbed with the hands or stirred vigorously with a paddle to clean. This water is then poured off and clean water added to cover the beans; the proportion, 200 g (1 cup) beans to 0.72 L (3 cups) water can be used. Depending on the air temperature, beans are soaked from several hours to overnight; in summer 6 to 7 h and in winter 24 h. Overnight soaking, however, is widely used. On a hot summer day, water should be changed several times during soaking to prevent bacterial growth. Under controlled laboratory conditions, beans reach maximum water absorption after soaking at 20° C for 18 h, or at 28° C for 8 h. Thoroughly soaked beans usually weigh about 2.2 to 2.4 times their original weight depending on the variety of beans, or slightly less than 3 times their original volume. Soaked beans are drained and rinsed and ready for use.

Beans can be dehulled easily after soaking by rubbing them against each other. The loose seedcoats are discarded with the water. In Indonesia, as well as in some other areas, dehulling is sometimes done by placing the soaked soybeans into a bamboo basket at the edge of a river and then treading on the beans to loosen the seedcoats. The seedcoats then float away with the flowing water.

Another method of preparing the dry beans is to parboil the beans for 1 min, and then let them soak overnight. This procedure will facilitate dehulling.

In Thailand, soybean foods are relatively new. The Thai prefer to soak soybeans in a sodium bicarbonate solution to reduce the beany flavor.

Tou chiang (soybean milk)

Tou chiang is said to have been originated by a Chinese philosopher long before the Christian era. Because it resembles dairy milk, tou chiang is generally known as soybean milk to the people outside of China. Tou chiang has a subtle milk sweetness and a strong characteristic flavor liked by practically all Chinese. A cafe specializing in tou chiang often has an open pot of boiling tou chiang in the front of the shop to lure customers.

Preparation

Materials.—Soybeans and water. Although any variety of beans may be used, those that have uniform size, light color, thin seedcoat, and high protein are preferred.

Equipment.—Soaking containers, cooking pots, cloth bag, cheesecloth-lined strainer or fine screen for filtration, and efficient grinder.

In China, a stone mill, consisting of two pieces of flat, circular stone with ridgelike grooves on one side of each stone, is generally used for grinding. One stone is put on top the other with rough sides touching. The top stone can be turned around by hand against the lower one. The beans and water are fed through a hole near the edge. The liquid that flows out between the stones is run into a container. In some shops, motor-driven mills with vertically mounted stone wheels are used for grinding.

In laboratories or at home, electric blenders or liquifiers, such as Waring Blendors,[2] are convenient to use for producing small quantities of milk. Other automatic food grinders, inexpensive burr-type feed grinders, and stone mills used by cornstarch manufacturers in the United States are useful (Chen and Chen *1962*).[3]

Procedures.—Making tou chiang is a simple process that has been described by several investigators (Piper and Morse *1923*, Chen and Chen *1962*, and Wang *1967*). In general, these procedures which are similar can be carried

[2] The mention of firm names or trade products does not imply that they are endorsed or recommended by the U.S. Department of Agriculture over other firms or similar products not mentioned.

[3] The author's name and the year (italics) are the key to References, p. 24.

out either at home or at village levels as well as in a modern factory.

About 200 g of beans are first washed, soaked, and drained as described in the section, **Soaking Dry Soybeans.** The soaked beans (500 g) are ground with a stone mill, while a small stream of water is added. Or the beans can be blended with a small amount of water in an electric blender for 2 min at high speed. The ground soybean mass is placed in a cooking pot and more water is added to make an 8:1 ratio of water to beans based on the weight of the dry beans (amount of water needed after soaking, 1.3 L). The ground mass is stirred for a few minutes and heated to boiling with constant stirring to prevent scorching. Often, skimming off the froth on the surface is necessary to prevent sudden boiling over. The cooked ground mass is strained through a cloth bag or double-layered cheesecloth. Some people prefer to filter the ground mass before cooking, even though filtering is much easier after cooking. The tou chiang or soybean milk (about 1 L) passes through the bag leaving tou cha or soybean pulp.

In many shops, the ground soybean mass is heated in a drum using steam from a coal-heated boiler. It is then run into a device similar to a Buchner funnel but fitted with a fine metal screen. The device is set over a big barrel into which the soybean milk filters.

To produce tou chiang that feels smooth when eaten, and has a fine-textured consistency, the beans should be fed slowly into the grinder with a small amount of water. Grinding soybeans with a large amount of water often results in a coarse-textured ground mass which, in turn, yields low-quality milk.

A ratio of 10:1 water to dry beans is commonly used in China. The ratio is not a critical factor in making tou chiang; however, a ratio higher than 10:1 will result in a low-protein product without increasing its total protein recovery. On the other hand, a ratio lower than 8:1 may yield milk with a high-protein content, but the total protein recovery might be low. Based on experience of the Chinese, ratios of 8:1 to 10:1 water to beans are most suitable for good-quality product.

In recent years, various procedures have been developed to reduce the beany flavor of soybean milk (Kanda and others *1976*, Kon and others *1970*, Nelson and others *1976*, Wilkens and others *1967*). The simplest ones include grinding the beans with boiling water or boiling the beans in dilute sodium bicarbonate solution before grinding. The heating process, however, may denature the soybean protein and thus reduce the protein solubility.

Byproduct.—Tou cha, the only byproduct from making tou chiang, is highly nutritious (Hackler and others *1963, 1967*). Although it is commonly used as animal feed, it is also eaten by some people.

Composition

The composition of tou chiang varies with variety of the soybeans used and with the method of preparation (Lo and others *1968a,b;* Wilkens and Hackler *1969*). In general, tou chiang is low in fat, carbohydrates, calcium, phosphorus, and riboflavin but high in iron, thiamin, and niacin in comparison with cow's milk. Tung and his coworkers (*1961*) give the following composition of 100 g of tou chiang sold in Taiwan: water, 94 g; protein, 3.3 g; fat, 0.9 g; carbohydrates, 1.4 g; ash, 0.3 g; calcium, 12 mg; phosphorus, 40 mg; iron, 0.7 mg; thiamin, 0.04 mg; riboflavin, 0.02mg; and niacin, 0.2 mg.

The properties of tou chiang are quite similar to those of animal milk. Acids and inorganic salts will coagulate the protein. Like cow's milk, tou chiang can also be fermented by some *Lactobacillus* bacteria to yield acid milk and a yogurtlike product.

Ways of serving

Direct uses.—Traditionally, tou chiang is made fresh daily and sold on the street or in small cafes. Even though tou chiang can be made easily at home, it is not commonly done because tou chiang is available commercially.

Tou chiang is a breakfast food. It is boiled and served hot either flavored with sugar, or soy sauce (chiang yu, a fermented soybean product containing 16 to 18 percent salt), a little green onion, a dash of sesame oil, and even little salt-pickled vegetables.

Traditionally, adults rather than children drink tou chiang. A middle class office worker or a college student who has enough education to know the nutritional value of tou chiang and who also has extra cash is the typical consumer.

As people are becoming more aware of the nutritional value of soybeans, tou chiang is increasing in popularity. In Taiwan, tou chiang stands or cafes are on almost every street corner. Tou chiang is also bottled and sold as a cold drink, but its popularity in China is limited.

To increase the nutritional value of tou chiang for infant feeding, Huang and his coworkers (*1976*) suggested enriching soybean milk with partially autolyzed egg. Communication with Huang[4] indicated that the idea of adding an egg to a bowl of tou chiang is practiced. However, this egg-soybean milk is usually consumed by adults and to a lesser extent by children. It is rarely given to infants.

Indirect uses.—Many soybean foods, which are more important and popular than tou chiang itself, are made from tou chiang. These foods will be discussed in the later sections.

Suggested uses.—Tou chiang can be used the same way as cow's milk in many Western recipes. It can also be made into yogurt, or acid milk-type products. First, it is heated to boiling, mixed with sugar (5 percent), poured into a container, allowed to cool, and then inoculated with pure culture (Wang and others *1974*, Kanda and others *1976*), yogurt, or a commercial yogurt starter. The container is then covered and kept in a warm place, usually overnight depending on the temperature, until yogurt consistency is obtained. Inoculated soybean milk was incubated in the laboratory for 20 h at 37° C.

Yogurt made from soybean milk is best when served cold, or it can be mixed with equal parts of water and served as a sour-cold drink.

Tou fu (soybean curd)

Tou fu is closely associated with tou chiang (soybean milk) because the initial step in making tou fu is to make soybean milk. When a mineral salt or acid is added to soybean milk, coagulation occurs that is similar to cottage cheese produced from dairy milk. When the coagulated mass is drained, the end product is a soft-white curd called tou fu by the Chinese and soybean curd by the people from the Western world.

Tou fu has a bland taste and is white or grayish white. It has a soft but firm texture like cream cheese. Traditionally, tou fu is made daily and sold in the form of a wet cake. The size of the cake is usually 10 by 10 by 3 cm. although the size may vary.

Tou fu is, perhaps, the most important soybean food in the Orient. It has much the same importance to the people of the Orient that meat, eggs, and cheese have for the people in Western countries.

Preparation

Manufacture of tou fu started during the era of the Hang dynasty; Liu An (*179-122 B.C.*), King of Wainan, invented the method of preparation. Centuries later, numerous procedures for making tou fu have been described (Adolph and Kiang *1920*, Chen and Chen *1962*, Chin and Van Duyne *1961*, Piper and Morse *1923*, Shurtleff and Aoyagi *1975*, Smith and others *1960*, Wai *1964*, Wang *1967*); however, the underlying principle for making tou fu is still based on the simple one invented by Liu An. The details of these procedures may vary to some extent, just as any household art may vary from one family to another, but in general they are similar.

Materials.—Soybeans, water, and coagulants. Any variety of soybeans may be used for making tou fu; however, yield, color, and texture of tou fu vary with the variety (Piper and Morse *1923*, Smith and others *1960*). Original protein and oil content of the beans is a factor in yield as well as in the final protein and oil content of the tou fu. In general, Chinese prefer beans having high protein content, uniform maturity and size, thin seedcoats, and a bright, light color, which are essentially the same as those required for making soybean milk.

The most commonly used precipitating agents or coagulants are powdered gypsum (a mixture of calcium sulfate and magnesium carbonate)

[4] Huang, P. C., professor of nutrition, College of Medicine, National Taiwan University, Taipei, Taiwan, R.O.C. 1976.

and yen-lu (the concentrated liquid obtained in the manufacturing of salt from sea water, containing mainly magnesium sulfate and magnesium chloride). Because the Chinese diet is low in calcium, the most desirable coagulant would be calcium salts: calcium sulfate, calcium chloride, calcium lactate, calcium gluconate, and calcium citrate (Wai *1964*). Acids, such as citric or vinegar, have also been used but not commonly in China.

Equipment.—In addition to the equipment required for making soybean milk, as described under tou chiang, square wooden boxes about 4 to 5 cm deep are used to press and mold tou fu. The boxes should have small holes or slits, lined with cloth so the excess whey can be drained off, and the curd formed into the size of the box.

Procedures.—The first step in preparing tou fu is to make tou chaing (soybean milk as previously described). Next, the protein is precipitated by a coagulating agent and then placed into a molding box to form a cake.

About 1 L of tou chiang obtained from 200 g of dry beans is brought to a boil and 3.5 g of calcium sulfate ($CaSO_4 \cdot 2H_2O$) suspended in 20 ml hot water is slowly added to the hot milk (70° to 80° C). In many shops, where the ground bean mass is cooked before filtering, no cooking is applied to the resulting soybean milk before the addition of the coagulant. Because tou fu is frequently eaten without further cooking, boiling the milk for 20 to 30 min before adding the coagulant increases the nutritional value and also lessens the beany flavor. During cooking, constant stirring is necessary to avoid scorching. Steamers or double boilers are convenient for this purpose.

Coagulating the soybean protein by adding salt is the most difficult step in making tou fu. The right amount and the kind of salt used are two factors necessary to attain a satisfactory curd. Recommended is 3 to 4 g of $CaSO_4 \cdot 2H_2O$ per liter of milk obtained from 200 g of dry beans. Shurtleff and Aoyagi (*1975*) suggest using 24 to 36 g (3 tbsp) magnesium chloride, calcium chloride, calcium sulfate, or magnesium sulfate for the amount of soybean milk obtained from 1.6 kg of soybeans (ratio of water to beans is 8:1).

The kind of salt used also affects the quality of the tou fu. Calcium sulfate seems superior to other calcium or magnesium salts. It coagulates the protein slowly to give the most gelatinous type of precipitation and the smoothest texture.

The salt should first be dissolved or suspended in hot water and then added to the hot milk (70° to 80° C) with gentle mixing by a paddle or scoop. Adding an insufficient amount of salt or adding it too quickly not only causes incomplete precipitation but also results in a turbid suspension. This makes separating the whey from the precipitated protein difficult. On the other hand, too much salt makes the tou fu too hard, which is not liked by most Orientals.

Satisfactory and complete curd formation is indicated by the slow aggregation of the small curd into a large mass, which gradually settles to the bottom of the container, and change of the milk into a light yellowish, clear liquid. A sudden flocculation usually means excess precipitating agent. With close observation and some practice, this most difficult step of making tou fu can be easily achieved.

After the curd settles, the whey (supernatant) is partially removed, and the curd is transferred to a wood box lined with coarse filter cloth. A 12 by 12 by 5 cm box with small holes or slits in the sides and at the bottom is a convenient size to handle the quantity of curd made from 200 g of soybeans. The ends of the filter cloth are folded over, and a board placed upon the curd. It is then subjected to pressure from the top with about 500 g of stones or other weights to squeeze out the whey. When draining has stopped, a cake, which should be solid enough to stand handling, is ready to be removed from the box. From 200 g of soybeans, 450 to 500 g of tou fu with a moisture content of 85 percent is made. The amount of curd, the weight of pressure, and the pressing time will affect the hardness of the tou fu. Large batches of tou fu can be made by using the same procedure and the same simple and inexpensive but larger equipment. When pressing curd, the wooden boxes can be stacked and pressed under a weighted lever.

Byproducts.—Tou cha and whey are the only

byproducts from tou fu manufacture. Both are used for animal feed. Tou cha is also used for food.

Composition

The composition of tou fu may vary depending on the variety of bean used and the method of preparation. The following is the composition of tou fu (100 g) made in Taiwan, as reported by Food Industry Research and Development Institute (*1971*): water, 86.3 g; protein, 7.3 g; fat, 3.5 g, carbohydrates, 2.3 g; fiber, 0.3 g; ash, 0.7 g; calcium, 95 mg; phosphorus, 106 mg; iron, 2.8 mg; vitamin B_1, 0.05 mg; vitamin B_2, 0.03 mg; and niacin, 3.8 mg.

Ways of serving

Because tou fu is rich in protein, fat, and minerals, it is known in China as "meat without bones," even though tou fu, as used in the Orient, has a soft, cream cheeselike consistency that is quite different from meats. However, a variety of products processed from tou fu are available that have less moisture content and a more chewy texture.

Tou fu is consumed almost daily by everyone in China—rich and poor, young and old. No report has been given of the amount of tou fu consumed by each person daily, but a figure of 84 to 112 g is reasonable.

Tou fu is usually made, sold, and eaten the same day, although it can be kept in cold water for a couple of days when the weather is not too hot and for as long as 2 to 3 wk in the refrigerator with changes of water. When fresh, tou fu is a rather bland product, but it can be made into a great variety of delicious dishes.

Without cooking.—A delightful way to serve tou fu without further cooking is simply to serve it with the addition of soy sauce, sesame oil, green onion, hot oil (if one has a taste for hot food), or with any other spices or flavoring agents one prefers.

Boiling.—Tou fu is frequently used in soups with vegetables, such as chicken broth with tou fu and peas, depending on availability and preference. Cooking time for tou fu is short, just a few minutes, but not critical.

Tou fu is also served by boiling and then dipping into a favorite sauce. It is the key ingredient in huo-kuo (firepots), which is an entire meal similar to fondue.

Quick stirring.—Using a small amount of oil in a heated skillet, cook slices of tou fu until both sides are brown. Add soy sauce or other flavoring agents as desired and serve hot. Sometimes, sliced pork or beef are browned and then mixed with tou fu.

Simmering.—Shredded pork or beef are cooked in a little hot oil, stirring constantly. Add small cubes of tou fu, salt, soy sauce, hot bean paste and a small amount of water, and bring to a boil. Cover and simmer for about 5 min.

Shrimp is also cooked with tou fu in the same manner.

Steaming.—Tou fu cakes are stuffed with flavored ground meat or shrimp and then steamed. Tou fu is also steamed just with flavoring agents, such as soy sauce or sufu (fermented tou fu).

Stewing.—Bean curd cooked in an earthen pot is a common way of eating tou fu in the Szechuan region. Place cut-up chicken, pork, ham, dry seafoods, vegetables, mushrooms, tou fu, or any other foods one prefers in the earthen pot. Add salt and soup stock, and simmer over low heat until served.

Chinese dishes are usually meat or seafoods cooked together with vegetables or tou fu, so that the vegetables and tou fu are enriched with the meat flavor. Here, Tou fu can be cooked in all the major ways it is available in China. Its versatility is evident. With a little imagination, tou fu can be used in the national cuisine of countries around the world.

Processed tou fu products

Tou fu nao, tou fu kan, chien chang, yu tou fu, and tung tou fu are different forms of tou fu. These products, with different degrees of hardness and water content, are made from tou fu by applying various amounts of pressure when tou fu is pressed at the molding stage. The material and equipment and the procedure to make these products are the same as for making tou fu.

Tou fu nao (soft curd)

Tou fu nao has a softer consistency than tou

fu. It is prepared by adding less than the regular amount of coagulant required for making tou fu, and it is not pressed. The soft custard-like curd looks like thickened soybean milk and is served just like soybean milk. Some prefer to add a sweetner to tou fu nao; others like it with soy sauce, sesame oil, pickled vegetables, dry shrimp, and even chopped meat.

Tou fu nao is also served as a part of breakfast, but it is not as common as tou chiang.

Tou fu kan (dry bean curd)

Kan in Chinese means dry; tou fu kan contains less water than tou fu. When tou fu is pressed under pressure until as much whey as possible is expelled, a product with a low 50 percent water content can be obtained. With thinner cakes of tou fu, drier products can be made. These products are known as peh tou fu kan (white, dry bean curd) because they are still white. The curd can be sliced into thin strips and used as noodles in soups or sauteed with meat and vegetables. White, dry bean curds sometimes are immersed into a special vegetable stalk-salt solution that yields a fermented product.

Frequently, the curds are simmered in hot strong tea and burnt sugar for a short time followed by surface-drying over a slow open fire to produce a brown product generally known as tou fu kan. Tou fu kan has a chewy, meatlike texture and also has a special aroma and taste.

Many variations of tou fu kan exist. Usually it is further seasoned with soy sauce, star anise, pepper corn, or a special Chinese five-spices powder, and then dried over low heat. All these products can be eaten as a side dish with regular meals or as between-meal snack. However, they are usually cooked with meat and vegetables in sauteed and simmered dishes. Tou fu kan is not as commonly consumed as tou fu.

Chien chang

This product is formed by pressing thin layers of bean curd between sheets of cloth. Chien chang, which looks like a piece of cloth, can be cut into thin strips and used as noodles in soups. It can also be stewed with meat. Sometimes it is wrapped around ground meat and then cooked.

Mei chien chang (fermented chien chang) is made by rolling chien chang into thin rolls, sprinkled with salt, and then packed into a bowl and covered. After setting at room temperature for a few days, a natural fermentation takes place which yields the strong-flavored product. It is steamed before serving. This fermented product is usually made at home.

Yu tou fu (fried tou fu)

The fresh tou fu with a low-moisture content is cut into small squares and deep-fried. Yu tou fu is just another form of tou fu and can be served just like other tou fu products.

Tung tou fu (frozen tou fu)

Because of lack of freezing facilities, frozen tou fu is usually consumed only during the winter months. Fresh tou fu is cut into small pieces and exposed to severe cold weather until frozen. The structure of tou fu when frozen is greatly changed; all the water becomes ice. When the frozen tou fu is thawed, only a network of protein and other solids is present; it looks like a piece of sponge—resilient and absorbent. It has a chewy texture, which is remarkably similar to that of tender meat.

Frozen tou fu is used in soups or stewed in an earthern pot with meats, seafoods, and vegetables. In general, processed tou fu products are not as frequently eaten as tou fu.

Tou fu pi (protein-lipid film)

Tou fu pi is another product closely related to soybean milk or tou chiang. It is the film formed on the surface of soybean milk during heating, just as skin forms in the heating of cow's milk. The cream-yellow film is usually air-dried and sold in the form of sheets, sticks, or flakes.

Preparation

In preparing tou fu pi, soybean milk is heated to a boil in an open pan and then maintained at a temperature just below boiling over low heat. When a film is formed, it is removed from the milk by passing a stick underneath the film surface. The stick with the film is then

hung to air-dry or to dry over a low charcoal fire (Piper and Morse *1923*). Succeeding films are removed in the same fashion until no film is formed. Piper and Morse (*1923*) reported that the milk from 1.35 kg (3 lb) of beans would yield about 30 sheets of tou fu pi. Wu and Bates (*1972a*) reported that after film formation ceased, the soybean milk remaining contained about 34 percent protein, 11 percent total lipid, 28 percent carbohydrates, and 13 percent ash (percent dry-basis), whereas the starting milk contained 50 percent protein, 29 percent total lipid, 16 percent carbohydrates, and 6.6 percent ash.

Frequently, the tou fu maker harvests a few sheets of tou fu pi before adding salt to make tou fu.

Composition

The composition of tou fu pi is not consistent. Wu and Bates (*1972a*) found that the protein and lipid content of successively formed films generally decreased. The carbohydrate content of the first groups was always the lowest and increased in the subsequent groups. The ash content of the successive groups of films also increased gradually and was especially high in the last groups. Wu and Bates (*1972b*) also found that the film is not a compound of fixed chemical composition because the ratios vary somewhat with the composition of soybean milk and processing conditions. In general, they found the film contained 55 percent protein, 28 per cent total lipids, 12 percent carbohydrate, 2 percent ash, and 9 percent moisture, which is comparable to that cited by Borgstrom (*1968*), 52 percent protein and 24 percent fat.

Even though the moisture content of tou fu pi is low, its shelf life is short because of the high lipid content.

Ways of serving

Tou fu pi, or Yuba in Japan, is a popular foodstuff in the Orient; however, it is not eaten daily.

Tou fu pi is quite brittle. It is always softened by soaking in cold water before cooking. It can be used in soups or wrapped ground meat or vegetables and then steamed, simmered, or fried. Vegetable chicken, a must for a vegetarian's banquet, is made by folding several rehydrated sheets of tou fu pi seasoned with soy sauce and other spices, and then steamed and sliced.

Huang tou ya (soybean sprouts)

Bean sprouts, which are quite popular in the United States, are not made from soybeans; they are sprouts of the tiny green mung bean (*Phaseolus aureus*). Soybean sprouts are popular in China and are known as huang tou ya, which means yellow bean sprouts. They look like mung bean sprouts except that the bean portion (cotyledons) of the soybean sprout is more distinct because it is large and light yellow. Soybean sprouts have the same crispy texture as mung bean sprouts but are more tasty. However, mung bean sprouts are more frequently eaten than soybean sprouts because they cost less.

Preparation

Materials and equipment.—Soybeans, sprouting container, and cover. Any container equipped with draining outlets is suitable. Bamboo baskets are frequently used with straw mats as cover. Clay flower pots can also be used. Cover the bottom hole of the clay pot with rustproof screen wire or cheesecloth to prevent beans from falling through the hole.

Procedures.—Sprouting beans at home is quite simple with only a few rules to follow. Beans need enough moisture to germinate, but with too much water they may rot; with too little, they will not germinate. Germination occurs best in a dark place and at a temperature of about 25° C.

Soybeans (200 g) are washed and soaked in water overnight. Soaked beans are poured in the sprouting container (24 by 20 cm), rinsed thoroughly, drained well, and covered tightly to keep out the light and to prevent evaporation. The container is then kept in a dark place. The beans must be watered 3 to 4 times daily by pouring water through the container without disturbing the sprouts. If the room temperature is quite high, the beans should be watered more often. It usually takes from 3 to 5 days in the summer and almost 2 wk in the winter for the sprouts to reach full growth. At

that time, they can be pulled out from the pot. After most of the seedcoats have been washed out, the sprouts are ready for cooking.

Composition

The composition of soybean sprouts as reported by Leung and others (*1972*) is moisture, 81.5 percent; protein, 7.7 percent; fat, 1.8 percent; carbohydrates, 8 percent; fiber, 0.7 percent; ash, 1.0 percent.

Ways of serving

Bean sprouts are eaten as a common vegetable throughout the year. However, like many vegetables, they are not eaten daily.

Sprouts, used frequently in soups, can also be steamed with salt, oil, and some green onion. They may be used in almost any way that green vegetables are used. They must be cooked, but require only a short cooking time.

Whole soybeans

Whole soybeans can be used in several ways in the Chinese diet, even though the use of whole soybeans as food in China is not as common as that of the other processed soybean products.

Mao tou (hairy bean, green soybean, or immature soybean)

When soybeans are picked green or at three-fourths maturity—pods are greenish yellow and the beans are large and soft—they are the most delicious and nutritious green vegetable. Standal (*1963*) found steamed green soybeans to have the highest net protein utilization value among all soybean products investigated in the study: tou fu, natto, green soybeans, soybean sprouts. Green soybeans are composed of moisture, 68.2 percent; protein, 13 percent; fat, 5.7 percent; carbohydrate, 11.4 percent; fiber, 1.9 percent; ash, 1.9 percent (Leung and others *1972*).

Green soybeans cooked in the pods with salt for 10 to 15 min are a good between-meal nourishment. They can also be shelled and cooked like peas. Chinese like to cook their vegetables with meat, so the shelled green beans are often steamed or sauteed with meat.

Green soybeans are a seasonal vegetable. When they are in season, they take the place of some other soybean products and vegetables.

Dry soybeans

Roasting and frying.—Dry soybeans are often roasted over an open fire and are eaten as a snack, like peanuts. Some prefer to fry soybeans in deep oil, which seems to give added taste. The texture of roasted or fried soybeans is too hard to suit the American's taste, but they have been enjoyed by Chinese for centuries.

Stewing and boiling.—After soaking, dry soybeans are also cooked with pork, similar to pork and beans in the United States, but with different seasonings—soy sauce being the most common one. Cooking time is usually about 2 h. Longer cooking time may result in a more tasty dish, but soybeans will not cook as soft as other beans because they contain little starch. Sometimes, soaked soybeans are boiled with soup bones to make a tasty soup. Or they are cooked with bamboo shoots, soy sauce, and other spices followed by sun-drying to use as a snack food.

Roasted soybean flour

Roasted dry soybeans are sometimes ground into flour and then mixed with lard and sugar. This mixture is used as fillings for pastry, or to coat the surface of other pastries. Soybean flour as processed in the United States is not commonly used in China.

Fermented soybean foods

Fermented products such as sufu, tou shih, soy sauce, and bean paste, made from soybeans or soybeans with cereals, have been used in China for centuries (Hesseltine and Wang *1972*). Most of the products have a strong characteristic flavor and are commonly used as flavoring agents. From their experiences, the Orientals consider fermented soybean products nourishing and easily digestible foods. The Oriental diet consists mainly of rice and vegetables, which can be rather bland. The strongly flavored fermented foods not only add taste to the rice-vegetable diet, but also, through stimulating the appetite, contribute nutritional value to people who may otherwise not consume enough food to meet their caloric requirements.

The Chinese developed these processes without the knowledge and the benefit of microbiology and modern technology. Today, many of them are still carried out as natural processes at home. However, some processes such as soy sauce, bean paste (miso), and sufu (fermented tou fu), have been extensively studied, and pure culture fermentation methods have been developed (Hesseltine and Wang *1972*). Because these fermentations require a long period and involve a number of complicated steps, their technology is not reviewed in this report.

Production and consumption

The People's Republic of China produced 10 million t of soybeans in 1975. Also, the FAO food balance sheets average for 1964-66 (*1971*) indicated per capita consumption of 6.7 kg yearly and a total food use of 5,123,000 t of soybeans per year.

In Taiwan, soybeans are mostly imported; however, sufficient crop grown on small acreage accounts for less than 10 percent of total soybeans used in Taiwan. Soybean production and imports from 1962 to 1975 are given in table 1. In general, 85 percent of the soybean goes into oil, and the remaining 15 percent is for food use. In 1975, about 93,000 t of soybeans were used in making tou fu, 30,000 t for soy sauce, and 20,000 t for miscellaneous food use. The yearly per capita consumption of soybean foods by Chinese in Taiwan is shown in table 2.

TABLE 1.—*Soybean production and imports in Taiwan, 1962-75*[1]

Year	Production	Imports	Total supply
		1,000 metric tons	
1962	53.0	62.4	115.4
1963	52.6	182.5	235.1
1964	57.6	181.8	239.4
1965	65.7	161.4	227.1
1966	63.3	164.5	227.8
1967	75.2	347.0	422.2
1968	73.0	384.9	457.9
1969	67.1	472.2	539.3
1970	65.2	617.5	682.7
1971	61.0	524.9	585.9
1972	60.2	711.6	771.8
1973	60.6	626.0	686.6
1974	66.9	528.6	595.5
1975	61.9	827.3	889.2

[1] Republic of China (*1975*).

Japan

Tofu (soybean curd)

Tofu is the most popular soybean food in Japan. It was brought to Japan from China centuries ago by Buddhist monks who used tofu as a daily diet. Although Japanese tofu is similar to Chinese tou fu, the Chinese product generally has a firmer texture.

In Japan, tofu is processed into many forms; however, fresh tofu is used in the largest amount and is the starting point for all other types. Fresh tofu is usually made in small shops which process from 45 to 135 kg of beans daily. In recent years, large plants have begun to mass-produce tofu; each tofu cake (300 g) is water-packed in a polyethylene container, sealed with a sheet of transparent film, and pasteurized by immersion in hot water for 1 h to give a shelf life of up to 1 wk. This tofu is sold in supermarkets and neighborhood grocery stores at a price slightly below that of the tofu made by neighborhood shops.

Preparation

The preparation of tofu and other tofu products in Japan has been described by Smith (*1958*), Smith and others (*1960*), and more recently in much detail by Shurtleff and Aoyagi (*1975*). The basic steps of making tofu and the

TABLE 2.—*Consumption of soybean foods in Taiwan, 1964-74*[1]

Year	Soybean food	Tou fu (80 percent H_2O)
	(Kilograms per capita per year)	
1964	1.08	18.75
1965	1.13	20.14
1966	1.12	19.54
1967	1.40	28.50
1968	1.19	23.91
1969	1.87	28.95
1970	2.34	33.34
1971	2.35	32.30
1972	2.61	33.89
1973	2.36	31.30
1974	1.99	32.04

[1] Chinese-American Joint Commission on Rural Reconstruction (*1975*).

equipment required are essentially the same as described for tou fu in China. Following is a brief account for making tofu in a village or community; the method is detailed in the "Book of Tofu" by Shurtleff and Aoyagi (*1975*).

Materials.—Soybeans, 1.6 kg, water, solidifiers or coagulants. For subtly sweet tofu, use 30 g granular magnesium chloride or calcium chloride, or 37.5 to 60 ml natural nigari (the mineral-rich liquid remaining after salt is extracted from seawater), or 45 to 120 ml commercially prepared liquid nigari, or 1.9 L of freshly collected clear seawater. For mild soft tofu, use 36 or 24 g epsom salts (magnesium sulfate) or calcium sulfate. For slightly sour tofu, use 0.30 L lemon juice or lime juice or 0.24 L vinegar.

Equipment.—Grinding stones, electric blender, or electric stone mill; cooking pots and lids; pressing sack; rectangular sack (such as a small flour sack) about 60 cm long and 32 to 37 cm wide made of coarsely woven strong fabric; pressing barrel (22 to 30 L) made of wood or metal; pressing rack consisting of rods placed across the opening of the pressing barrel with several inches between each rod; and settling boxes for pressing and molding tofu. Use a 10 by 30 by 30 cm box with many holes 1 cm in diameter in all sides and bottom to allow drainage. The box should be lined with a piece of cheesecloth or other coarsely woven cloth and fitted with a flat lid.

Procedures.—Use 1.6 kg of dry soybeans that have been rinsed and soaked in 6 L of water for 8 to 10 h, or in cold weather for as long as 15 to 20 h as described under the section **Soaking Dry Soybeans**; they are again rinsed well and allowed to drain. In small portions (500 g), the soaked beans are blended with an equal volume of water in an electric blender at high speed for 2 to 3 min until smooth. The resultant soybean mash (known as "go" in Japan) is transferred to a large container. Pour the combined go into 3.8 L of boiling water and continue to heat the diluted go over high heat, stirring bottom of pot frequently with wooden paddle to prevent sticking. When foam suddenly rises in pot, quickly remove from heat.

To filter go, transfer hot dilute go into pressing sack, quickly place pressing rack across the opening of pressing barrel, and set sack on top of the rack. Twist sack closed and put a heavy pressing weight on top of the sack to expel as much soybean milk as possible. Pour another 3.8 L of hot water in the sack to rinse the residue and press again. Bring soybean milk to a boil, stirring bottom of the pot to prevent sticking, reduce heat to medium, and continue to heat for 5 min. Add 1.4 L of hot water to the solidifier, and then add the mixture to the hot milk.

Every tofu maker has a unique way of adding coagulant. Some stir in a circle and some stir back and forth across the pot; some stir rapidly, some slowly; some add all the coagulant at once, some in two or three portions; some pour it in from 15 to 30 cm above the milk surface, some sprinkle it gently over the surface, and some do both. However, it is the chemical nature and the quantity of coagulant used, not the manner of adding coagulants, that dictate the quality and yield of tofu. After the curd settles for about 8 to 10 min after the addition of coagulant, remove portion of clear whey and transfer curds to cloth-lined settling box. Fold corners of the cloth neatly over curds, place lid on top of cloth, and set a 2- kg weight on top for about 5 min. Increase weight to about 4.5 kg and press for 30 to 40 min more or until whey no longer drips from the box. Remove cloth-wrapped tofu from box, allow it to cool for 10 to 15 min and then unwrap. Tofu may be served immediately.

Many tofu makers in Japan soak tofu in water for a short time and then slice it into standard size cubes for the market.

Composition

The composition of tofu varies depending on the bean variety used. A typical analysis of tofu (Smith *1958*) is 88 percent water, 6.0 percent protein, and 3.5 percent fat. Protein ranging from 6 to 8.4 percent has been reported.

Ways of serving

Although Japanese cookery generally has some similarity to Chinese cuisine, the use of

ingredients and ways to serve are distinctive. The following are Japanese ways of serving tofu, which show its versatility.

Without cooking.—One of the most popular ways to serve tofu in Japan is chilled and uncooked. A creative cook can serve chilled tofu in different ways every day of the year by choosing seasonal garnishes, subtly flavored dipping sauces, and seasoned toppings. Cut tofu into small cubes and place in a shallow bowl. Sprinkle shoyu (soy sauce) or other favorite sauce over the tofu and top with garnishes. Also, sauces and garnishes can be served in separate dishes to satisfy individual taste. Chilled tofu is best to serve on a hot summer day. It is served with the meal or as a snack.

Boiling.—Fresh tofu adds protein, flavor, and variety to almost any kind of soup. It can be cut into small cubes, thin slices, or even crumbled and added to soup just a few minutes before cooking is finished. If cooked too long, tofu may lose some of its fine texture. Miso soups and other delicately flavored soups almost always contain tofu and are among the most popular at home or in restaurants. Miso, a flavoring agent containing 16 to 18 percent salt, is a paste made from soybean and cereals by a fermentation process. Of the three most popular ways of serving tofu—chilled, simmered, or in miso soup—only the latter is enjoyed throughout the year and at any of the day's three meals. Miso soup is an indispensable part of the traditional Japanese breakfast, together with rice and salt-pickled vegetables. In Japan, more tofu is used in miso soup than in any other types of cookery. In addition to tofu, miso soup contains seasonal vegetables and garnishes. To prepare, bring soup stock or water to a boil. Add vegetables and continue to boil for a few minutes. Add tofu and simmer for 1 min. Stir in miso creamed with a little of the hot broth and return just to a boil. Serve immediately.

Simmering.—In nabe (one-pot) cookery, which is similar to Chinese huo-kuo, the food is prepared right at the table in a large earthen pot placed on top of a charcoal brazier. The nabe contains the entire meal, and each individual cooks and serves himself from a wide range of seafoods, meats, vegetables, and tofu.

Broiling.—Tofu dengaku is made by taking firm pieces of tofu, the size of small match boxes, place on bamboo skewers and broil lightly. A simmered miso sauce or barbeque sauce is then spread on tofu surfaces. Then broil the pieces again until brown. In Japan, tofu dengaku is usually prepared over a bed of red, hot charcoal.

Deep-fat frying.—Deep-fried tofu is used in virtually every type of Japanese cuisine and is commercially available. At home, tofu tempura is prepared by deep-fat frying.

Japan is famous for its tempura cuisine. A typical tempura batter can be made by mixing 1 egg yolk with 0.24 L of ice-cold water. Add 200 to 240 g of wheat flour and 3 g of salt, and stir the flour lightly in the egg mixture until all flour is moistened and large lumps disappear. Dip sliced tofu in the batter and fry in hot oil until both sides are brown. Serve hot with shoyu or other favorite sauces.

Tofu-egg pancakes.—Pancake batter is made with wheat flour, egg, and milk or water with the addition of tofu and chopped vegetables. Serve pancakes with Worcestershire sauce, shoyu, or miso sauce.

Kinugoshi tofu

Kinugoshi tofu has a silky texture, soft and white; it is made from thick soybean milk. The curd and whey are not separated and pressed. Because whey is not removed in making kinugoshi tofu, it contains more of the nutrients originally present in the soybeans. This product is the same as tou fu nao in China.

Kinugoshi is easier and faster to prepare than regular tofu. The procedures for making tofu can be followed except only half as much solidifier is required. After the addition of the solidifier, let the curd stand for 20 to 30 min or until it is firm before serving. No pressing is required.

Kinugoshi is best served cool just as chilled tofu. Other main uses of kinugoshi are in miso soups, clear soups, and dishes served with sauces.

Kinugoshi is now prepared by many Japanese shops in the United States from powdered soybean milk coagulated with lactone or calcium sulfate.

Processed tofu products

Many types of tofu products are made in Japan from regular tofu by frying and drying. These products are so popular that they are made commercially.

Aburage (or age), nama-age, and ganmo

Aburage is fresh tofu fried in deep fat and is popular in Japan. Fresh tofu used for frying usually contains less moisture than regular tofu. To give the best results, the tofu slabs are cut into small pieces and fried in two oil pots at different temperatures. The first pot is at 100° to 110° C, where the tofu is held for 2 to 3 min. Then the tofu is removed to the second pot at 200° to 220° C, where it is held until golden brown (Smith *1958*). In deep-fat frying, the water content is reduced and the oil content is increased, thus aburage is rich in oil and protein.

A piece of aburage is about 20 cm long, 8 to 10 cm wide, and about 2 cm thick (Shurtleff and Aoyagi 1975). The outside has a skinlike formation. When the piece is cut in half, the cut end of each half is the opening of a pouch about 10-cm long. One way of eating aburage is to fill these pouches with rice, vegetables, eggs, or meats.

Aburage can also be used in the place of tofu. Like tofu, aburage has a rather bland taste and is served with sauces. Unlike tofu, aburage has more body and a chewy texture.

Besides regular aburage or age, there are nama-age (thick age) and ganmo. Nama-age or thick age refers to age that is made from thick or whole cakes of fresh tofu. When a thick cake of tofu is deep-fried, it combines the softness of tofu with the crisp firmness and flavor acquired from deep-frying.

Ganmo is a deep-fried tofu patty. Tofu, mixed with sesame seeds and finely slivered vegetables, is kneaded as if kneading bread. The mixture, after shaping into burger-sized patties or balls, is then fried in oil until golden brown. Grated yam or lightly beaten egg is frequently added to the mixture to serve as a binding agent. Carrots, onions, peas, mushrooms, and chopped nuts are the common vegetables used; sometimes they are slightly sauteed to increase their flavor.

Kori tofu (dried-frozen tofu)

Frozen tofu has a spongy appearance and a meatlike chewy texture quite different from that of fresh tofu. Because of lack of freezing facilities, frozen tofu is usually made by exposing it to cold weather; therefore, it is only consumed during the winter months. To create the spongy texture of frozen tofu and to prolong its shelf life, Japanese dry the frozen tofu.

The tofu slabs are cut into 1.5-cm thick slices, pressed in layers between boards to expel excess water, and then exposed to severe cold weather for 8 h or until frozen solid. The sliced tofu is maintained in the frozen state from 1 to 3 wk to develop the spongy texture. At the end of the freezing period, it is thawed in warm water and pressed to expel all the water. At this stage, it has a spongy look and is ready for drying. The villagers use a shed, heated with charcoal braziers, to dry the tofu cakes. Today in Japan, based on these basic procedures, there are large capacity plants for making dried-frozen tofu. In modern plants, the cakes are given a final treatment with gaseous ammonia to increase water absorbing and swelling properties.

Dried-frozen tofu should be rehydrated by placing it in cold water before cooking. It is commonly used to nabe cookery, in soup, and in simmered and sauteed dishes. Properly dipped in tempura batter or eggs and deep-fried, it makes an excellent food.

Yaki tofu (grilled tofu)

Regular fresh tofu is thoroughly pressed and then lightly broiled or toasted over open fire. Yaki tofu is delicious served hot with a favorite sauce.

Yuba (protein-lipid film)

Yuba is the dried sheets of soybean protein containing emulsified oil and is equivalent to tou fu pi of China. It is made by boiling soybean milk and then removing and drying the film formed over the surface of the milk. Yuba is commonly made in three different forms: fresh, half-dried, and dried. Dried yuba is brittle and is rehydrated before cooking.

In Japan, yuba, especially fresh, is prized as a delicate hors d'oeuvre. The variety of shape, textures, and flavors is unlimited. Fresh and warm yuba served with shoyu or other dipping sauce can be delicious. Yuba is also cooked with many other dishes, and it requires only a few minutes of cooking time.

Soybean milk

Although soybean milk is made at the first step of making tofu, it is not traditionally consumed by the Japanese.

Go (ground soybean mash)

Most of the go made in tofu shops is used directly in the tofu-making process. Traditionally, go has also been used in home cooking. The most popular use for go is in thick miso soup, known as gojiru.

Daizu no mayashi (soybean sprouts)

Daizu no mayashi is equivalent to Chinese huang tou ya, which has been discussed under China (p. 9). In Japan, soybean sprouts are also used as vegetables, either parboiled for fresh salads, in soups, or in sauteed and simmered dishes.

Whole soybeans

Like the Chinese, Japanese do not eat whole soybeans as much as processed soybean products.

Edamame (fresh green soybeans)

Fresh, green soybeans are a favorite vegetable in Japan just as they are in China. The green soybeans are simmered in the pot until tender, lightly salted, and served as a delicious hors d'oeuvre, often with sake or beer—or as a part of a meal. From mid-June until October, the green soybeans are served at the dining tables of restaurants and private homes throughout Japan. Cooked, green soybeans (hitashi mame) are packaged commercially.

Whole dry soybeans

Dry soybeans are only occasionally cooked at home; most people buy them at the local delicatessen as a snack. There are two common ways of cooking dry soybeans: In one, soaked soybeans are boiled in water with shoyu; in the other, soaked, and drained soybeans are deep-fried in a sweetened batter and sold as a soy brittle.

Kinako

Kinako is a Japanese full-fat soybean flour product (Smith *1958*). Soybeans are roasted for one-half hour or longer until the characteristic toasted flavor is acquired. The beans are then cooled by spreading in the open air and are ground to a moderately fine flour. This process was originally carried out at farm homes as a small-family industry; later, mechanization of the process was improved, and it became established as a commercial process. However, the production is still small as compared with all the other soybean foods.

Kinako is sprinkled on rice or rice cake. The poor people of Japan are said to be the principal users of kinako.

Fermented soybean foods

The Japanese consume great amounts of miso (fermented soybean-cereal paste) and shoyu (fermented soybean-cereal liquid) as flavoring agents. Although these fermentation processes, as well as other fermented soybean processes, have been carried out at small family-owned factories, they do require more sophisticated equipment, knowledge, and time. Miso, shoyu, and other fermented soybean foods, natto and hamanatto, are not reviewed in this publication.

Production and consumption

Japan is one of the world's major soybean consumers, 5.1 kg per capita yearly (FAO *1971*); however, it produces less than 2 percent of the soybeans used as shown in table 3. Japan uses more than 3 million t of soybeans yearly—78 percent for oil and 22 percent for food uses. The amount of whole soybeans used in making each one of the major soybean foods is given in table 4. Of the 2 million t of defatted soybean meal produced yearly from oil extraction, 15 percent was used for traditional foods (table 5). The yearly production of traditional soybean foods in Japan is shown in table 6.

TABLE 3.—*Supply and disposition of soybeans in Japan, 1971-74*[1]

	1971	1972	1973	1974
	1,000 metric tons			
Supply:				
Beginning stocks	269	251	278	401
Domestic	53	55	53	60
Imports	3,212	3,396	3,635	3,244
Total supply	3,518	3,702	3,966	3,705
Disposition:				
Crushing	2,481	2,636	2,739	2,729
Traditional foods	731	758	796	726
Feed	55	30	30	30
Total disposition	3,267	3,424	3,565	3,485
Ending stocks	251	278	401	220

[1] Japan Ministry of Agriculture and Forestry (*1976*).

TABLE 4.—*Whole soybeans used in the production of traditional foods in Japan, 1970-74*[1]

Type of food	1970	1971	1972	1973	1974
	1000 metric tons				
Miso	177	180	185	193	192
Shoyu	13	12	15	16	14
Tofu and others	508	521	537	550	539

[1] Japan Ministry of Agriculture and Forestry (*1976*).

TABLE 5.—*Defatted soybean meal used in the production of traditional foods in Japan, 1970-74*[1]

Type of food	1971	1972	1973	1974
	1,000 metric tons			
Miso	4	3	3	2
Shoyu	163	167	182	176
Tofu and others	130	130	130	NA

[1] Japan Ministry of Agriculture and Forestry (*1976*).

TABLE 6.—*Production of traditional soybean foods in Japan, 1970-74*[1]

Type of food	1970	1971	1972	1973	1974
	1,000 metric tons				
Miso	552.2	560.7	578.8	590.0	587.2
Shoyu	1,334.1	1,354.6	1,416.6	1,529.8	1,455.8
Tofu and others	1,867.8	1,928.8	2,177.8	2,264.9	NA

[1] Japan Ministry of Agriculture and Forestry (*1976*).

Korea

Tubu (soybean curd)

Soybean curd is an important item in the Korean diet, even though it may not be used as extensively as in China and Japan. A large percent of soybeans grown in Korea is consumed as soybean curd.

Soybean curd has been made at home, especially by farm families, as well as in more than a thousand small shops. According to Smith (*1949*), small shops, which on the average employ five men, can work up about 273 kg (10 bushels) of soybeans daily.

The method of preparing soybean curd is essentially the same as that used by the Chinese and Japanese. The curd is consumed as it is or in soup with fish, meat, and vegetable dishes.

Processed tubu product

Tubu is the only traditional variety of Korean soybean curd. During the Japanese occupation, the Koreans developed a variety of deep-fried products, which are popular among the Japanese.

Soybean sprouts

Soybean sprouts are as much in demand as vegetables, especially during the winter months. They are sprouted and used much the same way as in China. In Korea, soybean sprouts are more popular than mung bean sprouts.

Whole soybeans

Following are a few ways of eating whole soybeans in Korea.

Green soybeans

In Korea, eating soybeans before they reach full maturity is common practice. The beans in the pods are simply boiled and eaten.

Parched or roasted beans

Soybeans are placed in a pan and heated slowly until the skin breaks and part of the bean is blackened. They are used as snacks, mostly during winter months.

Boiled soybeans

Soybeans are cooked with rice or with seasonings and served with regular meals.

Soybean flour

Soybeans are first roasted and then ground

into flour. The flour is used extensively as an ingredient in food preparrations.

Fermented soybean foods

Soy sauce and bean paste are commonly used in Korea as flavoring agents. Natto, a *Bacillus*-fermented soybean product, is also enjoyed by many Koreans (Kwon *1972*).

Production and consumption

Soybeans have been grown and consumed in Korea for centuries. In the Korean diet, rice is the most important and preferred grain, but soybeans provide protein. A dietary survey of 1964-67 conducted by Pak and Han (*1969*) showed that about 45 percent of the total food consumed in 1964 was rice. The yearly consumption of rice per capita increased from 129.8 kg in 1964, 146.3 kg in 1967 and 167.2 kg by 1971. Bean consumption was low compared to rice, but it increased at a greater rate: 5.8 kg per capita in 1964, 11.6 kg in 1967, and 25.1 kg in 1971. Furthermore, the consumption of beans per capita per year was greater in amount and in growth rate than that of either meat or fish.

Production and food uses of beans and the consumption of four soybean products (Pak and Han *1969*) are summarized in table 7.

TABLE 7.—*Production and food use of beans and consumption of some soybean products in Korea, 1964-67*

Year and food items	Production	Food use	Amount consumed	Per capita per year
	1,000 metric tons			*Kilograms*
1964:				
Bean[1]	190	94		5.8
Bean curd			223	
Bean sprout			227	
Bean sauce			57.4	
Bean paste			22.9	
1965:				
Bean	203	104		6.9
Bean curd			243	
Bean sprouts			240	
Bean sauce			61	
Bean paste			24.3	
1966:				
Bean	195	117		10.2
Bean curd			263	
Bean sprouts			254	
Bean sauce			64.8	
Bean paste			25.8	
1967:				
Bean	236	134		11.6
Bean curd			290	
Bean sprouts			270	
Bean sauce			69.7	
Bean paste			27.7	
1971:	361	206		25.1

[1] Based on the production average of the 4 years surveyed, the beans consisted of 85 percent soybeans, 8.5 percent red beans, 1.6 percent green beans, 1.3 percent peanuts, and 3.4 percent other beans.

Indonesia

Tahu or tahoo (soybean curd)

Preparing tahu or soybean curd in Indonesia is essentially the same method as that used in China and Japan. Two types of tahu, regular and Chinese, are available in Indonesia. In making regular tahu, ground bean mash is filtered after heating. The curd is achieved by adding acetic acid, lactic acid, or biyang (the overnight whey from a previous batch of tahu). The Chinese tahu makers, on the other hand, prefer to filter the ground bean mash before heating and to coagulate the milk with calcium sulfate.

Tahu can be bought in the market every day. It is eaten by everyone. Spicy dishes are prepared daily from tahu by almost every household.[5]

Bubuk kedele (soybean powder)

Soybeans of the white variety are roasted until no beany flavor can be detected. They are ground into powder and mixed with such spices as garlic and chili. Bubuk kedele is kept in a jar and served on special occasions with a rice product, longtong (rice wrapped in banana leaves and boiled for 3 to 4 h). Bubuk kedele is always homemade and is eaten by everyone.[5]

Tempe kedele

Tempe (commonly referred to as tempeh in the literature) is one of the most important soybean foods in Indonesia. It is a cakelike product made by fermenting soybeans with *Rhizopus oligosporus* (Hesseltine and Wang *1972*). The fermentation process is so simple

[5] Communication with I. Gandjar, Nutrition Research and Development Center, Bogor, Indonesia. 1976.

that traditionally it is made in most households. Tempe is not only easily made, but it also possesses the kind of texture and flavor that is universally acceptable and that cannot be provided by any other known soybean product.

Preparation

Material.—Soybeans and tempe starter. Any variety of soybeans is suitable for making tempe, and a piece of fresh-made tempe is often used as starter in Indonesia. Recently, a powder spore preparation of *R. oligosporus* (Wang and others *1975*) was developed for tempe fermentation.

Equipment.—Incubator and fermentation container. The optimal temperature for tempe fermentation is around 30° to 32° C. The Indonesians use no special incubator at home; they carry out the fermentation at air temperature. A simple incubator, however, can be constructed from a Styrofoam picnic basket (30 by 40 by 30 cm) by connecting a 7½ watt light bulb as heat source. The basket can maintain a temperature between 30° to 31° C.

Traditionally, the Indonesians wrap the beans in banana leaves for fermentation. Shallow (2 to 2.5 cm) wooden, metal, or aluminum trays with pin-sized perforated bottoms and covers, or perforated plastic bags and tubes, are quite satisfactory. Pin-sized perforated containers would provide enough aeration to support adequate mold growth without excessive spore formation.

Procedure.—Making tempe in Indonesia is a household art. The procedures may vary in detail from one household to another, but the principal steps are as follows: Soybeans are soaked in tap water overnight until the hulls can be easily removed by hand. Some prefer to first boil the soybeans for a few minutes to loosen the hulls and then to soak the beans overnight. After dehulling, the beans are boiled with excess water for about 30 min, drained, and spread for surface drying. Small pieces of tempe from a previous fermentation, or ragi tempe (commercial tempe starter), are mixed with the soybeans. The inoculated beans are wrapped with banana leaves and allowed to ferment at room temperature from 24 to 48 h depending on the air temperature. By this time, the beans are covered with white mycelium and bound together to form a cake (Hesseltine and others *1963*).

Ways of serving

Tempe has a pleasant aroma and is usually consumed within a day. There are many attractive ways to serve tempe. The simplest and the most popular way, however, is to cut tempe into thin slices, dip into a salt solution, and fry in coconut oil. Sliced tempe can also be baked or added to soup as a vegetable.

Tempe is available in the big cities as well as in the villages. It is served daily as a side dish with rice and is also eaten as a snack. When fried dry, tempe is often served at official receptions.

Tempe gembus

Tempe gembus is made with the insoluble residue from making soybean milk and soybean curd. In other oriental countries, the residue is used as animal feeds or is considered as waste.

In making tempe gembus (Gandjar *1972*), the residue is washed two to three times with cold water, pressed to remove excess water, steamed, and then inoculated with ragi tempe. The inoculated bean residue is placed in a wooden tray and covered with banana leaves to ferment for 24 h. Also a tempe-like product can be made from onggok (waste of the tapioca plant).

Tempe gembus is soft as a sponge and easily sliced. When fried, tempe gembus has the soft texture and taste similar to that of french-fried potatoes. It is prepared and served just as tempe kedele. By Indonesian standards, the taste of tempe gembus is inferior to that of tempe kedele, which has a nutty texture and aroma. Because tempe gembus is a low-cost food, it is consumed more by low-income people. It is a popular food in central and eastern Java.

Oncom tahu

Oncom tahu is another fermented product made from the residue of soybean curd, but *Neurospora sitophila,* a mold used in the fermented peanut product, ontjom, is used. Oncom tahu is similar to tempe gembus and is

served in the same way. It is popular in western Java.

Other soybean products

Soybean sprouts and green soybeans are used as vegetables; roasted and boiled soybeans are eaten as snacks.

In addition to tempe, fermented soybean products used in Indonesia are kecap (soy sauce) and tauco (bean paste), which are used as flavoring agents.

Food mixtures

A number of soybean-containing food mixtures developed or produced in Indonesia were reported by Winarno and Karyadi (*1976*). These foods, however, are not traditionally used in Indonesia.

Saridele

Because soybean milk is not a traditional Indonesian soybean product, a similar commercial product known as saridele has been available. Made from soybean milk enriched with peanuts and sesame seeds, saridele production was discontinued after 1966 because of the irregular supply of soybeans and marketing problems.

Tempe-fish-rice (TFR)

This mixture is 30 percent tempe, 10 percent fish, 30 percent rice, 25 percent sugar, and 5 percent peanut oil.

Soy-rice baby food

This was a mixture of one part saridele to four parts of ground brown rice. The mixture was intended as a supplementary food for infants and children before 1966.

Soybean residue-fish-rice

In the preparation of soybean curd, a significant amount of protein is left in the residue. The soybean residue is dried and then blended with fish flour and rice flour. A blend of 75 percent dried soybean residue, 15 percent fish flour, and 10 percent rice flour has 43 percent protein. The blend can be made into cookies and crisps, added to vegetable soup, or roasted and eaten as is with rice.

Production and consumption

Soybeans are an important crop in Indonesia. Indonesian exports account for 0.02 to 0.25 percent of the total world soybean export and between 0.2 to 6.7 percent of the total national production (Somaatmadja and Gubardja *1976*).

Data on soybean use in Indonesia have not been available. A team of experts are conducting a nationwide soybean survey to obtain data on soybean production, total use, and food use.

From a phase-I progress report of the survey (Winarno *1976*), some preliminary data on production and food use of soybeans in Indonesia have been obtained and are listed in tables 8, to 10.

TABLE 8.—*Soybean production (metric tons) in Indonesia, 1960-74*[1]

Year	Production
1960	442,862
1961	423,294
1962	396,839
1963	350,204
1964	391,693
1965	409,529
1966	416,769
1967	415,852
1968	419,932
1969	388,907
1970	497,883
1971	515,664
1972	518,229
1973	541,040
1974	550,000

[1] Winarno, W. F. (*1976*).

TABLE 9.—*Consumption kilograms per capita per year of soybeans in parts of Indonesia in 1970*[1]

Province	Consumption
Aceh	0.71
Sumatera, North	.71
Sumatera, West	.20
Sumatera, South	1.05
Jakarta dan Jawa	5.04
Kalimantan	.16
Sulawesi, South, East, Central	.68
Sulawesi, North	.10
Bali	3.43
Northern Territory of Borneo	14.14
Maluku dan Irja	.90

[1] Winarno, W. F. (*1976*).

TABLE 10.—*Production (metric tons) of soybean foods in central Java*[1]

Year	Kecap	Tahu	Tempe
1968 ...	914,695	18,570	506
1969 ...	1,865,560	19,610	602
1970 ...	1,249,848	18,913	1,204
1971 ...	1,289,000	14,500	44,200
1972 ...	1,524,000	17,000	39,000

[1] Winarno, W. F. (*1976*).

Soybean production in Indonesia was fairly constant from 1960 to 1974 (table 8), but efforts are being made to increase total yields. Per capita consumption (table 9) varies greatly from one location to another, which perhaps reflects the distribution of the crop and also the eating habits. Kecap (soy sauce), tahu (soybean curd), and tempe are the most important soybean foods in Indonesia. The yearly production of these foods in central Java is shown in table 10.

Thailand

Soybeans are not a major agricultural product in Thailand, although traditionally they have been grown here. After having been brought to Thailand, probably by migrating Chinese, soybeans became part of the Thai diet, and have been favored by people of Chinese origin. Tou hu (soybean curd) and soy sauce are the most commonly used soybean products. However, green soybeans in the pods known as tou rae are also consumed.

Although soybeans have been consumed by the Thai for many generations, they are not a popular food. The Government of Thailand, realizing the seriousness of the protein deficiency problem in the Thai diet, has established a protein food development project at Kasetsart University, Bangkok, with the cooperation of AID to produce inexpensive protein foods for the nutritionally vulnerable groups of the population. A number of protein foods have been developed; some of these products are soon to be manufactured by small-scale industries (Bhumiratana *1970, 1976*). Because they are not traditional soybean foods, these processes are not reviewed.

In the past, not many soybeans were grown in Thailand. But in recent years, production has been increasing as oil extraction expands and demand for soybeans on the foreign market increases. Data on soybean production (table 11) for the past decade indicate that between 1972 and 1974 the area planted doubled, whereas total production more than tripled from 72,000 to 252,400 t. The utilization data are, however, scanty. The U.S. Interdepartmental Committee in Nutrition for National Defense (ICNND) Nutrition Survey, conducted in Thailand (October-December 1960) by the Ministry of Health, revealed that the average daily per capita consumption of soybeans by Thai civilians was 0.9 g. The FAO Food Balance Sheets 1964-66 (*1971*) average showed an increase per capita of daily consumption to 1.5 g or 0.6 kg yearly. Average yearly soybean use as food during 1964-66 was 17,000 t and average production was 41,000 t.

Philippines

The bean most commonly consumed by the Filipinos is the mung bean known locally as mongo. Soybean foods are eaten in the Philippines, but not to a great extent. In the Handbook of Philippine Agriculture (*1931*), the methods of preparing the following soybean foods were described: soybean sprouts, soybean coffee, soybean cake, soybean milk, tao-si (fermented soybeans), and toyo (soy sauce). Other

TABLE 11.—*Area planted to soybeans and total soybean production in Thailand*[1]

Year	Rais area[2]	Production
	(1000)	*Metric tons*
1964	213	31,300
1965	117	19,100
1966	285	37,900
1967	399	52,800
1968	329	44,800
1969	299	48,200
1970	368	50,400
1971	359	54,300
1972	500	72,000
1973	893	152,300
1974	1,016	252,400

[1] Tongdee, A. (*1976*).
[2] 6.25 rais = 1 hectare.

soybean foods consumed in China are also sold on the market in the Philippines.[6]

Soybean sprouts

Soybean sprouts are prepared and can be cooked in the same way as mongo sprouts. The beans are thoroughly washed, soaked in water overnight, and then poured into a large earthen jar that has a perforated bottom shielded by a bamboo or straw mat to prevent the beans from running out through the holes. The jar is covered with a straw mat to keep out the light. The beans are moistened at least two times a day for 3 or 4 d, after which the sprouts should be 1- to 3-cm long and ready for use. The sprouts may be allowed to grow up to 6 d and still remain palatable. When allowed to grow up to 9 d, they become fibrous. Soybean sprouts may be boiled and served as a hot vegetable or as a cold salad. In both cases, they make excellent food.

Soybean coffee

Dried soybean seeds, when roasted and finely ground like dry coffee beans, make an excellent substitute for coffee because the color and flavor are similar to coffee.

To prepare soybean coffee, clean the dried beans of dust and other foreign materials and roast them in a pot or frying pan as is done with coffee beans. Roasting usually requires from 15 to 20 min, depending upon the moisture content of the beans, the color of the roast desired (light, medium, or dark), and the skill of the operator. After roasting, the beans are ground finely in a grinder. The coffee is then ready for boiling. Although the protein content of soybean coffee has not been reported, it contains soluble soybean protein.

Soybean cake

Soybean flour is prepared by cleaning and grinding the soybeans in a grinder using the fine-sized plate. If the flour is too coarse after one grinding, it may be run through the grinder a second time. To make a soybean cake, use equal amounts of soybean and wheat flour.

[6]Personal communication with S. Ling, formerly manager planning, Manila Canning Corporation, Philippines. 1976.

Soybean milk

The beans are washed and soaked in water for about 6 h with three changes of water, drained, and then ground in a grinder with small amounts of water added during grinding. Total amount of water required is about four times the volume of beans used. The ground beans are then strained through cheesecloth. The juice is boiled about 1 h, after which it is again strained to remove the coarse particles that were not removed during the first straining. The resulting liquid is soybean milk to which a sweetner is often added.

Tou fu and processed tou fu products

These products may be the same as those eaten in China. Gypsum is usually used to make tou fu from soybean milk. Tou fu is the most popular soybean food in the Philippines. Although no production figure is available, the largest tou fu shop in Manila uses 550 kg of soybeans daily.

Production and consumption

Soybeans have long been grown in the Philippines; however, in spite of attempts to introduce several varieties, only a few may be considered adapted to Philippine conditions. Based on a report by Coffing (*1975*), the Philippines produced 1,000 t of soybeans in 1969, and production doubled by 1974. The Philippines imported soybeans to meet their requirements. In 1973, 6,400 t of soybeans were used for foods and 5,500 t for oil. The food use of soybeans, however, declined to 4,300 t in 1974. No figure was reported for oil in 1974. The per capita consumption of soybeans was 0.1 kg/yr as reported by Darby and others (*1959*) and 0.2 kg/yr during 1964-66 based on the FAO food balance sheets 1964-66 (*1971*). Data from the FAO report also indicated that the amount of soybeans used for food from 1964 to 1966 averaged 19,000 t, which is about three times the soybeans used for food in 1973 as reported by Coffing (*1975*).

Burma

Burma is not one of the Asiatic countries known to use soybeans as food. Based on the report of a nutrition survey in 1961 conducted

by the ICNND (*1963*), the Burmese have been eating a significant amount of groundnuts and pulses. Pulses constitute about 19 percent of their daily protein intake.

FAO food balance sheets, 1964-66 (*1971*), indicated that the average soybean production was 6,000 t, all of which was used for soybean oil. Over the years, the production of soybeans has increased from 12,000 t in 1969 to 15,000 t in 1974 (Coffing, 1975). The use of soybeans as food is still a question.

India

Dry legume seeds have an important place in the traditional Indian cuisine. The commonest way of preparing legumes for food (Aykroyd and Doughty *1964*) is to boil them until soft, after which they are mashed, mixed with water, and boiled again to give a soup or gruel of uniform consistency. This soup may be eaten by itself with salt, a little oil, or spices; sometimes vegetables may be added and the mixture boiled again. Other methods of preparing legumes include grinding into flour, roasting, sprouting, and fermenting. They may be eaten as a main dish or as a side dish in a variety of forms. They also serve as the basis of soups, grules, sauces, and savory snacks.

Soybeans, however, are not eaten by the Indians. The flavor and high oil content of soybeans make them unsuited to the Indian taste when prepared in the same way as the other legumes. Thus, if soybeans are to be consumed in India, a different processing technology is needed.

A method for parching soybeans is given by C. V. Ramakrishnan of the University of Baroda-2, India. The beans are soaked in water for about 5 min. Then remove the surface moisture and put the beans in a large frying pan that contains preheated sand (heated 250° to 280° C over an open fire) and place the pan in a specially built oven. The beans are rapidly stirred with an iron ladle for 4 to 5 min till they puff out, quickly transferred to a sieve, and the sand removed.

In a special report for the Rockefeller Foundation, Strecter (*1969*) indicated that one of the most interesting new high-protein food products in India is a precooked weaning food called Bal-Amul. It has a soybean and milk base but is enriched with several vitamins and amino acids, as well as calcium and iron. When mixed with warm water or fruit juice, it forms a smooth paste. Other soybean products tried in India include a precooked soup, soybean flour, and soybean milk.

At present, a small soybean milk plant is operating at G. B. Pant University of Agriculture and Technology, Pantnagar, Uttar Pradesh, India, with assistance from INTSOY.[7] About 600 to 700 L of soybean milk are sold daily on campus. Another pilot program has been planned that will produce 10,000 L of milk for the surrounding village area.

In promoting the home use of soybeans in India, a team of 10 housewives at the University from different states of the country tested and tried hundreds of Indian dishes using soybeans as a basic ingredient. As a result, a cookbook containing 221 recipes of low-cost, nutritious, attractive, and palatable dishes was compiled (Singh *1970*).

Soybean production, occupying an obscure position in India before 1964, has recently been brought into limelight as a new crop of great promise. In the past 10 years, several University of Illinois agronomists have been associated with the soybean production research program in India. The results have been encouraging (Leng *1969*, Hittle *1974*). Many on-farm demonstration plots were grown throughout the state of Madhya Pradesh; the yield varied from 405 to 1539 kg/A. According to a recent preliminary report prepared by Coffing (*1975*), soybean production in India increased from 11,000 t in 1970 to 40,000 t in 1974. Soybean use is still negligible.

Malaysia

Soybean products are consumed in various forms by both humans and livestock in Malaysia. Tau foo (soybean curd), soybean milk, fu chok (yuba or tou fu pi), bean sprouts, and soy sauce are the soybean foods recorded in a report by ICNND (*1964*).

[7] Personal communication from Professor L. K. Ferrier, INTSOY, University of Illinois, Urbana-Champaign.

In making soybean milk, the soaked soybeans are wet-ground in a stone mill, and then the ground mass is filtered. The resulting milk may be sold as such, or with a sweetener and flavor added, bottled, and sterilized. The milk may be heated in a shallow pan and the resulting skim removed and dried to be sold as fu chok. Tau foo is produced by coagulating the milk with calcium sulfate. All these products are produced mainly in small three- to eight-person establishments.

Soybeans have been grown in western Malaysia for 50 years. The soybean, which is grown among young rubber plants or as a single crop in rotation with other annual crops, is planted primarily on small farms. The domestic demand, however, greatly exceeds the local supply (Abu Kassim and Abu Baker *1976*).

The FAO food balance sheets, 1964-66 (*1971*), showed that Malaysia imported a yearly average of 17,000 t of soybeans, of which 16,000 t were for food use. The yearly soybean consumption per capita was 2.6 kg, which provided about 2.1 g/d of protein.

Nepal

Although soybeans have been grown in Nepal for centuries, the amount is insignificant. The farmers have cultivated different varieties of soybeans in the terraces at altitudes ranging from 1,200 to 1,800 m, along with corn or millet in the same row, or as the borders of rice fields (Panday *1975*). Growing soybeans or other edible legumes with other crops in an intercropping pattern is an old practice in Nepal. According to Panday (*1975*), the farmers only grow enough soybeans for domestic use because of lack of marketing facilities. The farmers use soybeans as animal feeds, especially for cows and buffalos during their lactating period.

No information is available on how popular soybeans are as food in Nepal, but Panday (*1975*) mentioned the methods of using soybeans for food as follows: (a) Roasted soybeans mixed with roasted corn are eaten in the daily tiffin, or lunch. (b) Roasted soybeans mixed with garlic, onion pieces, salt, and chili seasonings are served as a cocktail. (c) Sprouted soybeans mixed with other sprouted pulses are used in vegetable soups. (d) Green soybeans in the pods are eaten after steaming.

Recently, people in Nepal have started preparing milk and products similar to Yogurt from soybeans. Rice cooked in soybean milk with coconut pieces is becoming popular. Nepalese also use soybean flour in baby foods.

Singapore

Because 80 percent of Singapore's population is Chinese, the use of soybeans as food is not surprising. Based on communication with Bak,[8] tou fu (soybean curd) is the most common soybean food in Singapore, at home as well as in restaurants. However, tou fu is not popular among the younger generation. They prefer bottled soybean milk as a cold drink.

Most of the other soybean foods eaten in China are also eaten in Singapore. Some, such as tou fu, tou fu kan, soybean milk, and soy sauce, are made by traditional methods. Others, such as tou fu pi and chien chang, are imported.

Production of soybeans in Singapore is practically nil. Information from the FAO food balance sheets, 1964-66 (*1971*), indicated that 16,000 t of soybeans yearly were imported; of this tonnage, 8,000 t were used as food. Soybean consumption per capita was 11.8 g/d or 4.3 kg/yr.

Sri Lanka (Ceylon)

Information on production and use of soybeans in Sri Lanka shows that soybeans are used as food but not often.[9] When available, the cost of soybean products is high; also, soybeans do not appeal to everyone as a source of protein. Simple soybean processes such as manufacture of flour and the village preparation of soybean beverages have been proposed but have not been implemented on a large scale.

Because of the serious nutritional problem in Sri Lanka, the Sri Lanka Department of Agriculture has prepared a booklet on soybean recipes with the hope that the families will make more use of soybeans in their daily diet. The booklet provides information on simple ways

[8] Communication from H. S. Bak, Soybean Oil Company, Singapore. 1976.

[9] G. Breckenridge, food technologist, Central Agricultural Research Institute, Grannoruwa, Peradeniya, Sri Lanka.

to prepare soybean flour and soybean drinks, how to use soybeans as breakfast foods, sweet dishes, cakes, biscuits, and stews, and how to boil and toast soybeans.

With the assistance of the INTSOY program, soybeans are now grown in Sri Lanka on a large scale. At present, 600 ha are used to plant soybeans with a yield of about 10 hundredweight/A. The Sri Lanka Department of Agriculture is taking steps to increase the acreage to about 3,200 ha by 1978.

Most of the soybeans produced are used in the U.S.-sponsored CARE project for blending with wheat flour and other cereal flour to make triposhi—an infant weaning food. Present requirement for this project is 396 t.

INTSOY is setting up a village demonstration plant in Sri Lanka for making soy beverages, baby foods, and meatlike products using the processes developed at the University of Illinois (Nelson and others *1971*, *1976*). According to A. I. Nelson, the plant will be in full operation by 1978.

Vietnam

Soybeans are produced as well as used for food by the people of Vietnam. Dan fu (soybean curd) and soybean sprouts are the most popular foods. Information on serving and preparing these foods is not available. Probably these foods are prepared using the traditional Chinese methods.

Based on the information from FAO food balance sheets, 1964-66 (*1971*), the average soybean production in Vietnam during these years was 13,000 t, all of which was used for food. The yearly per capita soybean consumption was between 0.3 to 0.4 kg.

Middle East

In the Middle East, where dry weather prevails, crop output suffers. Low rainfall affects the total agricultural production in such countries as Jordan, Cyprus, Iraq, Israel, and Lebanon. However, in 1975 crop production increased substantially in Turkey and Iran, the two largest agricultural countries in western Asia. Wheat and cotton are the two big crops in that area (USDA *1976b*). Soybean planting is still in an experimental stage, even though it was introduced to Iran about 36 years ago. Potentially, soybean production is good. Under favorable conditions, Iran has produced 3 to 3.5 t/ha of soybeans. In 1973, Iran produced 22,000 t of soybeans; the production increased to 90,000 t in 1975 (Lee *1976*). Turkey produced about 13,000 t in 1974 (Coffing *1975*).

For expanding soybean cultivation in Iran, the problems are many. Lack of timely rainfall, fertilizer, proper inoculum, and problems in breeding, disease, agronomic operation, and planting technology are just a few. Despite all these problems, planting area in Iran is expected to increase to about 120,000 ha 5 years from now. Currently, soybean production in Iran is in Khuzistan and northern littoral plain of the Caspian Sea area.

Other potential soybean growing areas in western Asia include Iraq, Mauritius, and Saudi Arabia; however, these are in observation plots and field trials.

Soybeans used in western Asia are mostly for oil production. Defatted soybean meals are usually for livestock feed. Human consumption of soybean is limited to population with Chinese origin, and preparation methods follow traditional Chinese ways.

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Soybean Food Uses in Africa

Soybeans are a comparatively new crop to Africa, consequently traditional foods based on them have not yet developed. Studies have been conducted, however, to incorporate soybeans or soybean derivatives into traditional African diets. Meat protein and total protein consumption is low, and many diets are also lacking in calories. As a result, protein-calorie malnutrition exists in some African nations. Using whole soybeans in their diet would be advantageous, if those needing more protein and calories would eat soybean food products. Problems with cooking and palatability are often cited in attempts to use whole soybeans; specific details concerning these difficulties are not given.

Examples of studies in different nations have been selected to illustrate the approaches taken to incorporate soybeans into African diets. Many African nations have been exposed to soybeans in the form of cereal-soy blends under the Food for Peace Program. Because of the large number of nations involved, they are not discussed individually. However, table 16 in the Summary lists the nations receiving cereal-soy blends and the quantities received during fiscal year 1974.

Ethiopia

Work on the use of defatted soy flour in traditional recipes began about 1969 at the Ethiopian Nutrition Institute. Results were quite successful and work was later initiated with whole soybeans (Hiwot *1975*).[10] Full-fat flour was prepared by one of the following ways:

1. Untreated soy flour: Cleaned soybeans were split to dehull and ground into flour.

2. Roasted soy flour: Cleaned soybeans were roasted, dehulled, and ground.

3. Blanched soy flour: Cleaned soybeans were blanched in boiling water for 10 min, air-

[10] The author's name and the year (italics) are the key to References, p. 30.

dried, dehulled, and ground.

The full-fat flours were added to a number of traditional Ethiopian foods and evaluated by a trained test panel. Foods tested include the following:

Injera

A fermented pancakelike bread made from teff (*Eragrostis tef*), barley, sorghum, or corn, is used by almost all highland Ethiopians. Soybean flours were blended with each of the cereals and converted into injera. Acceptable products were obtained with roasted soy flour, but the usable level varied with the cereal. Up to 20 percent soy flour could be blended with teff whereas only 5 percent soy flour could be mixed with either sorghum or barley. However, soy flour could not be added to corn and converted into an acceptable injera.

Wots and allichas

These sauces are served with injera and usually are made from meats, fish, legumes, eggs, and vegetables. Roasted soy flour was found to be a successful replacement for the legumes—pea flour, split peas, or split lentils.

Kitta

This unleavened bread used in the highlands and lowlands is made from wheat, barley, sorghum, or ensete (false banana). Blanched soy flour was successfully added at levels of 15 percent to wheat and barley and 10 percent to barley. Roasted flour was preferred for addition to ensete; up to 20 percent soy flour was added satisfactorily.

Dabbo

Traditionally, dabbo is leavened bread made from wheat. However, up to 30 percent soy flour can be added to the wheat. Blanched soy flour gave excellent results; roasted soy flour resulted in a darker, but still highly acceptable, product.

Dabokolo

This snack food is commonly known as the travelers' food because of its keeping quality. Adding up to 9 percent of either untreated or blanched soy flour was acceptable.

Porridge

A porridge made from barley, corn, or sorghum is frequently used in the lowlands and on special occasions in the highlands. Up to 20 percent blanched soy flour was added successfully to barley and corn, but sorghum-soy blends did not give a satisfactory porridge.

The Ethiopian Nutrition Institute also produces two soy-containing food items used in famine relief activities. One is faffa, which is a weaning food, and the other is soy-wheat flour (SWF), an enriched wheat flour. Tons of the two products sold in 1973-74 and projections for 1975 are as follows:

Product	Sales (metric tons)		
	1973	1974	1975
Faffa	700	800	1,000
SWF	1,000	2,000	2,600

Kenya

Attempts have been made by the local government to develop soybeans as an oilseed crop in Kenya with financial assistance from international agencies (INTSOY, Rockefeller Foundation, and AID). At present, soybeans are being imported, but major interest is in the oil for cooking. Poultry and livestock production is low; hence, there is no demand for protein feeds. The Ministry of Agriculture has attempted to develop simple recipes including soybeans for rural families, but acceptance is poor because of problems with long cooking times, flavor, and flatulence (Rackis and Akers *1976*).

Morocco

Cereal-soy blends have been used extensively in Morocco. In fiscal year 1974, 6.7 million kg of cereal-soy blends were shipped to Morocco (table 16). Shipments of soy-fortified rolled oats and soy-fortified bread flour increased in fiscal year 1976. Wheat-soy blend is used in the school lunch program and apparently is accepted as a food item. However, wheat-soy blend is not sold in the commercial retail markets (Rackis and Akers *1976*).

Mmbaga (*1975*) reported briefly that soy flour is used in making porridge using one part soy flour to three parts maize flour. Breads containing 10 percent soy flour and 90 percent wheat flour are common, particularly in the

Morogoro region. School-feeding programs use porridge and soy milk extensively, and acceptability is reported to be high.

Nigeria

Soybeans are an established crop in several areas of the country, but they have never become a popular foodstuff. Ashaye and others (*1975*) list the following problems encountered in trying to incorporate soybeans into the Nigerian diet: (a) poor soaking and cooking qualities, (b) lack of palatability, and (c) undesirable changes in color during cooking. Most of the soybeans produced in Nigeria are exported as a cash crop to Europe, and a small amount is fed to animals. Kay (*1974*) has worked extensively to develop simple ways of incorporating soybeans into the Nigerian diet. These include using whole soybeans and a paste obtained by grinding beans after soaking them in water.

Whole soybeans

Whole beans are used in baked (roasted) form and in stews. The baked form is sometimes ground and mixed with sugar to taste. For stewing, the beans are boiled in water containing a small amount of baking powder.

Soybean paste

This paste is the starting material for a variety of food uses. It is made by soaking the beans 8 to 10 h with about two volumes of water, crushing with a grinding stone or corn grinder, and then grinding to a creamy paste in a mortar.

Two direct uses of soybean paste have been described. In one, the paste is mixed with cereal (guinea corn meal, maize, or wheat flour), minced onion, salt and pepper, and then deep-fat fried to yield kosei (akara ball). In the second direct use, the soybean paste is mixed with wheat flour, baking powder, beaten egg, and sugar. The resulting batter is then dropped into hot peanut oil and deep fried to give panke (puff-puff).

Less direct use of soybean paste consists of preparing soybean milk in essentially the traditional oriental way. The paste is mixed with two to three parts of cold water. The resulting bean slurry is filtered and the filtrate boiled 10 to 20 min. Because of the grassy-beany flavors that result when the beans are ground with water, the Cornell University method (Bourne *1970*) has also been considered. This process consists of grinding the beans with hot water (80° C or higher), filtering, and then simmering the filtrate for 10 to 20 min. Soy milk can be used to prepare protein-enriched pap (soy milk mixed with guinea corn meal and sugar and reboiled) and protein-enriched fu-fu (gari mixed with hot soy milk instead of hot water). The residue remaining after preparation of soy milk by the Cornell process still contains about 30 percent protein and can be incorporated into alele (moin-moin). Alele is made by mixing soy milk residue with akamu (guinea cornmeal), corn or wheat flour, or beaten egg, minced onion, salt and pepper, wrapping the mixture in leaves, and then steaming for 20 min or longer.

Soy milk has also been used to make tofulike products by adding calcium or magnesium sulfate or an acidic fruit juice (such as lemon or pineapple) to coagulate the protein-lipid complex.

Corn-soy mixtures (soy-ogi)

Corn (maize) is the principal cereal cultivated in southern Nigeria and is an important part of the human diet. Corn is eaten as whole grain in roasted or boiled form or may be consumed in the form of ogi, which is a partially fermented starchy product obtained by a wet-milling process. Corn is soaked in water for 3 d and allowed to ferment. During this time, an extensive microbial population develops. The steeped kernels are then ground in a corn mill. The resulting slurry is sieved to remove the hull. Next, the sieved starch suspension is allowed to settle to yield the product called ogi. The water is decanted, and the wet cake is added to boiling water to form a gruel known as pap, which is popularly consumed for breakfast (Oke *1967*).

Because ogi is primarily starch and its protein has a low biological value, it has been mixed with full-fat soy flour to improve its overall nutritive quality. Akinrele and Edwards (*1971*) assessed the nutritive value of a 70:30 mixture of ogi and full-fat soy flour called soy-

ogi. They found it had a protein efficiency ratio equal to that of a commercial milk-based infant food. Soy-ogi is well tolerated by weaning children, and clinical responses with it were as good as those obtained with the milk-based product.

Soy-ogi is currently produced on a pilot-plant scale in which corn is soaked, wet-milled, sieved, and blended with cooked, full-fat soy flour. After mixing, the slurry is spray-dried. Addition of vitamins and flavors yields an infant food of excellent acceptability. Commercial production is envisaged in the near future.[11]

Tanzania

Soybeans are grown on a limited scale, but Tanzanians are showing an interest in expanding growth of this legume and in its use for human food. In 1973, workers described a study in which soybeans were converted into full-fat flour in three Tanzanian villages using the simple process developed at the USDA's Northern Regional Research Center (Holm and others *1973*). The resulting flours were analyzed for protein content, amino acid composition, and trypsin inhibitor content. Large variations in trypsin inhibitor content were observed, but a composite of three flours gave a protein efficiency ratio of 2.2 (corrected to 2.5 for a reference casein), which is typical of an adequately processed soy flour.

Uganda

In the mid-1960's, Africa Basic Foods Inc. was established in Kampala by the Uganda government to develop low-cost, high-protein foods to help solve the problem of protein-calorie malnutrition. Pilot production of full-fat soy flour, soy milk, and soy cheese (similar to tofu) began, and marketing was directed toward the poorest segment of the population most in need of a better diet. Also, the growth of soybeans was actively promoted. The Ministry of Agriculture initiated field trials with different soybean varieties in 1965, and the University of Makerere started variety trials in 1966 (Harrison *1969*).

[11] Personal communication with O. O. Onyekwere, Federal Institute of Industrial Research, Ikeja, Nigeria. 1976.

Production

Soybeans are still a minor crop in Africa, and production is so small that listings of commodities often do not include this crop. Because of the small crop, production figures from different sources frequently do not agree. Areas harvested and production estimates for six African nations are as follows:

Nation	Area harvested[1]	Production[1]
	1,000 hectares	*1,000 metric tons*
Ethiopia	10	6
Nigeria	—	1
South Africa	12	19
Tanzania	5	4
Uganda	5	3
Zaire	2	1

[1] U.S. Department of Agriculture, Foreign Agriculture Service, (*1976*).

South Africa is the major producer and accounts for 56 percent of the total soybean crop in Africa. Nigeria is an example of a nation for which conflicting production figures can be found. The Food and Agriculture Organization of the United Nations (*1975*) estimates the 1974 production as 65,000 t as compared to 1,000 t reported above for 1976 (the Foreign Agricultural Service source also reports only 1,000 t for 1974 production).

Prospects for increasing soybean production in Africa are unclear at present. Although experimental plantings are underway in a number of countries, several major problems need to be resolved before significant increases in production are likely to occur. These problems include (a) climatic, (b) soil, (c) proven varieties adapted to different environments, (d) plant and insect pests, (e) lack of harvesting equipment, (f) lack of suitable innoculum to ensure effective nodulation, (g) lack of storage and processing facilities, and (h) suitable markets for this oilseed.

Many of the obstacles to increased soybean production do not appear insurmountable because similar difficulties have been overcome in other countries. Perhaps one of the most difficult problems will be to give the farmers sufficient incentives to grow soybeans in place of some of their present crops.

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Soybean Food Uses in Europe and U.S.S.R.

Soybeans are grown in only a few countries of Europe. Area and production estimates for Europe and the U.S.S.R. for 1976 are as follows:

Country	Area[1]	Production[1]
	1,000 hectares	*1,000 metric tons*
France	4	10
Spain	22	35
Bulgaria	58	100
Hungary	40	55
Romania	200	250
Yugoslavia	32	50
U.S.S.R.	850	500

[1] U.S. Department of Agriculture Foreign Agricultural Service (*1976*).

The major producer is U.S.S.R., followed by Romania and Bulgaria. These three countries account for 85 percent of the total crop grown in this area.

Most likely, no simple home or village uses of soybean protein in foods exist. The soybeans are processed into oil and meal, and the latter is used primarily as an animal feed.

Food uses of soy protein in Europe are typical of those in such developed countries as the United States. Two publications summarize food applications in Europe.[12]

Soybean Food Uses in Latin America

Argentina

In 1974, Argentina had a soybean production of 496,000 t (FAO Production Yearbook *1975*), but soybeans are not used as foods at the home or village level in this country. According to Predicasts (*1974*);

> Argentina had the highest per capita protein consumption in Latin America in 1972 as well as the highest meat consumption. Synthetic meats and extenders are expected to comprise only 5 percent of total meat consumption in 1985 because of the abundance of natural meats available to the con-

[12] American Soybean Association. World Soy Protein Conference Proceedings, Munich, Germany, 1974; Soya Protein Conference Papers, London, 1975.

sumer. Because of this, protein enrichment of the average diet is not really necessary in Argentina. In addition, consumer resistance to synthetic meats is expected to have a more adverse affect than in other Latin American countries. Consumption of soy-derived meats is projected at 50,000 [metric] tons in 1980 and 150,000 [metric] tons in 1985; highest consumption will in all likelihood be in scattered, very low-income, urban areas.

Soy flour, for the same reasons cited for synthetic meat, is projected to constitute a very small percent of total protein consumption, in all likelihood less than 0.5 percent in 1985. Wheat flour is providing (and will continue to provide) over 25 percent of Argentina protein consumption. Very little need is foreseen for protein-rich flours to augment a diet centered around meat and high-quality wheat flours (corn is not even utilized to any appreciable degree as a human food). Consequently, all engineered soy protein foods will comprise less than 3 percent of overall Argentina protein consumption in 1985, up slightly over an initial penetration of about 1 percent by 1980.

Bolivia

In 1974, Bolivia had a soybean production of 2,000 t, but soybeans are not grown or used as foods at the home or village level in this country (FAO Production Yearbook *1975*). According to Predicasts,

All other Latin American countries except for Argentina, Brazil, Mexico, and Uruguay, had protein-deficient diets during 1961-1972, derived from low-quality grains. Per capita protein consumption did not appreciably rise between 1961 and 1972 due to inordinately high population growth (about 3% per year) which outpaced supply of many high-protein foods.

Natural meat consumption will continue to increase at about the historical rate, 3% per year, to about 4.2 million metric tons in 1985, because of programs in Ecuador, Chile, and Uruguay to stimulate meat production more economically on massive corporate ranches.

Soy flour use will exceed 200,000 tons by 1985, capturing about the same share of the total protein mixture as meat substitutes, about 2.5 to 2.6 percent. Use of soy flour bakery additives and substitutes will not be as widespread in most of these countries as will be evident in Brazil and Mexico, because of less familiarity with soy products and their taste. Public dietary improvement projects and retail prepared food distribution channels are less evident than in Mexico or Brazil. Also, priority will inevitably be placed upon domestic soybean use as feed (rather than human food) to aid in bolstering output for already established meat and poultry export programs in Ecuador, Columbia, Chile, and Peru.

According to Buchanan (*1976*), covering his initial tour of Latin American countries, considerable migration has been shown from the rural areas of Bolivia to the urban outskirts. Jobs have not been available for the migrants. This has compounded the malnutrition problem. Buchanan states:

The Ministry of Health has started Mothers' Clubs supplying foods for the family and educational materials for use by groups as they meet. Mothers who are more educated and tend to be leaders are chosen to continue the program after the first meeting with a representative from the Ministry. There is some question as to the success of this program. Also, the Ministry of Health supports a rural school lunch program which is beneficial. The breakfast program in urban centers, however, is being phased out.

Brazil

Soybean production in Brazil for 1974 was 7.5 million t (FAO Production Yearbook *1975*) and estimated to increase to 11.6 million t for 1976 (World Agricultural Production *1974*). Soybeans have not been used at the home or village level in this country.

In 1967, at the request of the Brazilian Ministry of Health, Mustakas (*1967*), demonstrated his village process (full-fat soy flour) in Brazil for fortifying milks and other weaning foods with soy protein. Brazilian scientists were interested in the process and consequently, UNICEF made available six sets of machines for experimental study in Brazil. The machinery was sent to the Ministry of Health at Rio de Janeiro, Santa Maria Federal University at Rio de Janeiro, University of Ceara at Fortaleza, Federal University of Pernambuco at Recife, Federal University of Paraiba at Campina Grande, and the Ecole Superieure at Piracicaba, State of San Paulo.

So far, little information has been received on the results with these machines because no national organization was responsible for coordinating the experimental results. Chavez (*1967*) and his group at the University of Pernambuco not only processed soya, which is not produced in northeast Brazil, but also other edible beans like the feijao macassa bean. His results were encouraging. He stated that he would like to make the process available to the

rural areas of the south. According to Predicasts,

> Per capita Brazilian protein consumption was below the average world minimum of 0.070 kg per capita per day in 1972, and qualitatively the protein mix was characterized by large quantities of food having poorly balanced and incomplete amino acid components (such as fruits, vegetables, and low protein grains). Total meat consumption grew 3.5 percent per year.
>
> Total meat and substitute consumption will increase 4.5 percent per year to cover 4.2 million [metric] tons in 1985 due to rapid market penetration by soy-derived substitutes. Consumer resistance to the new synthetic meats is expected to be less of a hindrance than in Argentina; Brazil is a major soybean producer and the vast majority of its people are acquainted with and accustomed to the taste of this and other bean products in their diet. In fact, Brazilian culinary tradition includes wide use of related vegetables and fruits as integral parts of meat, poultry, and egg dishes.
>
> Soy flour is already a small part of the Brazilian protein mix, especially in depressed urban areas. Consumption will grow over 14 percent yearly between 1972 and 1980 and as fast as 25 percent annually thereafter to about 180,000 tons in 1985. By 1985, flour is projected to make up over 2.5 percent of total protein consumption.

Chile

Chile is producing only about 250 t of soybeans yearly (Crowley and Edozien *1976*), but soybeans are not used as foods at the home or village level in this country. According to Buchanan (*1976*),

> It is estimated there are 50,000 severely malnourished children in Chile, mostly in localized areas where a test pilot project could be tried. The Chilean government plans to use a food stamp program to try to reach these cases. Education is badly needed. Apparently the Allende administration encouraged the movement of thousands of poor and not so poor from the rural sectors, where they could, and did, subsist on their small farm plots, to urban areas, through his promised giveaway food program which failed to materialize—thus aggravating an already difficult situation of unemployment and welfare dependence.

According to Predicasts,

> Natural meat consumption will continue to increase at about the historical rate, 3 percent per year because of programs in Ecuador, Chile, and Uruguay to stimulate meat production more economically on massive corporate ranches. Total meat and substitute consumption will increase over 4 percent annually due to penetration of soy-derived substitute products which are expected to be about 13 percent of meat consumption by 1985. . . . Soy flour use will exceed 200,000 [metric] tons by 1985 capturing about the same share of the total protein mixture as meat substitutes, about 2.5 to 2.6 percent. Use of soy flour bakery additives and substitutes will not be as widespread in most of these countries as will be evident in Brazil and Mexico, because of less familiarity with soy products and their taste. Public dietary improvement projects and retail-prepared food distribution channels are less evident than in Mexico or Brazil. Also, priority will inevitably be placed upon domestic soybean use as feed (rather than human food) to aid in bolstering output for already established meat and poultry export programs in Ecuador, Colombia, Chile, and Peru.

Colombia

Our findings show that soybeans are not used in foods in this country. Although considerable effort is being made to introduce soy foods here, these efforts are all in the experimental stages.

Colombia has a population of 24 million with a per capita income of $370, of which 37 percent is spent for food. In 1974, 156,000 t of soybeans (FAO Production Yearbook *1975*) were grown in the country that exports coffee, petroleum, cotton, sugar, and bananas.

Five oilseed processors are in Colombia. Grasas S.A. has a 220 t/d solvent extraction plant now processing soybeans and other oilseeds. They are getting an extruder from the United States and will start making textured soy protein within a year.

Predicasts, has reported on per capita protein consumption and natural meat consumption. Soy flour use in Colombia as human food is considered to be small, and the highest priority will be for domestic soybean use to go to feed rather than human food (see Bolivia section pars. 1, 2, and 3) to bolster output for already established meat and poultry export programs.

A soy milklike beverage powder has been developed.[13] This yellow-white powder contains 45 percent protein and 25 percent fat and can be dispersed in water to yield a drink with milklike flavor:

[13] Communication with D. D. Delgado and N. Y. Lopez, chemisto, Instituto de Investigaciones Technologicas, Colombia, South America, March-April 1975.

Native Colombia foods that might be formulated with soy proteins are empinada (puffed pastry), ajiaco (potato soup), arepas (baked, small round breads with cornmeal), noodle soups, puchers (soup with pork, beef, or sausage and vegetables such as plantain, casava, and corn), cullada (atole), and cereal gruels made with oatmeal, wheat, or corn.

El Instituto de Investigaciones Tecnologicas is responsible for most of the product development activities of the national government agencies and appears to be the focal point of food product development for the malnourished in Colombia.

Ecuador

In 1974, Ecuador had a soybean production of 1,000 t (FAO Production Yearbook *1975*). Soybean production is being increased and new programs for food products from soy are underway. Quoting Buchanan,

> In Quito, one institute has a program on the development of flours for making bread, pasta products, and crackers. There is an intensive effort in the fortification of wheat with soy, potato, and rice flours. They have been successful in replacing from 30 to 50 percent of the wheat flour with other flours. A process is being developed to make soy milk. Another for full-fat soy flour. It is hoped the increased availability of soy products will help relieve protein malnutrition conditions in Ecuador.

According to information obtained from Meals for Millions workers who were doing field fork in Ecuador,[14] a group of Ecuadoreans living in the Sierras have adopted home-grown soybeans as a daily food prepared in their home. The food product called Matchaka consists of whole soybeans that are toasted then ground in hand coffee mills. Coarse sugar is added and the mixture eaten as a dry snack. Previously, corn was used to prepare this product.

Predicasts, has reported on per capita protein consumption and natural meat consumption. Soy flour use in Ecuador as human food is small. Highest priority will be for domestic soybean use for feed rather than human food (see Bolivia sec., pars. 1, 2, and 3) to bolster output for already established meat and poultry export programs.

Guyana

Soybeans are not grown or used as foods at the home or village level in this country. With a population of only 750,000, the government has a highly restrictive import policy against many food products. The main exports are sugar, bauxite, and rice, with an average per capita income of $300/yr (Mustakas *1975*). Some 60 A of soybeans have been grown experimentally, and plans are underway for the government to build a soybean and rice bran crushing plant.

Paraguay

In 1974, Paraguay had a soybean production of 170,000 t (FAO Production Yearbook *1975*), but no reported use of soybeans, as human food at the home or village level. According to Buchanan (*1976*),

> Paraguay is the only Latin American country in which we found a migration trend from urban to rural areas. It is estimated that an additional million acres of land have been converted to productive agricultural property in the past five years. Paraguay is a beef exporting country but the European market has deteriorated as a result of the EEC policies, so that now they are seeking other outlets. As a result, also, beef prices in the market place are very low, good, lean beef being the equivalent of less than a dollar per pound. Pasta products are now being made with 20 percent of soy flour and 80 percent wheat flour to conserve the limited wheat production. Malnutrition is not a severe problem in Paraguay but there are pockets of goiter in the Northwest rural areas and some vitamin A and calorie/protein malnutrition in some of the rural and suburban sectors.

Quoting Predicasts,

> All other Latin American countries except for Argentina, Brazil, Mexico, and Uruguay had protein deficient diets during 1961-1972, derived from low-quality grains. Per capita protein consumption did not appreciably rise between 1961 and 1972 due to inordinately high population growth (about 3 percent) which outpaced supply of many high-protein foods. Natural meat consumption will continue to increase at about the historical rate, 3 percent per year. Use of soy flour bakers additives and substitutes will not be as widespread in most of these countries (including Paraguay) as will be evident

[14] Personal communication from M. M. Sterner, executive director, Meals for Millions, Santa Monica, Calif. 1976.

in Brazil and Mexico, because of less familiarity with soy products and their tastes.

Peru

In 1974, Peru had a soybean production of 1,000 t (FAO Production Yearbook *1975*) but did not use soybeans as food at the home or village level. According to A. I. Nelson, University of Illinois, there is an AID-INTSOY program in Peru relating to soybeans and soy food production. In discussing this program at NRRC, Nelson related to us the specific and high interest at the Food Institute at La Molina (Lima, Peru) on soy food-related research, at NRRC, particularly the extrusion cooking process for producing full-fat soy flours.

Predicasts reported on per capita protein and natural meat consumption. Use of soy flour in Peru as human food is small, and highest priority is for domestic soybeans to be fed to animals to bolster output for already established meat and poultry export programs. (See Bolivia sec., pars. 1, 2, and 3.)

Uruguay

In 1974, Uruguay had a soybean production of 6,000 t (FAO Production Yearbook *1975*), but soybeans are not used as foods at the home or village in this country.

According to Predicasts, Uruguay had no protein deficiencies in the diets of its people during 1961-72. According to Buchanan (*1976*),

> It is quite obvious Uruguay is progressing well in the utilization of applicable technology not only from the developed countries but also from the other more developed Latin American countries, particularly Brazil. We were told malnutrition is not a severe burden, but they do want to improve nutrition among preschool children and pregnant and lactating women, therefore, they were much interested in our program and want to help in any way possible. The Ministry of Commerce and Industry working with the University is beginning to make progress in adapting and transferring applicable technology to industry.
>
> Natural meat consumption will continue to increase at about the historical rate, 3 percent per year because of programs in Ecuador, Chile, and Uruguay to stimulate meat production more economically on massive corporate ranches. Total meat and substitute consumption will increase over 4 percent annually due to penetration of soy-derived substitute textured products which are expected to be about 13 percent of meat consumption by 1985. This is slightly lower than the projected penetration in Mexico and Brazil because of the inclusion of Uruguay where dietary tradition is centered around a wide variety of natural meats and other relatively plentiful high-protein foods.

Venezuela

With a population of 12 million people, soybeans were still not being produced by 1975 even though about 55,000 t of soybeans and 83,000 t of soybean meal were imported in 1974 (Mustakas *1975*). Soybeans are not used as foods at the home or village level in this country.

Venezuela has a few small oilseed processors crushing imported soybeans into oil and meal. One company (Proteinal S.A.) makes edible soy flours.

Native foods include pabellon plate (stringy beef, rice, sauce, potatoes, and vegetables) and arepas (little round corn breads fried and stuffed with ground meat and highly seasoned onions, chili sauce, peppers, and garlic). Tamales (hiralloca) are cooked in banana leaves and stuffed with ground meat and cornmeal. During Mustakas' trip in March-April 1975, fried arepas were prepared as a food demonstration with textured soybeans and local green chili and tomato sauces. Acceptance was excellent as noted from the meeting attendance, which included representatives of government, industry, and academic institutions (Mustakas *1975*).

Mexico

Mexico has a population of over 55 million and 37 percent of the per capita income of $700 is spent on food. Government programs have been underway since 1970 to introduce soybeans in the diets of both the urban and rural population. Numerous nutritional studies in Mexico have shown that 31 percent of children in rural areas and 16 percent in urban areas are in a state of second and third degree malnutrition and require medical attention (American Soybean Association *1975a*). In Mexico, every year about 2 million children are born, of which 300,000 die before they reach the age of 5 because of problems related to the malnutrition-illness cycle (Anonymous *1975b*). According to

Predicasts,

> Mexican protein consumption has been highly deficient. Not only has it been below the minimum required level in quantity, but quality of the protein mix has been poor due to insufficient balance between low grade corn-derived proteins (47-54 percent of consumption) and meat-derived proteins. Per capita meat consumption has been among the lowest in Latin America due to insufficient local production, much of which was exported at higher prices than consumer incomes could afford. Total meat consumption increased only 1.3 percent annually between 1961 and 1972.

Before 1969, soybeans were planted only in the states of Sonora and Sinaloa along the eastern coast of the Gulf of California. Soybeans are now grown in most of the states across the north of the country and in Jalisco, a west-central state. Production has been increasing over 6 percent a year with 1975's production amounting to 500,000 t. Varieties that can be grown in the more tropical states are also available, making possible greater increase (Pontecorvo *1976*).

In the early seventies, when the President of Mexico was starting his new term of office, he created a Council of National Science and Technology (CONACYT) at the cabinet minister level. As part of this program, he announced publicly that he considered soybeans as a natural part of the diet for the Mexican people and he expected through the new program to promote soy proteins in the national food diets.

Since, both representatives of the Mexican government and industry have cooperated in the national program. Market development activities shared by the American Soybean Association, Mexican Government (Harrison *1972*), and private firms have helped raise the production and demand for soy protein products from 2 t daily in 1971 to over 40 t daily in 1975 (Tello *1975*), According to Predicasts,

> Soy flour will comprise an even larger percentage of Mexican protein consumption in 1980 and 1985 than soy-derived meats, 3.5 percent of the total protein mix in 1985 compared with 2.6 percent for meat substitutes. This will be a result of the composition of the traditional diet which is centered around grain flour and bean mixtures as staples, a custom that will facilitate easy acceptance of soy flour (especially as a "hidden additive" to popular low-protein corn flours). Hence, Mexico will have, in all likelihood, the highest protein mix penetration by soy flour (3.5 percent in 1985, or over 140,000 [metric] tons of flour) of all Latin American countries. As in the case of synthetic meats, Mexico's proximity to large American soybean and soy flour production centers (in Texas and throughout the Southern states) will stimulate availability in Mexican markets and aid in pushing total per capita protein consumption to the average minimum requirement of 0.070 kilograms per day by 1985.

New village process

Even at their low cost, most of the soy products on the Mexican market were not available to poor people.

During 1974-75, 30 sets of village process equipment were delivered to Mexico through the auspices of UNICEF. One unit was delivered to the National University of Mexico where workers there studied the process and its application toward traditional end-food products in Mexico. As a result, workers Berra and Pontecorvo-Valhuerdi (*1975*) published a slight modification to the original NRRC process as a means of guiding the process more directly toward such traditional food products as milk, atole, and pasta. Figure 1 is a flowchart showing modifications in the USDA village process (Mustakas and others *1967*).

According to the authors, the heavy liquid obtained after boiling could be used as atole or a soup containing such vegetables as potatoes, carrots, and onions indigenous to the region. A beverage was an alternate product and could be made even more acceptable to the people by boiling it with aromatic products such as cinnamon, vanilla, and cacao. Another alternate product referred to as a pasta could be used as human or animal food. Humans could eat it as cereal combined with the fruits of the region. It also could be dried in the traditional ovens to make cookies or ground again to make a powder to be combined with corn or wheat. In this way, it could be preserved a long time.

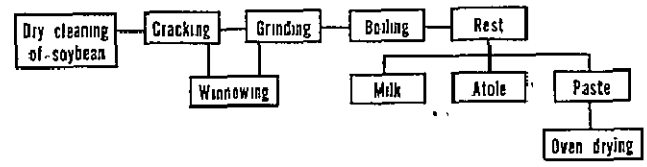

FIGURE 1.—Flowchart of USDA village process.

The yield and protein analysis (percentage) of the basic products from 1 kg soybeans, adding about 9 L water in the boiling process, are as follows:

Product	Yield	Protein
Milk ...	6-7 L	4
Atole ...	2-3 L	8
Pasta ..	2-3 kg	18

Commercial developments

Commercial use of soy foods is not the primary object of this publication. However, in Mexico a unique effort is being made by both government and industry to introduce soy products into the Mexican diet. A brief description follows of the products being promoted through retail outlets.

In 1973, the Mexican Government inaugurated a group of soy supplemented meat products under the name of PROTEIDA. Meat-soy products were made with approximately 25 percent texturized soy protein (TSP) and 75 percent ground meat. For example, one product, a precooked patty called milanesa, required no refrigeration. It was developed by the National Nutrition Institute. The products used TSP from defatted soy flour purchased by the government from private Mexican firms, were formulated and packaged in a government packinghouse, and then distributed by the government.[15]

Since 1973, other textured soy products have been independently manufactured and distributed in Mexico. For example, Miles/Worthington, Elkhart, Ind., has produced a beef-flavored TSP called ALBORADA, which has received good acceptance by the public and is being sold in leading supermarkets as well as to restaurants, hospitals, and meat-packaging plants, and by canned food producers.

At present, soy consumed as human food amounts to only about 30 t/d:

Full-fat soy flour	18 t
Soy milk and similar products	6 t
Texturized soy protein ...	6 t

The projected increase in consumption of these basic products is 100 t/d for the current year (Pontecorvo *1976*).

Another TSP product, PROTOLEG, is the oldest product on the market. Its producer, Industrial de Alimentos, is now the largest manufacturer of soy protein products in Mexico. This company also produces and markets a soy beverage powder called SOYACYT. The product is a direct application of a beverage process developed at NRRC by G. C. Mustakas and associates and introduced to the company in 1971.

The Mexico City regional office of the ASA, through Gilford Harrison, director, has become the center of great interest in soy protein products for human consumption. Through their development activities, the demand for soy protein products in Mexico has increased during the past few years.

The largest volume of sales is in soy flour for baking. The tortilla industry consumes some 60 percent of the total. The remaining 40 percent is about evenly divided between TSP and beverage or products similar to milk. The largest bakery in Mexico, BIMBO, plans to start producing a soy-based milk substitute containing sweet whey powder.

According to the ASA Nutrition Director for Latin America, considerable promotion of soy protein foods is taking place through cooperation with several sponsoring government agencies.[16] For example, soybeans are mixed in a 1:1 ratio with other local beans, soaked, and cooked. The director claims that cooking soybeans in a mixture of other beans reduces cooking time and gives a softer texture. In addition, the mixed beans take on the flavor and color of the other beans. About 45 min cooking is required in a pressure cooker and about 2½ to 3 h in an atmospheric cooker, depending on the elevation. Salt, garlic, onion, and bicarbonate of soda are some of the additives used in the cooking process. Soy flours are promoted as cereal gruels and in atole foods.

[15] Personal communication with J. L. Camacho, National Nutrition Institute, Mexico City, Mex. 1976.

[16] Personal communication with R. S. Orellana, nutrition director, (Latin America) American Soybean Association, Hudson, Iowa. 1976.

The Mexican Government is sponsoring a social security program, Seguras Social, to develop better nutrition among the poor. The soybean is one of eight nutritional food groups that is being promoted in the nationwide effort of 600,000 families.

Honduras

Commercial production of soybeans does not exist in Honduras, but since 1973, soybean production has been studied by several government, institutional, and private groups: the Ministry of Natural Resources, the Pan American School of Agriculture in Zamorano, and by the fruit companies, United Brands and Castle, Cooke, and Co., in La Lima and La Ceiba, respectively. At present, no governmental policy or laws regulate the cultivation of soybeans in Honduras, but the government is becoming increasingly interested in large-scale production because of the success of the growing experiments.[17]

The Honduras Government is embarking on a 5-year production program mainly for oil extraction and animal feed for domestic use. Through an AID nutrition loan, a 3-year Soya Project began in 1977. The project has three stages: production, consumption, and feasibility studies for commercializing soya. The production stage involves cultivation at the small-farmer level through cooperatives for home consumption purposes. The consumption stage is the home consumption involving the same groups who produced the soya. The feasibility studies will focus on commercially introducing soybeans through soy flour, soy milk, fortifying flour products and tortillas, and finding methods to incorporate the soya into the local diet.

CARE/Honduras is beginning small agricultural projects with housewives clubs in rural areas to introduce a means of providing foods to take the place of CARE foods now supplied to the school and preschool feeding programs. They are planting soybeans on a small scale and are experimenting with them in feeding centers by testing recipes and acceptability.

[17] Personal communication with G. E. Storms, nutritionist, CARE/Honduras. 1976.

Costa Rica

Soybeans are not produced or consumed as a food, although experimentation is being carried out at the University of Costa Rica and also with CARE. Costa Rica has a GNP of some $1.2 billion and a population of 2.1 million with a per capita income of $590, of which about 30 percent is spent on food. The government is starting a family assistance program to employ 500 nutritionists financed by a 2-percent tax on payrolls (Mustakas *1975*).

The Ministry of Agriculture and IMAS, a Costa Rican national counterpart of CARE, are planting about 100 ha of soybeans with farmers in Guanacaste. In conjunction, the Costa Rican Food Research Center, CARE, negotiated a special grant with AID to use a Brady Soybean Extruder to process the beans from the crop (at least 95,000 kg).[18]

According to Helen Hennessy[19] reporting on the CARE program in Costa Rica, housewives are using soybeans in their tortillas. Also the program is teaching children and their mothers how to substitute soybeans for black beans, which are more expensive and contain only half the protein.

Panama

Panama grows no soybeans and does not use soybeans in foods. They use fairly large quantities of soybean meal (39,000 t imported in 1973) for animal feeding, and some firms are interested in using defatted soy flours and TSP for foods (Mustakas *1975*).

Dominican Republic

Soybeans are not grown or used as food in this country. About 6,250 ha were planted in 1974 on an experimental basis. During a visit there, Mustakas (*1975*) talked with oilseed processors (Industria Mancera, Industria Lavador) who are now crushing peanut and copra, but soybean and cottonseed oils are imported. Industria Lavador's oilseed plant plans to increase production to 300 t/d and, with the ex-

[18] Personal communication with K. Bachman, Costa Rican Food Research Center, CARE, Costa Rica. 1976.

[19] Personal communications with H. Hennessy, CARE/Costa Rica.

pansion, hopes to produce soy food products in some form.

Jamaica

Soybeans are not grown in Jamaica and are not used for food in the home or village. However, in an ASA-FAS sponsored visit (Mustakas *1975*), considerable interest was shown for using soybeans in school lunch programs. The government food plant is manufacturing and distributing milk and vegetable-meat pie products for a school lunch program in the Kingston area. They hoped to expand the program to 52,000 children per day with an eventual target of reaching the whole island of Jamaica, which has 700,000 children. Milk is made from nonfat dried milk and deodorized soy oil. A highly accepted meat pie is produced with meat and vegetables. The crust is made with wheat flour containing 6 percent soy flour and hydrogenated soy oil. Beef patties were also produced and distributed. They were most interested in TSP for meat replacement and soy beverages for milk extenders.[20]

Jamaica Nutrition Holdings, Ltd., the central government buying agency, is interested in soy food products for government feeding programs. I. S. Joseph, a U.S. firm 36 km from Kingston built a 300 t/d soybean plant that is 60 percent government owned.

Haiti

Soybeans are not grown or used as food in the home or village in this country. The people of Haiti, the poorest country in the Caribbean with a GNP of only $600 million and a population of 5.3 million, have serious caloric and protein deficiencies in their diets. Food staples consist of beans, rice, bananas, yucca (cassava), coconut, and bread.

Trinidad

Soybeans are not grown or used as food in the home or village in this country. Local experiments are being conducted under a project agreement between the governments of West Germany and Trinidad and Tobago (Mustakas *1975*). Trinidad has considerable interest in soybeans but no processing plants. A chain of Hi-Lo supermarkets sells a soy-protein beefburger that contains 25 percent textured soy flour.

Much interesting information was received recently from a home economist with the John Donaldson Technical Institute:[21]

> Originally, it was contemplated that Soya would be cultivated here in Trinidad and Tobago to alleviate the edible oil problem, since coconuts, which traditionally provided all the edible oil in the country, were plagued with a multitude of field and economic problems. As a byproduct of oil extraction, soya meal would be used as livestock feed, thereby reducing, to some extent, the dependence of livestock farmers on foreign soya supplies. An exploratory extraction exercise conducted by Lever Brothers, an industrial concern in this country in December 1975, yielded recovery of both oil and meal of over 95% from a 15,000 lb [7,000 kg] lot of soya beans processed.
>
> However, the stimulation of consumers' awareness to the need for a cheap source of high protein food; the inconsistency in the logic of consuming soya protein via livestock, and the versatility of the bean itself as a multi-purpose food have given rise to complete review of the original objectives of Soya cultivation here and entirely new dimensions have been assumed in the exercise.
>
> Crop production personnel in the Chaguaramas Agricultural Development Project (CADP) and Home Economists at the John Donaldson Technical Institute have been collaborating to refine, demonstrate, and promote the production and utilization of locally grown soya. To this end, the agronomists have published a booklet on the growing of Soya while the Home Economists have produced several booklets and pamphlets with information on preparing dishes from soybeans. A booklet is about to be published.
>
> It might be of interest to you to note that Guyana, St. Kitts, and Trinidad and Tobago have embarked upon a program of Corn/Soya production in the hinterland of Guyana as part of the Caribbean Food Plan.
>
> It is envisaged that soon a programme will be formulated with the Extension Division in the Ministry of Agriculture, Lands and Fisheries to exhibit soya growing at vantage points in rural Trinidad and Tobago with accompanying demonstrations by Home Economists in food preparation. I am currently working in conjunction with the

[20] Personal communication with B. Lewis, general manager, Nutrition Products, Ltd., Ministry of Education, Kingston, Jamaica. 1975.

[21] Personal communication with U. Lashley, home economist, John Donaldson Technical Institute, Ministry of Education, Port of Spain, Trinidad. October, 1976.

Government Broadcasting and Film Unit to produce a documentary on 'Soya for Food.' I am dealing with basic steps Cleaning, Soaking, and Blanching: I also hope to deal with the preparation of:

(1) Soy Milk, Soy/Choc Milk
(2) Soy Fudge. Soy/Choc Fudge—A candy
(3) Soy/Almond Paste—Marzipan
(4) Soynut Butter
(5) Soy Nuts
(6) Curried Soybeans
(7) Phulouri (An East Indian Dish Using Dhal)

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Soybean Food Uses in North America

United States

Soybeans are not a traditional food in the United States, but great changes in the uses of soybean crops have occurred in recent years.

During the early part of soybean history in the United States, two-thirds of the acreage was used for forage; the remaining third was harvested for beans, which perhaps were also used for animal feeds. Today, the United States is the largest soybean producer in the world. More than 50 percent of the soybeans produced are used for oil, 30 percent for exports, and the remaining for seed and feed (table 12). The defatted meal is one of the basic protein sources for livestock production. In the food-processing industry, soybean flour is a valuable ingredient for bakery products. Other food products from processing soybeans are soybean grits, textured protein, soybean oil, soybean meal, and lecithin.

A small amount of whole soybeans, however, is consumed as food in the United States. But the amount is so small it does not warrant mentions in any official statistics. About 1 percent of the U.S. population is Oriental (U.S. Bureau of the Census *1975*); even after living in the United States for generations, Orientals have kept their food habits. Oriental foods, either imported or made locally, often are available in a Chinatown or specialty shops. Soybean curd is the most popular soybean food and is always made locally by the traditional method.

Such processed tofu products as tou fu kan and deep-fried tofu are frequently available. In California and Hawaii, which have high oriental populations, traditional soybean foods are often sold in the supermarkets. In the past few years, because of increasing interest in vegetarian diets, tofu and soybean milk have become regular items in natural health food stores.

Many vegetarian communes have also used whole soybeans as their main protein food

TABLE 12.—*Supply and disposition of soybeans in the United States, 1967-76*[2]

Item	Year beginning September								
	1967	1968	1969	1970	1971	1972	1973	1974	1975
	1,000,000 bushels[1]								
Supply:									
Stocks	90.1	166.3	326.8	229.8	98.8	72.0	59.6	170.9	185
Production	976.4	1,107.0	1,133.1	1,127.1	1,176.0	1,270.6	1,547.2	1,214.8	1,521
Total	1,066.5	1,273.3	1,459.9	1,356.9	1,274.8	1,342.6	1,606.8	1,385.7	1,706
Disposition:									
Crushing	576.4	605.9	737.3	760.1	720.5	721.8	821.3	701.3	865
Exports	266.6	286.8	432.6	433.8	416.8	479.4	539.1	420.7	565
Seed	48.6	47.3	48.5	48.1	51.0	60.8	56.1	57.2	—
Feed	.9	.9	.9	1.1	1.1	1.1	1.2	1.0	76
Residual	7.7	5.6	10.8	15.0	13.4	19.9	18.2	20.5	—
Total	900.2	946.5	1,230.1	1,258.1	1,202.8	1,283.0	1,453.9	1,200.7	1,506

[1] Metric tons $= \frac{\text{number bushels} \times 60}{2{,}204.6}$

[2] U.S. Department of Agriculture. August 1976. Fats and Oils Situation. Economic Research Service.

source. Some communes even plant their own soybeans. The most popular foods made are soybean milk, tempeh, tofu, soybean ice cream, and soybean yogurt. Generally, commune cooks follow the traditional oriental methods for making soybean milk, tofu, and tempeh; then they develop their own recipes to suit their taste.

The Farm commune in Tennessee, which has over 1,000 people, makes about 4,560 L of soybean milk, 135 kg of tofu, 950 L of soy yogurt, and 270 kg of tempeh weekly. Commune members also eat whole-cooked soybeans, plain or in a sauce. They roast soybeans into soynuts and make soyburgers, soy loaf, and soy sausage. From soybean oil, they make mayonnaise, salad dressing, whipped cream, and dessert frostings. In winter, the beans are sprouted to be used as a vegetable. On the average, they eat soybeans in some form at least once a day, but often more. In 1975, the commune members harvested and consumed 162 t of soybeans and 27 t each of pinto, kidney, and black beans.

As a nation, the extent of using simply processed soybeans, however, is insignificant. One of the factors that affects the use of whole soybeans for food is the lack of knowledge of how green soybeans and dry soybeans can be properly prepared for consumption. In "The Joy of Soybean Cooking," Smith found that dry soybeans can be used in casseroles, soup, salad—anywhere one would use navy or kidney beans. Excellent recipes with soybeans were developed with the claim that they are so good, so versatile, and so satisfying that one can easily eat them once a week. Other publications on soybean cooking for this country include the following:

"The Farm Vegetarian Cookbook," L. Dotzler. The Book Publishing Company, The Farm, Summertown, Tenn. 1975.

"Cooking with Soybeans," D. C. Mueller, B. P. Klein, and F. O. Van Duyne. Circular 1092, Cooperative Extension Service, University of Illinois, Urbana-Champaign. 1974.

"Soybeans in Family Meals," P. Sinclair, R. S. Vettel, and C. A. Davis. U.S. Department of Agriculture Home and Garden Bulletin No. 208. 1974.

"The Joy of Soybean Cooking," B. B. Smith. *In* Woman's Day, June 1973, p. 200.

"The Protein for Pennies Cookbook," J. Wood. Peter W. Wyden Publishers, 750 3rd Ave., New York, N.Y. 10017. 1975.

In these publications, instructions are usually given on how to boil soybeans. They are basically the same: soak the beans overnight, cook with the addition of salt or chopped onion, bay leaf, and pepper for more flavor, and simmer for 1 to 3 h. Some suggest reserving the soaking-water for cooking. However, laboratory results and the oriental experience have shown that soaking processes remove some undesirable factors. Therefore, the soaking-water should be discarded.

Canada

Canadians consume a fair amount of peas and beans, 5.1 kg per capita yearly (FAO *1971*); however, they do not use soybeans in their diet. Canada, like the United States, has a great number of Orientals as well as many vegetarians. Soybean consumption as food in Canada is quite similar to that in the United States.

Canadian soybean production, which began during World War II, is largely confined to southwestern Ontario. The major crop expansion occurred between 1947 when 24,700 ha were planted and 1957 when 104,000 ha were planted, primarily to alleviate a shortage of fats and oils (Canadian International Grains Institute *1975*). Possibility for increase is limited because soybeans are not adapted to a large portion of the cultivated land in Canada. Canada produced 397,000 t of soybeans in 1973 and 367,000 t in 1975, with the area planted reduced from 31,200 ha in 1973 to 25,900 ha in 1975 (USDA *1976*). Canadian supply and distribution of soybeans from 1964 to 1975 are given in table 13.

TABLE 13.—*Soybean supply and distribution Canada, 1964-74*[2]

Year beginning August 1	Production	Imports	Supplies	Exports	Processed for oil and meal
			1,000 bushels[1]		
1964	6,976	16,457	23,433	3,179	19,541
1965	8,030	17,058	25,088	2,152	20,654
1966	9,012	16,295	25,307	3,599	19,876
1967	8,091	13,328	21,417	1,571	19,846
1968	9,027	12,469	21,496	1,123	20,054
1969	7,664	17,430	25,094	1,111	23,679
1970	10,398	15,690	26,088	772	23,443
1971	10,288	14,771	25,059	1,360	23,314
1972	13,779	10,986	24,765	1,066	22,507
1973	14,587	10,628	25,215	1,062	—
1974	10,362	11,306	21,668	1,055	23,601

[1] Metric tons = $\frac{\text{number bushels} \times 60}{2{,}204.6}$.

[2] American Soybean Association. March 1975. Soybean Digest Blue Book.

References—Soybean Food Uses in North America

American Soybean Association. 1975. Soybean Blue Book. Hudson, Iowa.

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U.S. Bureau of the Census. 1975. Statistical abstract of the United States. Washington, D.C.

U.S. Department of Agriculture. 1976. The agricultural situation in the Western Hemisphere, review of 1975 and outlook for 1976. U.S. Department of Agriculture Foreign Agricultural Economic Report No. 122. Washington, D.C.

Soybean Food Uses in Australia

Soybean production in Australia averaged 800 t from 1962 to 1966 but increased to 56,538 t in 1974.[21] Unfavorable weather limits the expansion of soybean planting. Most of the current production is in Queensland, with the rest in the New South Wales area. In 1970 Australia imported 70 t of soybeans, used mainly for oil and feeds. Contacts from Australia are scanty, and no information on use of soybean as food has been obtained.

Summary of Soybean Food Uses

Traditional Soybean Foods

Traditional soybean foods have been limited to the Orient, where soybean foods have been eaten by everyone—young and old, rich and poor. Preferances for soybean foods, ways to prepare them, and the manners of consuming them are deeply imbedded in oriental culture. These traditional soybean foods are summarized as follows.

Soybean milk

Soybean milk is the water extract of wet ground soybeans. It looks like dairy milk and can be used as dairy milk, but it has its own characteristic odor and taste. Although soy-

[21] American Soybean Association, Soybean Blue Book. Hudson, Iowa. 1975.

bean milk is the starting material for many other soybean foods, the direct consumption of soybean milk is popular only among the Chinese.

Soybean curd and processed soybean curd products

Tou fu, tofu, tubu, tahoo, touhu, tau foo, and dan fu are some of the phonetic renditions for soybean curd from different countries. Soybean curd is, perhaps, the most important and popular soybean food in the Orient. The curd, a cottage cheese-like product formed into a cake, is precipitated from soybean milk by calcium sulfate, vinegar, or other coagulating agents and then transferred to a molding box to form a soft cake. Soybean curd has a bland taste so that it can be flavored easily with seasonings or blended with other foods. Products processed from soybean curd are made by dehydration, freezing, and frying. These processed products have less moisture content and a more chewy texture than that of soybean curd itself.

Protein-lipid film

Tou fu pi, fu chok, and yuba are the traditional names for this popular food product. It is the film formed over the surface of soybean milk when the milk is heated nearly to boiling. Then the cream-yellow film is air dried and made in the form of sheets, sticks, or flakes.

Soybean sprouts

Huang tou ya (Chinese), or daizu no moyashi (Japanese), is produced by germinating soaked and drained soybeans in the dark for 1 to 2 wk until the sprouts reach full growth (about 3 to 4 cm). Soybean sprouts are often used in soups, steamed, or sauteed for hot vegetable dishes. After cooking they can also be used in salads.

Tempe (Tempeh)

Tempeh is an Indonesian fermented soybean product. The fermentation process is short and simple. Soaked and dehulled soybeans are boiled, drained, surface-dried, mixed with tempeh starter (*Rhizopus oligosporous* spores), wrapped in banana leaves or perforated containers, and then incubated at about 30°C for 20 to 24 h. At that time, the beans are bound together by mycelia, resulting in a cakelike product. When sliced and fried in oil, tempeh has a pleasant flavor, aroma, and texture that would be acceptable to people of different cultures around the world. A product similar to tempeh has also been made from the residue of making soybean milk and soybean curd. In Indonesia, the product is known as tempe gembus.

Green soybeans

Immature soybeans, mao tou, or edamame are consumed in the Orient as a seasonal vegetable. The most popular way to prepare the beans is to boil them in the pods for 10 to 15 min in salt water. Often the pods are removed before eating.

Boiled soybeans

Dry soybeans are soaked and boiled in water with seasonings, such as soy sauce, and served as snacks. Sometimes they are cooked with seasonings and meat to serve with regular meals.

Roasted soybeans

Soaked or unsoaked soybeans are often roasted above an open fire or fried in oil to use as snacks.

Soybean flour

Roasted soybeans are ground into flour that is then used in pastry. Soybean flour as processed in this country is not traditionally used in the Orient.

Soy sauce

Soy sauce (known as chiang yu in China, shoyu in Japan, kecap in Indonesia, and toyo in the Philippines) is a dark brown liquid with a salty taste (16 to 18 percent salt) and a pleasant aromatic odor suggestive of meat extracts. It is made by fermentation from a combination of soybeans, wheat, and salt with a mixture of molds, yeast, and bacteria. Soy sauce is the prominent all-purpose seasoning agent used in the preparation of oriental foods, as well as a table condiment.

Fermented soybean paste

Fermented soybean paste (miso in Japanese and chiang in China) is also a common flavoring agent in the Orient. It has an aroma and salty taste similar to that of soy sauce and is a brown paste resembling peanut butter. Fermented soybean paste is made from soybeans and salt with or without a cereal by a process comparable to that used in soy sauce. For centuries, the product has been produced and consumed in many oriental countries. In some countries, a variety of bean pastes may be made by varying the ratio of bean to cereal, salt content, fermentation time, or addition of other ingredients such as hot pepper.

Fermented whole soybeans

Tou shih, or hamanatto, is made by fermenting whole soybeans with a strain of a mold, *Aspergillus*. The fermented beans can be used as a condiment with bland foods such as rice porridge, or they can be cooked with vegetables, meats, and seafoods as a flavoring agent.

Natto

Natto, a fermented soybean food in Japan and Korea, is made from whole soybeans by fermentation with a bacterium, *Bacillus subtilis*. The process is simple and quick, similar to that of tempeh fermentation except that a different microorganism is used. Natto is well known in Japan, but it is considered unpalatable by many because of the characteristic strong odor, flavor, and slimy appearance.

Fermented soybean curd

Fermented soybean curd, known as Chinese cheese, or sufu, is made from cubes of soybean curd by the action of a mold, *Mucor or Actinomucor*. The molded curd cubes are then aged in a salt solution, resulting in a soft cheese-type food. Sufu is made and consumed primarily by Chinese.

Experimental Soybean Foods

In recent years, various approaches have been taken to incorporate soybeans into native diets of countries that do not traditionally use soybeans as foods. The following soybean products have been in use.

Whole soybeans

Soybeans are soaked, drained, boiled in water with salt, baking powder, or sodium bicarbonate, and then simmered for 1 to 3 h. The cooked beans are used in salads, soups, stews, and casseroles—anywhere one would use any kind of bean.

Soybean paste

The paste is made by first soaking the beans and then grinding to a creamy paste. It is usually mixed with cereals. The paste may be made from boiled soybeans and used in the recipes for spread or pie filling.

Soy flour

Soybean flours, full-fat or defatted, have been incorporated into many native diets and are frequently combined with cereals in preparing familiar foods. Soy flour seems to be the most versatile soy product for use in the diets of people outside the Orient.

Soy beverage

Traditional oriental soybean milk and soy beverage made from whole soybeans have been introduced into many countries.

Production and Consumption

World soybean production (Table 14) is concentrated in three countries: the United States, Brazil, and China; however, soybeans are grown in small areas throughout the world. Although U.S. soybean production in 1976 was down nearly 18 percent from the 1975 output, Brazilian production was up about 15 percent. The production in the People's Republic of China remains the same. Among other producers, Argentina and Indonesia produce significant amounts of soybeans, but only Argentina shows a great interest in expanding soybean planting.

The FAO food balance sheets, 1964-66 (*1971*) has been the chief source for consumption data, although more recent information was received from a few individual countries. In general, food patterns of each nation have remained unchanged. For comparative purposes, soybean use data for soybean-consuming countries (FAO report), are summarized in table 15.

In the Far East, significant amounts of soy-

TABLE 14.—*Soybeans: area and production in specified countries and the world, annual 1970-76*[1]

Continent and country	Area[2]							Production						
	1970	1971	1972	1973	1974	1975[3]	1976[4]	1970	1971	1972	1973	1974	1975[3]	1976[4]
	1,000 hectares							*1,000 metric tons*						
North America:														
Canada	136	149	164	190	180	158	146	283	280	375	397	280	367	291
Mexico	140	155	240	306	255	355	150	240	250	375	510	420	625	256
United States[5]	17,098	17,281	18,494	22,580	21,193	21,694	19,992	30,675	32,006	34,581	42,108	33,062	41,406	34,012
South America:														
Argentina	26	38	68	160	339	369	442	27	59	78	272	496	485	695
Brazil	1,319	1,716	2,840	3,615	5,143	5,824	6,227	1,509	2,077	3,700	5,011	7,876	9,892	11,344
Bolivia	1	1	1	2	6	6	6	1	1	1	3	8	10	10
Chile	(6)	2	2	1	1	2	2	1	3	3	1	1	2	2
Colombia	58	58	58	54	57	88	60	95	106	122	114	114	169	136
Paraguay[7]	40	54	76	92	120	150	180	52	75	97	122	185	218	230
Peru	(6)	1	1	1	2	3	3	1	1	1	3	5	8	7
Ecuador	(6)	1	1	1	2	8	12	1	1	1	2	3	10	14
Europe:														
France	0	0	0	0	2	2	4	0	0	0	0	4	5	10
Spain	2	2	2	13	18	20	22	3	2	3	13	39	16	35
Bulgaria	9	18	14	19	25	31	58	8	16	13	16	18	62	100
Hungary	0	0	0	0	15	25	40	0	0	0	0	14	41	55
Romania	79	146	109	183	239	122	200	91	165	186	244	298	195	250
Yugoslavia	4	5	4	9	8	15	32	5	4	6	13	14	25	50
USSR	860	868	905	838	830	811	850	603	535	258	424	357	780	500
Africa:														
Ethiopia	10	10	10	10	10	10	10	6	6	6	6	6	6	6
Nigeria[8]	—	—	—	—	—	—	—	11	1	4	1	1	1	1
South Africa[7 9]	14	9	12	9	13	13	12	4	2	3	5	21	20	19
Tanzania[10]	5	5	5	5	5	5	5	4	4	4	4	4	4	4
Uganda	5	5	5	5	5	5	5	3	3	3	3	3	3	3
Zaire	2	2	2	2	2	2	2	2	2	2	2	1	1	1
Asia:														
Burma	20	20	23	21	21	21	22	13	13	14	15	15	14	14
China, People's Republic	8,000	8,100	8,400	8,500	8,800	9,200	9,200	6,900	6,700	6,500	8,000	9,500	10,000	10,000
China, Republic of Taiwan	40	40	36	36	45	45	45	65	61	60	61	67	62	59
India	24	30	32	35	40	40	40	11	18	20	25	30	35	35
Indonesia	694	666	696	750	753	758	753	498	475	518	507	550	575	575
Iran	6	8	7	14	30	54	54	6	7	10	22	36	70	70
Japan[7]	96	100	89	88	93	87	87	126	122	127	118	133	126	120
Khmer Republic	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Korea, North	395	400	405	405	405	405	405	228	230	235	235	235	235	235
Korea, Republic of[7]	298	277	284	312	286	275	289	232	222	224	246	319	311	311
Philippines	2	2	1	2	3	8	12	1	1	1	2	2	6	10
Thailand[7]	83	75	81	95	102	115	126	70	67	80	100	115	140	155
Turkey	11	7	5	5	4	4	4	12	11	13	7	9	9	9
Vietnam[11]	34	36	36	36	36	36	36	15	17	19	18	18	18	18
Oceania:														
Australia[6]	5	7	18	28	41	46	28	5	9	34	38	63	74	31
Estimated world total	29,560	30,338	33,170	38,466	39,173	40,856	39,605	41,811	43,556	47,985	58,671	54,326	66,030	59,700

[1] Years shown refer to years of harvest. Southern Hemisphere crops which are harvested in the early part of the year combined with those of the Northern Hemisphere harvested the latter part of the same year. [2] Figures refer to harvested areas as far as possible. [3] Preliminary. [4] Forecast. [5] Hectarage harvested for beans. [6] Less than 1,000 hectares. [7] Planted area. [8] Quantities purchased by the Nigerian Marketing Boards for exports. [9] European farms only. [10] Sales. [11] Includes former South Vietnam.

U.S. Department of Agriculture. Foreign Agricultural Service. Prepared or estimated on the basis of official statistics of foreign governments, other foreign source materials, reports of U.S. Agriculture Attaches and Foreign Service Officers, results of office research and related information. Foreign Agriculture Circular FOP 17-76, November 1976.

TABLE 16.—*Amounts of cereal-soy blends distributed under Title II, Public Law 480 in fiscal year 1974*[1]

Country	Commodity (1,000 lb)[2]		
	CSM[3]	CSB[3]	WSB[3]
Africa:	49,660	34,004	26,344
Botswana	8,864	2,185	—
Burundi	120	35	—
Cameroon	200	355	205
Central African Republics	—	180	—
Chad	688	—	—
Congo	—	—	788
Dahomey	46	—	116
Ethiopia	4,458	36	—
Gabon	—	—	66
Gambia	213	100	—
Ghana	2,244	1,137	1,368
Ivory Coast	—	365	867
Kenya	155	1,819	—
Lesotho	2,458	227	610
Liberia	388	572	323
Malagasy	188	182	—
Mali	840	66	—
Mauritania	80	5,799	—
Morocco	509	3,558	10,596
Niger	33	45	—
Nigeria	200	6,821	329
Rwanda	100	200	1,458
Senegal	1,318	—	—
Seychelles	129	—	—
Sierra Leone	556	1,356	149
Somali Republic	—	—	2
Sudan	—	2,454	—
Swaziland	—	105	—
Tanzania	2,299	5,419	—
Togo	—	340	2,923
Tunisia	3,366	6,544	2,883
Upper Volta	197	515	—
Zaire	199	—	—
Zambia	22	133	—
Sahel-Regional	19,810	—	—
East Asia:	6,362	24,015	12,435
Cambodia	70	30	—
Indonesia	110	—	9,167
Korea	317	521	—
Laos	857	165	1,449
Malaysia	22	—	192
Philippines	4,933	22,660	382
Singapore	10	—	330
Vietnam	43	639	915
Latin America:	51,789	34,171	41,560
Antigua	—	18	—
Latin America—*continued*			
Bolivia	1,592	2,997	—
Brazil	18,753	5,656	2,442
British Honduras	149	—	43
Chile	—	421	5,386
Colombia	11,346	2,444	10,931
Costa Rica	526	1,714	228
Dominica	—	100	—
Dominican Republic	1,442	6,987	7,520
Ecuador	5,791	498	2,905
El Salvador	2,880	896	1,725
Guatemala	381	2,506	773
Guyana	256	70	—
Haiti	780	2,392	2,655
Honduras	376	1,142	3,429
Jamaica	813	17	39
Nicaragua	2,856	2,891	443
Panama	579	1,755	796
Paraguay	2	—	—
Peru	3,155	1,607	2,170
St. Kitts	—	60	—
St. Lucia	83	—	25
St. Vincent	29	—	50
Others:			
Europe	—	14	—
Malta	—	14	—
Near East-South Asia	45,191	32,326	40,186
Bangladesh	10,888	—	2,581
British Solomon Islands	115	—	80
Egypt	1,394	2,229	—
Gaza	159	640	3,481
India	30,965	27,626	17,092
Jordan, E.	156	170	310
Jordan, West Bank	525	119	247
Nepal	989	1,542	193
Pakistan	—	—	685
Sri Lanka	—	—	6,994
Turkey	—	—	7,959
Yemen	—	—	126
Grand total	153,002	124,530	120,525

[1] Food for Peace Program 1974 Annual Report, U.S. Government Printing Office, Washington, D.C., 1976.
[2] 1,000 pounds = 450 kg.
[3] Definitions: CSM (corn soybean mix); CSB (corn soybean blend); WSB (wheat soybean blend).

beans produced are used directly as food; however, the world food consumption of soybeans is low. Most of the soybeans produced are used for oil and feeds. Even in the two major countries that do consume soybeans, China and Japan, the percentage used as food is low. Only 15 percent of 889,000 t of soybeans used in the Republic of China in 1975 were for food; in Japan, only 22 percent of more than 3,000,000 t used yearly are for food.

Table 15 is on next page

TABLE 15.—*Use of soybeans by soybean-consuming countries (1964-66)*[1]

	Production	Import	Domestic use			Per capita consumption as food per year
			Food	Feed	Oil	
	1,000 metric ton					*Kilograms*
Asia:						
China, People's Republic	11,040	—	5,123	662	3,312	6.7
China, Republic of	62	169	88	—	143	1.1
Indonesia	367	—	294	29	22	2.8
Japan	223	1,931	497	16	1,594	5.1
Korea(s)	166	3	142	6	—	5.0
Malaysia	—	17	16	—	—	2.6
Philippines	1	18	6	—	13	.2
Singapore	—	16	8	—	—	4.3
Thailand	41	—	17	—	14	.6
Vietnam	13	—	13	—	—	.3 to .4
Africa:						
Nigeria	16	—	4	—	—	.1
Tansania	3	—	2	—	—	.2
Uganda	1	—	1	—	—	.1
Latin America:						
Brazil	474	—	95	—	263	1.2
Mexico	58	3	12	—	49	.3

[1] Food and Agriculture Organization of the United Nations, 1971, Food Balance Sheets. 1964-66 Average.

TABLE 17.—*U.S. exports of full-fat soy flour*[1]

Destination	1974	1975
	1,000 lb[2]	
Canada	146,974	111,409
Mexico	72,679	10,201
Salvador	1,099	2,581
Dominican Republic	2,222	3,295
West Germany	8,716	76
Switzerland	406	1,408
Portugal	4,566	66
Yugoslavia	—	3,442
Greece	5,654	3,234
Syria	—	18,637
Saudi Arabia	—	3,941
South Vietnam	2,310	—
Hong Kong	2,413	300
Australia	3,757	2
Egypt	26,479	11,034

[1] U.S. Foreign Agricultural Trade Statistical Report, 1975, Economic Research Service, U.S. Department of Agriculture, Washington, D.C., May 1976.
[2] 1,000 pounds = 450 kg.

In recent years, the United States has distributed cereal-soy blends to many countries. These mixtures may have been consumed as food in the recipient countries. The amounts of cereal-soy blends distributed and the recipient countries are summarized in table 16. Table 17 indicates the amounts of full-fat soy flour the United States exported during 1974 and 1975. This, too, was expected to be used as food.

Simple Village Process for Processing Whole Soybeans

During the 1960's NRRC developed a simple hand process for converting soybeans to a nutritious full-fat soy flour. The process was designed expressly for villages in foreign lands where skilled labor, electric power, and steam were not available.

Early studies showed that initial moisture was a highly significant factor in cooking rate. Beans soaked overnight, which reached moisture contents of 62 to 68 percent, cooked rapidly. Cracking the beans was not necessary for rapid cooking. Of the methods tried, water immersion was the best for rapid cooking and simple control. This method yielded a nutritive product and could be adapted to hand operation by untrained people.

Equipment

Table 18 lists the hand machinery for the process, capacities, and source. Capacities shown in the table are based on the use of hand power. Mechanical power can increase these capacities. For example, a ¼-hp motor could double the capacity of the hand grinder.

Process

The basic steps in processing whole soybeans are outlined in figure 2, and details for producing 136 kg of soy flour per day in figure 3.

Whole soybeans are soaked in water of drinking quality for several hours, drained, cooked in boiling water to cover, drained, air-dried, cracked, dehulled, and finally ground to flour.

TABLE 18.—*Equipment and cost information on making soy flour by hand process (capacity 136 kilogram soy flour per 8-hour day)*

Process step	Equipment needed	Capacity of equipment basis: soybeans		Source
		Kilograms	Time	
1. Soaking the beans	Four 208-L galvanized drums, plus 24 heavy porous cotton bags (about 46 by 115 cm)	172	Day	Generally available
2. Immersion cooking	Heavy gage galvanized steel tank, 200-L capacity	90	Hour	
3. Air-drying	Cloth, paper, or flat trays	—	—	
4. Hand cracking	Corn crusher, type S	—	Hour	
5. Winnowing (dehulling)	Hand-grain winnower, type A-1	45	Hour	CeCoCo Chuo Boeki Kaisha Central Commercial Co., Osaka-Fu, Japan
6. Hand grinding	Flour grind mill, type D (2 mills)	9	Hour per mill	

Of the original bean solids, 7 to 9 percent is lost in soaking and cooking.

The six steps follow and are illustrated in figure 4, A to F.

Step 1.—Soaking the beans

If possible, start soaking the beans before sunrise. This allows as much daylight time as possible for the drying step. Fill a cloth bag, or a perforated basket, one-fourth to one-third full with soybeans and lower it into fresh water in a container, such as a 208-L drum. The water temperature should be 240°C, or less, to minimize growth of micro-organisms.

To improve the flavor of the beans slightly, add 1 kg of sodium bicarbonate (baking soda) to 100 kg of soak water. Baking soda, however, does not have to be added.

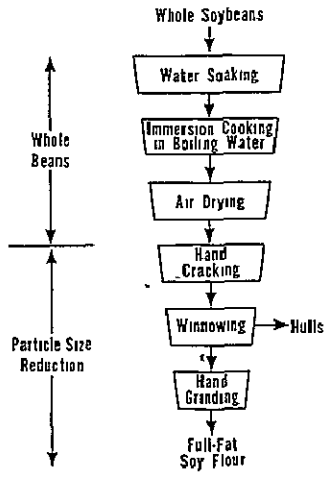


FIGURE 2.—Basic steps in processing whole soybeans.

After 4 to 6 h of soaking, the beans will swell to about twice their size and will contain more than 40 percent water. This soaking is needed for uniform cooking. Lift the beans out of the soak water, drain briefly, and put them into the cooking pot (fig. 4, A).

Step 2.—Immersion cooking

Cook the beans, still in the bag, in water at full boil for 10 min. Cooking can be done in an open pot over an open fire. In high altitudes, up to 3,000 m, cook at full boil about 15 min. This cooking is necessary to make the beans safe for eating but does not remove or destroy protein.

Lift the bag of beans out of the boiling water and allow to drain for a few minutes.

Cooking water can be reused about six times. The soybean hulls removed later in the process can be used as fuel.

Step 3.—Air drying

After the beans are cooked, spread them out to air-dry (fig. 4, B). The area required for drying soybeans in a single layer is about 0.5 m^2/kg of dry soybeans or a total area of 86 m^2 for 1 d production.

Drying conditions required for preventing mold or bacteria growth are discussed under **Sanitation Requirements.**

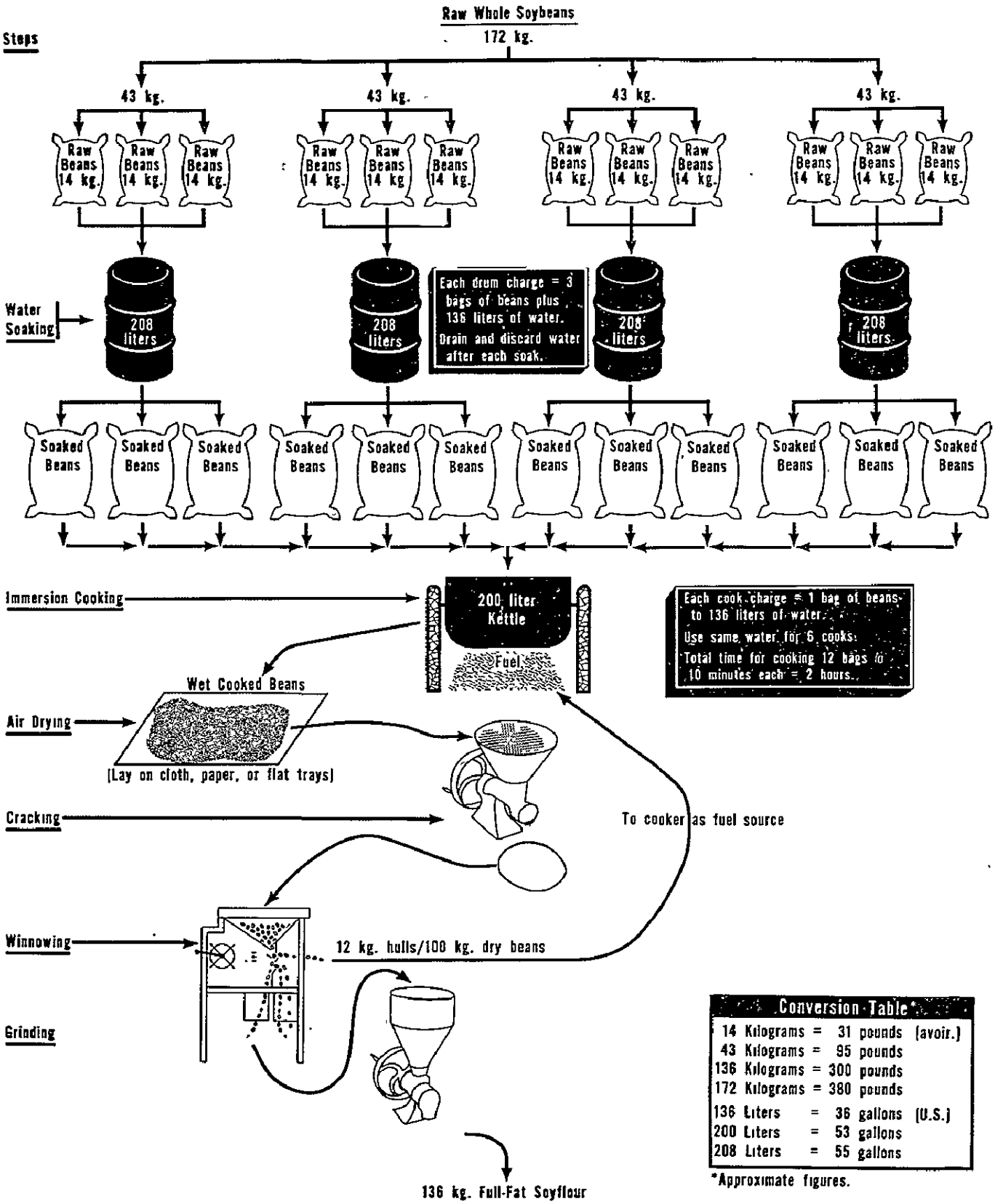
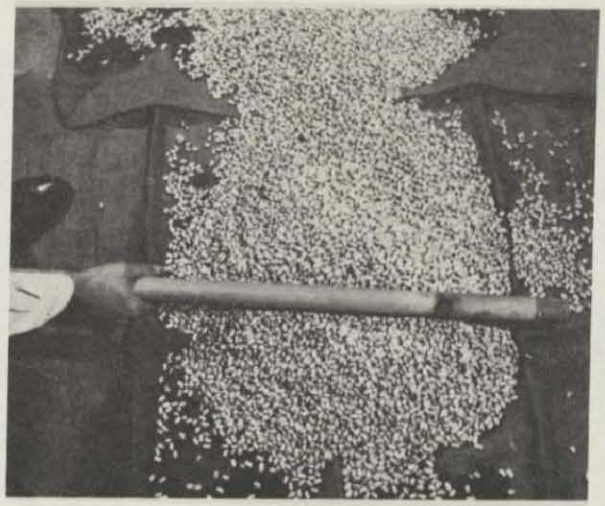


FIGURE 3.—Details for producing soy flour.

A PN-6302



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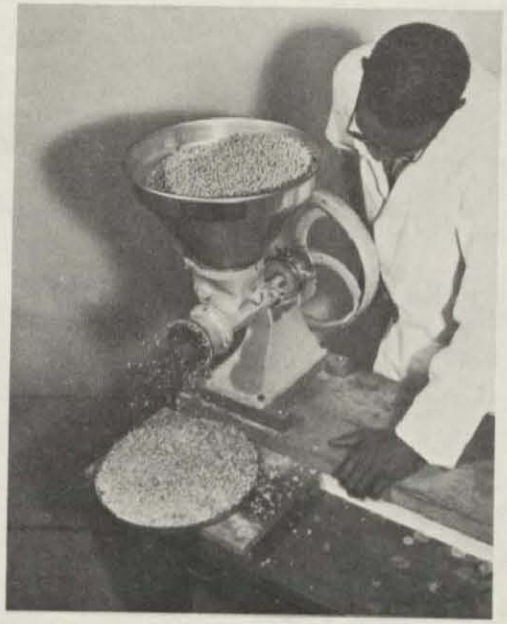

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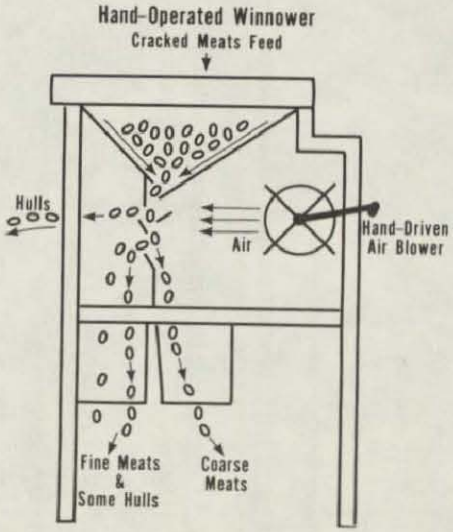
D PN-6305



E

F PN-6306

FIGURE 4.—Processing whole soybeans: A, cooking; B, air-drying; C, cracking cooked, dried beans; D, winnowing to separate hulls; E, diagram of winnower operation; and F, hand-grinding meats to flour.

The water content at the end of drying should be low enough to permit good separation of hulls in the cracking step (about 9 percent or less). A simple impact test may be used as a guide to determine when the beans are dry enough for cracking. In this test, place a few beans on a flat hard surface and hit sharply with a small mallet or a flat stone. The beans should break easily with clean separation of the hull.

Ideally, soy flour should be produced during the driest season. If poor drying conditions exist because of wet weather, high humidity, or lack of sun, make changes by drying with heated air.

Step 4.—Hand cracking

Crack the air-dried whole beans by using hand-operated equipment (fig. 4, C). Cracking frees the hulls (seedcoat) from the seed. Remove the hulls.

Step 5.—Winnowing

Place soybeans in the winnowing (dehulling) machine and hand crank the blower (fig. 4, D and E). The moving air lifts the light hulls and carries them to one side. The heavier meats (free of hulls) fall directly below. Put the rest through the machine again.

Step 6.—Hand grinding

Hand grind the dehulled soybean meats (fig. 4, F) to make the flour.

Sanitation Requirements

In all food processing operations, sanitary conditions are necessary to ensure wholesome food products. Food contamination can be prevented by strict observance of the following conditions.

Village workers

All workers must understand the need for maintaining clean, sanitary conditions. They must be in good health and keep their hands clean at all times.

Soaking

Use clean, pure water for soaking the beans. If the water is contaminated, boil before using. Do not reuse water to soak a second batch of beans. Examine the beans for insect or rodent contamination and wash the beans before soaking. Clean all equipment before using. Cover the soak pots during soaking. Wash all bags, soak pots, ropes, and utensils thoroughly with clean water after each use. Turn the bags inside out and expose to the sun to dry.

Cooking

Clean all cooking pots, utensils, and other equipment before using.

Drying

After cooking, spread the beans out in thin layers on clean paper, cloth, or trays in an area with good air circulation. Complete drying within 30 to 36 h with as much exposure to direct sunlight as possible. If air-drying cannot be finished within 36 h, use heated air. When drying conditions are bad, the flour made from the beans will not be good. For example, with slow drying, high bacteria counts and putrefaction can develop in 2 d; flour from such beans might be contaminated with molds that could produce toxic products. When mold can be seen, throw the beans away. Keep the drying area as free as possible from dust or any kind of dirt. Protect the drying beans from rain and dew.

Milling

Clean the winnower, cracking mill, and flour mill at the beginning and at the end of each day.

Flour storage

Store the flour in clean containers off the ground. Protect the containers and storage area against moisture, rodent, insect, and other possible contamination.

Quality of Product

Analytical data for typical full-fat soy flour produced by this process are shown in table 19. Protein efficiency ratios[22] of 2:0 and available

[22] Determined by A. N. Booth, Western Regional Research Center, Science and Education Administration, U.S. Department of Agriculture, Albany, Calif. 94706.

TABLE 19.—*Analysis of full-fat soy flour*

Constituent		Range	
Protein	Percent	41.0 to	42.0
Crude fat	do	20.0 to	23.0
Ash	do	5.0 to	7.0
Moisture	do	6.0 to	8.0
Crude fiber	do	2.5 to	3.0
Urease activity, pH change		0 to	.1
Nitrogen solubility index		15.0 to	20.0
Available lysine, percent of protein		6.0 to	6.5
Protein efficiency ratio average		2.0 (Casein, 2.5)	

lysine values in the range of 6 to 6.5 indicate good nutritional value.

The flour has been tested in many basic food formulas and food combinations in cooperation with SEA's Nutrition Institute, Agricultural Research Center, Beltsville, Md. It has good flavor acceptability and stability. Types of food that were prepared include breads (with wheat and corn flour), cooked vegetable and stew dishes, cereal products (noodles, porridge), cooked desserts, and beverages for babies and young children (table 20). In infants' beverages, a flour-water dispersion of improved smoothness will be obtained if the flour is finer ground or if the mixture is homogenized.

Evaluation of Product in Formulas and Procedures for Family and Institutional Use in Developing Countries

Full-fat soy flours processed by the village method at NRRC were supplied to the Nutrition Institute to evaluate. Basic formulas, food combinations, and preparation procedures suitable for use by families and community groups were developed for flours made from soybeans.

The maximum amount of soy protein flour to provide a palatable food product was determined. Formulas for soy flours included beverages and soups, main dishes, breads, cereal products, and desserts. All products were evaluated for appearance, texture, flavor, and acceptability by a panel at the Nutrition Institute and at Howard University, Washington, D.C.

The panel at the Institute rated the palatability of most of the food products prepared with soy flours from fairly good to very good. The soy products rated very good were bean cake, creole eggplant, biscuits, cornbread with egg, cornmeal squares, seasoned rice, rice-spinach, and puff-puff doughnut holes.[23]

TABLE 20.—*Yield and protein analysis of basic products*[1]

Product	Yield	Protein
		Percent
Milk	6-7 L	4
Atole	2-3 L	8
Pasta	2-3 kg	18

[1] From 1 kg soybean, adding about 9 L water in the boiling process.

NRRC Village Process

The village process has had a considerable impact in the field as indicated by its introduction overseas and the large number of requests for information. UNICEF purchased and shipped equipment to countries in Latin America, Asia, and Africa.

In July 1967, the Government of Brazil requested that USDA representative visit their country and demonstrate the village process to their Children's Bureau, Department of Health. NRRC sent an engineer for 3 weeks to meet with Brazilian officials, present technical details, and develop interest in the process. Since then, UNICEF has distributed six sets of village process machinery to several locations in Brazil to evaluate, principally, to child nutrition and education centers. In a rural extension service project approved by the UNICEF board at Santiago, over 100 sets were sent to Brazil. Procurement, however, was withheld until a complete evaluation was made of the previous sets provided to Brazil. Since that time, UNICEF has been supplying sets of machines for the village process to various countries.

In 1969, Y. H. Yang, FAO nutrition officer, stopped at NRRC and reported a successful 2-year field service program in Korea. In 1968, UNICEF supplied two sets of village equipment there. His report indicated a successful village operation at the pilot village of Kang Wondo,

[23] Schlosser, G. C. and E. H. Dawson. Cottonseed Flour, Peanut Flour, and Soy Flour: Formulas and Procedures for Family and Institutional Use in Developing Countries, U.S. Department of Agriculture, ARS 61-7, July 1969.

where the process was taught and carried out. Full-fat soy flours of good quality and acceptability were produced. The flours were used to make instant dry powder formulations that would be reconstituted with water as porridge, soups, or enriched noodles.

In addition, UNICEF has furnished village equipment to India, Tanzania, Philippines, Guatemala, and Mexico. In Tanzania, five sets were provided to the Ministry of Agriculture Training Institute, Morogors, implemented by a food scientist and a food technologist to direct the training program in three African villages. More recently, 30 sets of village equipment were delivered to northwestern Mexico.

Industrial Production and Selling Prices of Edible Soybean Protein Products

Table 21 gives estimates of U.S. production of soy flours, concentrates, isolates plus textured flours and concentrates for 1976. Soy flours are the predominant form produced, and they sell at the lowest price of the five protein types. Concentrates and isolates are manufactured at about one-eighth the scale for the flours but they sell at more than two to five times the price paid for flours. Flours are the major form used for preparing textured items. Textured concentrates were introduced in 1975 and, consequently, have not developed a large market yet.

Faced with the question of whether to start producing and marketing edible soy protein, several soybean processing cooperatives turned to USDA's Farmer Cooperative Service (now a part of the Economics, Statistics, and Cooperatives Service) for help. Because the requests were similar, the facts were published in "Edible Soy Protein—Operational Aspects of Producing and Marketing," FCS Research Report 33, January 1976.

Barriers To Accepting and Using Soybeans in Food

Introducing a new food in any country is difficult, and hurdles must be overcome if such a venture is to succeed. Some of the major factors likely to have influence on soybeans in the diet of a developing country are discussed below.

Availability

Soybeans must be available through imports or local production; local production is preferable. Ideally, soybeans should be available at a cost below that of other legumes for which soybeans may be substituted.

TABLE 21.—*U.S. production estimates for soy proteins, 1976*[1]

Protein form	Protein content	Selling price per kilogram	Annual production (estimated)
	Percent		*Million kilograms*
Flours	50	$0.31	281
Concentrates	70	0.70-0.77	36
Isolates	90	1.58-1.65	34
Textured flours	50	0.48	54-59
Textured concentrates	70	0.73-0.77	1.8-2.3

[1] Personal communication with N. R. Lockmiller, A. E. Stanley Mfg. Co., Decatur, Ill. 1976.

Cultural and Social Factors

Soybeans consumed directly in family meals have been the subject of a number of books and manuals presenting simple-to-follow cooking recipes. However, the main and critical deterrent to using soybeans as food is cultural background. Except for the Far Eastern countries, food use of soybeans is new to the cultures of most peoples of the world. Social taboos can be a major hindrance to the food consumption of soybeans. For example, soybeans have sometimes been called a poor man's food or animal feed. When this occurs, promoting soybean foods to the poor undernourished populations, where the need is greatest, becomes extremely difficult. In countries such as Mexico, soybeans have been promoted as a food for the

affluent class before introducing soybeans as food for the poor. The cultural situation must be assessed carefully in selecting possible methods for integrating the soybean into the traditional or indigenous foods of a given country.

Texture

The whole soybean is the simplest form for introducing directly into the diet, but like other legumes, soybeans must be cooked before eating. Unlike legumes such as peas and beans, soybeans are more difficult to cook, and texture of cooked soybeans differs from that of other legumes. Difficulties in cooking to a desirable texture is a complaint cited by many who have attempted to develop simple processes for food use of soybeans in various countries (Final Report on Contract AID/CM/ta-c-73-19, University of Illinois). If soybeans are converted into flours and added to foods, texture may also be influenced adversely. For example, replacement of wheat flour in bread with soy flour results in undesirable textural changes that can be overcome only by adding special emulsifiers.

Flavor

Soybeans in their raw state have characteristic beany and bitter flavors that make them unpalatable. These flavors are decreased significantly by cooking and other processing, but residual flavors are often still objectionable. In many of the oriental soybean food products, the flavor problem has been overcome by fermentation to develop new flavors and destroy objectionable ones. Although acceptable to many of the Eastern populations, such flavors are foreign to many others and may be unacceptable.

Nutrition and Food Safety

In any program introducing soybean as a food, nutritional quality plays an important role. Much has been published about the destruction of antinutritional factors during heat treatment or processing of soybeans. Antinutritional and physiological factors in raw and improperly processed soybean products have been a barrier to soybean product use particularly where soy has replaced a food of such proved, high-nutritional properties as milk, meat, or eggs. Developing new processes, whether for the village level or for larger scale commercial application, will require careful study to ascertain that maximum nutritional properties of soy protein are developed and maintained during each of the process steps.

Food safety also must be maintained in the processing. Otherwise, this becomes a serious barrier to soybean use. Particular attention must be paid to the quality of the soybeans used as a raw material as related to storage problems and development of bacteria and mold toxins. Soybeans in storage must be protected from insects and rodents. Soybeans must be handled to minimize breakage because broken beans are more subject to mold and bacterial attack and nonuniformity in cooking. During processing, especially if high moisture and temperatures prevail over lengthy periods, bacteria can be a big problem with soy proteins and may lead to contaminated products unfit for human food.

Technology Development

As summarized in this publication, a variety of simple methods are available for introducing soybeans into the diet. Nonetheless, many of these processes may be unsuited to some countries for a number of reasons. For example, fuel may be scarce, so that the usual, long cooking times required for soybeans would be unacceptable. Therefore, a continuing need exists for alternate technologies to incorporate soybeans into the diet in different countries. This can consist of new processes and modification of available technologies to suit a local situation.

Technology Transfer

Even with a variety of technologies for using soybeans in foods, many problems are encountered in attempting to transfer them to a foreign country. Developing the technology is only a first step. Successful promotion of a method requires immediate followup by setting up a field program to train local groups to produce soybean food products and then to use them in the native diets. Feedback from the local

groups to the original process developers is of utmost importance so that process modification can be made to better fit the field situations if necessary. In addition, promotional efforts would be aided by communication between all parties involved. Lack of information exchange in the past has resulted in little or no progress and in duplicated efforts by different groups.

*U.S. GOVERNMENT PRINTING OFFICE: 1979 0-280-931/SEA-32