Government Role and Participation in Development and Marketing of Soy Protein Foods

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ABSTRACT

Japan has a history of utilizing soybeans as human foods. Currently, a great quantity of defatted soybeans is used as animal feed in Japan, and governmental and commercial enterprises are anxious to turn the defatted soybeans directly into foods for humans. Therefore, they are putting great efforts into soybean research and development. Since the demands for better foods are rising and their resources are not abundant, I feel that soybean protein will play an important role by exerting its unique properties, not only to supplement other foods, but also to grow into new types of foods when their unknown properties are disclosed.

INTRODUCTION

Large amounts of soybeans have been consumed by the Chinese and Japanese as foods for many generations. Miso, soysauce, tofu, natto, and other traditional soybean foods are important parts of the diets of the Japanese. Based upon this fact and considering the world food situation, I will discuss soy protein food marketing, research, and development, emphasizing our governmental role and participation. Before discussing the main subjects, I would like to describe the recent Japanese situation regarding nutrition and supply and demand of foods and feeds, including the significance of soybeans.

Recent nutritional figures for the Japanese are almost satisfactory, with supply of 78 g protein and 2500 cal/person/day. Protein supply has increased by 7-8 g compared with 10 years ago and total calories by 100. Protein from animal, including fish, supply ca. 40% total protein. Rice is still the most important food item in Japan, but its position is gradually declining. Its proportion, including other grains, in total calories is 50% or less which is a 10% reduction in the last 10 years.

The above tendency is supported by the increase of national income, and it seems it will continue if economical growth of Japan keeps its present pace. Of course this is desirable from the nutritional view point, since it means the increase of the supply of oil and animal protein in diets.

However, it is a problem to meet these increasing demands for animal foods. Japan does not produce all the foods and feeds necessary but depends on imports, which

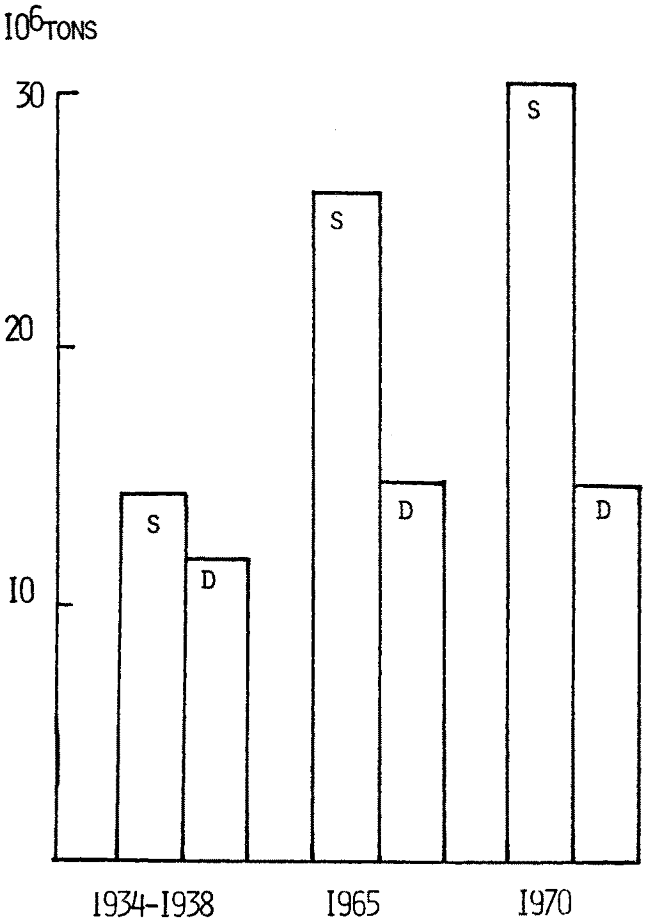

FIG. 1. Supply of grain in Japan. S = total supply, D = domestic production.

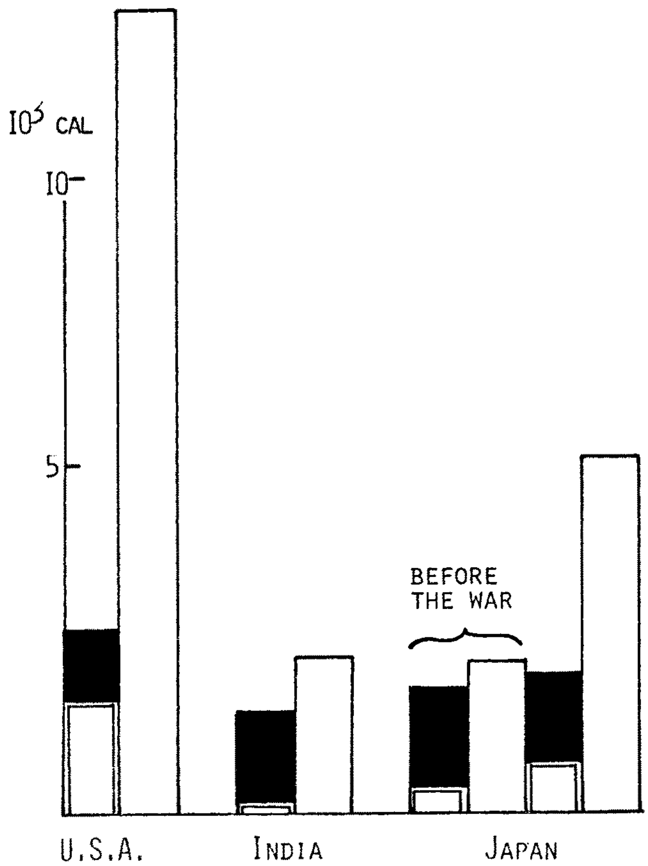

FIG. 2. Calorie intake/head/day in U.S., India, and Japan.

□ total original calorie

■ total calorie { vegetable / animal

TABLE IA

Supply and Demand of Whole Soybeans in Japan (1000 metric tons)

		1970	1971	1972
Supply[a]	Domestic production	57	57	58
	Imported	3420	3461	3644
	Total	3477	3518	3702
	Crushed for oil	2505	2521	2636
Demand	Miso	174	180	185
	Shoyu	13	12	15
	Tofu and fried tofu[b], Kori-tofu, Natto, Kinako, Others	522	534	558
	Total of foods	709	726	758
	Feed (kinako)	10	20	30
	Grand total	3224	3267	3424

[a]Includes carry over but not producers' home use.

[b]Ca. 360,000-380,000 tons.

TABLE IB

Supply and Demand of Defatted Soybeans in Japan (1000 metric tons)

		1970	1971	1972
Foods	Miso, Shoyu	168	170	175
	Tofu and fried tofu[a], Others[b]	135	130	130
	Total of foods	303	300	305
Non-Foods	Chemical industry	3	2	2
	Fertilizer	13	5	3
	Feed	1639	1670	1803
	Others	8	5	6
	Total of non-foods	1663	1682	1814
	Grand total[c]	1966	1982	2119

[a]Ca. 70,000-80,000 metric tons.

[b]Over 10,000 metric tons for chemical shoyu.

[c]Corresponds to whole soybeans crushed for oil.

will continue to increase in the future. Grains for feeds for raising hogs, chickens, and other livestock are imported from foreign countries. Figure 1 illustrates how grain supplies have been changed from prewar to postwar. Figure 1 shows totals of rice, wheat, barley, soybean, corn, and milo and indicates how grain consumption increases year after year, while domestic production does not increase. This means, of course, the increase of imported grains, which, except for wheat, are used mainly for feeds.

It is said that calorie needs for animals is 10 times what humans get from animal foods, such as meats, eggs, milk etc., because a great many calories are consumed by animals for maintaining their life and physical activities. In the case of these animal foods which are obtained by giving feeds to animals, calorie need sometimes is calculated by way of original calories. Original calories include calories of vegetable foods and calories of animal foods multiplied by 10 as that of feeds necessary for producing these foods. Figure 2 compares per capita/day original calorie intake of the U.S., Japan, and India. It is clear from these data that the original calories rise according to the rise of animal food consumption and that Japan's original calorie rise after the war is striking. From the standpoint of better economy of natural resources, the animal industry is fairly inefficient, and it is evident to us now that we must make efforts to develop new feed from resources which are not now suitable for food uses. At the same time, we must investigate new ways of using wheat and soybeans for foods.

JAPAN'S SOYBEAN SUPPLY AND DEMAND

As already suggested, large amounts of soybeans are consumed in Japan every year for traditional foods, such as miso, soysauce, tofu, and natto and also for getting oil (1). Total consumption of soybeans in a year is ca. 3.5 million metric tons. Ca. 1 million metric tons of soybeans are used for foods, some of which are available after removing oil. Over 80% of the total consumption is for oil.

Figure 3 shows the recent trend of soybean consumption in Japan. Soybean meals, the resulting products of oil extraction, are used mainly for feed, perhaps accounting for 75% total meals. The meals also are used for foods, such as soysauce, miso, tofu and its derived products, seasoning, such as acid-hydrolyzed amino acid solution, and new protein foods, including textured protein foods.

It must be noted that over 90% of the soybeans consumed in Japan are imported from foreign countries, mainly the U.S. Domestic production has been decreasing rapidly over the years. Table I shows supply and demand of soybeans and defatted soybean meals. Table IA presents figures for whole soybeans, and Table IB presents those of defatted meals. Consumption of the traditional soybean foods will continue to be a major portion of the diet, even if not markedly increased; however, the Japanese diet pattern now is changing by the rapid increase of new food items into the diet. This is the reason why soybeans should be processed into the nontraditional foods, such as meat extender, meat substitute, milk substitute, and other new food ingredients.

THE PRESENT SOYBEAN PROTEIN FOOD MARKET IN JAPAN

Several companies are now producing new protein foods from soybeans and wheat. As in other countries, new uses for soybean protein have been found in viscoelastic modification and emulsification in meat products, prevention of retrogradation of starch in bread, and permeability control of oil in cakes. Using 5% maximum in bread, sausage, cookies, etc. is the practice. Another use of soy protein is as an extender in meat products, milk products, and sometimes their substitute. In the case of meat products, it must have a chewy property like meats. A 30% incorporation seems to be the present practice, but if the property can be even further improved, its use will increase. It is important, however, to remove the beany flavor in this case; and it seems that isolation of protein from soybean is the best approach.

In Japan soybeans for new food uses are in the form of defatted soybean meals, dehydrated soy milk, protein concentrate, and protein isolate. Defatted soybean meals and protein concentrates are used as ingredients but are not suitable as extenders because of flavor. They can only be mixed in breads, cakes, and meat products, such as sausages. Dehydrated soybean milk is mixed in fish sausages, and its binding property is highly desirable. Protein concentrates are prepared by removing soluble nitrogen and carbohydrate compounds from defatted meal with alcohol or dilute acid. Beside these, there is another type of concentrate which is made by heating defatted meal with water, adding calcium chloride to precipitate protein, filtering, and then washing. This is wet protein concentrate which is composed of calcium-precipitated protein and insoluble carbohydrate. This product is used for mixing with fish to make fish paste products, because protein mixed with fish can form a gel when heated.

Protein concentrates usually are processed by cooking extruder to make textured protein foods which have chewy characteristics and less beany flavor. Protein isolate which is prepared by alkali extraction of defatted meal, precipitation by acid, and washing is used in bread, cake, and

TABLE II

Production of New Plant Protein Foods in Japan[a] (metric tons)

	Total	Textured and spun (frozen)	Powder	From soybean	From wheat
1970	24,217	8504 (7585)	15,713	14,401	9816
1971	27,309	9591 (8200)	17,718	15,895	11,414
1972	28,016	10,637 (9016)	17,379	14,485	13,531

[a]Figures show wt of products.

[b]All figures include such uses as of emulsifying, fat retention, and retardation of starch retrogradation.

sausage, as already mentioned, and also to mix with ground meat or fish. When it is mixed with water, it can form firm gel when heated. Protein isolate also is used as a material for spun protein which has excellent chewing characteristics. It is then mixed with ground meat and other meat products. The problem is that alkali treatment may destroy some amino acids and decrease its nutritional value. It is also necessary to solve the problem of cost and pollution by whey. Table II shows recent production of new protein foods from soybean and wheat in recent years. Amounts of soybeans for these foods are 30-40 thousand metric tons/year.

ADMINISTRATIVE ASPECTS WITH RESPECT TO SOYBEAN PROTEIN FOODS

What administrative measures have been taken to cope with this situation? I am going to describe a few measures taken by Japanese government and add a personal view.

Japan Agricultural Standards (JAS) (2) specify how the foods sold to consumers should be qualified. As already mentioned, soybean and wheat proteins are mixed in hams and sausages because of their functional properties. The Ministry of Agriculture and Forestry authorizes this fully recognizing the functional properties within the limit of certain percentages, and the Ministry permits the foods with soybean and wheat protein to bear JAS mark as shown in Table III. Soybean protein is incorporated in this case for its oil-emulsifying property and viscoelastic modification, not its meat-like chewiness. As development of new products continues, use of soybean protein as a meat extender naturally will call for an adjustment of JAS. There also will be a time when specifications of materials themselves will be discussed. In a country like Japan where resources are short, it is not wise to make specifications on food standards too rigid. If that is done, it may shut out use of new materials. Rather, specifications should be directed toward avoiding undesirable or inferior materials. To make foods delicious, nutritious, and cheaper, the use of new materials should be promoted.

As for labeling, it should be strict. For instance, what to name a hamburger steak which contains soybean protein is a matter that requires much caution to avoid confusion. When a product like ham or sausage is made only from soybean protein and has characteristic properties which real ham or sausage do not have, a name entirely different from existing products is needed, as in the case of margarine in place of natural butter.

Our Ministry of Education is interested in using soybean protein in school lunches (3), because of its relatively low price and its high nutritional value. The Ministry is trying to get protein for school lunch from milk, milk products, animal meats, poultry, eggs, fish and shellfish, and soybeans and soy products. For a child of 9-11 years old, the protein requirement/day is 30 g, of which 13 g must come from animals and the rest from vegetables. This year's budget for school lunches suggests that they positively

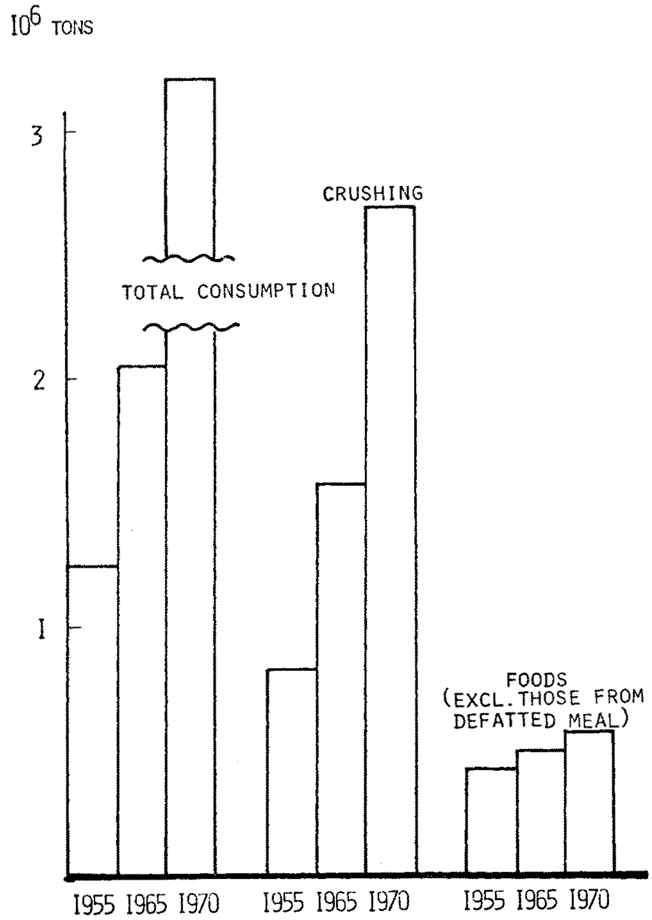

FIG. 3. Consumption of soybeans in Japan.

intend to use soybean protein in the school lunch program.

National School Lunch Corporation of Japan recently drew up recommended school lunch menus, one of which contained potato mix, which incorporates a meat-like material made of soybean protein. This material (10 g) is mixed in each 100 g flake products. The Prefectural Educational Committee also has made recommended menus, including a "school hamburger" which authorizes use of a vegetable protein as an ingredient. Dried soybean protein material (2 g) is allowed to be mixed in each 80 g hamburger. Other Committee menus use a meat-sauce containing minced meat mixed with soy protein, where 30% meat is replaced with hydrated soy protein. In any case, the reason why the new soy protein products came to be used for school lunch is because Japan's cheaper traditional soybean foods compared unfavorably with bread in menus. The fact that the mixture of 30% soybean protein in the meat has been authorized in the U.S. also has encouraged the above movement.

Several firms in Japan which are now manufacturing soybean protein isolate have a problem of whey, which is a by-product solution containing sugar and nitrogen compounds. It has no reasonable use and may cause waste disposal problems. Kori-tofu manufacturers have the same problem. The Ministry of Agriculture and Forestry now is subsidizing a project to promote practical use of reverse osmosis for recovery of useful materials from the whey. The government always is willing to grant assistance for soybean protein projects for food use to encourage this industry.

RESEARCH AND DEVELOPMENT PROJECTS CONCERNING SOYBEAN PROTEIN FOODS AND THEIR ACHIEVEMENTS

I would like to discuss some achievements of a large

TABLE III

JAS Specification Concerning Use of Soybean Protein in Ham, Fish Ham, Fish Sausage, and Kamaboko

Product	Binder	Grade		
		Special	High class	Standard
Press ham	Starch, wheat flour, corn meal, vegetable protein, or skim milk	Below 3%	Below 3%	Below 5% (Below 5% in the case of starch, wheat flour, or corn meal)
Mixed ham	Starch, wheat flour, corn meal, vegetable protein, or skim milk	Below 5% (Below 3% in the case of starch, wheat flour or corn meal)		
Fish ham and fish sausage	Material should not contain binder other than starch, egg white, vegetable protein, casein, and gelatin			
Casing kamaboko	Material should not contain binder other than starch, egg white, and vegetable protein			

governmental project, termed "utilization technology of protein and development of protein resources." I would particularly like to focus on the part concerning soybean protein. This project has been carried out under the various institutes in the Ministry of Agriculture and Forestry and will be completed within this fiscal year.

I already have described the background of this research, and I shall not repeat it, except to say that the project includes work on use of wheat protein, single cell protein, and development of new feeds and breeding of high protein rice and soybean varieties. Briefly, I will summarize the basic principles behind this research on food uses of soybean protein.

In Japan, soybeans have been processed into many types of foods which vary in appearance, state, and physical properties. For instance, tofu is a light, elastic gel, while aburaage (fried tofu) has tough, porous texture and kori-tofu is a sponge. This example indicates soybean protein's wide possiblilities of changing the property depending upon processing conditions, such as temperature, ionic strength, and pH; and it suggests that it might be possible to develop new properties under different conditions, thereby discovering new uses.

If we have more detailed knowledge on soybean protein's nature, exploratory work for new food materials from soybean could be better systematized for more efficiency. However we still do not know much about it, so the primitive trial and error methods still have to be used. However, the exploratory work on soybean protein is progressing rapidly, and it will soon be made more effective. Before I discuss the results obtained in the research and development projects, I think it will be helpful to mention some of the results of our research on the traditional soybean foods.

Standardization of Tofu Manufacturing (4)

Tofu is a curd made by coagulating the hot extract of soybean with calcium salt. Its technique still depends upon experience. Tofu plants are small, on the average, consuming only 50 kg soybeans/day. We have analyzed the procedures and discussed how the conditions for manufacturing affect the yield and quality of tofu and established standard procedures. This has helped to make imported soybeans useful as tofu material, which otherwise had been not welcome by tofu manufacturers.

Influence of Variety of Soybeans on the Quality and Yield of Tofu (5)

It is known that the quality and yield of tofu were different depending upon soybean variety, but the reason for this was not known. Now we have found that soybeans with higher P/N (ratio of phosphorus to nitrogen content) value are better for tofu making and that the ratio of 7S to 11S fractions in the soybean protein must be in a certain range for making satisfactory tofu.

Standardization of Kori-Tofu Manufacturing (6)

The product termed kori-tofu is a porous cake made by freezing, frozen storage, dehydrating, and drying soybean curd. The process was analyzed, as in the case of tofu, and standardized.

The Spongy Property of Kori-Tofu (7) (8)

The process is the way of drying tofu without case-hardening and denaturation of soybean protein during frozen storage. We found that concentration of protein during freezing and storage caused formation of intermolecular S-S bonding which may result in the formation of sponge texture.

Evaluation of Variety of Soybean for Miso Manufacturing (9)

Miso is a product made of steam-cooked soybeans mixed with rice "koji," water, and salt and left for fermentation. It was discovered that the hardness of the cooked soybeans greatly influenced the quality of the final product, which comes from carbohydrate content of soybeans which are fairly different depending upon the variety.

The results of work on the traditional soybean foods were almost entirely utilized by our large research and development projects, and the main results obtained are reported below.

Separation of 7S and 11S Fractions (10)

During our research on the variety evaluation for tofu making, distinct differences of physical properties of the curds were observed between 7S and 11S components. From this observation we developed a conventional method of separating 7S and 11S fractions and found a possibility of using those materials for a special food use.

Development of a New Protein Material by Freezing and Frozen Storage (11)

During research on the formation of the spongy texture of kori-tofu, we discovered that freezing the soybean protein solution caused the insolubilization of the protein. By selecting the conditions, a fibrous product could be obtained. The product has an excellent property as a meat extender.

Removal of Beany Flavor of Soybeans (12)

By treating soybean milk with a strain of Rhizopus, the beany flavor of soybeans could be removed partially. Milk run through Rhizopus layer in pipe removed the flavor continuously.

Separation of Enzyme for Coagulation of Soybean Milk (13)

By separating an enzyme from a Streptococcus for coagulation of soybean milk, a possibility was found to get new protein foods by combining this enzyme process with the method of removing beany flavor.

Research on Microorganism Enzyme which Dissolves Carbohydrates of Soybeans (14)

It was impossible to find a single enzyme which digests carbohydrates of both soybean hulls and cell wall. However an enzyme which could extremely enhance the digestion of the carbohydrates if mixed with other cellulases was separated from a strain of *Bacillus subtilis*. With this, a major portion of soybean carbohydrates could be made soluble, and we could foresee possibilities for developing new products and making improvements in the process of tofu and protein isolate production.

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