19. ADVANCED FOOD TECHNOLOGY OF SOYBEAN AND OTHER LEGUMES IN JAPAN

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Ancient Chinese literatures reveal that soybeans were extensively cultivated and highly evaluated as food resource. It is true that the legumes including soybean have been quite familiar for centuries to the people in the Orient, and therefore, many food items derived from them are still very popular in their eating habits.

In Japan, a large amount of soybeans and other legumes are consumed traditionally after reasonable processing. Recent amount of consumption of soybean and other legumes for these traditional food in Japan are shown in Table 1.

Soybeans consumed for these products depend more heavily upon import from

Table 1. Amounts of soybean and other legumes consumed for the traditional foods.

Food	Production (1000 metric ton)
Whole soybean products	
Tofu and Fried-tofu	295
Miso	169
Natto	47
Kori-tofu (dried or frozen Tofu)	34
Shoyu (dried or frozen Tofu)	15
Kinako	12
Others	70
Total	642
Defatted soybean products	
Shoyu	154
Tofu and Fried-tofu	77
Miso	8
Others	45
Total	284
Other legume products	
Ann (bean paste)	240
Cooked bean	42
Toasted bean	21
Amanatto (sweets)	12
Others	33
Total	349

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Table 1. (cont.)

Food	Production (1000 metric tonn)
Peanut products	
Toasted peanut	
Confectionary use including	56
Peanut butter	48
Total	104

the U.S. and China than domestic production, and peanuts are also imported from China, Indonesia and Holland. Other legumes are partly and increasingly depending on import from abroad.

These traditional foods have been greatly influenced by the change of the nation's eating habits. The changes of food consumption patterns along with the extraordinary growth in the economy in the past decade are principally an increase in protein and fat intake with a corresponding decrease in carbohydrate. Protein intake per capita per day in 1970 was 76 g and that of fat was 40 g. This is a 20% and 25% increase, respectively, compared with 1960. This increase in protein intake is attributed to increased consumption of animal products including beef, pork, chicken, eggs and milk. Table 2 shows current price of Japanese protein foods. Generally speaking, traditional soybean foods are lower in price than meat products, but egg keeps reasonable price because of successful system of supply. New soybean foods, though they are not still processed, show the lowest price in spite of their sophisticated processes and it suggests the possibility that they are

Table 2. Current price of Japanese protein foods.

Food and Food Materials	Yen/100g	Yen/100g protein
Soybeans	7	20
Defatted soybean meal	6	13
Tofu	10	166
Aburaage	45	240
Kori-tofu	50	93
Miso	20	158
Fried kamaboko	50	417
Fish sausage	40	265
Egg	30	235
Chicken meat	70	333
Milk	15	518
Beef	150	775
Ham	150	800
Pork	80	600
Spun protein	20	75
Textured protein	40~50	60~80
Dried soy milk	18	30
Concentrate	20	30
Isolate	40	36

used as imitative or substitute foods for animal protein resources.

Moreover, the westernization of the eating habits has had remarkable effects on the kind of daily dishes which go well with cooked rice or on sweets and cakes. All of traditional foods should compete to new food forms in the market, for instance, Tofu and its derivatives compete to meat products and Ann to cakes and chocolate. That is, it may mean that recent eating habits in Japan has had a multiform property, including all kinds of food types, namely Western, Chinese and traditional Japanese foods and then changing into just adequate and favorite food type for the Japanese themselves.

In this presentation, the traditional food processing of soybean and other legumes including the introduction of new technologies will be discussed. Soybean will be the focus of the discussion because its utilization is most promissing in Japan. Fermented soybean foods will not be included here because they will be reviewed next by Dr. Ebine. Finally, production of new protein foods which are recently becoming popular in Japan will be briefly described, and then our recent research results concerning new protein technologies of soybean will be introduced.

Traditional Food Use of Soybean

From the list of the traditional soybean foods in Japan, fresh Tofu, Abura-age, Kori-tofu, Yuba and Kinako are picked up as non-fermented ones. These foods have been very popular among the Japanese people for a long time, and at present, being supported by the development of machinary and processing technologies, they are still very popular and important protein source for the Japanese people.

1) Fresh Tofu.

Procedure of Tofu making is shown briefly in Fig. 1. Soybean milk is obtained by hot extraction of ground soybeans. Protein in soybean milk is coagulated with oil by calcium and magnesium salt. It contains 88% moisture, 6% protein, 3.5% oil in average, easily digestable and highly nutritive because all indigestible fibrous matters and most part of toxicological substances like trypsin inhibitor in original soybeans are removed by filtration or heating processes. From 10 kg soybean 40 kg of Tofu is obtained. Momen-tofu, most popular type of Tofu shown in Fig. 1 is made by coagulating, molding in box with holes and removing whey. By changing partly the process of Momen-tofu, several kinds of fresh Tofu are prepared.

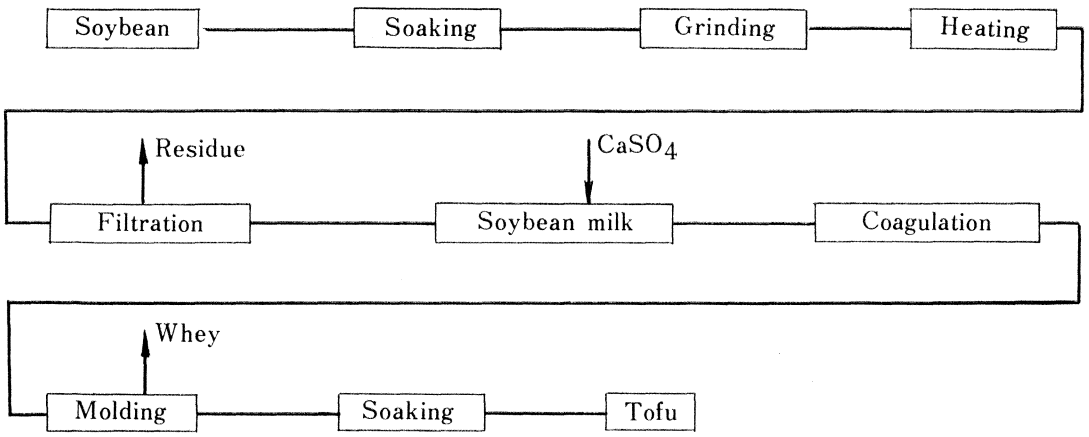

Fig. 1.

Among them, Kinugoshi-tofu is fairly popular especially in summer season, and produced by coagulating more condensed thick soybean milk without removing whey. The resulted curd is softer on tongue and homogeneous than Momen-tofu. Packed Tofu is becoming popular because of their sanitary condition and easy transportation. They are made by heating the mixture of soybean milk and coagulant sealed in plastic film bag.

Generally speaking, Tofu is produced in small scale because fresh Tofu is fragile and not preservable for long distance, but now by the development of new type of packing film and machines, new transportation facilities, continuous cooker and filter, large scale plants are increasing. The continuous production of Tofu in large scale requests scientific process control and it is easy in the case of packed Tofu, especially when glucono-delta-lactone (GDL) is used as coagulant.

Spray-dried soymilk for Tofu making is also on market, saving the time for soaking beans and extracting milk. Soybean milk can be obtained only by heating with water. Small package of the dried soybean milk for home made Tofu is available. Defatted soybean meal is used for Tofu making being mixed with whole soybean. Fresh Tofu is eaten daily with soy sause and miso in raw or in hot dishes. The kind of dishes are numerous.

2) Aburaage.

Aburaage is one of the most popular foods derived from Tofu. Thin sliced Tofu, after being dehydrated by press, is deep fried in two stages, at lower (110°C) and higher (180°C) temperature. By frying, Tofu swells about 3 times in square, its texture becomes porous and color of the surface gets yellow. Aburaage is made on a large scale than Tofu, using continuous deep frier, because they can be transported for longer distance and are more preservable. Aburaage is also eaten daily as Sushi or dishes cooked with vegetables.

3) Kori-tofu.

Consumption of soybeans for Kori-tofu is much less than those for fresh Tofu, about one tenth of fresh Tofu including Aburaage. It is local more or less. But it is interesting food for its characteristic texture and high protein content. Brief procedure of Kori-tofu (dried Tofu) making is shown in Fig. 2. Hard fresh Tofu of 80 to 85% moisture is frozen at about −10°C and then aged at −1 to −3°C for

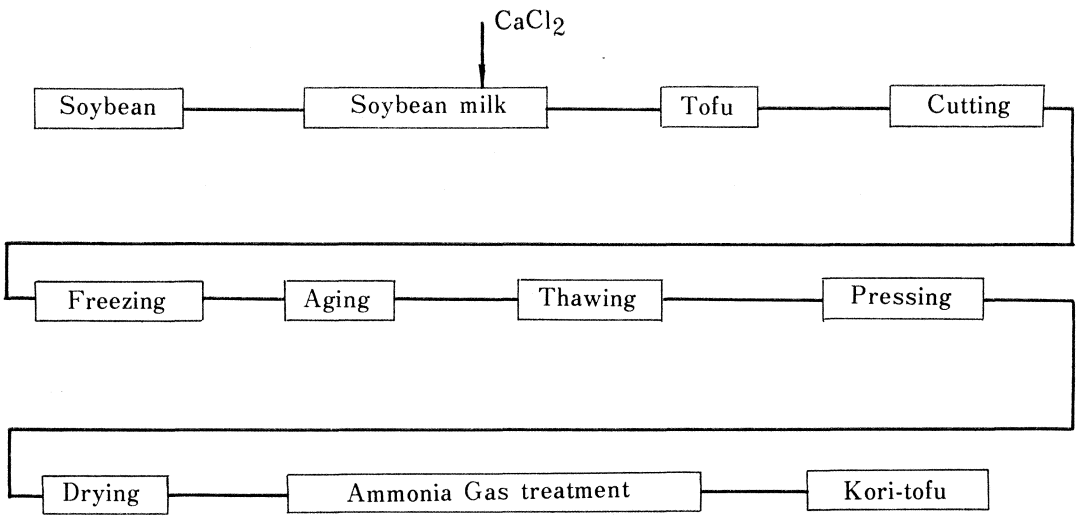

Fig. 2.

3 weeks. Tofu becomes easy to be squeezed out after thawing and then is dried by forced hot air until it becomes about 10% moisture. Its sponge-like texture formed during freezing and aging processes is the remarkable characteristics of Kori-tofu. From 10 kg of soybeans about 5 kg of Kori-tofu is obtained. Because of better preservability and transportability, its production scale is much larger than fresh Tofu and Aburaage. Ten metric tons of soybeans are used daily in large plants.

National Food Research Institute has found that the formation of sponge-like texture in aging is caused by intramolecular exchange of disulfide bonds in protein, and a small amount of reducing agents such as sulfite salt is effective to shorten the aging period which may contribute to Kori-tofu industry. Kori-tofu is served as an ingredient for Sushi or in several daily dishes.

4) Others.

Yuba is one of the interesting use of soybean. It is heat-induced surface film of soybean milk and rich in protein and oil. It is served in soup or cooked with vegetable.

Kinako is the flour of roasted whole soybean. It is mainly used in confectional industry.

Unmatured soybean called "Edamame" is cooked and served for table use. Some varieties of soybean called Hitashimame are also served in the same way as Edamame in limited district in Japan for table use. It is different from Edamame because it is completely matured, but not the same with ordinary soybeans in the point of starch content and taste.

New Food Use of Soybean

Beside these traditional use of soybean, a wide variety of soybean proteins come out as the new food materials in current market in Japan. This trend is understandable when one considers that a large amount of soybean meal is supplied in this country along with oil from soybean. Meat-like substances from these materials has appealed industrial people because of the change of eating habits of the Japanese people and increasing of their meat consumption. The amounts of soybean and wheat products in 1967–71 are shown in Table 3.

Soybean protein comes in varieties of forms; soybean meal and flour (about 45–50% protein), soybean concentrate (70% protein), dried soybean milk (60–70% protein) and soybean isolate (90% or more protein). As soybean protein is quite delicate to heat denaturation or pH effects, fairly simple but cautious treatment can vary the functional properties of products. And the functional properties ,namely production torelance like retention, gelation capacity, elasticity, etc. are often tailered to specific necessary end-use.

Table 3. Production of new protein foods in Japan (tons)

Year	Total	Materials		State		
		from soybean	from wheat	Spun or textured	(Frozen)	Flour
1968	12,141	6,536	5,605	4,321*	(4,148)**	7,814
1969	19,344	11,173	8,171	6,092	(4,943)	13,252
1970	24,217	14,401	9,816	8,504	(7,585)	15,713
1971	27,309	15,895	11,414	9,591	(8,200)	17,718

* Partly dried and partly wet state

** Wet state

In present current market of Japan, soybean products are mainly utilized as food ingredients for their functional properties and from economical point rather than nutritional purpose. In this paper, dried soybean milk, concentrate and isolate are explained in connection with textured and spun protein.

1) Dried soybean milk.

Dried soybean milk is prepared from soybean meal by water or alkaline extraction. The extract is concentrated by treating physically or chemically to remove beany flavour. It is used as a supplement of milk in ice-cream and other confections because of the stability of their whip. It is also used as a material for fish or ordinary sausage because of its water retention and binding capabilities.

Dried soybean milk from whole soybean is mainly used for "packed Tofu" as already mentioned.

2) Concentrate.

By leaching soybean meal in diluted acid, diluted calcium salt carbohydrate, low molecular nitrogen compounds, inorganic substances and also some beany flavour substances are washed out. Residue becomes rich in protein, being over 70% on dry basis. It is used in backed goods and processed meat or fish products. Recently these are processed to textured protein by extrusion method by several companies.

3) Isolate.

Protein extracted from meal with water or diluted alkaline solution is precipitated at isoelectric point. The precipitate is separated from whey and dried, sometimes after neutralizing to pH 7.0. Isolate protein has less beany flavour and shows functional properties such as good moisture retention, binding power for ground meat, emulsion stabilizing effect and heat stability. It is used in processed meat and fish products and processed to protein fiber by spinning method. There are several companies producing protein fiber by this method.

Micellaneous Use of Other Legumes

1) Ann

The traditional food use of Phaseolus group, especially red been (Azuki bean), as Ann (bean paste for confection) is noteworthy in Japan. Brief procedure of Ann making is shown in Fig. 3. In this procedure, cooking process is most important and effects distinctly on the yield and quality of the final product. To form the characteristic texture of Ann, it is necessary to convert starch granules in the cell into α-form without disruption of cell walls, and keep so called Ann cells. The Ann cells are separated from fibrous matters by centrifugation and from protein, sugars and the other contaminants by washing with water. It contains 65% moisture, 10% protein and 25% carbohydrate. From 10 kg of red beans 12-15 kg Ann is obtained.

As same as Tofu production, Ann plant is very small in scale. But recently increase of large scale plants or machinary and technological development have been also remarkable for the broadenning of the distribution region.

Ann produced in the plant is sent to confectionaries as the materials of various traditional Japanese sweets.

2) Bean noodles and bean sprout.

Bean noodles (harusame) have been prepared from mung beans traditionally but recently from white potato or sweet potato starch. Starch is mixed throughly without water to gelatinize partially. After blending with added raw starch, it is extruded from a perforated plate into boiling water. The resulting noodle-like strings are refrigerated or even frozen and then air dried. The rigid insoluble gel shown in Harusame attributed to the retrogradation of gelatinized starch during freezing.

Bean sprout (Moyashi) is produced mainly from mung beans and sometimes from

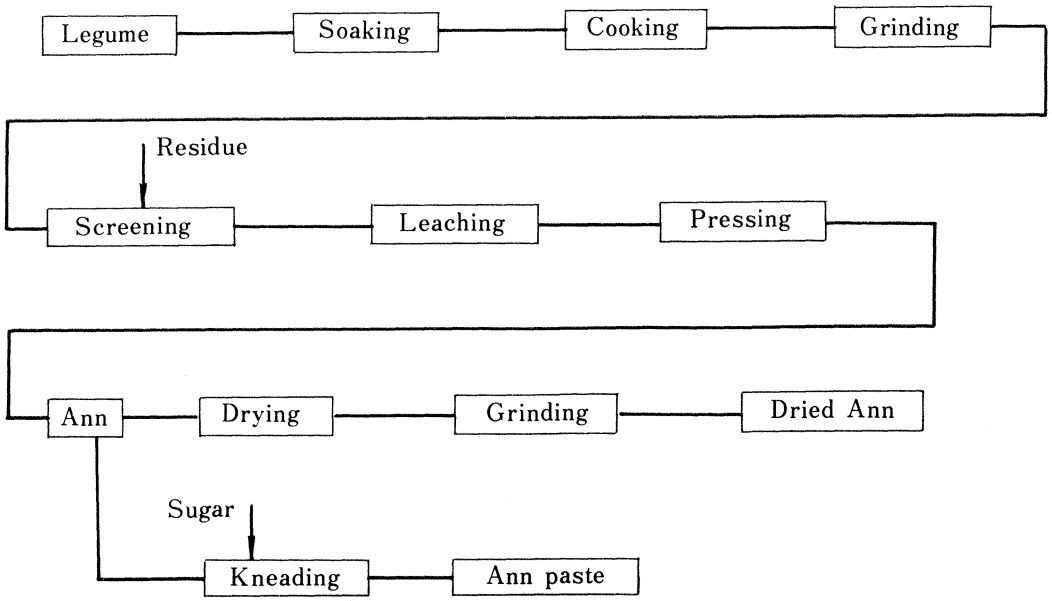

Fig. 3.

soybeans. It is young seedling grown under less light and eaten daily as a vegetable.

3) Others.

Besides the materials for Ann making, beans of Phaseolus group, kidney beans, red beans, broad beans etc. are used as daily dishes by cooking with sugar or soy souce. By the development of preservatives, plastic film and packaging machine, cooked beans are prepared in fairly large scale and mass-sold in supermarket. These beans are also processed to Amanatto by dipping into sugar syrup after being cooked.

Peanut is used by toasting, sometimes with butter. And peanut is used in various foods such as confections or seasonings. Peanut Tofu is made by mixing peanut flour or milk with gelatinized starch and then cooling down in refrigerater. Although peanut can be processed to Tofu by the same method with soybean, it is not yet sold on market.

Research and Development in the National Food Research Institute

Here, finally we will introduce briefly our recent researches on the utilization of soybean protein. They are examples of our trials to establish new protein food technologies based upon our research results on the traditional soybean foods.

1) Sponge-like protein materials from soybean

As we mentioned in Kori-tofu, aging process is an important process to dry up Tofu without case-hardening and to obtain such a characteristic sponge-like texture.

Sponge-like protein materials recently developed by our Institute is a product made by following the principle of Kori-tofu. By applying protein denaturation caused in Toku to the protein solution, we succeeded to get unique texture, so called sponge-like texture, but fairly different from Kori-tofu texture. The material is prepared from isolated protein solution by freezing, for instance, at $-5°C$ for 24 hours with a small amount of calcium chloride, and then aging for several days. After thawing, almost all protein forms tight protein net-work and is able to be easily

squeezed out. The density of net-work depends on the temperature of freezing, namely, the rate of freezing and gives the effects on the characteristics of products. The materials are successfully used as ingredient or suplement of meat or fish sausage and other products.

2) Industrial separation of 7s and 11s components of soybean proteins

In the course of our investigation of Tofu making, it has been found that 7s and 11s components which are main parts of soybean glycinin have quite different food processing characteristics to each other. That is to say, 11s component forms harder and more elastic calcium or heat gel than 7s component. The physical properties of Tofu prepared from the mixture of 7s and 11s components are quite different depending on the ratio of the both components. We propose, therefore, the simple separation way of crude 7s and 11s components from defatted soybean meal and possible usage of each fraction. The principle of separation based on the fact that 7s component can be extracted from the meal with more dilute calcium solution than 11s component.

Physical properties of the components are apparently different as expected from the result of purer preparations. The 11s component can form elastic gel which promises the use as fish-paste-like product.

Conclusion

The consumer is increasingly aware of varieties of food items sophisticated, highly processed. In Japan, traditional food items will keep market appeal as well as imitative and synthetic foods. Traditional foods compete with new food items by their advanced technology in large scale production, while those newly developed foods expand their share in market by the advanced technology to make use of functional properties effectively.

Discussion

T. C. Tung, Republic of China: There is no heating process in making Kori-tofu according to your Fig. 2. Is there any possibility Kori-tofu still show anti-trypsin activity?

Answer: In order to show briefly in Fig. 2, we wrote soybean—Tofu, omitting intermediate processes. But the original tofu which prepares Kori-tofu, is manufactured almost as same as fresh Tofu mentioned the above, except the use of $CaCl_2$ for $CaSO_4$ as coagulant. So Kori-tofu is heated as well as fresh Tofu and most of antitripsin activity is inactivated.

H. Akemine, Japan: I'd like to know varietal responses in relation to "Tofu" processing

Answer: 1) The high protein content and the high amount of insoluble matter in soybean milk result in the high yield of Tofu. Consequently, soybean varieties having those characteristics are recommendable for Tofu processing.

2) As the taste of Tofu is blank, its textural properties decide consumer's likeness. The texture of Tofu changes not only by the various conditions during processing but also by variance of soybean milk. Phytic acid content and 7S to 11S protein in soybean milk are most significant. Namely, the higher the phytic acid content, the softer the texture of Tofu and the higher ratio of 11S protein to 7S protein, the harder the texture of Tofu.

3) The color of hilum and hull is also related to the visual quality of Tofu. The pale color is recommendable.