# Advanced Technology in Non-fermented Soybean Foods in Japan

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The amount of soybeans consumed in Japan in a year is about 2,000,000 metric tons, mostly depending on imports from the United States and Communist China. About 1,300,000 metric tons of the soybeans are used for oil extraction and 75% of the resulting defatted soybeans are for feed. One million metric tons of soybeans including defatted ones are used for food industry. Whereas the demand for soybean in Japan is increasing year by year, production is decreasing rapidly, perhaps because of high production price compared with those of the U. S. and China.

As Japanese traditional soybean foods we can list miso, soysauce, and natto from fermented foods, and tofu, aburage, koritofu and kinako from non-fermented foods. On the otherhand there are new foods or food materials derived from defatted soybean which can be used in fish and meat products. All of these foods or food materials are reasonably processed by fermentation or protein isolation and thus very nutritious and acceptable.

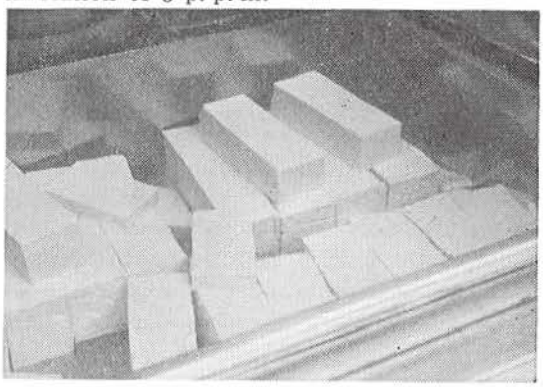
In this paper advanced technology in non-fermented soybean foods including traditional ones will be described.

**Tofu and derived foods.**

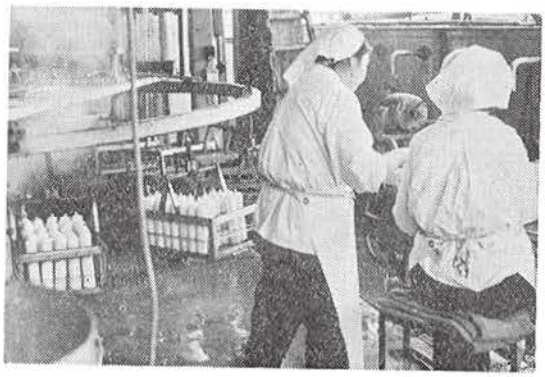
1) Fresh tofu

Brief procedure of tofu making is shown in Fig. 1. Protein in soybean milk is coagulated with oil by calcium or magnesium salt and the precipitated curd is, after removing the whey, moulded in box with holes by press. It contains about 88% moisture, and is rich in protein and oil which is digestible. Its smooth and elastic feeling on the tongue is preferred by Japanese consumers.

As tofu is not so preservable and very fragile it is produced in very small factories, consuming about 35kg soybeans per day on the average. For the development of packaging machine, several larger-scale factories are now being operated. Continuous cooker and filter have been developed for this purpose. Nitrofuran derivative is permitted to be added as preservatives of tofu in the limitation of 5 p. p. m.



Fresh tofu soaked in cold water for sale.



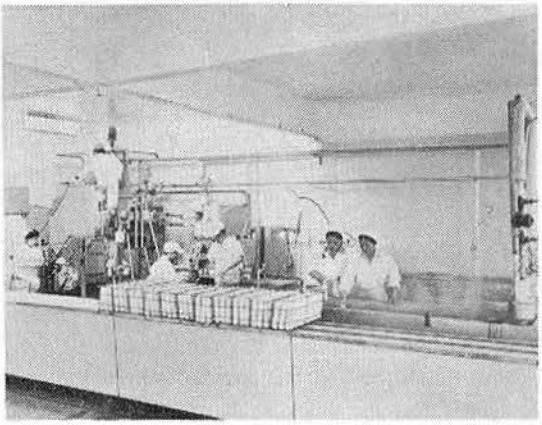
Continuous process of packed tofu making

Besides "momen tofu" described above, "kinugoshi and "packed tofu" are also made. They are more soft on the tongue and homogeneous than momen. Kinugoshi is made by mixing thick soybean milk with calcium sulfate suspension at about 70°C in a box which has no holes. The milk coagulates into homogeneous gel without separating the whey. Packed tofu is made by mixing cold thick milk with calcium salt in sausage-type plastic film bag, followed by closing and then heating in hot water at 90°C for 40 minutes. The milk coagulates into homogeneous gel like kinugoshi. Packed tofu is more sanitary, transportable and preservable than momen and kinugoshi.

Glucono-delta-lactone has been reported several years ago that it is available as coagulant for kinugoshi and packed tofu. It is water-soluble and separate gluconic acid by heating the solution. When it is mixed with hot soybean milk gluconic acid is produced gradually, which coagulates the milk into homogeneous gel without separating the whey. If cold soybean milk preliminarily mixed with glucono-delta-lactone is heated, the milk coagulates into gel by gluconic acid separated during heating. Continuous process of packed tofu may be possible by putting cold mixture of milk and the lactone in the bag, followed by closing and heating. Defatted soybean meal is blended sometimes with whole soybean to make tofu.

Spray-dried soybean milk is available on the market recently, from which soybean milk can be prepared by only mixing with water and heating with continuous agitation. This process does not need any grinder and filter, and also soaking soybeans in water for a night. It is now used for making packed tofu. Making of packed tofu from the spray-dried soybean milk is perhaps a modern technology to save labor in tofu making.

Spray-dried soybean milk is also on market being packed in 100 to 200 grams unit with separated package of glucono-delta-lactone as coagulant. This can be used by housewives for home-made tofu. Soybean milk is prepared by dissolving the powder in water and boiling. The milk is coagulated into kinugoshi tofu gel only by mixing with the coagulant at 80 to 90°C.



Packed tofu making from spray dried soybean milk

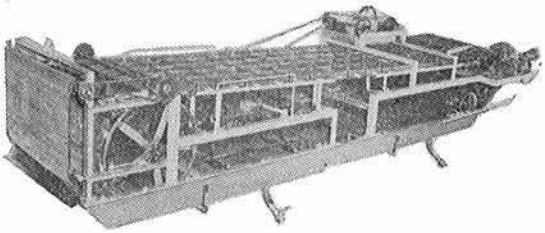
2) Aburage

Aburage 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 and higher temperature. The tofu is swollen and becomes porous by the evaporation of water. Aburage is made on a larger scale than tofu, using continuous deep frier because of its preservability and transportability. There are more than ten or twenty factories in Japan which consume 600 kg of soybeans per day. Aburage must be swollen much larger compared with original tofu and it can be attained by limiting the heating temperature for producing soybean milk to limit protein denaturation. In aburage defatted soybean meal is used in larger amount than in tofu for blending with whole soybean.

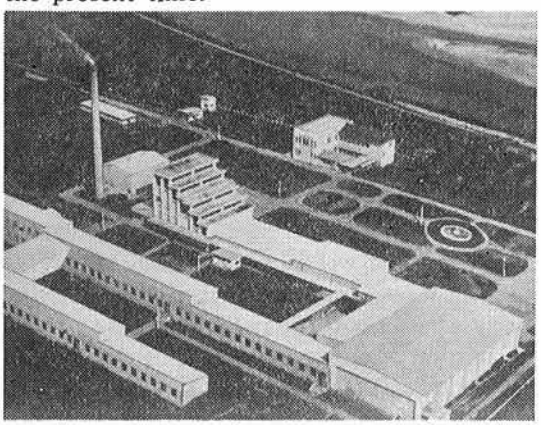
3) Kori-tofu

Kori-tofu or dried tofu is made by freezing hard fresh tofu of 80 to 85% moisture at about-10°C and then aging at-1 to -3°C for three weeks as shown in Fig. 2. Tofu becomes easy to be squeezed out after thawing and then dried by forced hot air. Aging is an important process to dry up the tofu without case-hardening. Kori-tofu is nutritious for its 53% protein and 26% oil contents. It is very digestible because it is isolated protein and oil mixture. The production of kori-tofu

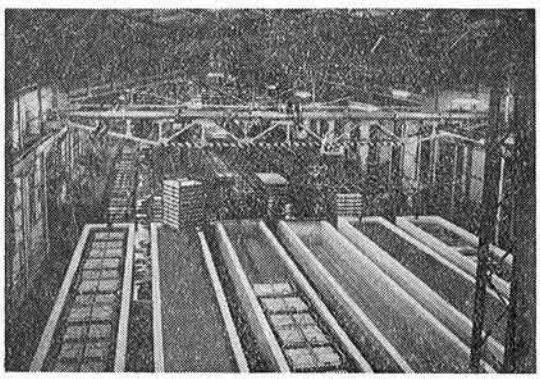
is on a much larger scale than aburage because it can be preserved longer and transported more distantly. Several factories consume 10 metric tons of soybeans per day. Shortening of the aging period at -1 to -3°C may bring much profit to this industry, but no economical method is still developed at the present time.



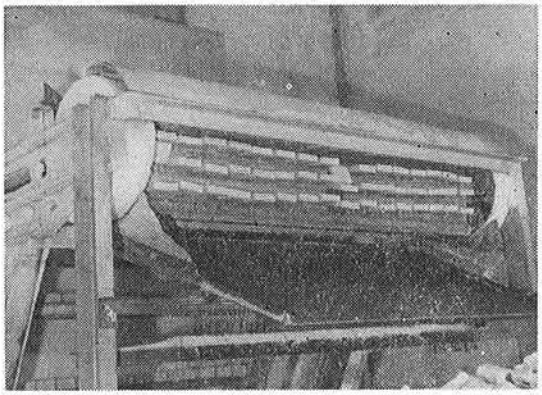
Continuous deep-frying equipment for aburage making.



Birds-eye view of a large scale kori-tofu factory.



Soaking tofu-cakes in cold water for precooling and removing excess calcium chloride. in kori-tofu making



Continuous freezing of cut tofu-cakes in kori-tofu making

Newly developed kori-tofu which is now on the market is made by freezing, aging, thawing, seasoning and freezing. It is distributed as frozen food, and used after deep-frying in institutional feeding.

At the Food Research Institute new materials are made by freezing and aging fresh tofu followed by molding with salt after thawing. The material can be mixed with fish into homogeneous paste and becomes stick gel by heating.

**Soybean protein concentrates**

1) Dried soybean milk

To develop new use of soybean protein foods, it is necessary to increase protein content of soybean itself for the purpose of leveling up nutritive value and utilizing functional properties of soybean protein. Tofu and dried tofu are completely satisfactoty for this purpose. On the other hand soybean's protein content increases by removing oil, for instance from 36% of original soybeans to 50% of defatted soybeans. Defatted soybean meal prepared by using low-boiling point solvent such as n-hexan is usually starting material for further processing. Water and alkaline extract of the meal contains soluble matter including protein, oil and soluble carbohydrate. The extract can be condensed and spray-dried which contains 60% protein, 30% soluble carbohydrate and no insoluble matter. Beany flavor usually moves into the extract, so it must be removed by physical

or chemical treatments. The dried milk is used as a supplement of milk in ice cream and other confectionary industries. It is also used with fish or meat because it becomes hard gel by mixing with water and heating. Dried soybean milk from whole soybean is mainly utilized for packed tofu as already mentioned and also partly used for same purposes as that from defatted soybean meal.

2) Seventy percent protein concentrates

By leaching defatted soybean meal in diluted acid, diluted calcium salt solution or ethanol, soluble components except main protein, such as soluble carbohydrate, low molecular nitrogen compounds, inorganic substances and also some beany flavor substances are dissolved in the extract. Residue from the extract becomes rich in protein, being over 70% (Nx6.25) on dry basis. It is dried and used for blending with wheat flour in bread and cake making, and also for supplementation in fish and meat products. When defatted meal is heated with 3 to 4 times of water, then frozen and aged, protein becomes insoluble after thawing. Thus the meal becomes higher in protein by washing with water and removing the soluble matter including the beany flavor substances. It contains 65 to 70% protein on dry basis. Mild heating of the meals is more desirable, because color and flavor formation may occur by drastic heating. This 70 percent protein concentrates were developed by the Food Research Institute. The other one by the Institute is to leach defatted soybean meal in cold water at about 1°C to extract soluble substance other than protein selectively. By repeating the extraction the residue becomes higher in protein because almost all the protein may remain in the residue without leaching out in the extract. It is a kind of 70% protein concentrates derived from defatted soybean meal. If necessry it can be dried.

3) Soybean protein curd

This product is developed for blending in fish products as supplement. It has characteristics that it can be mixed with fish to homogeneous paste and forms elastic gel by heating. After heating defatted soybean meal with water calcium salt is added to this slurry to precipitate the dissolved protein. Then it can be washed with water and remove nonprotein substances including beany flavor substances. The residue may become higher in protein because it is not washed out by water. The product is usually called "soybean protein curd" because it is dealt and distributed in a wet state. It it also a kind of 70% protein concentrates in wide meaning, but different from the usual one in that its protein is an isolated protein by calcium salt.

**Isolated soybean protein**

Isolated soybean protein is superior as a food material because it may show characteristic functional properties of soybean protein and does not contain any beany flavor substances. Water or alkaline extract of defatted soybean meal is prepared and protein is precipitated from this extract by adding acid to pH 4.3. The precipitated protein is separated from the whey by filtration and washed. Isolated protein is made by drying the separated wet protein, sometimes after neutralizing to pH 7.0. Isolated soybean protein has been originally used as an emulsifier and foaming agent in confectionary, but now it is more important as a high quality protein supplement in the food industry, especially in the animal industry. It can be mixed with water to paste, which forms gel by heating like meat and fish paste. Soybean protein fiber which will be explained next is made from the isolated soybean protein.

**Soybean protein fiber**

Thick solution of isolated soybean protein in alkaline is forced through spinnerets into a bath of acid and salt mixture solution. The extruded precipitates are drawn away by pick up rolls. Protein fiber can be obtained only by washing acid and salt. By controlling thickness, strength and length the fiber can get chewing characteristics which is popular in meat and meat products. Protein

fiber whose production has been recently started is mixed in fish and meat products such as kamaboko, press ham or corned beef. The protein fiber of about 75% moisture is now distributed in frozen state in Japan. It is expected to succeed in making complete meatless meat from the protein fiber in the near future.


### Summary

The demand for animal industry product is anticipated to increase more rapidly in Japan. But it is not so feasible to meet this demand completely, because the world food demand will explosively increase within this half century owing to population increase and improvement of the living standard. The high cost and shortage of animal industry products have been acute recently. Soybean, therefore, will play an increasingly greater part in supplying substitutional materials in the animal and fishery industries, though it may also still continue to be an important material in traditional foods.

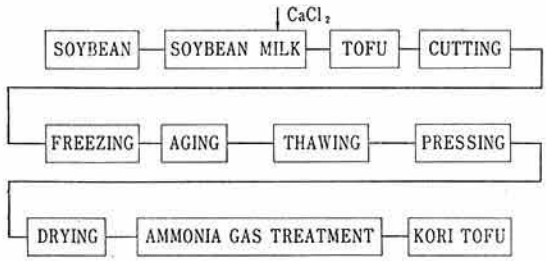




Fig. 1. Flow sheet of tofu making

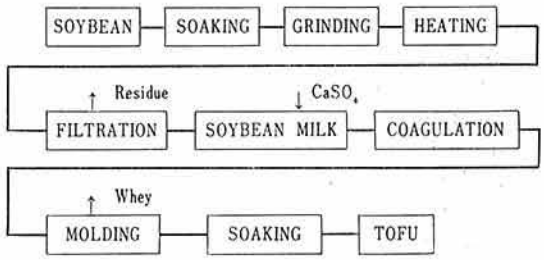



Fig. 2. Flow sheet of kori tofu-making

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