JARQ 24, 224–230 (1990)

Quality of Soybeans for Processed foods in Japan

Harue TAIRA*
Department of Utilization, National Food Research Institute
(Tsukuba, Ibaraki, 305 Japan)

Abstract
In Japan, soybeans have been consumed as a raw material for various types of processed foods such as Tofu, Miso and Natto. Regarding the quality of soybeans in food industries, protein and oil contents as well as ratios of these two components are critical in making Tofu; while appearance of the raw soybeans and hardness and color of the steamed beans are priority factors in making Miso and Natto. In relation to the taste of soybean foods, composition of free sugars contained is closely associated with the taste of Miso and Natto. Quality of the raw soybean materials had a great effect on the quality and suitability for processing Miso and Natto, but not so effective for making Tofu. In this respect, the differences in the raw materials were related with genetic factors or cultivars rather than with cultural conditions.

Discipline: Food
Additional key words: chemical compositions, Miso, Natto, Tofu

As of 1988, annual consumption of soybeans in Japan was approximately 4,663,000 t; a majority of which or 96.7% of the total demand was met by the imports from the United States (78.1%), Brazil (12.3%) and China (6.3%). Of the total consumption, about 79% was used for oil extraction and 19% for food industry. In 1983, an amount of approximately 886,000 t was directed to the food industries, including Tofu, Miso and Natto processings with the proportions of 57%, 20% and 11%, respectively (Fig. 1)[6].

Processed soybean foods in Japan consist of a variety of products, which include Tofu (bean curd), Abura-age (fried bean curd), Kori-tofu (frozen and dried Tofu), Yuba, Kinako (roasted soybean flour), Nimame (Cooked-beans), soybean milk as non-fermented products; and Soy sauce, Miso, and Natto as fermented products. Among these products, Tofu, Soy sauce, Miso, and Natto are predominant[6]. The U.S. soybeans are, apart from oil extraction, mainly used for non-fermented products except for Cooked-beans, and the Chinese soybeans for fermented products. However, defatted soybeans are only used for Soy sauce. All the domestic soybeans, though the amount is small, are exclusively used for food products because of their good quality (Fig. 1)[6]. However, since the domestic soybeans are high in price and inconstant in supply to the markets, major part of the demand has to be met by the imports from abroad.

This paper reviews the current status of the quality of soybeans consumed in Japan in connection with the suitability in processing Japanese soybean products.

Quality for food processing

1) Tofu

The procedures for making Momen-tofu, Kinugoshi-tofu, Soft-tofu and Packed-tofu are briefly explained as follows: at first, soybean milk is produced by extracting ground soaked beans under heating. Protein in the soybean milk is coagulated with oil by adding calcium or magnesium salt. Glucono-delta-lactone is used as a coagulant for Kinugoshi-tofu and Packed-tofu as well. Tofu contains about 89% moisture, 5.5% protein and 3.8% oil. Its yields and textures slightly vary according to the raw soybeans used. The qualities of Tofu are affected by the cultivars used, more specifically by

* Present address: Japan Women's University (Bunkyo-ku, Tokyo, 112 Japan)

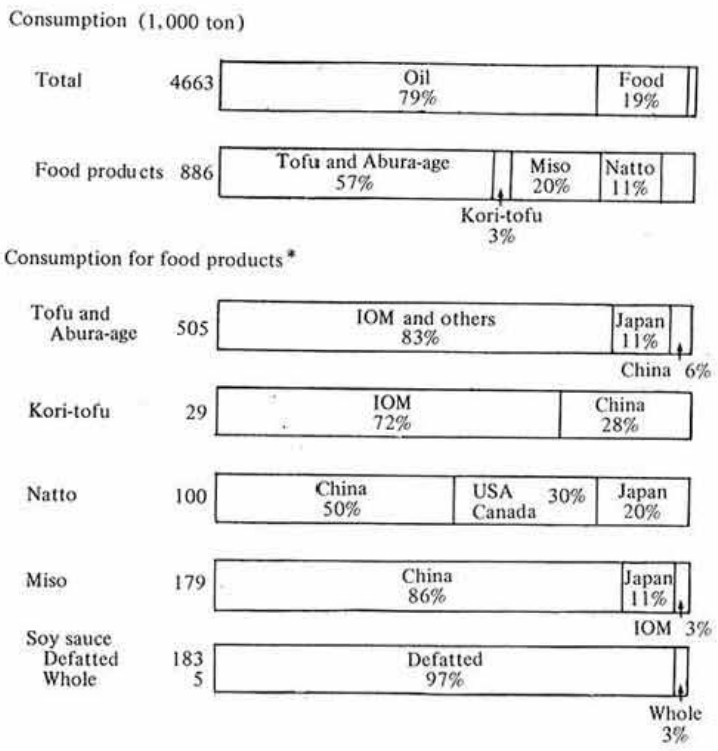
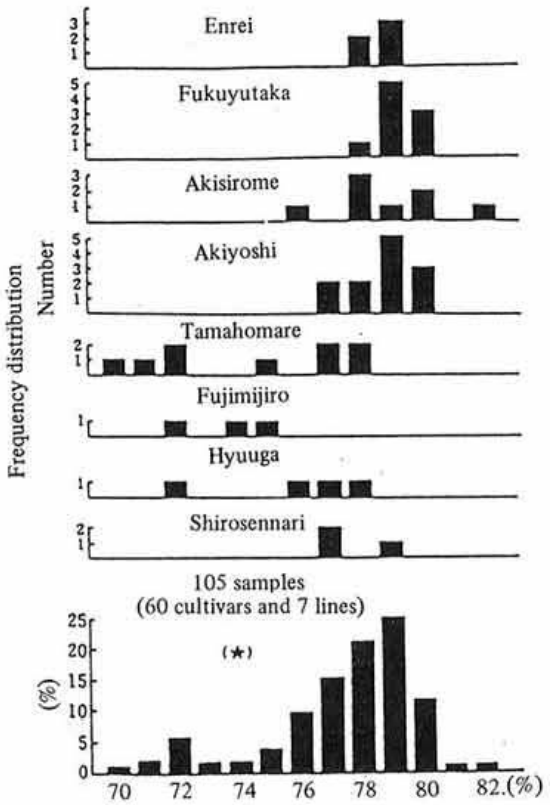


Fig. 1. Consumption of soybeans in Japan in 1988
* Additional 69,000 t are consumed in the forms of Cooked-beans, Yuba, Kinako, Moyashi and others.

the protein and oil contents contained[2] (Tables 1 & 2). They are highly correlated with chemical compositions of soybean milk, which are much dependent on the raw materials of soybeans[3]. In case where the soybean milk contains a large amount of protein and oil available, a high yield of Tofu is obtained (Fig. 2)[6]. In this connection, the ratios of protein to oil in soybean milk are also important. Tofu becomes hard under a high protein ratio, whereas Tofu becomes soft under a high oil ratio (Table 2). The ratio of the proteins 11S to 7S fractions does not give any influence on Tofu yield and hardness. The taste of Tofu, especially in Kinugoshi-tofu and Packed-tofu, is closely related to the free sugar contents in soybeans because these Tofus contain a large amount of whey. Sucrose, or a main sugar in soybeans, varies substantially among the cultivars[5]. High protein cultivars generally have low contents of sucrose: such a negative correlation is presented in Fig. 3[5]. The results of the analyses of chemical compositions (on a dry matter basis) indicate that the soybeans suitable for processing quality Tofu have a middle level in each constituent, as seen in a Japanese cultivar Fukuyutaka: i.e. protein; 44.7%, oil; 19.9% and sugar (total sugar); 31.5% (Table 2).

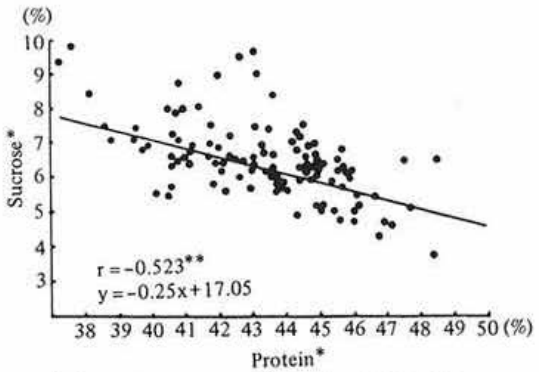
2) Miso

Miso is classified into three groups, comprising Rice-koji miso (sweet type, light yellow color type, dark yellow color type), Barley-koji miso and Soybean-koji miso. The procedures for making Miso are as follows: soybeans are washed and soaked to absorb enough water for cooking. The soaked beans are cooked in water or steam. Rice-koji, a companion from a culture of *Aspergillus oryzae* on steamed rice, is prepared with the purpose of saccharification of starch in rice and decomposition of protein in the cooked soybeans. Rice-koji is mixed with salt and with the cooked beans and starters (cultured



★ : Average value of the US soybeans

Fig. 2. Frequency distributions of solid matter extractability in soybean milk



* Contents are expressed on a dry matter basis

Fig. 3. Correlation between protein and sucrose contents in soybeans

yeast and lactic acid bacteria). Fermentation continues at 25–30°C. The fermentation period varies widely in accordance with the kind of final product of Miso: i.e. approximately one week for sweet type of Miso; one to three months for light yellow color type of Miso; and over one-year period for Soybean-koji Miso. In the course of fermentation, palatable flavor and taste originate from increased polypeptides, amino acids, alcohol, organic acids and other components.

The desirable quality of soybeans for producing Miso has a white hilum color, a high water-absorbing capacity under soaking, and a soft structure and a bright or light-yellow color of cooked beans (Tables 1 & 2)[6]. The high water-absorbing capacity is correlated with a high carbohydrate content as well as with tenderness of the cooked beans[3]. No correlation is observed between the protein and oil contents and the water-absorbing capacities. The compositions of free sugars also have influences on the taste of Miso. Sucrose content in 105 Japanese samples, including 60 cultivars and 7 breeding lines, varied in the range 3.67 to 9.64% on a dry matter basis[5]. From the viewpoint of quality in terms of appearance and chemical composition of raw beans, domestic soybeans are generally most suitable for producing Miso.

3) Natto

In producing fermented soybeans, or Natto, raw soybeans are washed and soaked as the case in Miso. The soaked soybeans are steamed, cooled down to 60°C, and mixed with a starter of *Bacillus natto* for 8 hr fermentation at 42°C. Surface of the fermented beans are covered by white-colored viscous substances. Natto has strong smell of its own. For processing Natto, soybeans with bright surface-color without broken beans have to be selected (Tables 1 & 2)[2]. In getting soft steamed beans, a high water-absorbing capacity is required for soaked beans[3]; otherwise hard steamed beans bring about unfavorable ammoniac flavor on Natto (Fig. 4)[4]. The composition of free sugars of beans also influences the effective fermentation: sucrose is consumed faster than raffinose and stachyose on the fermentation process. Under a high sucrose content, the temperature rises at the early stage of fermentation process. This temperature condition is not suitable for making Natto. Stachyose is consumed later than sucrose

Table 1. Relationships between soybeans and processed foods in raw soybeans, soybean milk, and steamed seeds

Characters of soybeans	Yield and/or quality of the processed foods
Raw soybeans	
Fine seeds	Appearance of Natto and Cooked-beans
Broken seeds	Yield
Weight	Appearance of Natto and Cooked-beans and yield of Tofu
Moisture	Yield
Protein, oil, carbohydrate	Yield, texture, and taste of Tofu Texture, taste, and color of Miso, Natto, and Cooked-beans
Number of microorganisms	Preservation of Tofu and Cooked-beans
Increasing ratio of water-soaked seeds weight	Yield and texture
Germination ratio	Yield
Solid matter in soaked water	Yield
Soybean milk for Tofu	
Solid matter	Yield
pH	Amount of salt for coagulation
Color (Y%, x, y)	Color
Number of microorganisms	Preservation
Steamed seeds for Miso, Natto, and Cooked-beans	
Increasing ratio of seeds weight	Yield and hardness
Moisture	Yield and hardness
Hardness	Ammonia-N in Natto, texture of Miso
Fine seeds	Appearance of Natto and Cooked-beans
Broken seeds	Ammonia-N in Natto
Color (Y%, x, y)	Color

is; thereby the fermentation process proceeds gradually. This provides suitable conditions for processing. A high stachyose content is generally observed in a small size of beans[7]. The small sized seeds are obtained in an indeterminate type of soybeans imported from the U. S. and China. They are used through a sieve for making Natto.

Variation of the beans quality and its suitability for processing

The variations in chemical compositions and qualities of beans among the cultivars for making Tofu, Miso, Natto and Cooked-beans are shown in Fig. 5[6]. Those 105 samples originating from 60 cultivars and 7 lines were taken from locally produced soybeans in Japan. The coefficients of variation (CV) indicate great variations among the samples in moisture content of seeds, weight of 100 seeds, germination ratio, solid matter ratio in soaked water, and hardness and number of broken seeds in a steamed form. On the other hand, small variations are observed

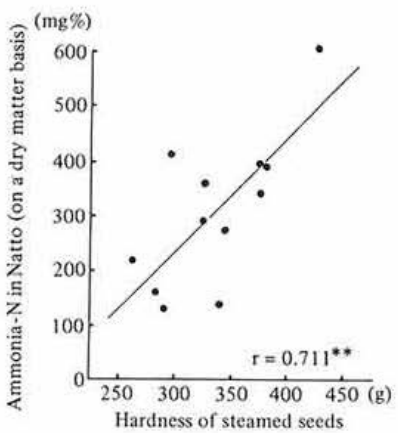


Fig. 4. Correlation between hardness of steamed seeds and ammonia-N content in Natto

in protein and oil contents, some charcters directly related to the suitability for making Tofu; i.e., ratio of solid matter, pH and color of soybean milk (Fig. 5)[6]. The hardness and number of broken seeds while steaming are particularly relevant to the quality

Table 2. Chemical compositions and suitability of soybeans from USA, China and Japan for processing

Soybean cultivar	Character	Seeds					Tofu			Miso, Natto, Cooked-beans		Uses
		Hilum color	Size	Protein[a)]	Oil[a)]	Carbo-hydrate[a)]	Yield[b)]	Hardness	Taste	Hardness of steamed seed	Taste	
Enrei (Japan)	High protein, Low carbohydrate	White	Large	46.8	19.5	26.8	4.3	Hard	Average	Hard	Average	Tofu, Miso, Cooked-beans
Fukuyutaka (Japan)	High protein High carbohydrate	Brown	Middle	44.7	19.9	31.5	4.3	Suitable	Good	Average	Good	Tofu, Miso
IOM (USA)	Low protein High oil	Black	Small	42.2	20.3	29.5	4.5	Soft	Average	Hard	Average	Tofu
Tamahomare (Japan)	Low protein High oil High carbohydrate	White	Middle	41.2	20.5	32.0	4.8	Soft	Good	Hard	Good	Tofu, Miso, Natto, Cooked-beans
Kitamusume (Japan)	Low protein High carbohydrate	Black	Middle	38.8	20.9	30.5	Low	Soft	Good	Average	Good	Miso, Natto
Miyagisirome (Japan)	Large size seed	White	Large	44.3	19.1	31.9	—	—	—	Soft	Good	Cooked-beans, Confectionery
Nattoshoryu (Japan)	Small size seed	White	Small	42.6	18.8	30.4	—	—	—	Soft	Good	Natto
Chinese (China)	Low protein High carbohydrate	White	Middle	42.3	20.4	28.3	4.6	Soft	Average	Soft	Good	Miso, Natto, Cooked-beans

a): Percent on a dry matter basis.
b): Times of weight over the original dry-weight.

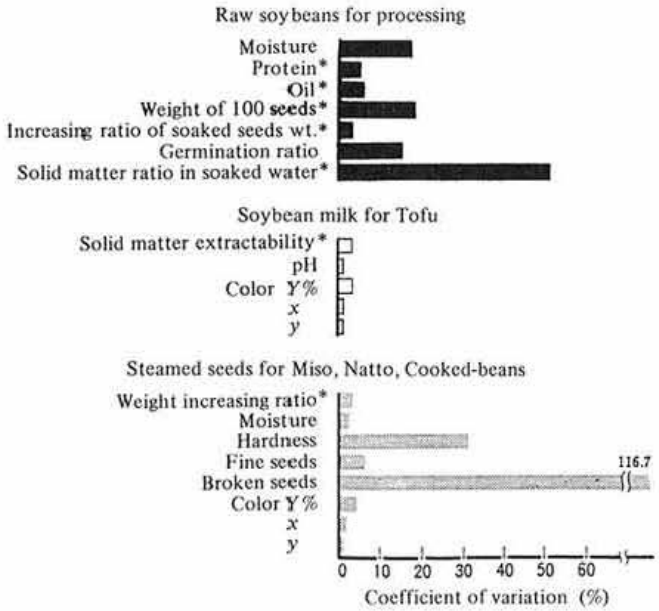


Fig. 5. Variation on chemical compositions and suitabilities of soybeans for processing

of Miso, Natto and Cooked-beans. The above results indicate that the quality of raw soybeans or cultivars is of a basic importance in making Miso, Natto and Cooked-beans. This implies that mixing of varieties of soybeans is acceptable for making Tofu, but not for Miso, Natto and Cooked-beans.

Factors inducing variations in the chemical composition and suitabilities for processing

It is important to specify the desirable qualities of soybeans in each type of processings. However, it would be equally important to identify the interactions between cultivars and cultural conditions, each of which may influence the soybean qualities in a different manner. Degree of the influences of the related factors are shown as contribution ratios for the respective factors.

Regarding the chemical composition, protein, protein components such as 11S, 7S, 7S/11S, amino acids, linoleic acid, raffinose and stachyose contents are influenced mainly by cultivars. In relation to the cultural conditions, carbohydrate, total sugar, free type of total sugar, pinitol, sucrose, ash, phosphorus and calcium are influenced by locations. There are significant yearly variations in oil, oleic, linolenic acids, total sugar, free type of total sugar, sucrose and calcium contents. In case where soybeans are grown under upland conditions converted from paddy fields, moisture, galacto-pinitol A and manganese contents of seeds are affected. In addition, seeding time gives significant variations in protein, oil and carotenoids contents. However, as far as the suitabilities of soybeans for making Tofu, Miso, Natto and Cooked-beans are concerned, it is only cultivars that affect significantly the quality of the processed foods[6,7]. From these results, it is concluded that the quality of soybeans for Japanese processed foods is primarily associated with cultivars rather than environmental conditions.

Effects of the changes in seeds quality during the storage under different temperatures and humidity conditions were examined. It was reported that the conditions generally influenced adversely for processing Miso, Natto and Cooked-beans, especially in increasing the hardness of steamed seeds. However,

significant influence was not observed in the Tofu processing by the storage conditions.

References

1) Taira, H. et al. (1979): Influence of dry treatment after harvest on quality of soybean seeds. IV. Suitability for food processing on stored seeds. *Jpn. J. Crop Sci.*, **48**, 291–302 [In Japanese with English summary].
2) Taira, H. (1982): Quality of soybean seeds grown in Japan. I. Physical property, chemical composition, and suitability for food processing. *Rept. Nat. Food Res. Inst.*, **40**, 35–54 [In Japanese with English summary].
3) Taira, H. (1983): Quality of soybean seeds grown in Japan. III. Correlation between physical property, chemical component, and suitability for food processing pairs. *Rept. Nat. Food Res. Inst.*, **42**, 27–39 [In Japanese with English summary].
4) Taira, H. et al. (1987): Quality of soybean seeds grown in Japan. XV. Suitability for natto processing of small seed cultivars and quality of the natto. *Rept. Nat. Food Res. Inst.*, **51**, 48–58 [In Japanese with English summary].
5) Taira, H., et al. (1989): Quality of soybean seeds grown in Japan. XVIII. Total sugar, free type of total sugar, and free sugar contents of domestic soybean seeds. *Nippon Shokuhin Kogyo Gakkaishi*, **36**, 968–980 [In Japanese with English summary].
6) Taira, H. (1989): Quality and suitability of domestic soybeans for food processing. *Nogyo Gijutu*, **44**, 385–391. [In Japanese].
7) Taira, H. et al. (1990): Quality of soybean seeds grown in Japan. XIX. Effect of cultivar, seed size, and crop year on total and free sugar contents of domestic soybeans. *Nippon Shokuhin Kogyo Gakkaishi*, **37**, 203–213 [In Japanese with English summary].

(Received for publication, June 13, 1990)