Soy Sauce (Shoyu) and Soy Paste (Miso)
~Typical Japanese fermented food~

For more than 1000years, people in Asia have been consuming soybeans in a variety of traditional soy foods. Today many popular soy foods are available worldwide including tofu, soy milk, soy sauce, soy paste and tempeh. Soy foods can be divided into two categories: fermented and non-fermented. Traditional fermented soy foods in Japan include soy paste (*miso*), soy sauce (*shoyu*) and *natto*. Soy sauce and soy paste are flavoring agents having similar aroma and flavor. Both are made by a two-step fermentation process from cereals and soybeans with a mixture of molds, yeast and bacteria. The first step involves fermentation with mold to produce proteolytic and amylolytic enzymes in the starter culture (*koji*); in a second fermentation with yeast and lactic acid bacteria in the presence of high salt concentration the characteristic aroma and flavor is produced.

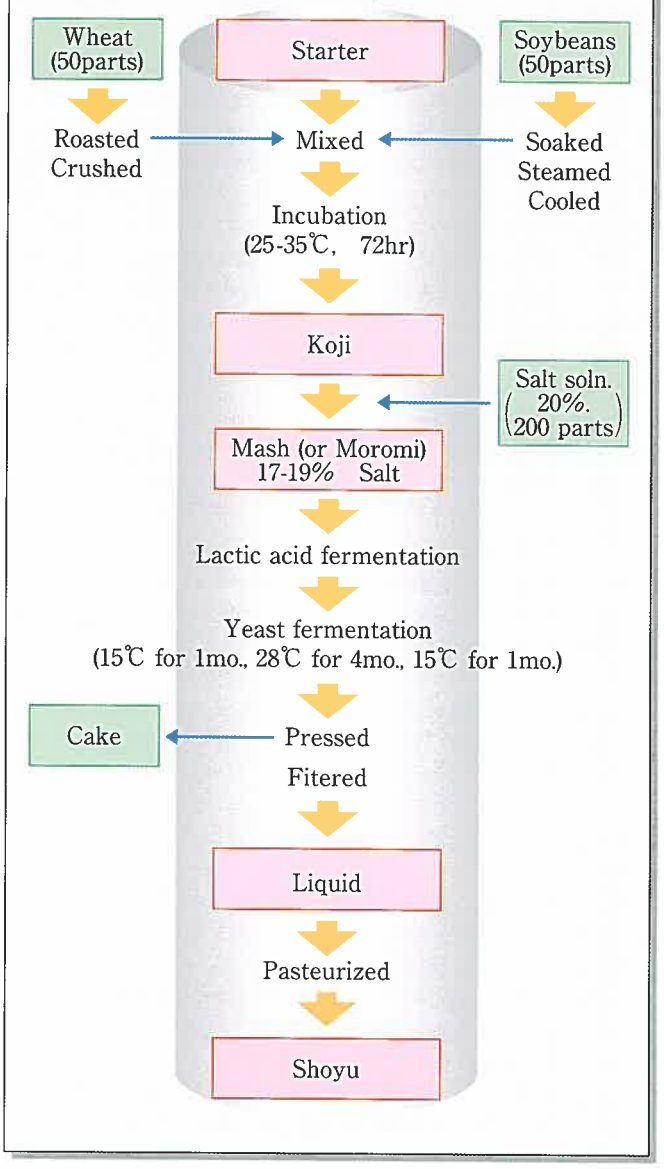
Soy Sauce (*Shoyu*)

Shoyu is a seasoning agent with a salty taste and a distinct aroma and is widely consumed in Asian countries as a condiment and coloring agent in the preparation of food and for table use. It is a dark brown liquid, stable at ambient temperature, which does not require refrigeration during storage due to its low water activity and high salt content.

Shoyu is produced by fermentation of a mixture of soybeans, wheat grain, water and salt. The production process consists of three steps: *koji* production, brine fermentation and refining. (A flowsheet for the process is shown in Figure 1.)

A scene of shoyu manufacture at old days

Figure 1: Flowsheet for manufacture of Shoyu



Koji is a mixture of proteolytic enzymes for converting soybean proteins into peptides and amino acids, and amylases for hydrolyzing starch into sugars. In *koji* production, defatted soybean flakes or whole soybeans are soaked in water and then cooked at a pressure of 6-7kgcm^{-2} for 20-30s in a continuous cooker; separately, wheat is heated in a continuous roaster with hot air at 150℃ for 30-40s at atmospheric pressure. The wheat is then cracked into 4 or 5 pieces per kernel. In making traditional soy sauce, the cooked soybeans are mixed with an equal amount of roasted wheat and then inoculated with 0.1-0.2% of starter mold (*Aspergillus oryzae* or *Aspergillus sojae spores*). After incubation at 25℃ for 72h, the *koji* becomes a greenish yellow mass as a result of mold growth and sporulation.

In the second step, the harvested *koji* is mixed with 20% salt brine and transferred by a pump into fermentation tanks. The selected lactic acid bacteria (*Pediococcus halophilus*) is cultured and added to the mash. To control growth the mash is kept at 15℃ for the first month while the pH decreases from 6.5 to 5.0 with the formation of lactic acid. Then cultures of *Saccharomyces rouxii* (osmophilic yeast) and *Candida sp*, are added as a starter culture for alcohol formation. The temperature of the mash is allowed to rise to 28℃ until alcohol fermentation starts. In the manufacturing process, 80-90% of the constituent proteins and starch are broken down into amino acids and sugars. Glutamic and aspartic acid are the major amino acids present in *shoyu*. Glutamic acid, produced from glutamine by glutaminase activity found in *koji*, is the most important component required for *shoyu* taste. The major sugars in *shoyu* are arabinose, glucose and galactose, with total sugar content about 4.45% as glucose.

The final process is refining which includes pressing, filtration, pasteurization at 70-80℃ for a few minutes and then packaging.

The quality of soy source is monitored by measurement of the pH, acidity, amino nitrogen, salt content, color, microbial contamination, and sensory attributes: color, aroma and flavor of the product. The most important aromatic compounds are HEMF (4-hydroxy-2-ethyl-5-methyl-3-furanon) and volatile compounds including esters, ketones and furans. These volatiles are formed by microorganisms during *koji* and brine fermentation.

There are several types of *shoyu* in Japan characterized by different fermentation processes that differ in the rate of mixture of wheat and soybean. The type of *shoyu* is classified by JAS (Japanese Agricultural Standard) and the properties of some Japanese *shoyu* are shown in Table I. Koikuchi is an example of fermented soy sauce that is very popular in Japan because of its strong aroma and attractive flavor.
Good *shoyu* stimulates the secretion of gastric juices and has the same effect as the caffeine in a cup of coffee. In other words, *shoyu* is an excellent appetizer and a digestive aid. A little *shoyu* gives taste to a dish and enhances its flavor.

Figure 2: Flowsheet for manufacture of Miso

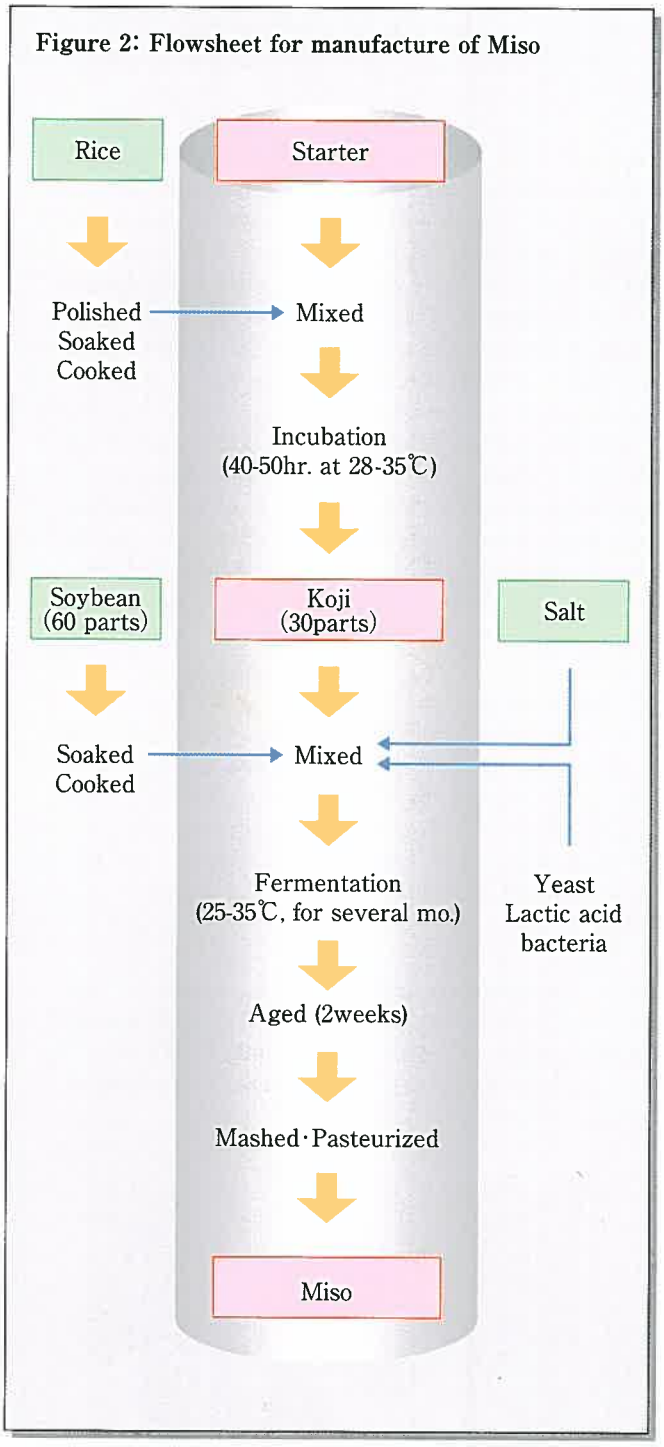


Table 1: Typical compositions of three varieties of shoyu

	Baume	NaCl (%,w/vol.)	Total - N (%,w/vol.)	Formol - N (%,w/vol.)	R -suger (%,w/vol.)	Alcohol (%,vol/vol.)	pH
Koikuchi	22.0	16.9	1.57	0.94	3.0	2.3	4.7
Usukuchi	22.2	18.9	1.19	0.80	4.2	2.1	4.8
Tamari	29.9	19.0	2.55	1.05	5.5	0.1	4.8

Soy Paste (*Miso*)

Miso or soybean paste is made from fermented soybeans, and occasionally in combination with wheat, barley or rice. Similar products are produced in China, Korea and other parts of Asia under a variety of names such as *Jang*, *Chiang* and *Tao-si*.

Miso is produced by a process similar to soy sauce, except that cooked whole beans are mixed with steamed rice and fermentation takes place after the addition of salt and a limited amount of water. The production method for rice *miso* is shown in Figure 2.

Rice soaked in water overnight is steamed for 40-60min and seeded with spores of *Aspergillus oryzae* at a rate of 1g per kg of rice. The rice is then incubated at 30-35℃ for 40-50hr. The resulting *koji*, a source of enzymes to hydrolyze soybeans and rice components, is mixed with sodium chloride (13%), cooked soybeans steamed at 115℃ for 20min, pure cultured yeast (*Sacchaomyces rouzii*), lactic acid bacteria (*Pediococcus halophilus*) and a small amount of water compared to *shoyu* fermentation. The resulting *miso* is a solid paste and therefore does not require filtration. The fungus and yeast used in *miso* production are similar and sometimes the same as in soy sauce production. After the second fermentation for an appropriate period (1 week to 1 year) at 25-30℃, the resulting aged mixture is mashed and packaged as *miso*. You need not worry about using *miso* quickly since it can be refrigerated for up to a year.

There are many varieties of *miso* in Japan. Rice *miso* is made from rice, soybeans and salt. Barley *miso* is made of barley instead of rice and soybean *miso* is made of soybeans only. Rice *miso* is currently most popular in Japan. The color of *miso* varies from a creamy, yellowish white to a very dark brown; in general, the darker the color of *miso* the stronger the flavor. The nutritional components of *miso* are 11-19% protein, 4-9% fat, 13-36% carbohydrate, 1-15% ash and 42-47% moisture.

Miso is very important to the Japanese diet and is consumed by nearly all Japanese in the form of *miso* soup which is served for breakfast, but also for lunch and dinner. It may be thinned and used as a dressing for vegetables and as a picking medium.

REFERENCES

1. B. S. Lub, (1995), Industrial production of soy sauce, *Journal of Industrial Microbiology*, **14**, 467-471.
2. D. Fukushima, (1981), Soy Proteins for Foods Centering around Soy Sauce and Tofu, *JAOCS*, 346-354.