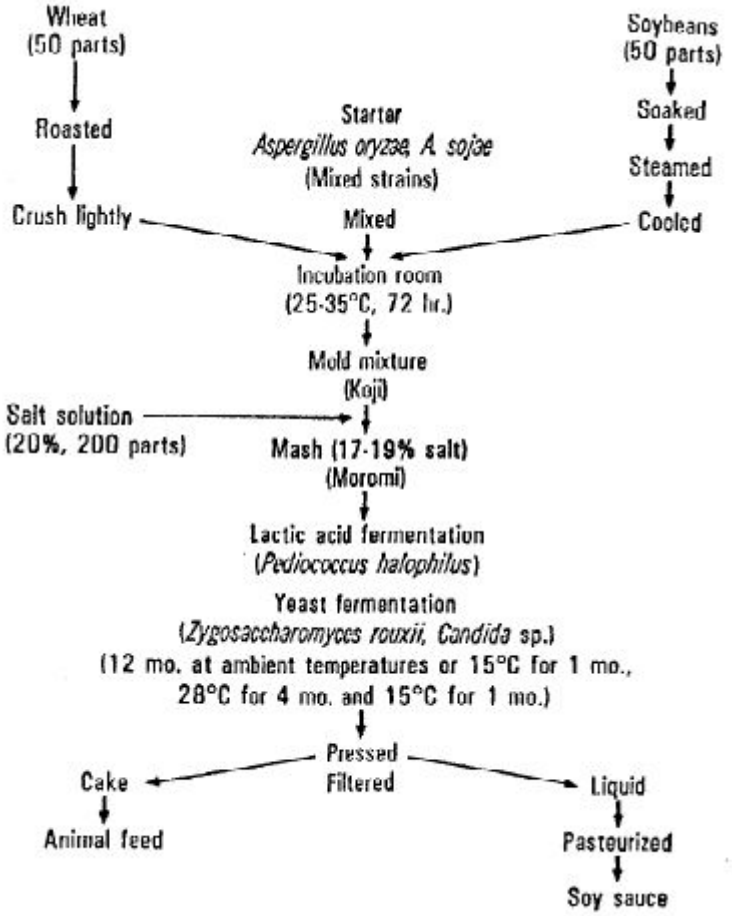
INDUSTRIAL PROCESS OF SOY SAUCE



Soy sauce is a seasoning agent with a salty taste and a distinct aroma suggestive of meat extracts. The sauce is made by fermentation of a combination of soy beans and wheat in water and salt. The microorganisms involved in soy sauce production, and biochemical and chemical changes in soy bean and wheat during fermentation influence greatly the sensory attributes and quality of soy sauce.

In general, good quality soy sauce contains 1.0-1.65% total nitrogen (w/v), 2-5% reducing sugars, 1-2% organic acids, 2.0-2.5% ethanol and 17-19% sodium chloride (w/v). About 45% of the total nitrogen is found in simple peptides, and 45% in amino acids. The processes for production of fermented soy sauce consist of three major steps namely Koji production, brine fermentation, and refining. There are some unit operations involved such as mixer, filtration and heat exchanger.

Manufacturing process:

1. Koji production

Koji is a source of proteolytic enzymes for converting soy bean proteins into peptides and amino acids, and amylase for hydrolyzing gelatinized starch into simple sugars. The substances converted by the enzymes in Koji become the nutrients for yeasts and lactic bacteria in the subsequent brine fermentation. In Koji production, defatted soybean flakes or soy beans are soaked in water to increase the moisture content and then cooked under pressure in a retort. Formerly, the soaked soy beans containing 60% moisture were cooked with saturated steam at 0.8-1.0 kg cm -2 gauge pressure for 40-45 rain in a batch type pressure cooker. Currently, the soaked beans containing 30-45% moisture are cooked at 6-7 kg cm -2 gauge pressure (about 170°C ~ for 20-30 s in a continuous cooker which allows high pressure and short time cooking. The wheat contains 8% moisture and is heated in a continuous roaster with hot air at 150 ~ for 30-45 s at atmospheric pressure. It is then cracked in a machine into 4 or 5 pieces per kernel accompanied by smaller particles of wheat flour. In making regular soy sauce, the cooked soy beans (or defatted soy flakes) 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)* in wooden trays, each loaded with a 3-5 cm thickness of the fermenting Koji. The ratio of wheat to cooked soybean may vary, depending on the type of soy sauce m be prepared. After incubation at 25 ~ for 72 h, the Koji becomes a greenish yellow mass as a result of mold growth and sporulation. It is necessary to stir the contents, to remove the metabolic heat formed, and to stir further to control the temperature at 25-28°C ~ The important factors are selection of the best strains of *A. oryzae and A. sojae* and controlling the product temperature in that range during the Koji fermentation process. More recently, the Koji manufacturing process has been changed from a manual process to an automatic equipment process. This includes a continuous cooker for the soy beans, a continuous wheat roaster, mixer, cooler, automatic inoculator, mechanical mixer, temperature controllers, conveyors, and mechanical devices for turning the substrates during incubation. The inoculated mixture is put into large shallow perforated vats in closed chambers and forced air is circulated through the mass. After 3 days, *A. oryzae* or *A. sojae* grows and the culture mixture

becomes green-yellow in color as a result of mold growth and sporulation. The automatic Koji-making system increases the protease activity of Koji and protects it from infection by undesirable microorganisms. This new device reduces the labor cost by 85-90% compared with the conventional manual method.

2. Brine fermentation

The second step in making fermented soy sauce is brine fermentation. It utilizes the lactic bacterium, *Pediococcus halophiIus* and the yeasts *Zygosaccharomyces rouxii and Candida* species both of which tolerate a salt concentration of 20 g per 100 ml. The brine effectively prevents growth of undesirable microorganisms. The harvested Koji is mixed with 20% salt brine, and transferred by means of a spiral pump into deep fermentation steel tanks coated with epoxy resins on the interior. The resultant mixture is called moromi mash. It is important to control the microorganisms in the brine fermentation. The specially selected *P. halophilus* is cultured and added to the mash. To control its growth rate it is necessary to keep the fermenting mixture at 15 ~ for the first month, allowing the pH of the mash to decrease slowly from 6.5 to 5.0. Then cultures of Z *rouxii* and *Candida* species are added as a starter. The temperature of the moromi is allowed to rise slowly to nearly 28 ~ until vigorous alcoholic fermentation starts. The temperature in the tank can be controlled by coiltype heat exchangers with mixing devices, thermocouples, and control systems. After the alcohol fermentation is finished, the temperature is kept at 25°C ~ Aeration stimulates microbial growth and mixes the contents. During the fermentation period, proteolytic enzymes from Koji hydrolyze the proteins in soy bean and wheat to form amino acids and low molecular weight peptides. Starch is converted to simple sugars which are fermented primarily to lactic acid, ethanol and carbon dioxide. During the brine fermentation, the pH of the mixture drops from 6.5 to 5.0 in the first month at 15°C ~ This is followed by fermentation at 28 ~ for four months. Sometimes it is necessary to add more pure cultures of *P. halophilus* and Z. *rouxii* and *Candida* species to the moromi mash during the fermentation.

3. Refining

The final process in soy sauce fermentation is refining which includes pressing, filtration, pasteurization and packaging. The aged moromi is pressed in a vertical automatic press to separate the soy sauce from the residue. After pressing, the filtered raw soy sauce is pasteurized in a heat-exchanger at 70-80°C ~ for a few minutes to ensure clarity, to inactivate residual enzymes, and to inactivate any undesirable microorganisms. It may be necessary to clarify the soy sauce additionally by centrifugation or sedimentation. The sauce is treated with caramel as a coloring agent, and then packaged either in clean glass bottles, enameled gallon cans or in plastic containers. The residue from the press can be extracted with more 20% salt brine to increase the yield. Much expertise is needed to produce a soy sauce that is attractive in flavor and taste, stable on storage at room temperature, and acceptable to the consumer. The quality assurance group must check the pH, acidity, amino nitrogen, salt content, color, microbial contamination, and sensory attributes: color, aroma and flavor of the product.

In conclusion, soy sauce produced and the undesired product is animal feed.