

MYCOLOGY ANSWERS

HOW ARE SOYA BEANS FERMENTED TO MAKE SOY SAUCE, AND WHY IS IT SALTY?

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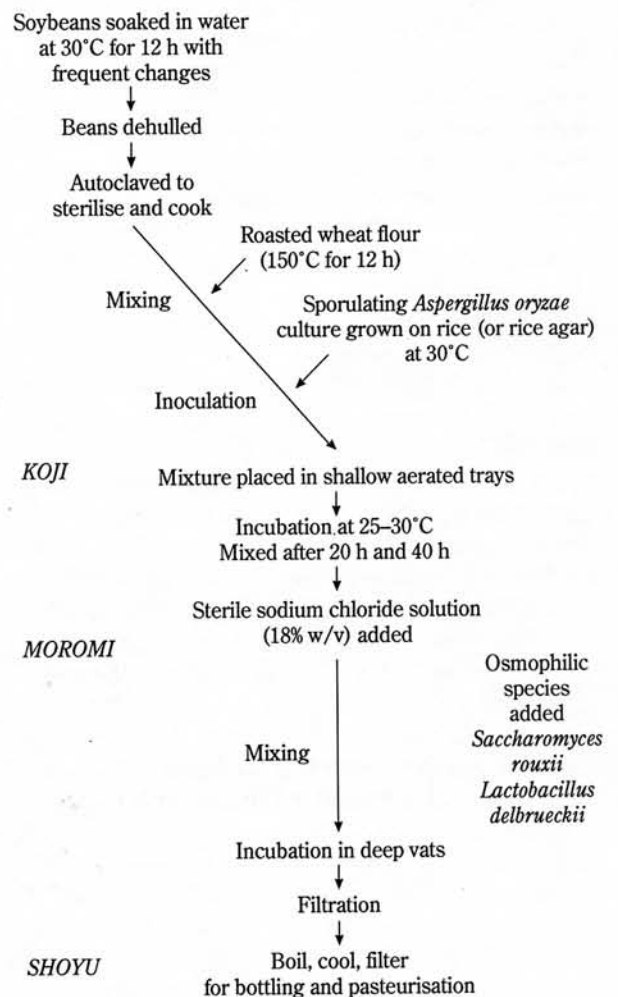
The dark brown savoury sauce, known as soy sauce (shoyu), has many culinary uses and although it has its origins in the Orient it has become well known in this country. It is now produced and used around the world in large quantities, by means of well controlled, modern hygienic methods, derived from those developed and used for centuries in Japan. The fermentation is a two stage process involving a fungus and also yeasts to produce a valuable flavouring, with good nutritional qualities, derived from rather unpalatable, indigestible soya beans. It has an important role in oriental cuisine, particularly where much available staple food is bland and rather uninteresting or where high protein foods are unavailable.

For the first phase of the fermentation, soya beans or soyabean meal are soaked, cooked (to kill bacteria associated with the beans, which might spoil the fermentation process), dehulled and mixed with ground, roasted wheat. All these treatments, and also the proportions in which the soya beans are mixed with the wheat, influence the flavour, colour, smell, and nutritional quality of the finished sauce.

The fungus *Aspergillus oryzae* is grown up for a few days on cooked rice grains or on rice agar. When this initial culture has grown to the stage where spores are formed it is mixed into the soya bean/wheat flour mash to inoculate it for fermentation. This inoculated mixture is known as the 'koji'. The koji is then incubated on shallow, well aerated trays, kept warm and mixed well at intervals. As it grows, the fungus may produce heat and the well aerated situation helps to keep the beans reasonably cool. During incubation the *Aspergillus oryzae* pours out enzymes (invertases, amylases and cellulases) which actively degrade (hydrolyse) carbohydrates in the bean/wheat flour mixture. Soya bean proteins, starch and polysaccharides are degraded in the koji and gradually the amounts of simple sugars and amino acids increase as the bean mixture is broken down by the fungus. It is important that the fungus should

grow over and through the mixture, fully colonising it and breaking down the component materials. However it is also important, for the value of the product, that the fungus does not grow too much and begin to produce spores in the koji. Additionally, patchy growth must be prevented.

Once the fungus is well grown, usually after a few days, the koji is again mixed and placed into deep vats for the second phase of the fermentation. Brine (sodium chloride solution) is added and it is from this brine that the salty taste is derived. This mixture is called 'moromi' and at this stage it is



usually inoculated with yeasts and/or bacteria which grow well in high levels of salt (osmophilic species) and are also able to grow under low levels of oxygen. Inoculation with *Saccharomyces rouxii* (osmophilic yeast) and *Lactobacillus delbrueckii* (a lactic acid bacterium) ensures that the process continues, although traditionally this part of the process was probably more of a chance event. In the secondary phase of the fermentation therefore, anaerobic conditions quickly develop and further growth of *Aspergillus oryzae* is prevented. The sugars in the mixture are fermented by the yeasts and lactobacilli so that after about a month, a sour (pH 4.5), dark coloured liquid is formed which contains large amounts of amino acids, particularly glutamic acid, simple sugars

and a range of vitamins.

Subsequently the brown liquid is drained off from the moromi and gently filtered. All the residual bean fibre and residue is removed. It is then boiled to inactivate the degrading enzymes and kill the microbes, cooled and filtered again. This is 'shoyu' which is then left to age (a few months to 2 years), traditionally in casks so that the characteristic flavours may develop fully. Pasteurized, bottled shoyu is then ready for sale and consumption. Both the taste and smell of shoyu are important and different qualities may command different prices. It has a savoury meat-like flavour and is high in valuable amino acids making it an important adjunct to many vegetarian foods.

