SOYBEAN TEMPE – A PROTEIN-RICH MOULDY PRODUCT

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Abstract. Tempe is a popular, low-cost protein rich, fermented soybean product from Indonesia. It has gained popularity in the West as a meat substitute. Fermentation is carried out by a Rhizopus species, which produces ramifying mycelium, binding the beans into a firm cake. The enzymatic activity of the mould on the soybeans has made the raw materials more digestable and improves the nutritional content of the beans.

Key words: soybean, tempe, fermentation.

Introduction
Tempe is a fermented soybean product, which originated from Java, Indonesia. It is a very popular low-cost protein-rich product, which may supply much of the total dietary protein of the Indonesians. It is consumed by all socio-economic groups in the country and serves as a major source of protein, vitamins and calories. It is also produced in Malaysia, Thailand and Singapore. Tempe has gained popularity as vegetarian food in the USA, Canada, West Indies and Netherlands. In recent years, there has been interest in the USA, to develop tempe as an ‘alternative’ protein source. The annual production in Indonesia is about 80,000 tons with individual daily consumption of 50-100 g (Campbell-Platt, 1987).

The soybeans (Glycine max) are cooked, dehulled and inoculated with one of several species of Rhizopus. It often described as ‘cultured soybean cake’ having a mild nutty flavour with a firm texture. Over-fermented tempe smells of ammonia and is usually less palatable. Tempe looks like cream cheese on the outside, but when sliced the individual beans are observed and these beans are bound together by the fungal mycelium.

Tempe has also been prepared from other type of legumes and raw materials and these products are known under different names according to the countries (Table 1).

Table 1. Tempe and tempe-like products (from Campbell-Platt, 1987).

<table>
<thead>
<tr>
<th>Name</th>
<th>Country</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kenima</td>
<td>Indian subcon</td>
<td>Glycine max (soybean)</td>
</tr>
<tr>
<td>Oncom</td>
<td>Indonesia</td>
<td>mixture of groundnuts, tapioca &amp; soybean</td>
</tr>
<tr>
<td>Bengkrok</td>
<td>Indonesia</td>
<td>coconut presscake with soybean</td>
</tr>
<tr>
<td>Tan-chey</td>
<td>Thailand</td>
<td>Glycine max (soybean)</td>
</tr>
<tr>
<td>Tempe bengkok</td>
<td>Indonesia</td>
<td>Mucuna pruriens (velvet bean)</td>
</tr>
<tr>
<td>Tempe garnerus</td>
<td>Indonesia</td>
<td>solid residue (tahu) from soymilk</td>
</tr>
<tr>
<td>Tempe kedele</td>
<td>Indonesia</td>
<td>Glycine max (soybean)</td>
</tr>
<tr>
<td>Tempe lamturo</td>
<td>Indonesia</td>
<td>(lamturo seeds) Leucaena leucocephala</td>
</tr>
<tr>
<td>Tempe kedele</td>
<td>Indonesia</td>
<td>soybean hulls (lower quality tempe)</td>
</tr>
</tbody>
</table>

All the products in Table 1 are fermented by mould except for kenima, which is produced in the Indian subcontinent. Kenima is made from soybean and the steps involved in the processing of this product are the same as that for soybean tempe of Indonesia. Bacterial fermentation by lactic acid bacteria is involved in the processing of Kenima. The fermentation is based on natural inoculation from the
environment. At the same time growth of *Bacillus* species occurs, producing mucilaginous material, which binds the beans together in cakes. Another tempe-like product, *tempe bongrek*, is made from presscake remaining after the oil has been extracted from copra. The presscake is first soaked in water for several hours with addition of vinegar, which reduces the pH. After soaking, the presscake is pressed before drying under the sun. Then inoculation with mould starter culture follows after steaming and cooling of the presscake. In improperly fermented *tempe bongrek*, growth of *Pseudomonas cocovenenans* inhibits the development of the desired mould. These bacteria can produce a potent toxoflavin, and bongrek acid, which have been reported to cause several deaths in Indonesia. It is therefore necessary to note visible mould mycelium on the *tempe* and the pH of the *tempe* should be less than 6 to prevent growth of the bacterium concerned.

**Consumption**

The *tempe* cake is consumed in a variety of ways. It is a good beef substitute in soups, casseroles, salads and can be barbecued. It is often sliced thinly, dipped into batter and deep-fried as crackers. It is eaten as snacks or taken with rice. *Tempe* may be substituted for the meat in almost any recipe. *Tempe* can be grilled on both sides and served on a bun.

**Traditional processing of Tempe**

*Usar* is the microbial inoculum for *tempe* fermentation. It is prepared by placing pieces of matured *tempe* between two hibiscus (or *Tectona*) leaves, which are then piled up and allowed to stand for a few days at room temperature (30° - 34° C). The leaves are then separated from the pieces of seed *tempe* and dried. For the inoculation of the microorganisms from *usar*, the leaves are rubbed on the materials to be inoculated. Heseltine (1965) reported that the microflora of tempe is predominantly *Rhizopus* species, consisting of *R. oligosporus*, *R. formossensis*, *R. oryzae*, *R. stolonifer*, *R. arrhizus* and *R. achlamydosporus*. Tempe made from soybean by inoculation with microorganisms from *usar* contains more soluble nitrogenous compounds than that made using a pure culture of any of the *Rhizopus* species tested.

There are several variations in the production of *tempe*; however, the traditional method of production is still used for low scale cottage industry. At the initial stage of processing, the soybean is washed in several changes of water. The beans are then hydrated in excess water. Hydration can be carried out by one or two soaking periods from 2 h to 24 h and may include a pre-cooking step. Hydration can also involve soaking in boiling water for 1 or 2 h at 70°C. The most common hydration technique is to soak the beans overnight at ambient temperature. The hydration of the soybean in water is accompanied by microbial fermentation causing a reduction in pH of soaking water. It is believed that soaking softens the beans and hence reduces cooking time. The soybean is then dehulled by hand or using small mills and in some case the beans are dehulled by using feet.

The cotyledons are then either steamed or boiled. The primary objective of the heat treatment either by boiling or by steaming is to remove the bitter tasting substances and the achievement of a desirable texture, colour and odour. The initial microbial load of the soybean will also be reduced. Boiling or steaming also destroys antinutritional factors such as trypsin and chymotrypsin inhibitors and releases some of the nutrients required for mould growth. Cooking also makes the beans more tender and hence facilitates fungal penetration. Once boiled or steamed, the soybeans are drained and allowed to cool on plaited bamboo trays. The beans are then inoculated with spores or mycelium of *Rhizopus* species. The soybean is either packed in small packages using banana leaves or in perforated plastic bags. Fermentation takes place with incubation at room temperature (30° - 34° C) for 36 - 48 hours. The process is complete when the white mycelium of the *Rhizopus* mould has tightly bound the soybean together into a white compact cake (Ko and Heseltine, 1979).
Composition and Nutritive value of Tempe

Basically, fermented food consist of agricultural products which have been converted by enzymatic activities of microorganisms into desirable food products whose properties are considered more attractive than the original raw materials. The enzymatic microbial action of the mould Rhizopus alters the texture and the chemical composition of the soybean, resulting in a more digestible, palatable and nutritious end product. The mould grows rapidly on the soybean, colonising the substrate by producing ramifying mycelium (aggregation of fungal hyphae) which penetrates the soybean cotyledons. The mycelium bounds the beans together forming a cohesive cake. Enzymes such as proteases are produced at the same time, allowed the mould to digest the soy protein. The proteases, which are released, convert the protein through peptides to amino acids, with some release of ammonia, causing the pH to rise again to a final 6.5-7.0. The mould also releases some lipases. The lipases convert up to 25% of the lipid in the soybean to free fatty acids. Four ounces of tempe contain approximately 17g of soy protein. Vitamins such as riboflavin, niacin, pantothenic acid and vitamin B6 are also found to increase during the fermentation. Klebsiella pneumoniae one of the microorganisms isolated from tempe, has been known to elevate the nutritional status of tempe by the production of vitamin B12 (Steinkraus et al., 1983).

Every 100 g edible portion of tempe provides 430-460 kcal of energy, contains 25-65% of moisture (the moisture content will be lower if the tempe is dried, or after frying), 45-55 g protein, 7.5-25 g fat, 3.7 g fibre, 5-10 g ash and about 15-25 g of carbohydrates. Tempe also contain vitamins and minerals such as Ca 400 mg, P 400mg, Fe 25 mg, thiamin 0.4 mg, riboflavin 0.7 mg, niacin 6mg, pantothenic acid 0.3 mg, traces of vitamin B and about 50 μg of vitamin A (Campbell-Platt, 1987). By selection from natural strains, an improved strain of inoculum has been developed and made available to the tempe industry in powder form.

With the influx of Indonesian workers in Brunei who brought with them the technology of tempe production, tempe is now easily available in the ‘wet’ market, Kianggeh Tum, and even supermarkets. Several entrepreneurs in Brunei are now producing tempe on a small scale for commercial purpose. The tempe is packed in a 3 x 4 inches perforated plastic bag, each costing BS$1.00.

Concluding Remarks

In spite of some prejudice against mouldy products and especially the fermented food of Oriental origin, superficially justified by the discovery of aflatoxin and other mycotoxins, studies of traditionally fermented foods shows that they do not produce toxins. Instead, the fungi used in traditional fermentation resist the accumulation of certain toxins which otherwise may be produced by other microorganisms in the food, hence providing protection to the product. Such protective role is demonstrated by Rhizopus oligosporus, used in the fermentation of tempe. This species does not produce toxins. If any aflatoxin is already present in the growth substrate, its content can be lowered by R. oligosporus to about 40% of its original content (Van Veen et al., 1968). It may be concluded that fermentation of indigenous foods introduces additional safety factors, provided the procedure of preparation is properly followed. Most of these fermented foods are rich sources of proteins, vitamins and minerals, and are important as a nutritional supplements in human populations where other sources of these are lacking.

References