Production and Health Benefits of Fermented Soy Products

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Abstract*-There are a number of nutritional diseases in the developing world today. Kwashiorkor, the result of protein deficiencies, and marasmus, caused by a combination of protein and calorie deficiencies, are found in large numbers of children between the ages of 1 and 3 in the developing world. The nutritional impact of fermented foods on nutritional diseases can be direct or indirect. Food fermentations that raise the protein content or improve the balance of essential amino acids or their availability will have a direct curative effect. Past several years of clinical and scientific evidences have revealed the medicinal benefits of the soy components against metabolic disorders as well as other chronic diseases. Many of the health benefits of soy are derived from its secondary metabolites, such as, isoflavones, phyto-sterols, lecithins, saponins etc. In this review we discuss the Types of fermented soybean products (Sufu, Misso, Natto, Douchi, Tempeh and Soy sause) in different countries and its health benefits like bioactive components of soybean and their role in prevention, maintenance, and/or curing of diseases.*

Keywords-Fermentation, Soybean, Nutritional, Protein

I. INTRODUCTION

The soybean (U.S.) or soya bean (UK) (Glycine max) is a species of legume native to East Asia. A cream-coloured oval bean about the size of a common pea. Soybean is increasingly consumed for economical and nutritional reason. Soybean products are an important low-cost source of proteins, minerals, phosphorus and vitamins. Furthermore, soybean products play an important role in health.

Soybean had been cultivated since 2800 B.C. in China, but acquired global importance only after later half of 18th century. India is 5th largest producer of soybean with average production of India's soybean production in 2016-17 is expected to come in at 11.5 million metric tons, up 19 percent from last month's estimate and 61 percent higher from last year. Average consumption in India is 9260 MT of soybeans, giving them the rank of sixth largest consumer of beans in the world. (Anon, 2017)Soybean composition: Soybeans are rich in protein and oil also. It contains 38% protein, 15% soluble carbohydrates like sucrose, stachyose, raffinose etc, 15% insoluble CHO, 18%oil, 10% moisture and 4.6% ash. Composition may varies from place to place. Soybean is only vegetable protein which contains all essential amino acid. (anon, 2015)

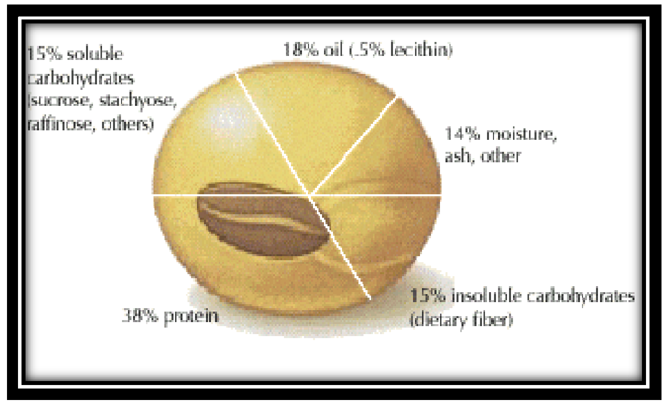

Fig:1 Chemical composition of Soybean

Table:1 The functional component of soybean and their impact as below: (Dixit, Antony, sharma, & Tiwari, 2011)

Functional component	Effect
α-Linolenic acid	Essential fatty acid, hypotriglyceridemic, improves heart health
Lecithins	Improve lipid metabolism, improve memory and learning abilities
Lectins	Anti-carcinogenic, immunostimulator
Peptides	Readily absorbed, reduce body fat, anticancer
Phytosterols	Hypocholesterolemic, improves prostate cancer
Protein	Hypocholesterolemic, antiatherogenic, reduces body fat
Linoleic acid	Essential fatty acid, hypocholesterolemic
Saponin	Regulates lipid metabolism, antioxidant

Health benefit of soybean: Soybean helps in various diseases like prevention in CVD, cancer (colon, breast, prostate), menopause, osteoporosis, diabetes, and obesity. (Jooyandeh, 2011)

II. SOYBEAN FERMENTATION

Soybean has some shortcomings which are ameliorated by fermentation. It contains certain compounds which make the legumes unattractive until they are removed by the various stages involved in their processing and fermentation. soybean contains carbohydrates which are not absorbed until they reach the colon, where the gases produced when they are broken by microorganisms gives rise to flatulence. These CHO includes the oligosacharides, raffinose and stachyose and the polysaccharide, arabinogalactan.

Soybean has bitter and beany teats when crushed. This is because the lipoxygenase enzyme which helps produce this taste and substrate are held in separate compartments in the tissues of seeds until the latter are broken and crushed. The ‘beany’ flavor is due to the presence of several carbonyl compounds such as hexanol and pentanol. These are removed by the action of microorganisms. Fermentation also reduces the carbohydrates of rice and proteins of the bean to lower molecular weights, hence rendering them more digestible. The anti-nutritional factors are destroyed by boiling during processing step.

Fermentation by R oligosporous produces an anti-oxidative compound (41, 61, 7 trihydroxy-bisoflavane) which is absent from raw soybean, and which helps preserve the fermented foods. Soybean are high in phytate (phytic acid) and oxalate (oxalic acid), substances that can block the uptake of essential minerals-calcium, magnesium, iron, copper and zinc in the intestinal tract. (okafar, 2007)

Change in functional properties while fermentation:

1. Protein is hydrolyses to amino acids and peptides by proteolytic enzymes.
2. Oligosaccharides are hydrolyzed to monosaccharides.
3. Phytic acid degraded to inorganic phosphates. (Liao, 2005)

Emerging technology in the production of fermented soybean product (FSBP)

Application of enzyme preparation in FSBP for example use of amylase in soy sauce for reducing sugar and dextrin, increase solid in sauce. Use of protease help to hydrolyze protein.

Combination fermentation process of multi-strains in the production of FSBP Ultra-filtration process to clarify and to sterilize the soy sauce. (Liao, 2005)

Fermented soybean products
2.1. SUFU:

Sufu or furu is a fermented soybean product originating in China. It is a cheese-like product with a spreadable creamy consistency and a pronounced flavour. Sufu is made by fungal solid-state fermentation of tofu soybean curd followed by aging in brine containing salt and alcohol Choice of processing can result in mould fermented sufu, naturally fermented sufu, bacterial fermented sufu, or enzymatically ripened sufu. Depending on the choice of dressing mixture, red, white or grey sufu may be obtained. Fungal starters include *Actinomucor spp.*, *Mucor spp.* and *Rhizopus spp.* Used for the sufu inoculation. (Han, Frans, & M.J., A Chinese fermented soybean food, 2001)

There are many different types of sufu, which are produced by various processes in different localities in China (Liu, 1997)
1. Four types of sufu can be distinguished according to the processing technologies. The base for all form types is tofu, a curd from soybean milk by adding Calcium salts.

1.1. **Mould-fermented sufu:** Four steps are normally involved in making this type of sufu;
(1). Preparing tofu, (2). Preparing pehtze pizi. with a pure culture mould fermentation, (3). Salting, (4). Ripening

1.2. **Naturally fermented sufu**: Four steps are also normally involved in making this type of sufu; (1). Preparing tofu, (2). Preparing pehtze pizi. With natural fermentation, (3). Salting, (4). Ripening

1.3. **Bacteria-fermented sufu**: Five steps are normally involved in making this type of sufu; (1). Preparing tofu, (2). Pre-salting, (3). Preparing pehtze pizi. with a pure culture bacterial fermentation, (3). Salting, (4). Ripening. During the pre-salting, the tofu adsorbs the salt till the salt content of tofu reaches about 6.5%, which takes about 2 days. Pehtze is prepared by pure cultured *Bacillus spp*. or *Micrococcus spp*. at 30–38°C for about 1 week. In order to keep the shape of the final product, pehtze is dried at 50–60°C for 12 h before salting. The ripening time normally takes less than 3 months.

1.4. Enzymatically ripened sufu: Three steps are normally involved in making this type sufu; (1). Preparing tofu, (2). Salting, and (3). Ripening. Because there is no fermentation before ripening, some koji is added in the dressing mixture for enzymatic ripening. The ripening time takes 6–10 months.

2.1.1Chemical composition and nutritional quality of sufu:

From a nutritional point of view, sufu has a higher content of protein-nitrogen than other oriental soybean foods, such as miso and natto (Su, 1986). Nutritionally, soybean milk, tofu and sufu have the same importance to people of

Asia as cows milk and cheese do to the people of the Western Hemisphere. Asians prefer the salt-coagulated bean curd, not only because it has the desired texture, but also because it serves as an important source of calcium (Wang & Hesseltine, 1970); (Zhao, 1997)Glutamic acid and aspartic acid were the most abundant amino acids found in red sufu and grey sufu. The ratio of glutamic acid aspartic acid.:total amino acid content. was around 30%, which provides sufu with a delicious taste. The cystine and methionine contents of grey sufu may be lower than those of red sufu because of their degradation or conversion to other sulfur compounds during maturation, which may contribute to the offensive odor of grey sufu.Yen (1986) reported that the average amine contents in 15 samples of commercial sufu from Taiwan, China were: cadaverine (0.039) mg/g., histamine (0.088) mg/g., beta-phenylethylamine (0.063) mg/g., putrescine (0.473) mg/g., tryptamine (0.150) mg/g., and tyramine (0.485) mg/g. Tyramine and putrescine were the major amines found, and these might have a potential harmful effect on human beings if levels are very high. The complex flavour of sufu was reported to contain 22 esters, 18 alcohols, 7 ketones, 3 aldehydes, 2 pyrazines, 2 phenols and other volatile compounds by (Hwan & Chou, 1999). Maturation in the presence of ethanol resulted in higher levels of volatiles. (Ho, Zhang, & Shi, 1989)compared the volatile flavor compounds of red sufu and white sufu. Red sufu contains much larger amounts of alcohols, esters, and acids, which may be due to the fermentation of angkak by *Monascus* spp. The esters give red sufu its characteristic fruity aroma.

2.2MISO:

Miso, a fermented paste of soybean, wheat and salt is the most important of the soy fermented products in Japan. Miso provides low cost protein with nutritional values of amino acids and short chain of peptides for consumers. Consumption of this fermented soybean will be an alternative to increase balance of nutritional requirement of protein. The starter cultures used in the manufacture of miso consist of mold, yeast and bacteria. The different types of paste produced vary according to the proportions of wheat, soybean and salt used, and the lengths of the fermentation and ageing. Rice or barley are going to be ferment and then resulted koji (fermented rice) mixed with salt, cooked soybean, pure cultured yeasts, and lactic acid bacteria and then fermented for a second time. It is then aged and packaged as miso. Miso with a higher proportion of koji made from rice or barley (mugi) is whiter and sweeter, while that with a higher proportion of soybeans is saltier and brown in colour. Mame-miso is made with hardly any rice or barley and is rich and full of flavour because of its high nitrogen content. (kiuchi, 2002)

2.3NATTO:

The Japanese ferment soybeans with *Bacillus subtilis*after soaking and cooking to yield a protein-rich food called natto.It was invented by accident in Japan’s Tohoku region in the eleventh century when boiled beans that were going bad were eaten and found to be rather tasty. Although the research of natto has made dramatic improvement recently, there is little research about douchi. The fibrinolytic enzyme was first discovered from natto (Sumi, Hamada, Tsushima, & Mihara, 1987). The Indians also ferment soybeans by similar processes to produce kenima. Thus, these alkaline fermentations involving bacilli fermenting protein rich beans and seeds are of considerable importance in widely separated parts of the world.It was an extracellular enzyme produced by *Bacillus* natto. Nattokinase can prevent thromboembolism, which is a lethal factor of cardiovascular disease and a direct reason for inducing apoplexy and myocardial infarction. It works by activating the natural fibrinolytic system and generates plasmin from plasminogen; plasmin- like proteins can dissolve thrombi rapidly and completely by directly degrad- ing the fibrin in blood clots with their fibrinolytic activities. There are two types of natto, itohiki-natto and hamma-natto. Hama-natto is produced by the action of Aspergil1us. Natto is famous for its unique aroma, flavor, and viscous texture. Cooked soybean grains are inoculated with the Bacillus and put into a small tray, covered, and incubated at 40°C. After 14-18 hour, the packed tray cooled to 2-7°C and then shipped to the market. It is cheap and nutritious and natto is usually served with shoyu and mustard. The natto bacillus produces amylase and protease, which soften the soybeans and give the final product its taste. The bacillus grows only on the surface of the beans, producing the distinctive sticky texture. It is this stickiness, along with the aroma, that sets natto apart from other foods. (kiuchi, 2002)

2.4DOUCHI:

Douchi is a traditional Chinese soybean-fermented food. Douchi is fermented and salted black soybean. The black type soybean is most commonly used and the process turns the beans soft, and mostly dry (if the beans are allowed to dry).Douchi was prepared by inoculating the cooked soybean made from 15 soybean varieties [Glycine max (L.) Merr.] With Bacillus subtilis DC33 and fermented at 28-30oC for 30 hrs. (YANGCHAO LUO, et al., 2010)

Preparation of Fibrinolytic Douchi The method for making fibrinolytic douchi was as follows: 5.0 g (dry weight) of soybean sample (different soybean variety) was placed in a plastic basin. The soybeans were washed three times with water and drained. The soybeans were soaked in water (three times the weight of the dry soybeans) at 20^{o}C for 5 h. Each sample of the soaked soybeans were then put into a glass jar and autoclaved with some water (soybeans were immerged in water) at 121^{o}C for 15 min, then cooled down immediately. The soybeans were inoculated with 8 mL of starter and fermented at 30^{o}C for 30 h. After fermentation, the samples were kept at 4^{o}C for 24 h. Douchi production from each variety was replicated.

The effects of the 15 soybean varieties (Glycine max [L.] Merr.) on the fibrinolytic activity and sensory characteristics of douchi were investigated. Yellow soybeans were more suitable than black ones. The products of yellow soybean varieties with higher soluble sugar and smaller 100-grain weight had higher fibrinolytic activity. According to the sensory evaluation and fibrinolytic activity, Longxiaolidou 1 was recognized as the optimal variety for fibrinolytic douchi processing.

2.5TEMPEH:

Tempeh is a cake of cooked and fermented soy beans held together by the mycelium of the fungus Rhizopus oligosporus. Air dried soybeans are socked in water, coats are removed than water is drained cooled after than inoculated with mold. Beans are than packed in parcles and incubate at room temp about 40^{o}C for 40 hrs. Fermentation is complete when beans become bound tightly bt the mold mycelium into compact white cakes. A wide variety of tempeh-based meat analogues are available. (okafar, 2007)

2.6SOY SAUCE:

Soy sauce known as shoyu in Japan is a salty pleasantly tasting liquid with a distinct aroma and which is made by fermenting soybeans, wheat, and salt with a mixture of molds, yeasts and bacteria. Five different types of shoyu are recognized by the Japanese Government, depending on the proportions of the ingredients used and the method of preparation. Koikuchi-shoyu is the most produced, forming 85% of the total produced. Koikuchi-shoyu is deep red-brown in colour and is an all-purpose seasoning, with a strong aroma and myriad flavour. The manufacture of koikuchi-shoyu can be divided into four sections:

The preparation of the ingredients, Koji preparation, Brine fermentation, refining process. (okafar, 2007)

III. CONCLUSION

The soybean (U.S.) or soya bean (UK) (Glycine max) is a species of legume native to East Asia. Its average composition is 38% protein, 15% soluble carbohydrate, 15% insoluble carbohydrate, 18% oil, 10% moisture and 4.6% ash. Soybean is only vegetable protein which contains all essential amino acid. The ‘beany’ flavour is removed by the fermentation, reduce the CHO which are not absorb in GI tract and also eliminates the anti-nutritional factor.The enzymes like cellulases, amylases & proteases play imp role in production of FSBP. Now-a-days use of ultrafiltration technique is used for sterilization of soy sauce. The fermented soybean products includes: miso, sufu, natto, douchi, soy sauce, tempeh, etc. The bioactive components present in FSBP are saponins, melonidin, oligosaccharide, isoflavones and polypeptide.

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