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STUDIES ON THE DEVELOPMENT OF CALCIUM FORTIFIED HOMEMADE TOFU

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ABSTRACT:

As the excellent source of various nutrients as well as due to the medicinal properties, the use of soybean based food in the daily diet is proved to be essential for good health. The poor population of India is facing the problem of protein-energy malnutrition. They may be benefited with the soy-rich diet. Soy food helps in lowering blood pressure, good for diabetics, prevents cardiovascular diseases, protein-energy malnutrition, overall health promotion. Tofu which is also known as soy paneer is one of the best soy food. Tofu has its functional health benefits especially for those who suffer from lactose intolerance. The use of soybean products in the feed and food industry has increased steadily. The world soybean production is currently 346.02 million metric tons out of which India produced 10 million metric tons constituting about 5% of the total world production. Out of this production, less than 10% is directly used for human consumption.[1] In the present study, the tofu is prepared by the traditional method. Calcium sulphate is used as a coagulant, which is beneficial to increase the calcium content of the tofu. This will help in the development of tofu with excellent nutritional value. The tofu is rich in proteins, various vitamins, and minerals and it is cholesterol free. The calcium content of tofu is increased after fortification. Tofu prepared using home appliances is healthy, nutritious and affordable as it is low in cost.

KEYWORDS: *tofu; soy food; calcium fortification; health .*

INTRODUCTION

Soybean contains near about 35-40 % protein on a dry weight basis which makes soybean a very rich and inexpensive source of protein.[2,3] Under the guidance of the FDA and WHO the quality of protein was evaluated. Soy protein isolate got the highest possible score equal to that of meat and milk proteins.[4,5] Tofu is a protein-rich, nutritious food product made by coagulating soy milk. It is often referred to as the "cheese of Asia." Tofu has a bland, slightly nutty flavor, its real appeal comes from its unique ability to adapt and take on the flavors of the food with which it is cooked. Texturally, tofu is both smooth and creamy. It is prepared using home appliances so that preparation of tofu becomes easy and affordable and containing all the nutritious values. It is believed that tofu is mainly originated in China, as in documents it is first mentioned in China.[6]

Tofu is also known as a soy curd in some areas, obtained by coagulating soy milk.[7] In China, the original name of tofu was '*Doufu*', meaning 'bean curd'. It was also known as 'Vice Mayor's Mutton'. There was an interesting story behind this. In some village, there was a vice mayor, named Jishu. He was so poor that he used to consume tofu with rice instead of mutton, as he could not afford to buy it. The people started calling tofu as 'Vice Mayor's Mutton'.

The moral of the story is that tofu was widely consumed in China those days and it was less expensive but highly nutritious.[8]

HISTORY OF TOFU:

As already mentioned above, "Tofu" is actually a Japanese term that stems from the Chinese word "doufu," meaning bean curd.[9] The tofu was first mentioned in Japan in the year 1183. In 1457, the word TOFU was first written in Japanese characters and firstly mentioned in a European language in 1603. Benjamin Franklin, the famous politician of US, mentioned about tofu in his letter written in 1770. In 1821 AFM Willich mentioned the tofu as a 'curd or jelly made from the Chinese plant seed (soybean)', in *The Domestic Encyclopaedia*.

In 1880 tofu was first made in Europe on a non-commercial basis for some society. In 1896 tofu was appeared for the first time in an American Scientific Journal. In 1905 some Japanese shops of tofu were opened in the US in 1910 first commercial production started in Europe. Then after tofu is now becoming the famous food consumed all over the world. There are many famous manufacturing companies in many countries of the world. There were many books on tofu has been published. In 1985 the library of Congress decided to retain the name '*tofu'*, which was known as *'bean curd'* in many publications. In 1999 Food and Drug Administration (FDA) authorized the health claim about tofu which is stating that 'consumption of soy protein may reduce the risk of heart disease by lowering the cholesterol levels.[10,11]

NUTRITION IN TOFU

Tofu is an excellent source of protein. All eight essential amino acids i.e. isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine are provided in tofu. Thus tofu protein can be a good option to overcome the protein-energy malnutrition. Tofu is a rich source of vitamins and minerals like calcium, iron, manganese, selenium and phosphorous. Vitamin B_1, copper, zinc and magnesium also found in tofu in good amount.

Tofu has been proved good in lowering the risk of heart disease. It helps to reduce the bad cholesterol (LDL) level in the body which results in enhancing cardiovascular health. Tofu is a source of selenium which is effective against colon cancer. Women can get their calcium needed during menopause from tofu. It is found useful for preventing rheumatoid arthritis. [12]

Soybean is one among the very few plant sources of omega-3 fatty acids, which is very important for brain functioning and normal growth.[13] The infant from China using soy milk, found practically free from rickets. May be due to this plenty of health benefits, in China soybean is honored by giving the names like '*cow of the field'* or *'gold from soil'*.[14]

NEED OF THIS RESEARCH

The result of the nutritional survey carried out by the National Nutrition Monitoring Bureau (NNMB) and the National Institute of Nutrition (NIN) in 12 states of India shows that the diet of rural areas is found mostly inadequate in most of the nutrients especially proteins. At present in an average Indian diet, nearly half the protein comes from cereals. The cereals are low in protein. India stands on the fifth position in the production of soybean in the world. The protein content of soybean seeds is about 35% to 40% on a dry weight basis, which makes them a relatively inexpensive source of protein for human consumption.[15]

The protein malnutrition can be overcome by developing soybean-based high value and healthy food products. Tofu is a non-fermented soybean product and it is rich in protein as well as B-vitamins, and isoflavones. The calcium content can be improved by using calcium sulphate as a coagulant. As already mentioned the soybean also has some medicinal properties. Thus in Indian recipes, soybean products like tofu could be an affordable, healthy and nutritious substitute for the vegetarians.

MATERIALS AND METHODS

MATERIALS

There are very few ingredients required for making tofu. The main ingredients are soybean milk, water, and coagulating agents.[16]

Soybean was purchased from local market. We used calcium sulphate as a coagulant. The coagulant *Nigari* was used for the manufacturing of tofu traditionally. It is a sea water precipitate rich in some minerals such as magnesium and calcium chlorides.[17,18] Calcium sulphate was taken from the college laboratory.

METHODS

TOFU PREPARATION

Soybean, the main ingredient of tofu, was purchased from an authorized retailer in the local market. The grains were soaked in sufficient water for overnight. The soaking water was removed. For the inactivation of trypsin inhibitor, the soaked grains were treated with hot water for 3-5 min. Then the grains were ground with hot water in the proportion 1:10 w/v to get a smooth paste. The prepared paste was added to boiling water to get a semi-condensed mixture. The mixture is then filtered with fine muslin (cheese) cloth to obtain a white liquid known as soymilk.

Here I took 12 batches of milk with one liter each for the preparation of tofu. The 12 milk batches were divided into three groups. Thus each group will content four batches of milk with one-liter milk in each batch. In each group the four batches were heated to the temperature of 80°C, 85°C, 90°C and 95°C respectively.

0.5% food grade calcium sulfate solution was added to each milk pot with constant stirring for coagulation. Stirring was continued till the completion of the process of coagulation (6-10 minutes). Then the content was kept undisturbed at room temperature for 15-20 minutes. The coagulum was separated with the help of fine muslin cloth and then it is transferred to a special wooden mold for pressing. By putting weight the pressure was applied on the bulky solid coagulum for 45 minutes (around 1.5 Kg/cm^2) as does in paneer preparation. The water is removed in this process and the coagulum becomes more intact. The pressed bulk (tofu) so obtained was then removed from the mold and immediately dipped in chilled water for 30-40 minutes. The tofu was then placed on clean muslin cloth for the removal of excess water. The yield of freshly formed tofu was recorded.[19]

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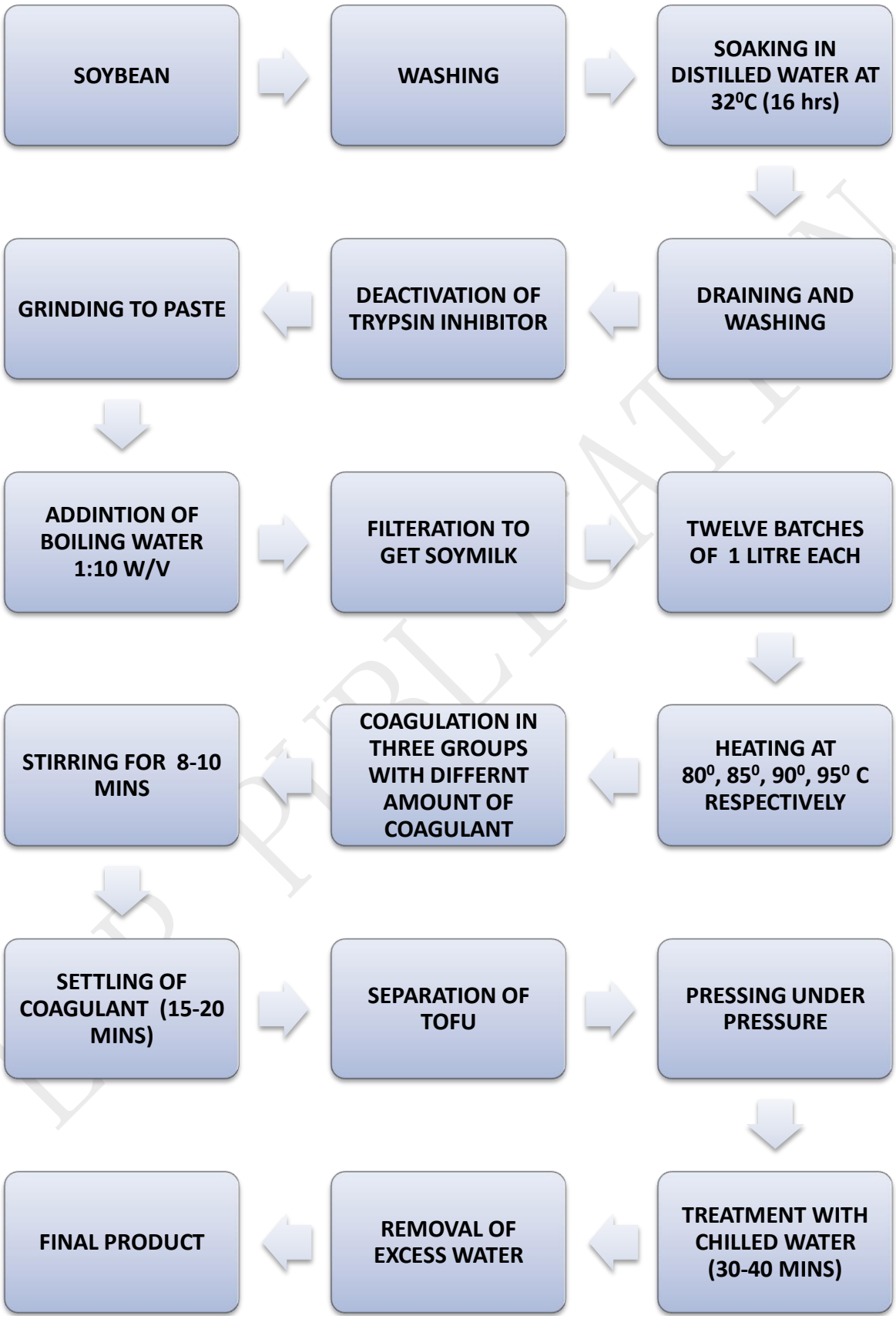
FLOW DIAGRAM FOR MANUFACTURING TOFU



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DETERMINATION OF MOISTURE

A clean and dry Petri dish was taken. Accurately 2 gm of tofu sample was taken using a digital balance into a tarred Petri dish. The dish was kept in a thermostatically controlled oven at 98º C temperature for about 5 hours. The dish was removed and kept in a desiccator for cooling. The dish was weighted after cooling. There was a decrease in weight observed due to loss of moisture. The dish was again kept in the oven and then again weighed after cooling. It was observed that there was again a reduction in weight. The procedure was repeated until there was no loss of weight and the constant readings were obtained. The final reading was recorded.

$$\text{Moisture (\%)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Weight of sample}} \text{ X } 100$$

RESULT AND DISCUSSION

EFFECT OF COAGULANT CONCENTRATION ON THE YIELD OF TOFU

As a good manufacturing practice, it is recommended that the optimum amount of coagulant should be used for the coagulation. The optimum amount of coagulant is that minimum amount which will give clear and transparent whey. The insufficient amount of coagulant will result in incomplete coagulation of proteins which will result in the formation of too cloudy whey. The resulting tofu will be very soft. The yield of such tofu will be high due to the high content of water but the solid and nutrient content will be low as insufficient coagulation of soymilk proteins. The effect of concentration of calcium sulphate used as a coagulant on the yield of soy paneer (tofu) is shown in the following tables.

EFFECT OF CALCIUM SULPHATE CONCENTRATION ON THE YIELD OF TOFU

TABLE 1:

Serial no.	Coagulation temperature	Weight of Calcium-sulphate taken for 200 gm grains	Moisture content of tofu (%)	Yield of tofu (gm)
1	80 °C	7 gm	77.4	354.8
2	85 °C	7 gm	79.2	358.4
3	90 °C	7 gm	82.1	364.2
4	95 °C	7 gm	82.5	365.0

TABLE 2:

Serial no.	Coagulation temperature	Weight of Calcium-sulphate taken for 200 gm grains	Moisture content of tofu (%)	Yield of tofu (gm)
1	80 °C	9 gm	78.4	356.8
2	85 °C	9 gm	80.2	360.4
3	90 °C	9 gm	82.7	365.4
4	95 °C	9 gm	82.4	364.8

TABLE 3:

Serial no.	Coagulation temperature	Weight of Calcium-sulphate taken for 200 gm grains	Moisture content of tofu (%)	Yield of tofu (gm)
1	80 °C	11 gm	80.2	360.4
2	85 °C	11 gm	81.3	362.2
3	90 °C	11 gm	84.1	368.2
4	95 °C	11 gm	84.0	368.0

It is observed that a relatively small increase in the amount of calcium sulphate above the optimum amount leads to a rather large increase in the bulk yield. Commercially it is considered as the most important factor. The firmness of tofu also found to be increased. However, considering the percentage of solids or the yield of nutrients, these most important factors remain virtually unaffected.

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The additional amount of calcium sulphate used over its optimum level simply makes the tofu to contract giving it a richer and denser flavor and also a high percentage of protein, calcium and other nutrients per gram. An average coagulant amount appears to be 0.015 N which corresponds to 2 to 3 grams of coagulant per 100 grams of dry soybeans

The coagulation of the relatively dilute soymilk (12:1 water: beans ratio) yields relatively firm tofu, whereas rich soymilk (6.5:1 ratio) yields a soft, smooth variety resembling silken or pressed silken tofu.

It is observed that the hotter the soymilk at the time of coagulation, the lesser the amount of coagulant required and the resulting tofu is more firm. When the soy paneer is coagulated at high temperature, it is observed that a small increase in the amount of coagulant, results in a high increase in the firmness of the tofu but rather a large drop in its bulk yield. The yield of the solid relatively appears to be unaffected by the temperature of coagulation or the amount of coagulant used. But it should be noted that as per the observations the hotter the soymilk, the faster the speed of coagulation reaction.

The method of coagulation and the rate of addition of coagulant are highly affect the quality and yield of tofu. The amount is also affected by the variety of the soybeans and the required coagulant.

RESULTS AND DISCUSSION

Very few ingredients like Soybean, coagulant, and water are needed for the production of tofu. The process is also quite simple. So instead of using large and expensive types of equipment, the experiment of producing the tofu using the simple home appliances was carried out. Calcium sulphate was used as a coagulant for the coagulation of soymilk. Another purpose of using calcium sulphate as a coagulant is to enhance the calcium content of the tofu. The tofu thus prepared was not only rich in protein and calcium but it is also cholesterol free. During the coagulation process at the high temperature of soymilk, a good yield of tofu was obtained even using less amount of calcium phosphate. Increase in Calcium-sulphate concentration at a high temperature of milk lowers the bulk yield.

CONCLUSION

As the simple process using home appliances was applied the cost of manufacturing is low in comparison. The high moisture content of tofu increased the yield by 25% over the quantity of used raw ingredients. The research is taken in such a way to get the perfect and low-cost protein-rich food alternative, which can be given to the commercial market of developing countries like India, which will contribute to minimizing the problem of protein-energy malnutrition. The other protein-rich animal foods are associated with the risk of various health problems, but our product is with increased calcium content and cholesterol free. The present study is basically aimed for the development of calcium fortification of tofu using home appliances. The product obtained is highly nutritious and lower in cost, to make affordable to poor people.

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