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Utilisation of Lemon Juice in the Preparation of Tofu from Black Soyabean

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The present study was undertaken to study the effect of lemon juice on the quality of tofu prepared from black soyabean. Soymilk tofu coagulated with three different coagulants viz. calcium chloride, calcium sulphate and lemon juice were compared in terms of yield and sensory attributes. The yield percentage and overall acceptability of lemon juice tofu was significantly higher than calcium chloride tofu but no significant change was observed with calcium sulphate tofu. The crude protein, crude fat, crude fiber and ash content of the lemon juice tofu was found to be 51.58%, 13.45%, 6.88% and 3.15 % in dry basis, respectively.

Keywords: Coagulants, lemon juice, sensory quality, tofu, black soyabean

Introduction

Tofu, also known as soyabean (or soybean) curd, is made by coagulation of heated soya milk with a coagulant, followed by moulding and pressing the curd to draw the whey. Yield, quality and texture of tofu are influenced by several factors such as variety of soyabeans and storage conditions, time and temperature of soaking the soybeans, extent of heat-treatment of soymilk, type and concentration of coagulant and rate of stirring and coagulation temperature (Cai *et al*., 1997; Karim *et al*., 1999; Noh *et al*., 2005; Obatolu, 2008; Prabhakaran *et al*., 2006; Shih *et al*., 2002; Sun and Breene, 1991). Various coagulants have been used in the preparation of tofu, each coagulant resulting in a product with textural characteristics. Calcium sulfate, calcium chloride, magnesium sulfate and magnesium chloride are many of the different types of coagulants used on an industrial scale for the preparation of tofu. Coagulation occurs due to the cross-linking of protein molecules in soymilk with the divalent cations (Saio *et al*., 1967; Lim *et al*., 1990).

Among a variety of soyabeans, the black soyabean is reported to have discriminating components, such as phenolic acids, anthocyanins and isoflavones (Xu and Chang, 2008) and is also known to display superior biological activities to yellow and green soyabeans, such as free radical scavenging activitiesand inhibition of LDL oxidation (Astadi *et al*., 2009; Takahashi *et al*., 2005; Xu and Chang, 2008). In addition, anti-inflammatory (Kim *et al*., 2008) and anticancer (Hung *et al*., 2007) activities of black soyabean have also been reported. A study has been done on black soyabean *touhua* using glucono-δ-lactone (Chang *et al*., 2009). However, study on black soyabean tofu has not been found yet. On the other hand, lemon juice as a coagulant could serve as the cheap source as compared to expensive salts. Further, lemon is readily available in the local market in all seasons which could help small-scale processors in tofu preparation. Hence, an attempt was made to study the use of lemon juice as a coagulant in the preparation of tofu from black soyabean and compare its yield with commercial coagulants.

Materials and Methods

Materials

Common black variety of soyabean *(Glycine max*) locally known as '*sathiya'* was collected from the Everest Seed Industries, Khumaltar, Lalitpur, Nepal. The coagulants calcium chloride and calcium sulphate dehydrate were of Fisher Scientific Inc., India while lemon was obtained from the local market.

Preparation of tofu

400 gm of black soyabean was taken separately for each of the three coagulating agents and were soaked separately in water (six times bean weight) for 12 h at ambient temperature (24±2 °C).The swelled beans were dehulled manually and grinding was done with intermittent addition of potable water. The raw bean to water ratio was maintained at 1:10 by adding water. The mash was heated and boiled for 10 minutes and filtered through muslin cloth.The temperature of milk was lowered to 75 °C. Then the coagulating agents were added with continuous stirring. The concentration of the salts used was 0.3% and the titratable acidity of lemon juice was

5.0%. The resultant curd was transferred to a home-made mould (20.3 x 20.3 x 18.4 cm^3) lined with muslin cloth and pressed for 3 h by placing a weight of 8 kg. After pressing, tofu samples were weighed and dipped in 2 % brine.The tofu prepared from calcium chloride, calcium sulphate and lemon were coded as CC-tofu, CS-tofu and LJ-tofu respectively.

Yield, sensory and proximate analysis

The yield of tofu was calculated as the weight of fresh tofu obtained from a specified amount of the soyabean used for its preparation (Prabhakaran *et al*., 2006). Sensory attributes of freshly prepared tofu was done by ten semi-trained panelists. Tests on color, texture, taste and overall acceptance were conducted using a 9-point hedonic scale (1= dislike extremely, 9 = like extremely) as per Ranganna (2008). Moisture content, crude fat, crude protein and crude fiber were determined as per Ranganna (2008). Carbohydrate was determined by difference. Results were expressed on dry matter basis.

Statistical analysis

Data were analyzed in triplicates and subjected to the analysis of variance (ANOVA) using Genstat® software. Mean comparisons were made by least significant difference (LSD) test. A significant level was defined as a probability of 0.05 or less.

Results and Discussion

Yield of tofu

The yield of tofu varied with the type of coagulants, as shown in Table 1.

Table 1. Effect of coagulants on yield of tofu

Sample	% Yield
CC-tofu	126.61 (4.05)^a
CS-tofu	146.66 (13.77)^b
LJ-tofu	147.30 (6.34)^b

Values are the mean of three determinations. Figures in the parenthesis are the standard deviations

CC calcium chloride coagulated tofu, CS calcium sulphate coagulated tofu, LJ lemon juice coagulated tofu

Different superscripts within the same column are significantly different ($p<0.05$)

The yield percentage of tofu varied from 126.61% to 147.30%. CC-tofu had the least yield and was significantly lower than the yield of CS-tofu and LJ-tofu, the latter being significantly similar. The yields of tofu depend on different factors. Hou *et al*.(1997) reported that the coagulants, stirring speed and stirring time had a significant influence on yield and textural properties of tofu. Hou and Chang (2003) reported that storage time also influences the yield of tofu. The yield of tofu was also found to be influenced by heating time (Noh *et al*., 2005). In a study by Karim *et al*. (1999), the yield of calcium sulphate coagulated tofu was found to be 140.5 g based on 700 ml soymilk. In the same way, Obatolu (2008) reported the yield of calcium sulphate coagulated tofu to be 565.7 g, and that of lemon juice coagulated tofu to be 477.1 g based on soymilk. In another study, the yield of calcium chloride coagulated tofu was 209.99 g and that of calcium sulphate coagulated tofu was 232.49 g, based on 500 g soymilk (Prabhakaran *et al*., 2006).

Sensory analysis

Table 2 shows the results of sensory evaluation of tofu for different quality attributes such as color, texture, taste and overall acceptability by a panel using a 9-point hedonic scale.

Table 2. Effect of coagulants on the sensory characteristics of tofu

Sample	Color	Texture	Taste	Overall acceptability
CC-tofu	6.32^a	6.73^a	6.10^a	6.50^a
CS-tofu	7.20^b	6.35^b	6.85^b	6.90^b
LJ-tofu	7.05^b	6.90^a	7.30^b	7.42^b

Values are the mean of three determinations. Different superscripts within the same column are significantly different ($p<0.05$)

CC calcium chloride coagulated tofu, CS calcium sulphate coagulated tofu, LJ lemon juice coagulated tofu

The overall acceptability scores of tofu ranged from 6.50 to 7.42. The highest score was achieved by the LJ-tofu which was significantly similar ($p>0.05$) with CS-tofu, but both differed significantly ($p<0.05$) with CC-tofu. In a study conducted by Obatolu (2008), similar results were found. The lemon juice coagulated tofu was more preferred in terms of flavor, mouthfeel and overall acceptability. The preference is attributed to the elimination or reduction of the L2 and L3 lipoxygenase isozymes.

Proximate analysis of LJ-tofu

Table 3. Proximate composition of LJ-tofu

Parameters	Value
Moisture content (%wb)	71.88 (0.96)
Protein (%db)	51.58 (0.69)
Fat (%db)	13.45 (0.02)
Crude fiber (%db)	6.88 (0.07)
Ash (%db)	3.15 (0.05)

*Values are the mean of three determinations. Figures in the parenthesis are the standard deviations.

The proximate composition of LJ-tofu is given in Table 3. The tofu preparation from black soyabean by using lemon as a coagulating agent contained 71.88% moisture content (dry basis). The contents of protein, fat, crude fiber and ash were 51.58 %, 13.45 %, 6.88 % and 3.15 % respectively on dry basis. The protein content was at par with the tofu prepared from T3 black soyabean (Shih *et al*., 2002). However, the crude fat and ash content were found to be lower in LJ-tofu. The results were not found to comply with that of Obatolu (2008) too. This might be due to difference in variety of soyabean, type of coagulant and the amount of coagulant used (Cai *et al*., 1997; Karim *et al*., 1999; Obatolu, 2008; Prabhakaran *et al*., 2006; Shih *et al*., 2002; Sun and Breene, 1991).

Conclusions

It has been confirmed the feasibility of replacing commercial salts by lemon juice for the coagulation of soyabean milk in the manufacture of tofu from black soyabean. The yield of tofu was also higher and sensory properties were also better.

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