

Utilization and Standardization of Fermented Maize Waste Liquor as a Coagulant for Tofu Production and Its Effect on Tofu Quality

China, Mercy A. H.^{1*} and Amadi, Gift Amukeru¹

¹Department of Home Science and Management, Rivers State University, Nkpolu Oroworukwo, Port Harcourt, Rivers State, Nigeria.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Coagulation of soymilk is the most important step in the production of tofu. Industrially, CaCl_2 , CaSO_4 , MgSO_4 and MgCl_2 are many of the different types of coagulants. Effluent from pap produced from maize is a local coagulant used; however, this has not been standardized. This study therefore aimed at standardizing fermented maize waste liquor (FMWL) as a local coagulant for tofu production. FMWL at ratios of 600 ml, 550 ml, 500 ml, 450 ml to 1000 ml soybean milk was used to prepare tofu and compared with tofu coagulated with lemon juice. The result revealed that the tofu coagulated with 550 ml of FMWL exhibited higher fat (47.78%) while tofu coagulated with 600 mls of FMWL had significantly ($p < 0.05$) higher protein (31.75%). On the other hand, sample coagulated with 500 mls FMWL had significantly ($p < 0.05$) higher crude fibre content. Soymilk coagulated with 400ml of FMWL exhibited significantly ($p < 0.05$) higher contents of magnesium (75.42 mg/100g) and calcium (46.32 mg/100g) and iron (15.85 mg/100g) while the sample coagulated with lemon juice (control) had higher potassium content (201.17 mg/100g) The sensory evaluation result revealed that the control sample was highly acceptable to the panelists and this was followed closely with the sample coagulated with 550mls of FMWL. Hence, FMWL when utilized at a level of 550 mls will yield soybean curd that is acceptable and comparable to soybean curd coagulated with lemon juice. The use of FMWL will serve as an alternative, cheap and natural coagulant for soybean curd preparation at household and commercial levels.

*Corresponding author: Email: mercy4china@gmail.com;

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1. INTRODUCTION

Tofu is a soymilk curd production made through a non-fermented process from soymilk. It is generally made by protein coagulation of heated soybean milk with a coagulant (CaCl_2 , CaSO_4 , or $\text{C}_6\text{H}_8\text{O}_7$). The role of the coagulant is to produce a soy protein gel which traps water, soy lipids and other constituents in the matrix forming curds and the curds are then pressed into solids to drain the whey [1]. It is one of the most highly versatile and nutritious food which is traditionally consumed in East and South Asian countries and is gaining an increasing popularity throughout the world as a healthy vegetable protein source as compared to meat, fish and cheese [2]. Yasin et al. [3] reported tofu to contain moisture content of 72.45-74.95%, 53.04-56.73% protein, 27.92-33.88% fat, 0.36-1.13% crude fibre and 1.81-2.22% ash. It is cholesterol free, rich source of protein, minerals and polyunsaturated fatty acid [4]. Isoflavones (genistein, daidzein and glycitein) in tofu have several health-promoting functions like anti-carcinogenic, lowering blood cholesterol and sugar and reducing the risk of cardiovascular disease [5].

Tofu is popularly produced using soybean milk. The yield and quality of tofu are influenced by soy bean varieties, soy bean quality (growth and storage environment dependent) and the processing conditions of the coagulants [6]. Soybean (*Glycine max*) has recently become popular in the West Africa sub-region providing vegetable protein for most persons and ingredients for different food products. Soybeans seed is a valuable source of famine food with many uses and benefits. Soybean seed as a functional food provides health benefit beyond basic nutrition. Soybeans is considered as an excellent source of protein (35-40%) and also rich in minerals and vitamins such as iron, zinc, copper, thiamine, riboflavin, niacin and pantothenic acid [7]. The variation in the chemical and physical properties of soybean varieties may consequently affect the quality and yield of tofu [8].

Coagulation of soymilk is the most important step in the production of tofu. Coagulation of soymilk can be carried out with the aid of coagulants. Coagulation of soymilk for tofu production can be accomplished using two types of coagulants (salts and acids) [9]. Industrially, CaCl_2 , CaSO_4 , MgSO_4 and MgCl_2 are many of the different

types of coagulants used for the preparation of tofu. The process of coagulation involves cross-linking of protein molecules in the soymilk with the divalent cations. After which the whey is removed for the preparation of a firm tofu [10]. The different coagulant used in the preparation of tofu determines the nutritional composition of tofu [11]. In Nigeria, tofu is usually produced at household level using various types of coagulants such as calcium chloride, alum and steep water i.e. effluent from pap produced from maize. Fermented maize (*Zea mays*) waste liquor (FMWL) locally known as “akamu waste water” has being used traditionally as a local coagulant for tofu production however, this has not been standardized. Akamu is a lactic acid fermented food made from maize. The maize is soaked for 2-3 days, wet milled and sieved through a screen till the following day. The akamu is allowed to settle and the waste water is removed and sometimes discarded [12]. Akamu waste water is acidic because of the fermentation. Lactic acid bacteria (*Lactobacillus delbrueckii*, *Lactobacillus plantarum*, *Lactobacillus fermentum*, *Lactobacillus amylovorus*) have been shown to be predominantly involved in the fermentation of akamu, playing roles as aroma development, microbial stability and flavour enhancement [13,14]. The acidic nature therefore qualifies it to be used as a coagulant.

The type and amount of coagulant may affect the qualities of tofu. Panyathitipong and Puechkamut [15] reported increased tofu hardness and decreased tofu yield upon increasing coagulation concentration. According to Liu and Chang [16], coagulation is the most difficult to master in tofu production, since it relies on complete inter-relationship of the following variable; soy bean chemistry, soy milk cooking temperature, volume solid content and pH, coagulant type amount, concentration and the method of adding and mixing and the coagulation temperature and time. The variation in controlling all these variables greatly affects tofu yield quality. Tofu coagulants used commercially are expensive and in most cases, they may not be available. There is therefore a need to standardize the utilization of FMWL to ensure sustainable utilization in the production of textured vegetable protein (tofu) and to sustain protein consumption at the family level, especially among households in rural areas as part of measures to combat protein shortages in form of meat analogues (meat alternative).

Hence, the important of this study which aims at utilizing and standardizing FMWL as a coagulant for tofu production and to determine its effect on the quality of tofu produced.

2. MATERIALS AND METHODS

2.1 Raw Materials

Soybean (*Glycine max*), salt, pepper, stock powder and vegetable oil were bought from Mile 3 market, Port Harcourt, Rivers State, Nigeria. Other chemical and regents were provided by the analytical laboratory of Food Science and Technology, Rivers State University, Nigeria.

2.2 Processing of Tofu from Soybean Milk

Milk was processed from soybeans using the method of China et al. [17]. Soybeans seeds were sorted, washed and soaked overnight. Thereafter, it was dehulled and wet milled using a commercial mill and sieved using chiffon cloth to obtain soybeans milk that was used for preparation of soybeans curd. The soybean milk was boiled for 1 h followed by the addition of two coagulants: fermented maize waste liquor and lemon juice. Lemon juice coagulant (100 ml) served as the control while FMWL was used at a ratio of 600 ml, 550 ml, 500 ml, 450 ml and 400 ml to 1000 ml of soybeans milk (Table 2).

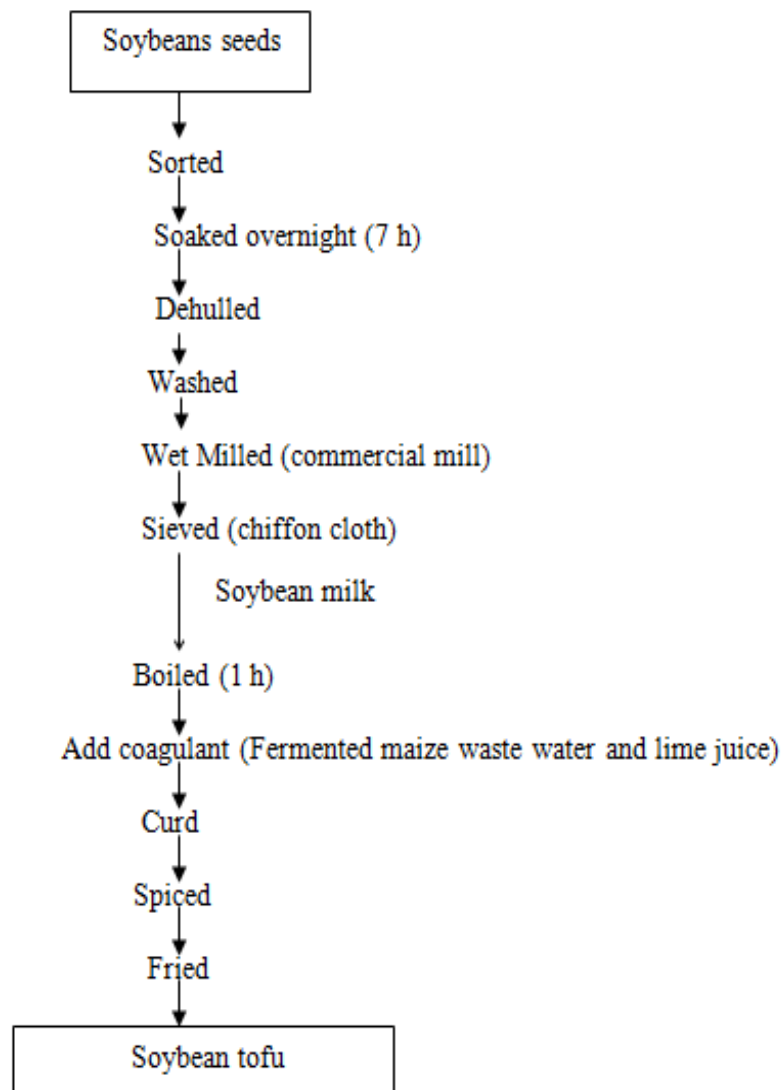


Fig. 1. Processing of tofu from soybean milk

Source: China et al. [17].

Table 1. Recipe and standardization of fermented maize waste liquor for tofu production

Ingredients	Samples					
	SBAA	SBAB	SBAC	SBAD	SBAE	SBAF
Soybean milk (ml)	1000	1000	1000	1000	1000	1000
Fresh pepper (g)	25	25	25	25	25	25
Vegetable oil (ml)	250	250	250	250	250	250
Salt (g)	1.5	1.5	1.5	1.5	1.5	1.5
Stock powder (g)	1.5	1.5	1.5	1.5	1.5	1.5
FMWL (ml)	600	550	500	450	400	-
Lime juice	-	-	-	-	-	100

Keys: SBAA= 1000ml soybean milk: 600 ml FMWL; SBAB= 1000ml soybean milk: 550 ml FMWL; SBAC= 1000ml soybean milk: 500 ml FMWL; SBAD= 1000ml soybean milk: 450 ml FMWL; SBAE= 1000ml soybean milk: 400 ml FMWL; SBAF= 1000ml soybean milk

2.3 Proximate Composition of the Tofu Samples

Moisture, ash, fat, crude protein and crude fibre content of the samples was carried out according to AOAC [18] methods of analysis while carbohydrate content was evaluated using the formula below:

$$\text{Total carbohydrate (\%)} = 100 - (\text{Fat \%} + \text{Protein \%} + \text{Moisture \%} + \text{Ash \%} + \text{Crude Fibre})$$

2.4 Sensory Evaluation of the Tofu Samples

A twenty-member trained panelist consisting of students of the Rivers State University, Port Harcourt, Nigeria was used for sensory evaluation. Soybean curd (tofu) coagulated with fermented maize waste liquor at different ratios were compared to soybean curd coagulated with lemon juice. Sensory evaluated for colour, taste, texture, aroma and overall acceptability was determined by the panelists. The coded samples were served on a white saucer. Water was also served for cleaning the mouth in-between each sample to prevent the transfer of sensory attributes from one sample to the other. Each attribute was rated on a 9-point Hedonic scale where 1 and 9 represented dislike extremely and like extremely, respectively [19].

2.5 Statistical Analysis

Results were analyzed statistically by the analysis of variance and differences between means separated using Turkey's Multiple Comparison Test and significance accepted at $p > 0.05$ level. The statistical package in MINITAB 16 computer programme was used.

3. RESULTS AND DISCUSSION

3.1 Effect of Fermented Maize Waste Liquor (akamu waste water) on the Proximate Composition of Curd Produced from Soymilk

Table 2 shows the proximate composition of soybean curd coagulated with fermented maize waste liquor (FMWL). Moisture content of the soybean curd samples ranged from 13.67-24.04% with sample A (sample coagulated with 600 ml FMWL) having the lowest value (13.67%) while the control sample F (soybean curd coagulated with lemon juice) had the highest value (24.04%). Moisture content of the samples decreased significantly ($p < 0.05$) as the amount of FMWL increased. Shokunbi et al. [20] reported higher moisture content (59.63-77.93%) for soybean curd processed with CaCl_2 , MgCl_2 , CaSO_4 , MgSO_4 and alum. The variation in the moisture content of soybean curd prepared with different proportions of fermented maize waste liquor is probably due to the differences in gel network within the soybean curd particles that is influenced by different anions and its ionic strengths towards the water holding capacity of soy protein gels [1]. The moisture content from this study is however comparable with the values of 18.38-43.56% reported by Ifesan and Oguntoyinbo [21] for soybean curd produced from soy-sesame seed blends. The low moisture content of soybean curds coagulated with higher percentages of fermented maize waste liquor may provide them superior shelf-life as compared to soybean curd coagulated with lemon juice. High moisture content has been associated with short shelf life of food products, as they encourage microbial proliferation that lead to spoilage [22].

Ash content of the soybean curd samples ranged from 1.34-1.44% with sample D (Sample coagulated with 450 ml of FMWL) having the lowest value (1.34%) while sample F (control sample) and sample C (sample coagulated with 500 ml FMWL) had the highest values (1.44%). The use of FMWL as a coagulant had no significant effect ($p>0.05$) on the ash content of the soybean curd samples. The ash content of the soybean curd samples obtained from this study (1.34-1.44%) were lower than those (5.80-8.80%) reported by Shih et al. [23] for soybean curd produced from black soybean. The values are also slightly lower than the values of 1.75-4.77% obtained by Ifesan and Oguntoyinbo [21] for soybean curd produced from blends of soybean and sesame seed. The differences in ash content may be due to differences in processing procedure as well as soybean varieties used. The ash content is a measure of mineral elements in a food.

Fat content of the soybean curd samples ranged from 24.85-36.32% with sample D having the lowest value (24.85%) and sample C having the highest value (38.09%). Fat content of the soybean curd coagulated with 500-550ml of FMWL showed no significant ($p>0.05$) difference indicating that there was no significant effect of FMWL on the fat content at this level. Fasoyiro [24] also reported increased fat content (12.30-13.40%) for soybean curd coagulated with roselle extract as the proportion of roselle extract increased. The result for fat content of the soybean curds from this study is comparable with the values of 18.70-35.20% for soybean curd using various types of coagulant [25]. Ifesan and Oguntoyinbo [21] also reported fat content of soybean curd produced from soybean milk and sesame blends to be within the range of 30.56-75.67% which is within the values obtained from the study. The results are however higher when compared to the values of 7.87-15.39% for soybean curd processed with different coagulants (CaCl_2 , MgCl_2 , CaSO_4 , MgSO_4 and alum) as reported by Shokunbi et al. [20]. The high oil content in the soybean curds coagulated with fermented maize water liquor will affect the shelf stability. Fat is essential component of tissues and a veritable source of fat soluble vitamins (A, D, E and K). It is able to supply thrice the amount of energy required by the body [26].

Protein content of the soybean curds ranged from 21.68-31.75% with the sample coagulated with 450 ml FMWL having the lowest value

(21.68%) while the sample coagulated with 600 ml of FMWL had the highest value (31.75%). Protein content of the sample coagulated with 600 mls of FMWL was significantly ($p<0.05$) higher than all other samples. These differences might be as a result of the incorporation of FMWL at higher levels which might have increased the protein content of the soybean curds. Ojokoh and Oromosele [27] reported that fermentation is a method which can be used to improve food product functionality and protein content. The reason might also be as a result of the increased metabolic activities of the microorganisms which resulted to the increase of extracellular enzymes into the soybean curd on coagulation with fermented maize water liquor. The high protein content of the soybean curd coagulated with 600 ml of fermented maize waste liquor has a good implication in a society with high protein deficiency and will no doubt complement protein from cereals and other plant foods in the diet of Nigerians. Protein is a major nutrient needed as building block for the body, necessary for growth and for the repair of damaged tissues [26]. The result for protein from this study is comparable to the values of 8.52-30.33% for fried and unfried soybean curd produced from soy-sesame seed. Ndatsu and Olekan [25] reported soybean curd from different coagulants to contain 32.10-39.00% protein which is also comparable with the values obtained in this study. Crude fibre content of the soybean curds ranged from 11.97-14.95% with sample B (sample coagulated with 550 ml FMWL) having the lowest value (11.97%) and sample C (sample coagulated with 500 ml FMWL) as the highest (14.95%). Crude fibre content of the tofu samples were significantly ($p<0.05$) higher than the sample coagulated with FMWL (except for sample coagulated with 500 mls FMWL). This may be attributed to enzymatic breakdown of the crude fibre by the fermenting microorganisms present in the liquor. High fibre food expands the inside walls of the colon, easing the passage of waste and this making it an effective anti-constipation. They are useful in the management of diseases such as obesity, diabetes, cancer and gastrointestinal disorders [20]. The fibre content of the soybean curds from this study (11.97-14.95%) is viable enough to support the management of the afore-listed diseases. Crude fibre content from this study is higher than the value of 6.88% reported by Gartaula et al. [28] for lemon juice coagulated soybean curd. It is also higher when compared with the values of 6.67-9.75% reported by Shokunbi et al. [20] for soybean curd coagulated

with different coagulants (CaCl₂, MgCl₂, CaSO₄, MgSO₄ and alum).

Carbohydrate content of the soybean curds ranged from 2.12-17.09% with sample C (sample coagulated with 500 mls FMWL) having the lowest value (2.12%) while sample D (sample coagulated with 450 mls FMWL) had the highest value (17.09%). Carbohydrate content of all the samples coagulated with FMWL (except for sample coagulated with 500 mls FMWL) was higher than the control sample. This could probably be due to the use of fermented maize waste liquor as maize is rich in carbohydrate. It is possible that starch in the akamu effluence might have been transferred in to the soybean curd. The result obtained from this study for the soybean curds coagulated with FMWL is higher when compared with the values of 1.38-2.34% reported by Ifesan and Oguntoyinbo [21] for soybean curds produced from blends of soybean and sesame seed.

3.2 Effect of Fermented Maize Waste Liquor (akamu waste water) on the Mineral Composition of Curd Produced from Soymilk

Table 3 shows the mineral composition of soybean curd coagulated with FMWL liquor. Magnesium content of the soybean curds ranged from 51.70 mg/100g in the control sample to 75.42 mg/100g in sample coagulated with 400 ml of FMWL. The samples coagulated with FMWL had higher magnesium content than the control sample. This could be attributed to the action of fermenting organisms in the waste water. The high levels of magnesium in the soybean curds coagulated with FMWL is good for the body as magnesium is needed for proper bone formation, as co-factors and other biochemical functions in the body [29].

Calcium content of the soybean curds ranged from 29.45-46.32 mg/100g with sample B having the lowest value (29.45 mg/100g) while sample E had the highest value (46.32 mg/100g). Calcium content of the soybean curds coagulated with 400 ml of fermented maize waste liquor was higher than the control sample; however, at levels beyond 400 ml, a significant ($p < 0.05$) decrease in the calcium content of the soybean curds was observed. Calcium is required in our diets for proper bone and teeth formation and development, blood clotting and other numerous body functions [28].

Potassium content of the soybean curds ranged from 70.39 mg/100g in sample A to 201.19

mg/100g in the control sample. In this study, the potassium content of all the soybean curds coagulated with fermented maize waste liquor were generally lower than that of the control sample (lemon juice coagulated soybean curd). These values are also lower when compared with the values of 828.28-1351.97 mg/100g for soybean curds processed with different coagulants as reported by Shokunbi et al. [20]. It is however comparable with the values of 81.66-200.66 mg/100g for soybean curd produced from soy-sesame blends reported by Ifesan and Oguntoyinbo [21]. Potassium is needed in fluid balance and regulation of nerve impulse conduction, regular heart beat and cell metabolism [30].

Phosphorus content of the samples ranged from 6.64-7.54 mg/100g with sample B having the lowest value (6.64mg/100g) and sample C as the highest (7.54 mg/100g). Phosphorus content of all the samples coagulated with fermented maize waste liquor (except for sample coagulated with 500 ml FMWL) was generally lower when compared with the control sample. The result obtained was also lower than the values of 687.66-703.66 mg/100g for soybean curd produced from soy-sesame blends as reported by Ifesan and Oguntoyinbo [21]. Phosphorus is an important constituent of every living cell. It is also very essential in bone formation and other cellular reactions in the body [27].

Iron content of the samples ranged from 7.49 mg/100g in the control sample to 18.00 mg/100g in sample D. The soybean curds coagulated with fermented maize waste liquor were generally higher than the control sample. These values were comparable with the iron content of soybean curds produced from soy-sesame blends (7.70-14.56 mg/100g) as reported by Ifesan and Oguntoyinbo [21]. Regular consumption of food that is rich in iron has the potential to prevent anemia in infants and young children [29].

3.3 Effect of Fermented Maize Waste Liquor (akamu waste water) on the Mean Sensory Scores of Curd Produced from Soymilk

Table 4 shows the mean sensory scores of soybean curd coagulated with FMWL. Colour of the soybean curds ranged from 2.40-3.85 with sample C (sample coagulated with 500 ml FMWL) as the least preferred sample while sample B (sample coagulated with 550 ml of FMWL) as most preferred sample. Colour of the

samples coagulated with higher amounts of fermented maize waste liquor (500 and 550 ml) were more preferred than all other samples; however, the control sample did not differ significantly ($p>0.05$) from all the soybean curds in terms of colour.

Taste of the samples ranged from 2.45-4.30 with sample C as the least preferred sample while the control sample was most preferred. There was a decrease in the taste scores as the proportion of FMWL increased; however, an increase was observed at levels beyond 500 mls. Taste of the samples were not significantly ($p>0.05$) different among the soybean curd samples.

Aroma of the samples ranged from 2.75-4.30 with sample D (sample coagulated with 450 ml FMWL) as the least preferred sample and the control sample as most preferred. Similarly, a decrease in the aroma of the samples was observed as the proportions of FMWL increased. Texture of the samples ranged from 2.95 in

sample E to 4.25 in the control sample. The result also showed a decreasing trend in the texture scores of the soybean curd samples as the proportion of fermented maize waste liquor increased.

Overall acceptability of the samples ranged from 2.91-3.87 with sample D as the least preferred and the control samples as most preferred sample. A decrease in the overall acceptability of the soybean curds was also observed as the proportion of FMWL increased; however, increased were observed at levels beyond 400 mls of FMWL. The decreased sensory scores of soybean curd coagulated with fermented maize waste liquor could be attributed to the fact that the liquor is an heterogeneous mixture with characteristic taste, odour and colour and it might have imparted its taste and aroma on the soybean curds which actually reduced the acceptability of the soybean curds coagulated with fermented maize waste liquor despite its high nutrient content. Similar findings were also

Table 2. Percentage Proximate Composition of Soybean curd coagulated with Fermented maize waste liquor (akamu waste water)

Samples	Moisture	Ash	Fat	Protein	Crude fibre	Carbohydrate
A	13.67 ^d ±0.38	1.39 ^a ±0.14	36.32 ^a ±0.00	31.75 ^a ±0.62	12.22 ^{cd} ±0.17	4.65 ^d ±0.65
B	14.10 ^d ±0.00	1.39 ^a ±0.14	37.78 ^a ±0.67	24.32 ^c ±0.62	11.97 ^d ±0.09	10.46 ^b ±1.23
C	19.52 ^{bc} ±0.39	1.44 ^a ±0.21	38.09 ^a ±0.09	23.88 ^c ±0.71	14.95 ^a ±0.31	2.12 ^d ±0.30
D	21.11 ^b ±0.59	1.34 ^a ±0.07	24.85 ^c ±0.70	21.68 ^d ±0.61	13.92 ^b ±0.72	17.09 ^a ±1.38
E	19.13 ^c ±0.54	1.39 ^a ±0.14	30.86 ^b ±0.29	27.41 ^b ±0.51	13.08 ^{bc} ±0.68	8.13 ^c ±0.56
F	24.04 ^a ±0.07	1.44 ^a ±0.21	29.94 ^b ±0.78	27.38 ^b ±0.00	14.47 ^a ±0.54	2.74 ^d ±0.11

Mean ± Standard deviation with the same superscript in the same column show no significant difference ($p\leq 0.05$); Keys: A= 1000 soybean milk: 600 ml fermented maize waste liquor (akamu waste water); B= 1000 soybean milk: 550 ml fermented maize waste liquor (akamu waste water); C= 1000 soybean milk: 500 ml fermented maize waste liquor (akamu waste water); D= 1000 soybean milk: 450 ml fermented maize waste liquor (akamu waste water); E= 1000 soybean milk: 400 ml fermented maize waste liquor (akamu waste water); F= 1000 soybean milk: 100 ml lemon juice

Table 3. Mineral Composition (mg/100g) of soybean curd coagulated with fermented maize waste liquor (akamu waste water)

Samples	Magnesium	Calcium	Potassium	Phosphorus	Iron
A	59.29 ^c ±0.01	29.70 ^e ±0.01	70.39 ^d ±0.00	6.96 ^c ±0.00	9.86 ^{cd} ±0.04
B	55.17 ^e ±0.04	29.45 ^e ±0.00	85.74 ^d ±0.05	6.64 ^e ±0.05	11.98 ^{bc} ±0.00
C	55.60 ^{bd} ±0.00	35.33 ^c ±0.08	138.23 ^b ±0.14	7.54 ^a ±0.04	15.10 ^{ab} ±1.41
D	60.15 ^b ±0.07	32.41 ^d ±0.01	79.98 ^e ±0.11	6.83 ^d ±0.00	18.00 ^a ±1.41
E	75.42 ^a ±0.02	46.32 ^a ±0.00	119.50 ^c ±0.14	6.82 ^d ±0.02	15.85 ^a ±0.00
F	51.70 ^f ±0.00	40.45 ^b ±0.00	201.17 ^a ±1.41	7.19 ^b ±0.00	7.49 ^d ±0.01

Mean ± Standard deviation with the same superscript in the same column show no significant difference ($p\leq 0.05$); Keys: A= 1000 soybean milk: 600 ml fermented maize waste liquor (akamu waste water); B= 1000 soybean milk: 550 ml fermented maize waste liquor (akamu waste water); C= 1000 soybean milk: 500 ml fermented maize waste liquor (akamu waste water); D= 1000 soybean milk: 450 ml fermented maize waste liquor (akamu waste water); E= 1000 soybean milk: 400 ml fermented maize waste liquor (akamu waste water); F= 1000 soybean milk: 100 ml lemon juice

Table 4. Mean sensory scores of Soybean curd coagulated with Fermented maize waste liquor (akamu waste water)

Samples	Colour	Taste	Aroma	Texture	Overall Acceptability
A	3.80 ^a	4.05 ^a	3.10 ^{bc}	3.25 ^b	3.50 ^{ab}
B	3.85 ^a	3.80 ^a	3.25 ^{abc}	3.45 ^{ab}	3.63 ^a
C	2.40 ^b	2.45 ^b	3.75 ^{abc}	3.40 ^{ab}	3.01 ^b
D	2.50 ^b	3.25 ^{ab}	2.75 ^c	3.25 ^b	2.91 ^b
E	2.80 ^{ab}	3.85 ^a	4.05 ^{ab}	2.95 ^b	3.41 ^{ab}
F	2.65 ^{ab}	4.30 ^a	4.30 ^a	4.25 ^a	3.87 ^a

Mean with the same superscript in the same column show no significant difference ($p \leq 0.05$); Keys: A= 1000 ml soybean milk: 600 ml fermented maize waste liquor (akamu waste water); B= 1000 ml soybean milk: 550 ml fermented maize waste liquor (akamu waste water); C= 1000 ml soybean milk: 500 ml fermented maize waste liquor (akamu waste water); D= 1000 ml soybean milk: 450 ml fermented maize waste liquor (akamu waste water); E= 1000 ml soybean milk: 400 ml fermented maize waste liquor (akamu waste water); F= 1000 ml soybean milk: 100 ml lemon juice

reported by Ndatsu and Olekan [25]. Among the soybean curds coagulated with different proportions of fermented maize waste liquor, the sensory qualities was highest for the sample coagulated with 550 mls of FMWL and this compared favorably with the control sample. Hence, fermented maize waste liquor at a level of 550 ml is a promising coagulant for the production of quality soybean curd.

4. CONCLUSION

This study has shown that fermented maize waste liquor could be used in coagulating soymilk into soybean curd (tofu). Soybean coagulated with 550 ml of FMWL exhibited higher fat while soybean milk coagulated with 600 mls of FMWL had significantly higher protein. On the other hand, sample coagulated with 500 mls FMWL had significantly higher crude fibre content. The coagulation of soymilk with FMWL had no significant effect on the ash content of the resultant product. Carbohydrate content of the soybean curd coagulated with fermented maize waste liquor (except for sample coagulated with 500 ml FMWL) was significantly higher than the control sample. Potassium and calcium content of the soybean curds decreased as proportion of fermented maize waste liquor increased. On the other hand, magnesium and iron content of the samples coagulated with fermented maize waste liquor were generally higher than the control sample. Sensory attributes of the soybean curd (except for colour) decreased as the proportion of fermented maize waste liquor increased. Among the soybean curds coagulated with different proportions of fermented maize waste liquor, the sensory qualities was highest for the sample coagulated with 550 ml of FMWL and this compared

favorably with the control sample. Hence, fermented maize waste liquor when utilized at a level of 550 ml will yield soybean curd that is acceptable and comparable to soybean curd coagulated with lemon juice. Fermented maize waste liquor will serve as an alternative, cheap and natural coagulant for soybean curd preparation at household and commercial levels.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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