World Journal of Dairy & Food Sciences 7 (2): 135-141, 2012
ISSN 1817-308X

DOI: 10.5829/idosi.wjdfs.2012.7.2.1106

Effects of Different Types of Coagulants on the Nutritional Quality Tofu Produced in the Northern Part of Nigeria

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Abstract: In northern part of Nigeria, tofu, a coagulated product of soybean milk, is usually produced at household level using various types of coagulants such as calcium salt, magnesium salt, alum and steep water (effluent from pap produced from maize). This study sought to assess the effect of these coagulants on the yield, nutritional composition and the sensory evaluations of tofu. The apparent protein digestibility, the dry matter digestibility (DMD) and feed efficiency (FE) were assessed using three-week-old Wister strain albino rats of average of 50.2g. The results revealed that there was significant ($P>0.05$) differences between the yield of various coagulated tofu (17.5±2.10 - 18.3±2.14%), however calcium salt coagulated tofu recorded higher yield compared to others. There was significant ($P>0.05$) differences between the energy values (Cal/g) of various coagulated tofu. The energy values recorded significantly were (6.6±1.28 Cal/g, 6.2±1.24Cal/g, 5.80±1.20 Cal/g and 5.3±1.30 Cal/g) for Steep water, Alum, magnesium and Calcium chloride coagulated tofu respectively. The steep water coagulated tofu was significantly higher in protein (39.0±3.12%) and ash (3.60±0.95 contents. While, calcium salt coagulated tofu had significantly higher carbohydrate (28.26±2.66%), fat (35.20±2.97) and Zn (0.6±0.39ppm) contents, apparent and dry matter digestibility, as well as the best sensory quality evaluated. Alum coagulated tofu had significantly higher moisture (5.5±1.17%), Fe (1.7±0.65ppm), K (33.9±2.91ppm), Na (21.2±2.30ppm) contents. It could be revealed that, all tofu produced were good nutritional, but the steep water coagulated tofu was better as typified with its high protein content, although had a very low general acceptability. Therefore, producing tofu with steep water appears promising nutritionally if the sensory quality is improved upon.

Key words: Coagulants · Nutrition · Soymilk · Soybean · Tofu

INTRODUCTION

Soybeans are an inexpensive and serve as high quality protein source. Soymilk and tofu consumption is increasing in the northern part of Nigeria due animals diseases such as Mad cow disease, global shortage of animal protein, strong demand for healthy (cholesterol free and low in saturated fat) and religious halal food and economic reasons [1]. The greatest acceptance of soy foods by the general population is due to increase recognition of the health benefits of soy foods, especially by those who want to reduce their consumption of animal products [2]. Tofu is popularly consumed in Nigeria because of the various nutritional and medical attributes associated with soybeans products such as reduction of cardiovascular disease, osteoporosis and cancer risks [3].

Tofu, also known as soybean curd, is a soft cheese-like food made by curdling fresh hot soymilk with a coagulant [4]. Traditionally, in the northern part of Nigeria, it is produced by curdling fresh hot soymilk with either $CaCl_2$, $MgSO_4$, Alum and steep water (effluence from pap produced from maize) [5]. Tofu is low in calories, rich in essential amino acids, contains beneficial amounts of iron and has no saturated fat or cholesterol [6]. For most Nigerians, tofu is receiving attention because it is high in protein and its usage as a substitute for meat. Bean curd has been prepared and consumed in China for thousands of years. It is a starting material for a variety of related products, including fermented, salted, smoked, dried and fried derivatives. Tofu is the Japanese name for bean curd products [7]. Tofu is low in calories, rich in essential amino acids, contains beneficial amount of iron,

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cholesterol free, low in saturated fat, high in protein, riboflavin and contained antioxidants, such as carotenoid, polyphenols, vitamin A, B and C [8]. The yield and quality of tofu have been reported to be influenced by soybean varieties, soybean quality, processing conditions and coagulants [9]. Coagulants have been reported to modulate hypocholesterolemic effect on experimental rats [10]. Soybean products reduce the risk of heart diseases by lowering levels of oxidized cholesterol, which is taken up more rapidly by coronary artery walls to form dangerous plaques. Previous study, Van Warden [11] reported that soy consumption reduces cholesterol in general while also decreasing the amount of bad cholesterol (Low Density Lipoprotein) in the body and maintaining the amount of good cholesterol (Low Density Lipoprotein) [12]. Because of this, people have started to take an interest in tofu consumption due to its good nutritional and health benefit to human. Therefore, there is need to compare the effect these coagulants have on the yield, General acceptability and nutritional quality and to know which of the coagulants is better for tofu production.

MATERIALS AND METHODS

Materials: Soybean (*Glycine max*), TGX923-1E variety was obtained directly from Ibrahim Badamasi Babangida University, Lapai Experimental Farm in Niger State of Nigeria. The alum, calcium salt ($CaCl_2$) and magnesium salt ($MgCl_2$) were industrial grade, while the steep water was collected from domestically processed pap. The water used in the analysis was glass distilled. The weanling albino rats used were of the same litter origin obtained from the rat colony of the Department of Biochemistry, University of Ilorin.

Tofu Preparation: Soybeans (2.0 kg) were soaked in water (6 liters) at 20-40°C for 9 hours. The soaked beans were drained, weighed and ground with grinder, tap water added at a ratio of 6:1 with raw bean and then filtered to separate soy cake from soymilk. The soymilk was subsequently heated to 98°C and maintained for 1 minute before delivering to the mix tank. When cooled to 87°C, 1 litre of soymilk was mixed at 420 rpm with each of the coagulants (50mL). The mixed solutions were held for 5 seconds and then filled on to tofu trays and allowed to coagulate for 10 minutes. The bean curd was pressed after which the tofu weight was recorded. Tofu was stored in water at 4°C overnight prior to analysis.

Methods

Determination of Yield: The amount of tofu produced per litre of milk with the different coagulants was weighed and recorded as the yield, expressed in gram.

Nutritional Analysis: The nutrient composition (ash, fat, moisture, carbohydrates and crude fiber) of the tofu from different coagulants was determined using the standard method of AOAC [13] and protein content was analyzed using the Micro - kjeldhal method (N × 6.25). The mineral composition (Zn, Ca, Fe, Mn, K, Mg and Na) were determined using a Perkin Elmer absorption spectrophotometer (model 372) method [14].

Determination of Energy Values: The 0.1 g of each tofu was ignited electrically in a Ballistic Bomb Calorimeter (Gallemkamp, CBB-330-010L) and burned in excess oxygen (25 atm). The rise in temperature obtained was compared with that of benzoic acid to determine the calorific value of the sample material [15].

***In vitro* Multienzyme Protein Digestibility:** The *in vitro* protein digestibility of each tofu was carried out using the method of Hsu *et al.* [16]. A suspension of the tofu produced from each coagulant was prepared by dissolving 1.75g in 50mL distilled water. The suspension was adjusted to pH 8.0 with 0.1 M NaOH, while stirring in a water bath at 37°C. A multienzyme solution consisting of 1.6mg trypsin, 3.1 mg chymotrypsin and 1.3mg/mL peptidase was maintained in an ice bath and adjusted to pH 8.0 with 0.1 M HCl. 05mL of the multienzyme solution was added to each tofu sample suspension with constant stirring at 37°C. The pH of the suspension was recorded 15min after the addition of the multienzyme solution and the i*n vitro* digestibility was calculated using the regression equation of Hsu *et al.* [16].

$$Y = 210.46 - 18.10X$$

Where,

Y = *in vitro* digestibility (%) and
X = pH of the sample suspension after 15min digestion with the multienzyme solution.

Sensory Analysis: The organoleptic properties of each tofu produced using the various coagulants were determined using the method of Jyoti Parma *et al.* [12].

Samples of tofu were presented to a laboratory panel of 10 judges for evaluation. The panel was asked to rate the samples for taste, texture, colour and general acceptability on a seven- point Hendonic scale (7, excellent; 6, very good; 5, good; 4, average; 3, fair; 2, poor; 1, very poor) and the attribute mean score calculated.

Feeding Performance: The nutritional quality of tofu was determined using three weeks' old Wister strain albino rats of average of 50.2g. The rats were divided in to three treatment groups (n=4); rats in group 1-3 were fed exclusively with various type of tofu and water *ad libidum* for 14 days. During the cause of the experiment; the weight of the rats and the leftover feed were daily measured. However, total feed consumed was determined using the differences between the feed supplied (20g) and leftover. Dry matter digestibility (DMD), total weight gained (TWG) and the total feed intake were calculated using weight of digested feed divided by total weight of food taken expressed in percentage; final weight gained subtracted from initial weight gained and subtraction of feed leftover from total feed supplied, respectively.

Analysis of Data: The results were presented as mean of three replicates and percentages. One-way analysis of variance (ANOVA) and Least Significant different (LSD) was applied [17]. Significant was accepted at p□0.05 probability.

RESULTS AND DISCUSSION

Soybean products are a good source of proteins, carbohydrates, low in fat and rich in mineral contents. The incorporation of soybean food (tofu) in to a western diet could be an important means of preventing and treating chronic diseases, such as cancer and cardiovascular studies [18]. In this study, the effect of $CaCl_2.2H_2O$, $MgCl_2$. $2H_2O$, alum (a double salt) and steep water (a heterogeneous acidic effluent produced during papa production) on the biochemical composition of tofu and their nutritional quality were highlighted below. The results of tofu yield and proximate compositions are shown in Table 1; the results revealed that there was no significant difference in the tofu yield of each of the coagulant. However, $MgCl_2$ and $CaCl_2$ gave the highest amount of tofu (18.52±2.15%, 18.30±2.14%), respectively, followed by steep water (18.0±2.12%) and the alum gave the least amount of tofu (17.5±2.10%). This trend is similar with those obtained by Oboh and Omotosho [18]. The fact that there was no significant difference (p.0.05) in the yield indicated that the various coagulants under consideration may not be differ in their coagulating ability, however, the slight difference could be as a result of extraneous substance introduced by the coagulants. Hence, this tofu yield is lower than 60.72-66.25% reported by [19]. This obvious difference in yield could be as s result of processing procedure and or soybean varieties processed. Conversely, there was a significant difference between the protein content of tofu (32.1±2.83 - 39.0±3.12 %). Steep water coagulated tofu recorded high protein value (39.0±3.12%), followed by $MgCl_2$ (37.20±3.05%), $Cacl_2$ coagulated tofu (36.6±3.02%) and alum coagulated tofu had (32.1±2.83%) the least protein value. These values of proteins are higher than the values (13.3-17.6%) obtained by Oboh and Omotosho [18] and lower than the values (56.89-59.98%) obtained by Shokumbi *et al.* [19]. These variations in protein contents of tofu could be because of soybean variety used and the processing method adopted. The high protein content of steep water coagulated tofu could be possibly be attributed to the likelihood that the protein in the pap effluence might have been transferred in to the tofu unlike calcium, magnesium chlorides and alum which are poor salt, without any protein content. It could be also attributed to the acidic medium created by the steep water have given a better coagulating environment for the protein present in the soymilk than the salts [18]. However, the protein content of the tofu produced using all the locally used coagulants had higher protein content than that of the commercially purchased tofu (12%) [20]. Furthermore, the protein

Table 1: Proximate composition of tofu using various types of coagulant [%]

Sample	Yield	Protein	Fat (%)	Ash	Carbohydrate	Moisture	Energy (Cal/g)
CST	18.30±2.14^{b}	36.60±3.02^{c}	35.20±2.97^{a}	3.30±1.82^{b}	28.26±2.66^{a}	3.70±0.96^{d}	5.30±1.30^{d}
MST	18.52±2.15^{a}	37.20±3.05^{b}	18.70±2.16^{d}	3.40±0.92^{a}	27.40±2.62^{b}	4.30±1.04^{c}	5.80±1.20^{c}
SWT	18.00±2.12^{c}	39.00±3.12^{a}	31.50±2.81^{c}	3.60±0.95^{c}	22.60±2.38^{d}	4.80±1.10^{b}	6.60±1.28^{a}
ALT	17.50±2.10^{d}	32.10±2.83^{d}	32.80±2.86^{b}	3.41±0.92^{a}	26.60±2.58^{c}	5.50±1.17^{a}	6.201.24^{b}

Value represents mean of triplicate readings. Value with the same superscript letter(s) within the same column is not significantly different (p=0.05). ALT: Alum coagulated tofu, SWT: Tofu coagulated with effluent from pap, CST: Calcium coagulated tofu, MST: Magnesium coagulated tofu content of tofu was high than that of some commonly consumed tropical plant food such as yam (4-10%), cassava products (4-12%) and some commonly consumed green leafy vegetables in Nigeria [21-23]. These values reported for protein (32.1-39.0%), is a little beat reflects the high protein content of soybeans, which makes it useful in combating protein-energy malnutrition, especially in the rural communities of developing countries. This is expected, as soybean is notable to contain significant amount of protein that is of high biological value with excellent essential amino acid composition comparable to animal protein except for methionine. The quality of protein in tofu has made it to be incorporated as animal-protein substitute in vegetarian diets [19]. In addition, the calcium coagulated tofu recorded high value of fat content (35.2±2.97%), followed by alum (32.80±2.86%), steep water (31.5±2.81%) coagulated tofu and $MgCl_2$ (18.70±2.16%) coagulated tofu had the least. The highest value of fat in calcium coagulated tofu could be as a result of coagulated protein in the milk, which might have trapped the fat in the tofu matrix. However, the fat content of tofu was lower than the value (9%) reported by Prestamo *et al.* [20] for some commercially purchased tofu. In addition, the fat content of the tofu produced by the various coagulants were generally high when compared with some commonly consumed plant foods in Nigeria [21-23]. The moisture and ash contents of alum-coagulated tofu (5.50±1.17% and 3.41±0.92%) were significantly higher than that of steep water, magnesium chloride and calcium chloride coagulated tofu (i.e. 4.8±1.10%, 4.3±1.04% and 3.7±0.96% for moisture and 3.6±0.95%, 3.4±0.92% and 3.3±1.82% for ash content s, respectively). The variation in the moisture content of tofu prepared wih different coagulants is probably due to the differences in gel network within the tofu particules that is influenced by dfferent anions and its ionic strengths toward the waterbholding capacity of soy protein gels. It may also be due to the unique coagulating properties of the coagulants used [19]. The ash content reported in this work (3.30-3.60%) is generally lower than the (5.80-8.80%; 5.64-5.76%; 3.57-4.24% and 5.2-7.9%) reported by Shokumbi *et al.*[19], Shih *et al.* [25], Bhardwaj *et al.* [26] and Obatolu [27], respectively. These differences may be due difference in processing procedure as well as soybean varieties procssed. The various modulating effects natable in the values of the proximate parameters is a reflection of the different coagulants used. The calcium chloride coagulated tofu recorded high carbohydrate (28.26±2.66%) content, followed by that of $MgCl_2$ (27.40±2.62%) and alum and steep water coagulated tofu had the least (i.e. 26.6±2.58% and 22.6±2.38%) respectively. Table 1 also shows the result of energy content of tofu prepared using different coagulants. The energy content of tofu coagulate by steep water (6.60 Cal/g) was significantly higher than that of alum and mg salt prepared tofu, while Ca salt coagulated tofu recorded the least value of energy. These value of energy obtained were in line with the results of Oboh and Omotosho [18], very low when compared with the result of Jyoti Parma *et al.* [12]. However, the energy content of tofu is high when compared to that of cassava products (flour and gari) (3.1 3.9 Cal/g) [28]. The basis for the high-energy content of the tofu could not be categorically stated, however, it could be attributed to the fact that that tofu is very rich in protein, fat and carbohydrate, which are energy-producing macromolecules [18]. Table 2 shows the result of mineral contents of tofu prepared by different coagulants and the result of mineral content (Fe, Zn, Mn, Mg, K, Ca and Na) of tofu was generally low when compared with some consumed plant foods in Nigeria. Fe, K and Na were significantly higher ($p < 0.05$) in tofu produced using alum coagulant than the other ones. However, calcium tofu recorded high Zn and Ca content value and the steep water coagulated tofu had high significant value for Mn (0.3±0.27ppm). These values of minerals in this work is generally low than that obtained by Oboh and Omotosho [18]. The differences could be because of the processing method adopted and the soybean variety involved and possibly attributed to the solubility of some of the salt of those minerals in the whey during tofu production, thereby preventing the trapping of the mineral in the protein matrix of the tofu. The mineral values obtained were generally lower than that of some commonly consumed plant foods in Nigeria such as edible wild seeds [29], cassava products [23], cultivated and wild yams [21] and green leafy vegetables [22, 8]. The sensory evaluation of tofu produced using various coagulants is shown in Table 3 and the results revealed that steep water coagulated tofu had a significantly lower (P□0.005) general acceptability than other coagulated tofu produced as typified by the taste, structure, texture, odor and color. The steep water coagulated tofu had low general acceptability (4.1±1.01%), while the tofu produced by alum, magnesium and calcium salts had very good general acceptability (6.3±1.25 - 6.5±1.27%), respectively. This result was in accordance when compared the results of sensory evaluation of tofu by Jyoti Parma *et al.* [12] that tofu coagulated with calcium salt was rated superior in terms of colour (8.0), texture (8.25), taste/flavor (8.50)

Table 2: Mineral composition of tofu with different types of coagulant [ppm]

Sample	Fe	Zn	Mn (Ppm)	Mg	K	Ca	Na
CST	0.5±0.35[c]	0.6±0.39[a]	0.2±0.22[b]	30.2±2.75[c]	23.1±2.40[d]	25.9±2.54[a]	13.6±1.84[c]
MST	0.49±0.35[C]	0.50±0.35[b]	0.2±0.22[b]	36.3±3.01[a]	24.0±2.45[c]	23.8±5.95[b]	13.5±1.84[c]
SWT	0.9±0.47[b]	0.2±0.22[d]	0.3±0.27[a]	34.2±2.92[b]	26.3±2.56[b]	19.0±2.18[c]	15.4±1.76[b]
ALT	1.7±0.65[a]	0.3±0.27[c]	0.2±0.22[b]	29.2±2.70[d]	33.9±2.91[a]	23.5±2.42[b]	21.2±2.30[a]

Value represents mean of triplicate reading. Value with the same superscript letter(s) within the same column is not significantly different (p=0.05). ALT: Alum coagulated tofu, SWT: Tofu coagulated with effluent from pap, CST: Calcium coagulated tofu, MST: Magnesium coagulated tofu.

Table 3: Sensory evaluation of tofu with various coagulants [%]

Sample	Taste	Structure	Color	Odor (%)	Texture	General Acceptability
CST	6.4±1.26[a]	6.8±1.30[a]	6.5±1.27[b]	6.2±1.24[b]	6.1±1.23[a]	6.5±1.27[a]
MST	6.2±1.24[a]	6.3±1.25[b]	5.9±1.21[c]	6.2±1.24[b]	6.2±1.24[a]	6.4±1.26[a]
SWT	4.3±1.04[c]	4.8±1.10[c]	3.2±0.90[d]	2.5±0.80[c]	4.8±1.10[c]	4.1±1.01[c]
ALT	5.2±1.14[b]	6.2±1.24[b]	6.7±1.29[a]	6.4±1.26[a]	5.8±1.20[b]	6.3±1.25[b]

Value represents mean of triplicate reading. Values with the same superscript letter(s) within the same column are not significantly different (p=0.05). ALT: Alum coagulated tofu, SWT: Tofu coagulated with effluent from pap, CST: Calcium coagulated tofu, MST: Magnesium coagulated tofu

Table 4: Nutrient utilization and response of albino rats fed with commercial diet and various coagulated tofu [g]

Sample	Total food Taken	Weight of digested food	Weight of faces	Total weight gained	Feed efficiency (g)
CST	157.8±6.28[b]	136.8±5.85[b]	21.0±2.30[b]	12.4±1.76[b]	0.2±0.22[a]
MST	157.3±6.27[b]	136.4±5.84[b]	20.8±2.28[b]	12.2±1.75[b]	0.18±0.21[a]
WST	112.0±5.30[c]	92.2±4.80[c]	19.8±2.22[b]	-5.4±1.16[c]	-0.1±0.16[c]
ALT	198.1±7.04[a]	160.0±2.00[a]	38.1±3.09[a]	18.6±2.16[a]	0.12±0.17[b]

Value represents mean of triplicate reading. value with the same superscript letter(s) within the same column are not significantly different (p=0.05). ALT: Alum coagulated tofu, SWT: Tofu coagulated with effluent from pap, CST: Calcium coagulated tofu, MST: Magnesium coagulated tofu

Table 5: Apparent protein, in vitro multienzyme protein and Dry Matter Digestibility of Albino Rats fed with Commercial diet and various Coagulated Tofu [%]

Sample	APD	IMPD	DMD (%)
CST	89.3±4.72[a]	61.7±4.00[c]	86.7±3.52[a]
MST	88.2±4.10[a]	62.0±4.00[c]	86.7±4.66[a]
SWT	86.8±4.66[b]	75.8±4.35[a]	82.3±4.54[b]
ALT	82.04±4.53[c]	66.9±4.09[b]	80.8±4.50[c]

Value represents mean of triplicate reading. value with the same superscript letter(s) within the same column are not significantly different (p=0.05). ALT: Alum coagulated tofu, SWT: Tofu coagulated with effluent from pap, CST: Calcium coagulated tofu, MST: Magnesium coagulated tofu, APD: Apparent protein digestibility, IMPD: *In vitro* multienzyme protein digestibility, DMD: Dry matter digestibility

and overall acceptability (8.24) to the tofu obtained citrus juices. This low general acceptability of steep water coagulated tofu compared to others, could be attributed to the fact that the steep water as an heterogeneous mixture with characteristic taste, odour and colour and it might have imparted its taste, odour and colour on the tofu, which actually reduce the acceptability of the tofu produced from the steep water despite its high nutrient content as highlighted earlier [18]. Table 4 shows the result of the nutrient utilization and performance of albino rats fed with various coagulated tofu and the result revealed that, rats fed with alum coagulated tofu consumed the highest amount of tofu in the duration of the experiment (198.1±7.04g), while that of rats fed with calcium and magnesium chloride coagulated tofu were not differ significantly and those rats fed with tofu coagulated with steep water consumed the lowest amount of tofu (112.0±5.30g). The feed efficiency, total weight gain and feed digested of rats fed tofu produced using different coagulants were significantly higher (P□0.05) in alum coagulated tofu (0.12±0.17g, 18.6±2.16g and 160.0±2.00g), respectively. Tofu coagulated with steep water significantly had the least feed efficiency value (-0.1±0.16) and calcium coagulated tofu had the highest feed efficiency value (0.2±0.22). The higher consumption of alum and calcium and magnesium chloride coagulated tofu might be because of good taste and odour as indicated in the. While, the low intake of the tofu coagulated with steep water could be because of the unpleasant odor imparted by the steep water to the tofu. The wide variation for tofu consumed by the various rats could be because of the difference in the sensory quality of the various coagulated tofu, where steep water coagulated had a low general acceptability. The feed efficiency, total weight gain and feed digested of rats fed tofu produced using different coagulants were significantly higher (P□0.05) in alum coagulated tofu (0.12±0.17g, 18.6±2.16g and 160.0±2.00±0.16g), respectively, which might be as a result of high nutritional quality and feed intake of the tofu. Tofu coagulated with steep water had the least feed efficiency value (-0.1±0.16). The negative feed efficiency value is because of the drop in weight of the rats fed tofu coagulated with steep water and this is because of very low feed intake. Table 5 shows the result of *In vitro* multienzyme protein digestibility, apparent protein digestibility and dry matter digestibility of tofu produced using various coagulants and the result revealed that there was no significant difference in the digestibility of the tofu produced using calcium and magnesium salts as coagulants when compared to the others. Steep water coagulated tofu had a significant higher ($P<0.05$) multienzyme protein digestibility (75.8±4.35%) than those produced using either alum as coagulant, which had digestibility of (66.9±4.09%), calcium chloride as coagulant (61.6±4.00%) or magnesium chloride as coagulant (62.0±4.00%). The percentage digestibility of steep water coagulated tofu (75.8±4.35%) was very close to that of maize (76.0), pigeon pea (77.2%) and African yam bean (77.0%) as reported by Akindahunsi *et al.* [22]. In comparison the digestibility of the apparent protein digestibility of steep water coagulated tofu (86.8±4.66%), calcium coagulated tofu (89.3±4.72%), magnesium coagulated tofu and alum coagulated tofu (82.04±4.53%) is significantly greater than that of *in vitro* multienzyme protein digestibility of steep water coagulated tofu (75.8±4.35%), calcium coagulated tofu (61.7±4.00%), magnesium coagulated tofu (62.0±4.00%) and alum coagulated tofu (66.9±4.09%). Calcium chloride and magnesium chloride coagulated tofu had the highest apparent digestibility and dry matter digestibility, which were not significant different, while the alum had the least apparent digestibility and the dry matter digestibility as (82.04±4.53% and 80.8±4.50%), respectively. These results contradict the result of *in vitro* multienzyme digestibility of the various tofu, where tofu coagulated with steep water had the highest protein digestibility (75.8±4.35%) and calcium chloride coagulated tofu had least protein digestibility (61.7±4.00%). Hence, the differences in the in vitro digestibility could be because of the differences in the coagulating ability of each of the coagulant with regard to the different type of proteins in the presence of the various protease inhibitors [31]. Tannin, trypsin inhibitors and chymotrypsin inhibitors can interact with the protein and thereby altering the digestibility of tofu. The higher apparent digestibility values could be because of works of proteolytic enzymes in the digestive tract and the metabolizing enzyme that could have render the various inhibitors less active *in vivo*; unlike in the *in vitro* assay where there was no provision for the inactivation of the protease inhibitors in the tofu during the assay.

CONCLUSION

In conclusion, all tofu produced using different coagulants were good nutritional, but the steep water coagulated tofu was better as typified with its high protein content, although had a very low general acceptability. Therefore, producing tofu with steep water appears promising nutritionally if the sensory quality is improved upon.

Recommendation: Based on the result of this study, it recommends that further research should be carried out on how to improve the sensory quality of tofu produced with the locally sourced coagulant (tofu coagulated with effluent from pap, a product of fermentation of maize) without compromising its nutritional quality.

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