Nutrient Properties and Sensory Evaluation of Tofu Prepared using Different Cooking Methods

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ABSTRACT

Background: *The development of nutritious and generally acceptable tofu will require the adoption of processing techniques that will improve its nutritive value and sensory attributes.*

Objective: *To determine the nutrient properties and sensory evaluation of tofu prepared with different cooking methods.*

Methods: *Tofu - produced from soybean using standard procedures, was subjected to different processing methods – steaming, baking, frying and microwave cooking. Chemical analysis and sensory evaluation of the samples were conducted and compared with the control (deep fried chicken). Descriptive and inferential statistics (ANOVA) were computed for the variables using SPSS Version 25.*

Result*: Carbohydrate (11.1g to 13.1g-15.5g), protein (14.1g to 27.6g-46.6g) and fibre (0.06 to 0.10-0.21g) content in the fresh tofu samples increased after processing. There was decrease in the moisture content of the cooked product (68.6g to 17.9g – 46.9g). Mineral content of all the cooked tofu increased; micro waved tofu was highest in calcium (0.350mg), potassium (0.061mg) and sodium (0.030mg). fried tofu was highest in iron (0.130mg) and baked tofu was highest in magnesium (0.082mg). The panelists accepted the micro waved tofu more than the control. No significant difference ($p \leq 0.05$) between the control and micro waved, baked and fried tofu. While there is a significant difference in terms of general acceptability between the control and the steamed tofu.*

Conclusion: *Cooking methods influenced the nutrient composition and sensory properties of tofu samples as microwave tofu recorded the highest nutrient and sensory attributes. Therefore, food industries can harness the potentials of tofu to provide healthy and affordable meat/food alternatives for addressing malnutrition.*

Keywords: Tofu, cooking methods, proximate analysis, nutrient composition, sensory evaluation

INTRODUCTION

Tofu is a cheese- like food made by curdling fresh hot soy milk with a coagulant, it has a subtle flavor and can be used in both sweet and savory dishes (1). It is an important source of protein which has helped in combating malnutrition in developed (2) and developing (3) countries. The Food and Agriculture Organization of the United Nations, (4) advocated for the introduction of soy and soy enhanced products in local diets, stating that high protein content of soybean may be a solution to the problem of protein deficiency in both the developed and developing countries where the effect of malnutrition is eminent.

Malnutrition is a serious problem in Nigerian households (5). An important factor that improves the nutritional status of an individual is adequate food intake that is rich not only in quantity but also in quality of food nutrients. Ukpore (6) observed that the nutritional status of an individual is grossly determined and wholly influenced by the utilization of nutrients in their diet, particularly protein. Plant proteins are cheaper than animal proteins and they are also readily available, this make them a veritable tool in alleviating the burden of malnutrition. Several studies (7-9), have advocated for the use of beans, soybean, breadfruits and other legumes in combating the malnutrition challenges in Nigeria. Gernah and Anyanikwaor (10) are of the opinion that nutrient-oriented agriculture and food processing could help combat the malnutrition problems in the country. This includes choosing certain agricultural commodities and processing them into acceptable food commodities that are economically sound and socially acceptable by the communities. Omueti and Jaiyeola (8) reported that tofu is a cheap and affordable source of protein in Nigeria and its processing should be greatly encouraged.

In Nigeria, there is lack of variety in the use of soybean, despite the fact that it is readily available, affordable and gaining wide acceptance. Apart from its use as soybean milk and powder, it is seldom used as a snack or as an accompaniment to meals because of little knowledge of other forms of its production. Du *et al.,* (11) opined that many countries have different ways of using soy bean and tofu. For example, the Japanese have fresh, soft/ silken tofu. Chinese have soft/ smooth tofu which may be eaten with sauces. Others may eat tofu with spring onions, soy sauce, chill sauce which is an example of douhua- a popular breakfast in China. In Nigeria, there are not much varieties in tofu production.

Cooking method plays a significant role in the cooking process owing to quality changes in the nutritional composition and sensory characteristics as a result of thermal denaturation (12). Boiling, grilling, pan frying, and microwave cooking methods are documented in literature as various methods generally used in meat processing (12,13). Therefore, the purpose of this study is to determine the nutrient properties and sensory evaluation of tofu prepared with different cooking methods such as steaming, baking, frying and micro wave cooking.

MATERIALS AND METHODS

Sample

The soy bean seeds used for the study was purchased from Ariaria International market in Aba North Local Government Area of Abia State, Nigeria. It was taken to the Department of Human Nutrition and Dietetics, Michael Okpara University of Agriculture, Umudike for identification and thereafter stored at room temperature before it was processed into tofu.

Methods of tofu preparation

The method used in tofu preparation was as described by Du et al. (11). The soy bean (2.0Kg) was winnowed to remove lighter materials, heavier materials such as broken seeds and sands were sorted and the seeds were washed to remove dirt and dust. It was soaked in cold water (12 liters) for 9 hours at room temperature (27°C – 32°C). The water was removed and the soybean was washed. It was ground in the grinder with

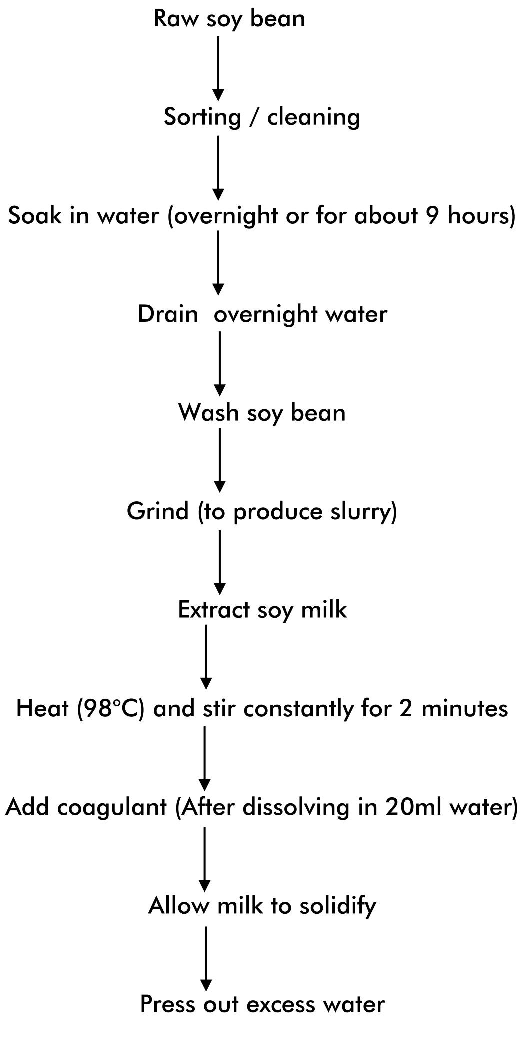

Figure1. Flow chart for tofu production

little water to obtain the slurry. The soy milk was extracted from the slurry using a muslin cloth (to obtain "Okara") The water ratio of 6:1 was used for the extraction. The "Okara" was sieved again to further extract more of the soy milk remaining. The milk was transferred into a pot and heated on a cooker to about 98°C with constant stirring. It was held at the same temperature for about two minutes. Coagulant (Epsom salt) was mixed with the milk. This was allowed to solidify to tofu. The tofu was removed from the cooker and put in a muslin cloth, it was further compressed to remove water with a 10kg load for 3 hours until all the water were completely drained. (Figure 1 shows the flow chart for the production).

Two hundred grams (200g) (Ax) of the fresh tofu was put in a cellophane bag and stored in the refrigerator for laboratory analysis. The remaining tofu was cut into smaller shapes (cubes). Seasonings (10g each of the following: salt, ground pepper, thyme, ginger and garlic) were mixed in 50ml of water. It was gradually sprinkled into the pot that contained the tofu. The mixture was allowed to marinade in the refrigerator for 3hours. The tofu was steamed for 20 minutes, Two hundred grams (200g) was cooled, put in a cellophane bag and stored in the refrigerator for laboratory analysis (Bx). The remaining was divided into three parts of 200g each. The first portion was baked (Cx) in a preheated moderately warm (160°C or gas mark 3) oven for about 20 minutes until tofu became golden brown. The second part was deep fried (Dx) in 75cl moderately hot soy bean oil (for about 20 minutes) until tofu was golden brown while the third part was micro waved (Ex) in a moderately hot micro wave oven. Each process was conducted three times (15minutes, 20 minutes and 25 minutes respectively) for all the cooking methods and the products cooked for 20 minutes was used. This was because at 15 minutes the baked product was still looking slightly pale and at 25 minutes the fried product was looking almost burnt. They were packaged in polyethylene bags and stored in the refrigerator for laboratory analysis.

Proximate analysis:
The tofu samples were analyzed in triplicates for proximate using method described by Williams (14) to determine the moisture content, protein, fat, crude fiber and ash. The carbohydrate content of the samples was determined using anthrone method (15). The minerals (calcium, magnesium, potassium, sodium and iron) were determined using spectrometric method using Atomic Absorption Spectrophotometer (AAS) (14).

Sensory evaluation:
Sensory evaluation was carried out with a twenty (20) trained panelist made up of both staff and students of Department of Human Nutrition and Dietetics, Michael Okpara University of Agriculture, Umudike. The cooked tofu (Bx, Cx, Dx, Ex) and the control (Fx) were each arranged and labeled in a clean plate. These were evaluated by the trained panelists for colour, flavour, taste and over all acceptability. Water was provided (Aquazan bottled water) for mouth rinsing in-between evaluations. A nine- point Hedonic scale was used for the evaluation with 1 (one) representing "Dislike extremely"; 9 (nine) representing "Like extremely" and 5 (five) the mid-point representing "Neither Liked nor disliked".

Statistical analysis:
The information obtained from the 20 panelists were analyzed in triplicates and subjected to analysis of variance (ANOVA) to compare the means using the statistical Package for social sciences (SPSS) version 25. Differences were considered significant at $p<.0.05$.

RESULTS

Table 1 showed the proximate composition of tofu prepared with different cooking methods (steaming, baking, frying and micro wave cooking). Results revealed that a high moisture content of fresh tofu (68.61%) while that of processed tofu ranged 22.10-46.95%, with the steamed tofu (Bx) having the highest moisture content of 46.95% and the least moisture content

Table 1. Proximate composition of tofu.

Cooking Methods	Moisture (%)	Protein (%)	Fat (%)	Fiber (%)	Ash (%)	Carbohydrate (%)
Fresh (Ax)	68.61	14.10	6.50	0.06	1.55	11.15
Steamed (Bx)	46.95	27.66	8.66	0.15	1.95	13.11
Baked (Cx)	21.53	36.35	22.75	0.10	2.01	15.59
Fried (Dx)	22.10	41.13	23.19	0.15	2.41	10.01
Microwaved (Ex)	17.97	46.69	18.29	0.21	2.39	14.78

Table 2. Mineral composition of tofu mg/100g

Cooking Methods	Calcium	Magnesium	Potassium	Iron	Sodium
Fresh (Ax)	0.12	0.01	0.01	0.03	0.01
Steamed (Bx)	0.21	0.06	0.09	0.09	0.02
Baked (Cx)	0.22	0.08	0.10	0.10	0.02
Fried (Dx)	0.32	0.04	0.13	0.13	0.03
Microwaved (Ex)	0.35	0.03	0.12	0.12	0.03

Table 3. Mean scores for the sensory evaluation of samples

Cooking Methods	Colour	Flavour	Taste	General Acceptability
Steamed (Bx)	4.900 ± 0.64^a	4.850 ± 1.18^a	5.050 ± 0.76^a	5.100 ± 1.21
Baked (Cx)	7.700 ± 1.08^b	6.150 ± 0.81^b	7.350 ± 0.86^b	6.300 ± 1.03^b
Fried (Dx)	6.300 ± 0.98^b	6.050 ± 0.89^b	6.650 ± 0.81^b	7.150 ± 0.75^b
Microwaved (Ex)	7.600 ± 1.19^b	8.1500 ± 0.75^b	8.260 ± 0.83^b	8.250 ± 0.64^b
Control (Fx)	8.200 ± 0.77^b	8.1500 ± 0.67^b	8.150 ± 0.75^b	8.150 ± 0.75^b

Values represent mean of triplicate readings. Values with the same superscript along the same row are not significantly different.

was recorded in micro waved tofu (Ex) 17.97%.

The fresh tofu had a protein content of 14.10% while protein content in the processed tofu was higher. The lowest protein value of 27.66% was recorded in steamed tofu and highest (46.69%) protein content was observed in micro waved tofu.

High fat content was observed in microwaved, baked and fried samples (18.29-23.19).

The fiber content of the fresh tofu was 0.06%, it increased to between 0.10% in the baked sample to 0.21% in the micro waved sample.

The ash content of fresh tofu was 1.55% and the cooked ranged from 1.95% in steamed tofu to 2.41% in fried tofu.
The carbohydrate content of fresh tofu was 11.15% while the cooked value ranged from 10.01% in fried tofu to 15.59% in baked tofu.

Table 2 presents the mineral composition of tofu. Cooking increased the magnesium and calcium content of the tofu from 0.01 and 0.12mg for fresh tofu to 0.03-0.08 and 0.21-0.35mg for the cooked samples respectively. Fresh tofu had a potassium content of 0.01mg which increased to 0.04mg in both the baked and steamed samples to 0.06mg in micro waved sample. The iron content of fresh tofu was 0.03mg increased to 0.09mg-0.13mg in all processed samples respectively. Fresh tofu had a sodium content of 0.01mg which increased from 0.02mg in steamed to 0.03mg in micro waved tofu.

Information on the sensory evaluation of the samples is summarized in table 3.
The result on colour showed that the most preferred sample by the panelist was the control (ex) 7.700, followed closely by the micro waved tofu (Ex) 7.600 both of which were liked moderately. The control Ex (fried chicken) 8.200 was preferred than all the tofu samples. There is no significant difference at $p \leq 0.05$ between the baked, fried, micro waved tofu samples and the control (fried chicken) but a significant difference was observed between the control and the steamed tofu.
Results showed that in flavour both samples; micro waved (Ex) and the control (Fx) 8.150 respectively were highly rated and as such liked much followed by baked tofu (Cx) 6.150 and fried tofu (Dx) 6.050, both of which were liked slightly. Steamed tofu sample Bx 4.850 was disliked slightly. The study showed that micro waved tofu sample was preferred than all the other samples of tofu (fried, baked, and steamed) in terms of flavour. Its acceptance was equally rated as that of the fried chicken used as control.
There is a significant difference at $p \leq 0.05$ between the flavour of steamed tofu and the control while there is no significant difference

between the flavour of baked, fried, micro waved tofu and the fried chicken used as the control.

The result on the panel acceptance of the taste of the tofu sample indicated that micro waved tofu sample Ex was rated highest 8.260 in terms of taste, followed by baked tofu sample Cx 7.350 which was liked moderately and fried sample Dx 6.650 that was liked slightly, steamed tofu (Bx) sample 5.050 was neither liked nor disliked.

There is significant difference at $p \leq 0.05$ between the steamed tofu and baked, fried and micro waved tofu while there is no significant difference between the control and micro waved tofu.

In general acceptability, results showed that micro waved tofu sample Ex (8.250) and fried chicken, the control Fx (8.150) was liked much followed by fried tofu sample Dx 7.150 which was liked moderately and baked tofu sample Cx 6.300 was liked slightly. Steamed tofu sample Bx 5.1 was neither liked nor disliked.

The panelists accepted the micro waved tofu more than the control. However there is no significant difference at $p \leq 0.05$ between the control and micro waved, baked and fried tofu. While there is a significant difference in terms of general acceptability between the control and the steamed tofu.

DISCUSSION

The moisture content of fresh tofu 68.61% reported in this work was similar to the 68.67% reported by Shokunbi et al. (16) in the use of different coagulants (magnesium chloride $MgCl_2$ and magnesium tetraoxosulphate (vi) $MgSO_4$) in tofu production. The similarity observed could be attributed to the (Epsom salt (Magnisium sulfate) coagulant used to coagulate the samples. However it was lower than 77.93% moisture content reported by Obatolu (17) in a similar study. The slight variation in the moisture content is probably due to the difference in gel network within the tofu particles that is influenced by different anions and its ionic strengths. Studies (16,17) have affirmed that gel network assists in the water holding capacity of soy protein. The moisture content of the cooked tofu products ranged from 17.97% – 46.95%. The low moisture content will make the processed tofu to keep longer than the fresh tofu by increasing the shelf life of the product.

The protein content in all the cooked samples (27.66-46.69) were higher than the range of 15.1% -17.6% reported by (16) and similar to than the range 24.90% - 42.71% reported by Shokunbi et al. (16). All these show the high protein content of tofu which make it a veritable tool for combating the protein- energy malnutrition in both the rural and urban communities in developing countries. The quality of protein in tofu has made it to be incorporated as animal protein substitute in vegetarian diets as it is practiced at Babcook University Nigeria, a Seventh Day Adventist (SDA) Institution of higher learning that strictly advocates a lacto-ovo vegetarian diets to her resident student population. Students are pre-informed of this dietary practice / pattern before admission is offered to them to conform to the globally practiced philosophy of education and health principles of the SDA. This according to Shokunbi et al. (16) is because soyabean contains significant amount of high biological value protein with essential amino acid composition comparable to animal protein except for methionine. The fat content of fresh tofu was 6.50% while the cooked tofu ranged from 8.66% in steamed to 23.19 % in fried tofu. The fat content reported in the study was similar to the range of 7.87% - 21.39% reported by Shih et al. (18) and 11.3% - 24.0% reported by Bhardwaj et al. (19).

The fiber content in this study (0.06-0.21) were lower than the range of 0.27% - 0.45% reported by Bhardwaj et al. (19). Fibers are plant based food components made up of lignins, cellulose, hemi cellulose, pectin, gum and mucilage which remain undigested on entering the human large intestine (20). They are useful in the management of non-communicable diseases such as obesity, diabetes, cancer, hypertension and other NCDs. The fiber content of the baked, fried and steamed tofu is viable to support the management of NCDs.

The high fat content observed in the fried sample could be as a result of the soy bean oil used which may have added extra nutrient to the sample. This is good and important to the food industries and individuals because fat from plant are unsaturated. Moreover, Wardlaw and Hampl, (20) noted that the oil from plants provide characteristics flavours and textures to foods as integral parts of the diet. More over because the oils are from plant origin, they are cholesterol free and thus helpful in the management of cardiovascular diseases (21-22).

The ash content of the samples compares well with the range of 2.10% - 3.80% reported by Bhardwaj et al. (19) but slightly lower than the range of 3.57% – 4.24% reported by Odoemelam (22). This showed that cooking improved the ash content of tofu. The increase in the ash content could be attributed to the Epsom salt used to coagulate the tofu. Bhardwaj et al. (19) reported that using magnesium salts to coagulate tofu increases the ash content of tofu which in turn increase the mineral content of the product. The various range reflected could be as a result of the different coagulants used.

The CHO values of the samples (10.01-14.78) were similar to the range of 11.38% – 12.34% reported by Odoemelam (22). This carbohydrate value in tofu is important considering the significant role that carbohydrate play in human nutrition.

Calcium content of cooked tofu samples agrees with values (0.181mg – 0.267mg) reported by Ifesan et al., (23) but lower than the range of 1.59mg - 2.35mg reported by Omotosho et al. (24).

Similarly, the magnesium values of the sample corroborates with reports (0.027-0.034mg) from other studies (24-25) but lower than 16mg reported by Amadou et al. (26) which may have been as a result of fermentation process in the later study.

The potassium content of 0.039-0.061mg in baked, steamed and microwaved samples was lower than 0.084mg – 0.339mg reported by Ifesan et al. (23) and Omotosho et al. (24).

The iron content of cooked tofu (0.086-0.130) was lower than reported to the range of 0.050mg – 0.145mg reported by Ifesan et al. (23) and Omotosho et al. (24). The range was lower than the 11mg reported by Omueti (25).

The similarities and differences in mineral contents of the products can be attributed to the differences in purity and concentration of the coagulant used in the different products as well as the variety of soy bean used. The high mineral content reported by Omueti (25) could be attributed to the effect of fermentation on the tofu used for the study. Amadou et al. (26) reported that fermentation increases not only the digestibility of soy but also aid in the absorption of phyto-nutrients (isoflavours, genistein and diadzein) which may have contributed to the increase in the mineral concentration of the products. Moreover the spices ginger (*Zingiberofficinales*) and garlic (*Allium Sativum L.)* added to the soybean may have contributes to the increased mineral content of the cooked products. Lanzotti (27) have shown that garlic and ginger are rich in minerals including calcium, iron, potassium and magnesium. They are also high in fiber and water. Moreover, spices have aromatic flavours which excite the taste and are composed of high quality phytonutrients, essential oils and antioxidants.

Microwaved tofu had better sensory properties (colour, flavor, taste, general acceptability) than all other processing methods used in this study, and this compares well with reports from other studies (12, 28) where microwaved steaks met the organoleptic expectations of panelists than other conventional methods.

CONCLUSION

The consumption of tofu should be encouraged in Nigerian meals in view of its high nutrient composition to improve the nutritional status of individuals and the various health benefits associated with it. The different processing methods improved the nutrient composition and bio-availability of the fresh tofu. Cooking (baking, frying, microwave) made tofu more acceptable to the panels, all the products were rated high except for the steamed tofu, however the micro waved sample was the most preferred of all the samples by the panelists.

RECOMMENDATIONS

Food industries should find ways of preparing and packaging baked, micro waved and fried tofu in order to make them more convenient for consumption.

Tofu can serve as a healthy and nutrient-densed snack/mid-day meals alternative.

The low moisture content of micro waved sample can be harnessed by food industries to prepare ready to eat meals from tofu with an increased shelf life than the steamed tofu.

Micro waved tofu product can be used as a substitute for meat as there is no significant difference between it and fried chicken used as the control

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