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Nutrients composition, sensory properties and storage stability of processed Nigerian soy cheese (Beske)

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ABSTRACT

Industrial commercialization of beske is limited due its poor presentation and high perishability. Local soy-cheese samples were produced from soymilk using two coagulants (10 ml of lime fruit juice to 3 litres of soy milk and 10 ml of fermented maize extract to 3 litres of soy milk) and different processing methods (boiling (100 °C), frying (180 °C) and drying (50 °C). The nutritional composition (proximate, vitamin and mineral content) and microbiological quality were determined using standard analytical methods. The sensory evaluation was carried out using 50 panelists. Data obtained were analyzed using ANOVA at $p \leq 0.05$. The moisture, ash, protein, fiber, fat and carbohydrates content ranged from 20.40 - 25.33%, 2.33 - 3.4%, 31.40 - 35.0%, 2.0 -3.0%, 30.50 - 34.4% and 4.20 - 9.83% respectively. The Ca, Mg and Fe content varied from 11.20 – 13.50, 20.33 – 26.20 and 33.0 - 67.2 mg/100 g respectively. The vitamin content ranged from 0.03 - 0.04, 0.01–0.21, 0.02 - 0.12 and 0.01 - 0.03 mg/100 g of vitamin A, K, E and C respectively. Sample LFD (Lime-Fried-Dried beske) had the lowest microbial counts, even at eight weeks of storage. Based on overall acceptability, nearly all the samples were rated above average by the panelists. Sample LFD should be recommended for commercial production, based on its nutrient quality, storage stability and sensory properties.

Introduction

Soybean (*Glycine* max L) is a leguminous plant, which is a rich source of good quality protein [1], it also provides several therapeutic benefits because of its essential amino acids in the amounts needed for human health. It is also rich in phenolic compounds, isoflavones and antioxidants [2]. Besides, soy products offer a considerable appeal for a growing segment of consumers with certain dietary and health concerns [3].

Protein percentage in soybean is about 70% compared with that of whole egg protein [4]. In tropics where animal protein is limited, expensive, and scarce, soybean meal is a good source of plant protein, it is available, and could be a supplement to cereal foods where lysine is limiting [4].

Soy cheese which is also known as 'beske' in the western parts of Nigeria is a nutritious meat substitute and it is prepared by curdling the milk extract from soybean. However, a similar product called tofu or fermented soybean curd is traditionally important and popular fermented food product in Asia [5]. Beske (tofu-like cheese) is a typical soybean curd product that is prepared through the coagulation of soybean protein with the addition of coagulants [6]. Soy cheese is made by soaking soybeans in water, wet-milling, removal of soy fiber by filtration, cooking, and coagulation of the soy protein by the addition of coagulants [7]. The precipitated protein is collected, and pressed to a firm consistency, and it is cooked before consumption [8]. Base on the physical and quality parameter of soy cheese, their texture is expected to be smooth, firm, and coherent but not hard and rubbery [9,10]. Since soy cheese is a soy protein gel, the amount of protein in soymilk is critical for the cheese yield and quality [11–13].

Beske is an acid-coagulated water based gel that can be used as an inexpensive meat substitutes, it is cholesterol-free, a rich source of proteins, minerals and omega-6 polyunsaturated fatty acids [7]. It possesses numerous health benefits, such as its ability to help lower cholesterol levels, prevent anemia and manage weight [7]. It also helps in maintaining cardiovascular health and lowers the risk of cancer, anemia, osteoporosis and kidney diseases [14]. In addition, it helps in lowering the levels of bad cholesterol [7,14]. However, isoflavones which is a group of chemical found in plant foods, have been found in beske,

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Note: Low-resolution images were used to create this PDF. The original images will be used in the final composition.

the compound possesses a structure which is similar to the female hormone estrogen and therefore behaves like estrogen produced by the body [14].

The industrial commercialization of beske has not been achieved despite its nutritional status and health benefits. This is as a result of its poor presentation, packaging, high perishability and poor preservation [15]. However proper packaging and establishment of processed beske storage stability will contribute significantly to its keeping quality in the future. Therefore, the aim of this research work is to determine nutrients composition, sensory properties and storage stability of processed beske.

2. Materials and methods

Soybeans of variety "TGX1835–10E" and lime used for this work were procured from Owode market, Offa, Kwara State, Nigeria. The fermented maize broth used as coagulant was obtained from ogi (fermented maize paste) which was processed at Food Processing Laboratory, Department of Food Technology, Federal Polytechnic, Offa, Kwara State, Nigeria.

2.1. Production of beske (tofu-like cheese)

The beske samples were produced using the modified method of James et al. [16]. The soybeans were sorted to remove the dirts and extraneous materials such as stone, broken bottle and spitted beans. The sorted soybeans was washed with clean water to remove any accumulated dust that can contaminate the product during processing. The cleaned soybean seeds (1000 g) were steeped in clean water at 1:3 v/w for 24 h to rehydrate the bean for easy de-hulling. The steeped soybeans were de-hulled manually by rubbing the seed through palm to remove the hull from the soybean. The de-hulled soybeans were drained to separate hull and water from seed to obtain clean beans. The clean soybeans were milled into paste by using a fabricated attrition mill. The soy paste was sieved by folding into muslin cloth and squeeze out to obtain soy milk. The soymilk (3 litres each) was boiled for 10 min. Exactly 250 ml corn-fermented maize extract and 10 ml of lime fruit juice were added separately to 3 litres of soymilk to aid curdling. The curds were drained and pressed to expel the whey by using mechanical hydraulic press. The drained beske (tofu-like cheese) were cut into uniform sizes by adopting cycle, shape of 2.0 mm thickness and they were divided into three portion. (A). The beske (tofu-like cheese) were boiled for 5 min, ground fresh scotch bonnet (spice) was added to give a peppery taste and dried in hot air oven at 50 °C for 8 h. (B). The beske (tofu-like cheese) were fried using hot vegetable oil and dried in hot air oven at 50 °C for 8 h. (C). The beske (tofu-like cheese) were dried directly in hot air oven at 50 °C for 8 h. The beske (tofu-like cheese) samples was allowed to cool at a room temperature, packed into seal-able laminated (polyethene-aluminum foil polyethene) bags and stored for further analysis (Fig. 1).

2.2. Sensory evaluation

Trained panel of fifty judges were selected from the students of Department of Food Technology, Federal Polytechnic, Offa, Kwara State, Nigeria, who were familiar with beske organoleptic properties. Sensory evaluation was carried out on both the rehydrated freshly produced beske and rehydrated stored beske samples. However, the modified method of Raji et al. [17] was used for beske rehydration, 100 g of each soy cheese sample was soaked with 721.67 ml of hot water (80 °C) for about 30 min, until the hard texture became soft. Rehydrated freshly produced beske samples and rehydrated stored beske samples were presented for sensory evaluation separately to the panelists. The panelists were further orientated on the soy cheese characteristics to check for during assessment. The sensory evaluation (color, aroma, taste and overall acceptability) of the rehydrated freshly produced beske samples was carried out immediately after production and that of the stored samples was carried out at two weeks of storage interval for four weeks, for consumer acceptance and preference using A 9 point hedonic scale in a well-ventilated sensory evaluation room at 25 °C. The hedonic scale was ranked as; like extremely to very much (8–9 scores), like moderately to like slightly (5–7 scores), neither like nor dislike to dislike slightly or dislike moderately (2–4 scores) and dislike extremely to dislike very much (0–1 score).

2.3. Proximate composition

Proximate composition was analyzed according to the official method of analysis described by the Association of Official and Analytical Chemist [18].

2.3.1. Determination of moisture content

The moisture content was determined by oven drying method. About 5 g of each sample was weighed using analytical balance into previously weighed petri dishes (W). The weighed samples in the petri dish were allowed to dry in an oven at 105 °C for 3hours. The samples were removed, cooled in desiccators to room temperature and the weight was noted. It was returned into the oven at 105 °C for 30 mins until a constant weight was obtained for each sample. The differences in weight between each petri dish and dried residue were recorded as the percentage of the initial sample. The percentage moisture was calculated as:

$$\%Moisture\ content = \frac{W1-W2}{Ws} x100$$

$$Where$$

$$W = Initial\ weight\ of\ crucible + Sample$$

$$W1 = Final\ weight\ of\ crucible + Sample$$

$$Ws = Weight\ of\ sample$$

$$= W$$

2.3.2. Determination of protein content

Exactly 0.5 g of sample was weighed into a digestion flask and Kjeldahl catalyst tablet was added, 10 ml of conc.H_2SO_4 was added and digested for 4 h until a clear solution was obtained (blue green color). The digest was cooled and transferred into 100 ml volumetric flask and made up to mark with distilled water. 20 ml of boric acid was dispensed into a conical flask and 5 drops of indicator and 75 ml of distilled water was added to it. 10 ml of the digest was dispensed into Kjedahl distillation flask, the conical and the distillation flask were fixed in place and 20 ml of 2% NaOH was added through the glass funnel into the digest. The steam exit was closed and timing started when the solution of the boric acid and indicator turned green. The distillation was done for 15 min and the distillate was titrated with 0.05 M HCl solution till the appearance of pink color. A blank was also run through all steps as above.

Therefore, the crude protein content was determined by multiplying percentage nitrogen by a constant factor of 6.25 as described in Eqs. (1) and 2.

$$i.e.\%crude\ protein = \%Mx6.25 \quad (1)$$

$$\%(N) = Titre\ Value\ x\ A \times tomic\ mass\ of\ nitrogen\ x\ M \times olarity\ of\ HCL\ used\ x\ 4 \quad (2)$$

2.3.3. Determination of fat content

Fat was determined by ether extract method using soxhlet apparatus, 1 g of sample was weighed and wrapped in filter paper, placed in fat free thimble plugged lightly with cotton wool and extracted with petroleum ether in soxhlet apparatus set up for 5 h. Water and heater were turned on to start extraction. After 4–6 times siphoning, ether was allowed to evaporate and beaker was disconnected before the last si-

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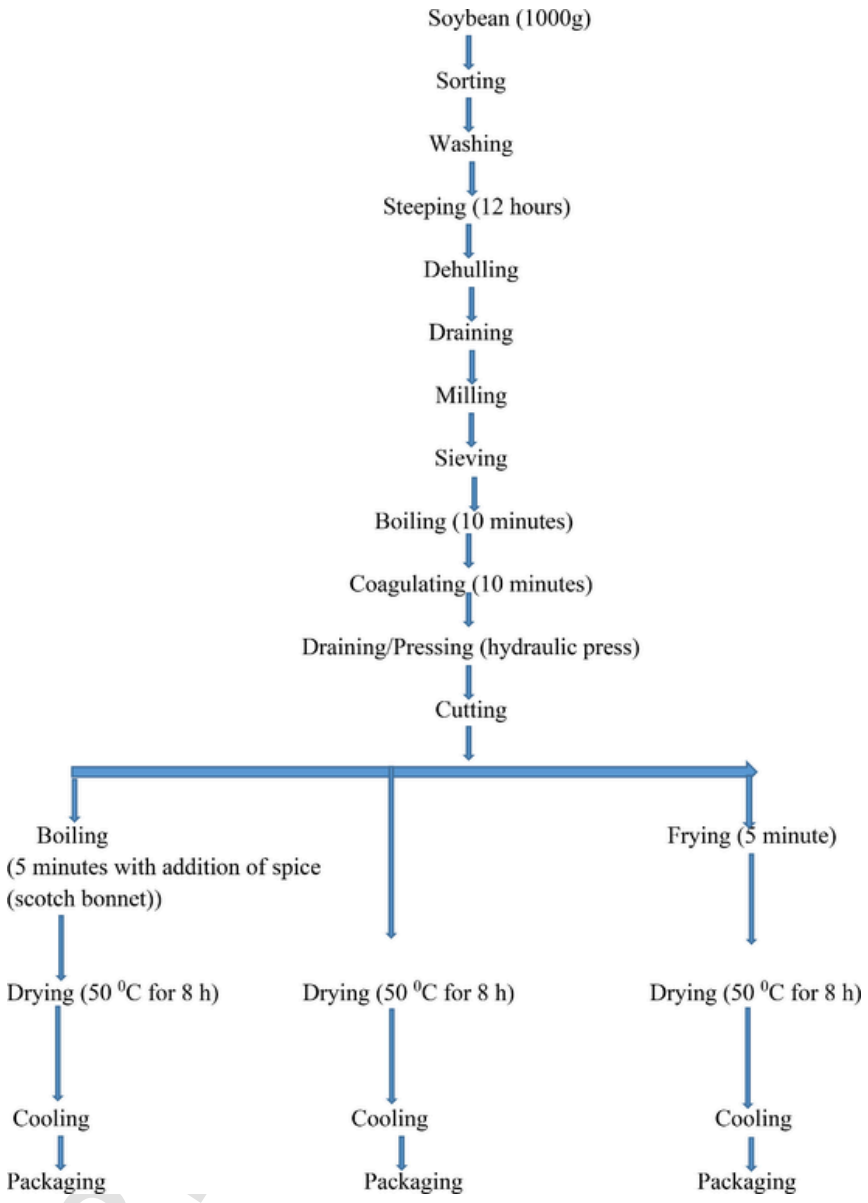


Fig. 1. flowchart for the production of dried and fried-dried beske Source: James et al. (2016) Modified.

phoning. Extract was transferred into clean glass dish with ether washing, which was evaporated on water bath. The residue extract in dish was then placed in an oven at 105 °C for 2 h and cooled in a desiccator and weighed. The fat content will be calculated as;

$$\%fat = \frac{(Weight\ of\ filter + weight\ of\ sample) - Weight\ of\ residue}{Sample\ weight} x10$$

2.3.4. Determination of ash content

Clean empty crucible was placed in a muffle furnace at 600 °C for an hour, cooled in dessicator and weighed (W). One gram of each sample was weighed in crucible (W_2). The sample was ignited over a burner with the help of blowpipe until it is charred. Then the crucible was placed in a muffle furnace set at 550 °C and left for 12–24 h. The appearances of gray white ash indicated complete oxidation of all organic matter in the sample. The crucible with the sample was cooled and weighed (W_3).The crucible with the sample was weighed and the percentage ash calculated as;

$$\%Ash\ content = \frac{W3 - W1}{W2} x100$$

Where W_3=weight of the sample with crucible before ashingW_2=weight of the sample with crucible after ashingW= weight of the sample

2.3.5. Determination of crude fiber

About 5 g of the sample was accurately weighed into flask; 200 ml of running water and 1.25 ml concentrated H_2SO_4 was added. The mixture was heated under reflux for 30 min. The hot mixture was filtered through a fiber muslin cloth. The obtained filtrate was thrown off and the residue was returned to the fiber flask of which 200 ml of running water and 1.25 g NaOH was added and heated for another 30 min. The residue was removed using "n-hexane" and ethanol and finally transferred into already weighed crucible. The crucible and the residue was oven dried at 105 °C overnight to drive off the moisture. The oven dried crucible containing the residue was cooled in a dessicator and later weighed to obtain the W_1. The crucible with W_1 was transferred to the muffle furnace for ashing at 550 °C for 4 h. The crucible containing

white or gray ash (Free of carbonaceous materials) was cooled in the dessicator and weighed to obtain W_2.

The difference $W_1 - W_2$ gives the weight of fiber.

$$\%Fiber = \frac{W1 - W2}{weight\ of\ sample} x100$$

2.3.6. Determination of carbohydrate content

The total carbohydrate was determined by difference. The sum of percentages moisture, ash, crude lipid, crude protein and crude fiber was being subtracted from 100%.

Carbohydrate = 100-(%moisture + %ash + %protein + %lipids + %fiber)

2.4. Determination of the mineral contents

The mineral contents of the soy cheese samples were determined using the methods of the AOAC [18] methods. Calcium, magnesium and iron were determined by atomic absorption spectrometry. Briefly, about 1.0 g of soy sample was first digested with 20 ml of acid mixture (650 ml Conc. HNO3, 80 ml perchloric acid, 20 ml H_2SO_4) by weighing the sample into a digestion flask followed by addition of the 20 ml acid mixture. The digestion flask containing the sample and the digestion acid mixture was heated until a clear digest was obtained. The digest was later diluted with distilled water to 500 ml mark. After obtaining the digest, aliquots of the clear digest were used for atomic absorption spectrophotometry using filters that matched the different elements. The concentration of calcium, magnesium and iron were determined with their calibration curves prepared with their standard solutions. The absorbance of each metal was read at 350 nm, the percentage values were later calculated by multiplying the concentrations by 100 and expressed as mg/100 g.

2.5. Vitamin A, E, c and k determination

The vitamins were determined using the methods described by AOAC [16].

2.5.1. Determination of vitamin a

Five grammes (5 g) of the test sample was first homogenized using acetone solution with the aid of pestle and Mortar. The solution was filtered after crushing. The filtrate was then extracted with petroleum spirit, using separating funnel. Two layers of both aqueous and solvent layer were obtained. The upper layer which contains vitamins was washed very well with distilled water in order to remove residual water; it was later poured out to the 50 ml volumetric flask through the tap of the separating funnel and made up to mark. The absorbance of the solution was recorded using spectrophotometer at wavelength of 450 nm calculation.

2.5.2. Determination of vitamin e

The vitamin E content of the samples were determined by phosphomolybdate method using α-tocopherol as the standard. One gram of each soy sample and 10 ml of n-hexane –acetone –ethanol (v/v;2:1:1) was placed in a flask extracted on shaker at 200 rpm for 20 min at room temperature and then centrifuged at 4000 rpm for 10 min at 4 °C and supernantant was collected and made up to 20 ml with extraction solvent. An aliquot of 0.1 ml of the fractions (100 μg) solution was combined with 1.0 ml of reagent (0.6 M sulfuric acid, 28 mM sodium phosphate and 4 mM ammonium molybdate). The tubes were capped and incubated in a boiling water bath at 95 °C for 90 min. After the samples had cooled to room temperature, the absorbance was measured at 695 nm against the blank using an UV spectrophotometer. The blank solution contained 1.0 ml of reagent solution and the appropriate volume of the same solvent that was used for the sample and it was incubated under same conditions as rest of the sample. The vitamin E content was expressed as mg/100 g equivalents of α-tocopherol by using the standard tocopherol graph.

2.5.3. Determination of vitamin c (Ascorbic acid)

About 10 gram of the sample or 10 ml of the coagulant was weighed into a 100 ml volumetric flask and diluted to 100 ml) with 3% metaphosphoric acid solution (0.0033 M EDTA). The diluted samples were filtered using a whatman filter paper no. 3. A 10 ml of the filtrate was pipetted into a small flask and titrated immediately with a standardized solution of 2.6 dichlorophenol-in-dephenol to a faint pink end point. The ascorbic acid content of the sample was calculated from the relationship below.

$$\frac{V \times T}{W} \times 100 = mg\ ascorbic\ acid\ per\ 100g\ sample$$

Where, V = volume (ml) of dye used for titration of aliquot of diluted sample.

T = ascorbic acid equivalent of dye solution expressed as Mg/ml of dye.

W = gram of sample in aliquot titrated

2.5.4. Determination of vitamin k (Phylloquinone)

Phylloquinone (Vitamin K_1) was determined by using spectrophotometric method. Phylloquinone content was determined by weighing 0.5 g of the sample and adding 30 ml absolute alcohol and 30 ml of 99.9% glacial acetate. The solution was then filtered using Whatman No1 filter paper. Then the absorbance was read on a spectrophotomerter (spectronic 20 model) at 415 nm. From the stock solution of standard phylloquinone, 0–10 ppm solution was prepared. Then, the absorbance on the spectrophotometer was taken and used to plot the standard curve. The result was extrapolated from the readings on the standard curve.

2.6. Microbial contents determination

The determination of the microbial quality (total bacteria counts) of the cheese products were performed by the method outlined in compendium of methods for the microbiological examination of foods [19] with some modifications. One gram of each sample was decimally diluted with distilled water and 0.1 mL of 10–1 dilutions was inoculated on nutrient agar plates and incubated at 37 °C for 24 h. After incubation, colony counter (Subra Scientific Co., India) was used to count the observed colonies. The dilution factors were considered in the final counts, thus providing the initial number of the cells. Analysis was repeated three times and the arithmetic mean was reported as the final result. The detection limit of the colony count method is $CFU/g > 0$ and if it is 0, it is negative. Data obtained were subsequently transformed into Log 10 CFU/g.

2.7. Statistical analysis

The data collected was subjected to statistical analysis using Minitab 16 statistical software. Analyses of variance (ANOVA) was used to determine the differences at 5% level of significance. In cases where differences occurred, the means was separated using Duncan multiple range test.

3. Results and discussion

The proximate composition of the variety of soybeans (TGX1835–10E) used are protein: 37.99%, fat: 15.98%, carbohydrate: 29.69%, moistre: 5.54%, ash: 4.89% and crude fiber: 5.91%, as reported by Bumba et al. [20]. The high percentage of protein and fat reported suggest that the results of this experiment are not likely to be badly influenced by processing methods and choice of coagulants dur-

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ing beske production. Also, the vitamin C contents of the fermented broth and lime juice were established to be 2.20 mg/100 g and 3.56 mg/100 g respectively. However, it is expected that the high vitamin C contents of the coagulants would have significant influence on the protein precipitation, which is one of the main operations of beske production [12].

3.1. The proximate composition of beske samples

The results of the proximate composition of beske samples are presented in table 1. There was no significant difference ($p < 0.05$) in the moisture content among the samples. The moisture contents of the samples ranged from 20.40 – 25.33%. Sample FFD (Fermented-maize-extract-Fried -Dried Beske) had the highest value of moisture content while, sample FBD (Fermented-maize-extract-Boiled -Dried Beske) had the least value among the entire samples. The variation in the results obtained from this study could be due to the different processing methods that the samples were subjected to, such as boiling, frying and drying, also different coagulants used could bring about differences in gel network within the tofu particles that was influenced by different anions and its ionic strengths toward the water holding capacity of soy protein gels [21]. However, Maijalo *et al.* [22], Omotosho *et al.* [23], Oboh and Omotosho [24] and Shokunbi *et al.* [25] reported moisture contents for cheese that were higher than what was observed in this study, but Orhevba and Taiwo [26] reported a similar range of moisture content. Sanni et al. [27] reported that the lower the moisture content of a product to be stored, the better the shelf stability of such product. The low moisture content could reduce the growth of microorganisms thereby increasing the shelf life of the product.

The highest ash content was found in sample LD which was the lime coagulated dried "beske" and the lowest was in samples FFD. There was no significant difference between the values of ash content of the beske samples. The ash contents reported in this work (2.33 – 3.4%) were lower than the 5.64 – 5.76% and 5.2 – 7.9% reported by Shih et al. [28] and Obatolu [29] respectively. These differences may be due to difference in processing procedure as well as soybean varieties processed. This trend will likely be noticed, if the mineral analysis of the samples is evaluated. The various modulating effects notable in the values of the proximate parameters is a reflection of the different coagulants used. Eka [30] reported that high ash contents could aid better growth performance, feed utilization efficiency and might also aid high amount of metabolisable energy in diet, since ash is a measure of total inorganic matter in foods [31]. The protein content of the sample ranged from 31.4 to 35.0%. Sample FD (Fermented maize extract- Dried) had the highest value of protein content, while sample LD (Lime-Dried) had the least value of protein contents of 31.4% respectively. There was no significant ($p \leq 0.05$) difference among the entire samples. However, the results showed that the fermented maize extract coagulated beske had the higher percentage of protein in respect of the processing they were subjected to. The high protein content of the fermented-maize-extract coagulated sample FD (35.0%) could possibly be attributed to the likelihood that the protein in the fermented maize extract that might have been transferred into the soy curd unlike the lime coagulant LD (31.4%). Furthermore, the protein content of the soy cheeses produced, was higher than those of the commercial soy cheese (12%) reported by Rinaldoni et al. [32]. This variation could be as a result of the difference in the variety of soybean, coagulants used and the processing condition under which production was carried out [33,34]. The crude fiber of the samples ranged from 2.0 – 3.0%. Sample LFD of Lime, fried & dried "beske" had the highest value, while sample FFD (Fermented-maize-extract-fried- dried beske) had the least value of 2.0% among the entire samples. However, sample FFD was significantly different from other samples. the results obtained from this work were lower than (4.34 – 5.52%) the crude fiber content of soy cheese reported by Ibrahim et al. [35], but higher than 0.45 to 0.50% reported by Ibironke and Alakija [36]. The low fiber content could be due to the soybean low fiber content [37].

Fat content showed significant difference ($p \leq 0.05$) among the entire samples except sample LBD and SD which were not significantly ($p \leq 0.05$) different from each other. Fat content of the samples ranged from 30.50 – 34.4%. Sample LFD (Lime-Fried-Dried) had the highest value of fat while FBD (Fermented-maize-extract –Boiled-Dried) had the least value of 30.50% among the entire samples. The higher value obtained from the fried samples of both coagulates could be due to frying processing the samples were subjected to, the vegetables oil used during frying could bring about increase in the fat content of the samples. The results of fat content of the samples obtained from this work were higher than 20.22 – 23.34% reported by Ibrahim et al. [35]. The carbohydrate content of the samples ranged from 4.2 – 9.83%. Sample FBD had the highest value, while sample FD had the least value respectively. There were significant ($p \leq 0.05$) differences among the samples except sample LBD and FFD which were not significantly different from each other. The highest carbohydrate obtained from fermented maize extract coagulant could be due the presence of starch in the fermented maize extract compared to lime. However, this results were lower than 12.72 – 17.10% reported by Ibrahim et al. [35], but higher than 4.2 – 7.46% reported by Ndife [38] for local cheese.

Table 1
The proximate composition of the beske samples.

Samples	Moisture (%)	Ash (%)	Protein (%)	Crude fiber(%)	Crude fat (%)	Carbohydrate (%)
LD	22.0 ± 0.39^{a}	3.4 ± 0.4^{a}	31.4 ± 0.44^{a}	2.8 ± 0.39^{a}	31.10 ± 0.43^{d}	9.10 ± 1.28^{ab}
LFD	20.50 ± 0.8^{a}	3.0 ± 0.42^{a}	33.44 ± 0.47^{b}	3.0 ± 0.42^{a}	34.4 ± 0.48^{a}	5.76 ± 0.81^{b}
LSD	23.50 ± 0.33^{a}	3.2 ± 0.45^{a}	32.30 ± 0.45^{ab}	2.5 ± 3.54^{a}	32.60 ± 0.23^{b}	4.9 ± 0.69^{bc}
SD	24.40 ± 0.34^{a}	2.8 ± 0.4^{a}	35.0 ± 0.47^{c}	2.77 ± 3.9^{a}	32.50 ± 0.2^{b}	4.2 ± 0.59^{c}
SFD	25.33 ± 0.35^{a}	2.33 ± 0.33^{a}	32.0 ± 0.45^{ab}	2.0 ± 0.82^{b}	33.60 ± 1.2^{c}	4.9 ± 0.69^{bc}
SLD	20.40 ± 0.28^{a}	2.77 ± 0.39^{a}	32.0 ± 0.45^{ab}	2.5 ± 0.35^{a}	32.50 ± 0.2^{e}	9.83 ± 1.32^{a}

Means score having the same alphabet along the same row are not significantly different ($p \leq 0.05$), values are mean ± standard deviation of triplicate determination.
Keys:.
LD = Lime-Dried Beske.
LFD = Lime-Fried- Dried Beske.
LBD = Lime-Boiled-Dried Beske.
SD = Steeped-water-Dried Beske.
SFD = Steeped-water-Fried-Dried Beske.
SBD = Steeped-water-Boiled-Dried Beske.

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3.2. The vitamin contents of Beske samples

The results of the vitamin content of the samples are shown in table 2. The vitamin A content of the samples ranged from 0.027 to 0.041 mg/100 g. Sample FBD (Fermented-maize-extract-Boiled-Dried beske) had the highest value, while sample LD (Lime-Dried beske) had the least vitamin A content among the samples. The values of the vitamin A obtained from this work were significantly lower when compared with the value (0.88 to 1.35 mg/100 g) reported by Joel *et al.* [39] for soy cheese produced from different coagulants. There was a significant increase in the vitamin A contents of soy cheese produced from fermented maize extract coagulant, compared to lime coagulant, this might be due to the fact that fermented maize extract extracted from maize could contain high amount vitamins. There was significant difference in the vitamin K content of the samples. Sample FFD and FBD had the highest value of vitamin K (0.021 mg/100 g), while sample LD and LBD had the least value (0.011 mg/100 g) of vitamin K content among the samples. The results obtained from this work showed that vitamin K contents in samples from fermented maize extract coagulant were significantly higher than lime coagulant samples. This could be due to the fact that the fermented maize extract extracted from maize had higher value of vitamin K compared to the lime juice. However, the results of vitamin K obtained from studied were in line with the report of Whiting and Vatanparas [40], for soy products. The vitamin E content of the samples ranged from 0.011 to 0.033 mg/100 g. Sample FD (Fermented-maize-extract-Dried beske) had the highest value, while sample LBD (Lime-Boiled-Dried beske) had the least of vitamin E content among all the samples. The values of the vitamin E obtained from this work were significantly lower compared with the values (0.021 to 0.056 mg/100 g) reported by Joel *et al.* [39] for soy cheese produced from different coagulants. However, the significant decrease in the boiled and fried treatments of the samples could be due to the high double heat treatments that the samples were subjected to. Vitamin E is considered as biological antioxidant and played principal role in fertility. The values of vitamins obtained from this study were in agreement with the previous works of Ibironke and Alakija [36]. The presence of vitamin E in all samples is a pointer to the beneficial nutritional values of soybean [41]. The vitamin C content of the beske were ranged from 0.013 to 0.029 mg/100 g. Sample LD (Lime -Dried beske) had the highest value, while sample FD (Fermented maize extract- Dried beske) had the least of vitamin C content among all the samples. Samples from fermented maize extract coagualant were significantly lower in Vitamin C contents than the lime coagulant samples. The higher results of vitamin C obtained from lime coagualant could be due to the fact that lime has higher amount of vitamin C which was reported to be 3.74 mg/100 g [42], compared to the fermented maize broth coagulant. The values of the vitamin C obtained from this work were significantly lower when compared with the values (0.61 to 33.13 mg/100 g) reported by Joel *et al.* [39] for soy cheese produced from different coagulants. The loss of vitamin C during heat treatments has been attributed to a combination of leaching and chemical destruction [42].

3.3. The mineral contents of Beske samples

The results of mineral contents (Ca, Mg and Fe) of beske as shown in table 3 were generally low when compared with some commonly consumed plants in Nigeria [43]. Sample LBD (Lime-Boiled- Dried beske) has the highest Magnesium and Iron (Fe) contents among the samples. However, sample LFD (Lime-Fried- Dried beske) had the highest calcium content. These values of minerals reported in this work were similar to the results of mineral contents of tofu produced from different coagulant by Ndatsu and Olekan [21]. However, the differences in results could be attributed to the processing methods adopted, the soybean variety and possibly the solubility of some mineral salts in the whey during production, thereby preventing the trapping of the mineral in the protein matrix [44].

3.4. Total bacteria counts of Beske samples

Among the products coagulated with different coagulants, the LD (Lime-Dried) beske samples (1.0, 1.08, 1.11, 1.18, 1.20 and 1.26 Log 10CFU/g) recorded the highest total viable count in 0, 24, 48, 72 h, 1 and 2 weeks respectively (Table 4) . This was followed by the FFD (Fermented maize extract-Fried- Dried) in 2 week storage period of the sample (1.43 Log 10CFU/g), LFD in 4 and 6 weeks of storage periods (1.51 and 1.71 Log 10CFU/g). However, LD (Lime-Dried beske) and (Lime-Fried-Dried beske) had the highest and the lowest values in the 8 weeks of the samples storages of (1.88 and 1.71 Log 10CFU/g) respectively. Nugusu and Gudisa [45] reported higher microbial loads (2.32 – 3.78 Log 10CFU/g) in soy cheese and these were higher than the results obtained from this study. There were significant differences in the bacteria population observed in the soy cheese samples at 95% confidence level. Based on the total bacterial count of the stored samples, it could be deduced that frying and drying processes or their combination drastically reduced the initial microbial load of the soy cheese and limited their proliferation during storage at ambient temperature. With respect to microbial hazard, dried food products are considered safe due to reduction of the water activity of food inhibits microbial growth, but drying does not result in a sterile product [46]. Microbiological quality of

Table 2
The Vitamin composition of the beske samples.

Samples	Vitamin A (mg/100 g)	Vitamin K (mg/100 g)	Vitamin E (mg/100 g)	Vitamin C (mg/100 g)
LD	0.03 ± 0.04^{a}	0.01 ± 0.16^{b}	0.03 ± 0.04^{a}	0.01 ± 0.20^{b}
LFD	0.03 ± 0.04^{a}	0.02 ± 0.03^{b}	0.12 ± 0.82^{b}	0.03 ± 0.04^{a}
LBD	0.03 ± 0.08^{a}	0.01 ± 0.03^{b}	0.01 ± 0.10^{b}	0.03 ± 0.4^{a}
SD	0.04 ± 0.05^{b}	0.02 ± 0.29^{a}	0.03 ± 0.50^{a}	0.03 ± 1.4^{a}
SFD	0.04 ± 0.06^{b}	0.02 ± 0.06^{a}	0.02 ± 0.03^{ab}	0.02 ± 0.2^{b}
SBD	0.04 ± 0.06^{b}	0.02 ± 0.03^{a}	0.02 ± 0.17^{ab}	0.02 ± 0.03^{ab}

Means score having the same alphabet along the same row are not significantly different ($p \leq 0.05$), values are mean ± standard deviation of triplicate determination.
Keys:.
LD = Lime-Dried Beske.
LFD = Lime-Fried- Dried Beske.
LBD = Lime-Boiled-Dried Beske.
SD = Steeped-water-Dried Beske.
SFD = Steeped-water-Fried-Dried Beske.
SBD = Steeped-water-Boiled-Dried Beske.

Table 3
The Mineral composition of the beske samples.

Samples	Ca (mg/100 g)	Mg (mg/100 g)	Fe (mg/100 g)
LD	12.50 ± 1.76^{a}	26.20 ± 0.3^{a}	60.22 ± 0.85^{b}
LFD	13.20 ± 1.80^{a}	22.3 ± 0.31^{a}	55.0 ± 1.70^{bc}
LBD	11.30 ± 0.15^{ab}	25.2 ± 0.40^{a}	67.2 ± 0.90^{a}
SD	11.20 ± 1.50^{ab}	21.1 ± 2.90^{a}	44.3 ± 0.62^{c}
SFD	11.77 ± 0.06^{b}	24.0 ± 0.33^{a}	33.0 ± 0.40^{d}
SBD	12.64 ± 1.70^{a}	20.33 ± 0.28^{a}	55.5 ± 0.01^{bc}

Means score having the same alphabet along the same row are not significantly different ($p \leq 0.05$), values are mean ± standard deviation of triplicate determination.
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Table 4
Result of microbial analysis of the Beske samples (Log 10CFU/g).

Samples	0	24hrs	48hrs	72hrs	1week	2weeks	3weeks	4weeks	6 weeks	8 weeks
LD	0.30 ± 0.02^{ab}	0.60 ± 0.01^{b}	0.78 ± 0.01^{ab}	0.85 ± 0.01^{ab}	1.08 ± 0.02^{a}	1.15 ± 0.02^{a}	1.32 ± 0.02^{b}	1.57 ± 0.02^{a}	1.73 ± 0.02^{a}	1.88 ± 0.03^{a}
LFD	0.00 ± 0.00^{b}	0.00 ± 0.01^{bc}	$0.30 \pm 0.00^{b`}$	0.48 ± 0.00^{b}	0.80 ± 0.01^{ab}	0.78 ± 0.00^{b}	1.08 ± 0.02^{c}	1.51 ± 0.02^{ab}	1.63 ± 0.03^{bc}	1.71 ± 0.02^{c}
LBD	0.60 ± 0.00^{ab}	0.70 ± 0.02^{b}	0.85 ± 0.01^{a}	$0.90 \pm 0.02^{ab`}$	0.95 ± 0.02^{ab}	1.04 ± 0.00^{ab}	1.23 ± 0.01^{bc}	1.52 ± 0.02^{ab}	1.66 ± 0.03^{b}	1.83 ± 0.03^{b}
SD	1.00 ± 0.00^{a}	1.08 ± 0.01^{a}	1.08 ± 0.02^{a}	1.18 ± 0.01^{a}	1.20 ± 0.01^{a}	1.26 ± 0.02^{a}	1.34 ± 0.02^{b}	1.42 ± 0.02^{b}	1.58 ± 0.02^{d}	1.86 ± 0.02^{a}
SFD	0.85 ± 0.01^{a}	0.90 ± 0.02^{a}	1.11 ± 0.01^{a}	1.00 ± 0.02^{a}	1.11 ± 0.02^{a}	1.11 ± 0.00^{ab}	1.43 ± 0.01^{a}	1.51 ± 0.01^{ab}	1.68 ± 0.01^{b}	1.80 ± 0.03^{b}
SBD	0.48 ± 0.01^{b}	0.85 ± 0.01^{a}	0.95 ± 0.02^{a}	1.04 ± 0.01^{a}	1.08 ± 0.01^{a}	1.15 ± 0.02^{a}	1.23 ± 0.02^{bc}	1.43 ± 0.00^{b}	1.61 ± 0.02^{c}	1.77 ± 0.04^{bc}

Means score having the same alphabet along the same row are not significantly different ($p \leq 0.05$), values are mean ± standard deviation of triplicate determination.
Keys:.
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LBD = Lime-Boiled-Dried Beske.
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SFD = Steeped-water-Fried-Dried Beske.
SBD = Steeped-water-Boiled-Dried Beske.

the samples is an indication of the hygienic conditions under which the product was handled and processed, and also it is a pointer to the type of fermentation and subsequent spoilage envisaged when stored [47].

The recommended microbiological limit for food is 3.70 Log 10CFU/g [48]. The bacteria counts reported in this study were far below the recommended microbiological limit, implying that the soy cheese can be kept in good quality beyond the eight weeks of storage at ambient temperature.

3.5. Sensory evaluation of rehydrated freshly produced Beske samples

Sample FD had the highest mean value while sample LBD had the least score. The variation in the color of the beske sample could be due to the different processing methods that the samples were subjected to. However, color is the major attributes of beske, while taste is a sensation of flavor perceived in the mouth and throat on contact with a substance, and it is one of the most important attribute watched out for in a product [36]. The taste the sample was ranged from 5.4 to 7.3. Sample FBD had the highest value, while sample LFD had the least value of 5.4. The highest value recorded for taste shows that the samples FBD were rated 'good' on the average by the judges. This implies the variation in the taste of the beske samples could be due to the different processing methods and coagulant used which could alter or improve the taste of the beske samples. Aroma is distinctive typical pleasant smell perceived by the olfactory sense. The aroma of the samples ranged from 6.1 to 8.2, was significantly ($p \leq 0.05$) different from one another. Also, the aroma of the sample showed that sample LBD had the highest value among the sample; while sample FD had the least mean value. Evaluation of the texture was based on the hand feeling appearance of a substance. These are important discriminative attribute of foods. It affects the mouth feel and appearance of the product. The texture of the samples ranged from 6.5 to 7.9. Sample LBD had the highest mean value, while sample LD had the least value. There was no significant difference of ($p \leq 0.05$) among the samples. The scores for general acceptability ranged from 6.7 to 7.9. Samples were not significantly different from one another. However, the observed variation might be due to the different processing methods and coagulant used. On average, samples were all rated above 6.5, indicating that they were acceptable by the panelists.

3.6. Sensory evaluation of the rehydrated stored Beske samples

The sensory score for the color of rehydrated samples ranged from 6.6 –8.0 and 7.7 – 5.5 for 2 and 4 weeks respectively. Sample LD, LFD (2 weeks) and LFD (4 weeks) had the highest mean values, while sample FFD, LBD (2 weeks) and FBD (4 weeks) had the least scores. However, color is the major attributes of beske. The taste of the samples ranged from 6.6 –7.6 and 6.9 – 4.3 for 2 and 4 weeks respectively. Sample LFD (2 weeks) and FFD (4 weeks) had the highest mean values, while sample FD (2 weeks) and FBD (4 weeks) had the least scores. The highest value recorded for taste shows that the samples LFD were rated 'good' on the average by the judges. However, there was a significant difference ($p \leq 0.05$). This implies the variation in the taste of the beske samples could be due to the different processing methods and coagulant used, which could altered or improve the taste of the beske samples. Taste is a sensation of flavor perceived in the mouth and throat on contact with a substance, and it is one of the most important attribute watched out for in a product. Aroma is distinctive typical pleasant smell perceived by the olfactory sense. The aroma of the samples ranged from 5.8 –7.6 and 4.9 – 7.0 for 2 and 4 weeks respectively, and was significantly ($p \leq 0.05$) difference from one another. Samples LD, LFD, FFD (2 weeks) and LBD (4 weeks) had the highest mean values, while sample FD had the least score for the both storage time of 2 and 4 weeks. Evaluation of the texture was based on the hand feeling appearance of a substance. These are important discriminative attribute of foods. It affects the mouth feel and appearance of the product. The texture of the samples ranged from 6.4 –7.9 and 6.8 – 7.5 for 2 and 4 weeks respectively. Samples LFD (2 weeks) and LBD (4 weeks) had the highest mean values while sample LD and FBD had the least score for the both storage time of 2 and 4 weeks.

The scores for general acceptability ranged from 8.0 –8.7 and 6.5 – 7.6 for 2 and 4 weeks respectively. Samples LFD had the highest mean value of overall acceptability for both 2 and 4 weeks respectively, while sample LBD and FBD had the least scores for the both storage time of 2 and 4 weeks. However, samples were all rated above 6.5, indicating that they were acceptable by the panelists.

5. Conclusion

The results showed that soy cheese produced from locally sourced coagulants (lime water and fermented maize extract) had improved nutritional and sensory qualities. It has also been demonstrated that beske produced from fermented maize extract coagulant had higher protein and vitamin contents, while soy cheese samples from lime water coagulant had higher mineral contents. Samples LFD (Lime-Fried-Dried beske) had the lowest microbial count among the entire samples, even at eight weeks of storage. Based on overall acceptability, nearly all the samples were rated above average by the panelists. However, samples LFD and FFD (Fried and Dried) had the highest values in terms of overall acceptability for both fresh and their rehydrated products. Lime-Fried -Dried (LFD) beske should be recommended for commercial production, based on its good nutrient quality, storage stability and sensory properties.

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Table 5
Sensory evaluation of the rehydrated freshly produced beske samples.

sample	Color	Taste	Aroma	Texture	Overall Acceptability
LD	6.90 ± 1.52^{b}	7.10 ± 1.60^{c}	8.00 ± 0.94^{c}	7.90 ± 0.88^{a}	6.70 ± 1.83^{a}
LFD	7.60 ± 1.80^{b}	5.40 ± 1.71^{a}	6.50 ± 1.72^{ab}	6.70 ± 1.70^{a}	7.20 ± 1.03^{a}
LBD	5.20 ± 2.20^{a}	5.60 ± 2.32^{ab}	6.10 ± 2.10^{a}	6.50 ± 2.40^{a}	6.70 ± 1.57^{a}
SD	7.80 ± 1.57^{b}	7.00 ± 0.82^{bc}	8.20 ± 1.40^{abc}	7.50 ± 1.20^{a}	7.40 ± 1.08^{a}
SFD	7.10 ± 0.97^{b}	7.00 ± 1.25^{bc}	7.00 ± 0.94^{abc}	7.40 ± 0.84^{a}	7.90 ± 0.88^{a}
SBD	6.70 ± 1.25^{b}	7.30 ± 0.68^{c}	6.70 ± 0.95^{abc}	6.80 ± 0.92^{a}	7.40 ± 1.27^{a}

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SBD = Steeped-water-Boiled-Dried Beske.

Table 6
Sensory evaluation of the rehydrated stored beske samples.

samples	color	Taste	Aroma	Texture	Overall acceptability
LD_{2wks}	8.00 ± 1.25^{a}	6.80 ± 1.03^{b}	7.60 ± 1.27^{b}	6.40 ± 0.70^{c}	8.50 ± 0.53^{ab}
LD_{4wks}	6.50 ± 0.50^{b}	5.50 ± 1.08^{b}	6.50 ± 0.03^{a}	7.00 ± 0.01^{a}	7.20 ± 0.98^{a}
LFD_{2wks}	8.00 ± 1.48^{a}	7.60 ± 1.78^{b}	7.60 ± 0.97^{b}	$7.901.37^{abc}$	8.70 ± 0.68^{b}
LFD_{4wks}	7.70 ± 1.23^{ab}	6.80 ± 1.20^{a}	6.80 ± 1.76^{a}	7.30 ± 1.34^{a}	7.60 ± 1.33^{a}
LBD_{2wks}	6.60 ± 1.08^{b}	6.80 ± 0.02^{ab}	$7.50 \pm .06^{b}$	7.40 ± 2.56^{a}	8.00 ± 1.45^{ab}
LBD_{4wks}	7.30 ± 1.64^{ab}	6.40 ± 0.97^{ab}	7.00 ± 1.58^{a}	7.50 ± 1.60^{abc}	7.30 ± 1.70^{a}
SD_{2wks}	7.50 ± 1.35^{ab}	6.60 ± 1.51^{ab}	5.80 ± 1.75^{a}	7.10 ± 1.08^{a}	8.20 ± 1.32^{ab}
SD_{4wks}	5.60 ± 0.09^{a}	5.50 ± 1.09^{b}	4.90 ± 1.23^{b}	6.90 ± 0.37^{a}	6.90 ± 0.98^{a}
SFD_{2wks}	6.60 ± 1.58^{b}	7.10 ± 1.37^{a}	7.60 ± 1.65^{b}	7.80 ± 1.62^{a}	8.20 ± 1.57^{ab}
SFD_{4wks}	7.70 ± 0.32^{ab}	6.90 ± 1.33^{a}	6.90 ± 1.57^{a}	7.00 ± 0.84^{a}	7.50 ± 0.7^{a}
SBD_{2wks}	6.90 ± 1.20^{b}	6.90 ± 1.20^{ab}	7.50 ± 1.27^{b}	7.50 ± 0.85^{abc}	8.40 ± 0.7^{ab}
SBD_{4wks}	5.50 ± 1.58^{d}	4.30 ± 0.08^{c}	6.00 ± 1.99^{a}	6.80 ± 0.24^{a}	6.50 ± 0.56^{ab}

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Authors' contributions

This work has been reviewed and approved by all the authors for submission to your respected publication.

AO, the lead investigator and the corresponding author, participated in the design idea, data collection, analysis, and interpretation, as well as the writing of the publication. His-involvement in the project is assessed at 30%.

The design concept, data analysis, interpretation, and manuscript drafting were also involved by **RM**, who is also a co-investigator. Her involvement in the project is assessed at 28%.

OM, who is associated with this study, participated in the design idea, data analysis, interpretation, and thesis writing. His-involvement in the project is assessed at 22%.

BA, participated in the design idea, data collection, analysis, and interpretation. Her involvement in the project is assessed at 20%.

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Table. 5, Table. 6

Declaration of Competing Interest

There are no competing interests with this work.

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