Nigerian Research Journal of Chemical Sciences **(ISSN: 2682-6054)**
Volume 12, Issue 1, 2024

Proximate Composition and Microbial Estimation of Soy Cheese Samples in Ibadan, Oyo State, Nigeria

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Accepted: April 2, 2024. Published Online: April 18, 2024

ABSTRACT

The objective of this study was to determine the proximate and microbiological compositions of soy cheese samples obtained from local food vendors at three locations within Ibadan Metropolis, Nigeria. The boiled, fried, and spicy soy cheese samples were randomly bought from three different producers in markets in Ibadan, Oyo State, Nigeria. Proximate composition determination, total microbial count and identification of microbes counted were carried out. Descriptive statistics including mean, standard deviation and range were calculated for proximate composition parameters and microbial counts. Data collected were further subjected to analysis of variance (ANOVA), and t-tests to assess differences between sample groups. The results showed that the moisture content ranged from 19.28±10.84% (spicy fried soy cheese) to 0.71 ±0.05% (fried soy cheese); carbohydrate content ranged from 78.49 ±1.62% (spicy fried soy cheese) to 1.82 ±0.01% (fried soy cheese) while protein content ranged from 60.07±0.02% (fried soy cheese) to 9.43±0.17% (boiled soy cheese). Fat content ranged from 7.78±0.45% (spicy fried soy cheese) to 0.48±0.06% (fried soy cheese), ash ranged 2.45±0.20% (spicy boiled soy cheese) to 1.12 ±0.18% (fried soy cheese), crude fibre content ranged from 10.28 ±0.15% (boiled soy cheese) to 1.46 ±0.01% (fried soy cheese) while 11.41±0.24% (boiled soy cheese) to 1.78±0.25% (spicy boiled soy cheese) was for the lipid content. The range of mean heterotrophic bacteria and fungi counts were 3.40× 10^3 cfu/ml (boiled soy cheese) to 1.33× 10^3 cfu/ml (fried soy cheese) and 5.01× 10^3 cfu/ml (spicy boiled soy cheese) to 1.78× 10^3 cfu/ml (fried soy cheese) respectively. The results of proximate composition of the tested samples showed insufficiency for the nutritional requirement of the human diet. Further research is recommended to explore optimization strategies for soy cheese production, including ingredient selection, processing

techniques and packaging methods, to enhance its nutritional quality, sensory attributes and shelf-life.

Keywords: Microbial estimation, proximate composition, soy cheese, heterotrophic bacteria and fungi.

INTRODUCTION

Cheese is a popular dairy product that is valued for its nutritious content, rich flavour and adaptability. Cheese is traditionally created from milk. To accommodate changing dietary requirements and health concerns, cheese production has expanded to incorporate a variety of substitutes. Soy cheese is a popular substitute that may be consumed by anyone who is lactose intolerant or follows a vegan diet because it is made from soy milk. In addition to having a texture and flavour similar to regular cheese, soy cheese is a plant-based alternative that may have health advantages [1].

Street-vended foods are an integral part of the culinary landscape in many urban areas in Nigeria, offering convenience, affordability, and a diverse array of flavour [2]. However, the consumption of ready-to-eat street-vended foods comes with inherent risks, particularly concerning proximate composition and microbial hazards [3]. In Ibadan, a bustling city in Oyo State, Nigeria, street food vendors play a significant role in the local food economy [4], catering to the tastes and preferences of residents and visitors alike [5]. Understanding the proximate composition, which refers to the relative amounts of macronutrients such as protein, carbohydrate and fat is crucial for assessing the nutritional quality and potential health impacts of street-vending foods [6]. Additionally, microbial hazards pose a significant threat to public health [7], with the potential to cause food-borne illnesses ranging from mild gastrointestinal discomfort to severe infections [8]. In this context, it becomes imperative to investigate the proximate composition and microbial hazards associated with ready-to-eat street-vended foods in Ibadan [9].

In the context of Nigeria, where dairy consumption is not as prevalent compared to other countries, exploring alternative sources of cheese production becomes pertinent. Soy cheese presents an opportunity to not only diversify the cheese market but also to promote sustainability and address nutritional challenges. In spite of the growing interest in soy-based products, there remains a dearth of comprehensive studies examining the proximate composition and microbial

quality of soy cheese, particularly within specific cities such as Ibadan, Oyo State. Understanding the proximate composition of soy cheese is essential for assessing its nutritional value and quality. Proximate analysis involves determining the percentage of key components including moisture, protein, fat, ash, and carbohydrates, providing insights into its overall nutrient profile. Additionally, microbial estimation is crucial for evaluating the safety and shelf life of soy cheese, as microbial contamination can lead to spoilage and pose health risks to consumers.

Ibadan, the capital city of Oyo State, Nigeria, represents a significant hub for food production and consumption, making it an ideal location for studying the characteristics of locally produced soy cheese. By investigating the proximate composition and microbial quality of soy cheese samples in Ibadan, valuable insights can be gained into its nutritional adequacy, safety, and potential for commercialization.

This study aims to fill the gap in the existing literature by conducting a comprehensive analysis of soy cheese samples sourced from various producers in Ibadan, Oyo State. Through proximate composition analysis, the study seeks to determine the nutritional content of soy cheese, while microbial estimation will assess its microbiological safety. The findings of this research are expected to contribute to the knowledge base on soy cheese production and inform policymakers, food manufacturers, and consumers about the quality and potential benefits of incorporating soy-based alternatives into the local food supply chain

MATERIALS AND METHODS

Study area

This research was carried out in Ibadan, Oyo State, situated in the Southwestern part of Nigeria. Ibadan is located between latitude 7.376°N and 10.250°N and longitude 3.9397°E and 11.167°E. The State has an area of 28,454 km² and a population of around 7,976,100 people according to the 2023 population census. It shares common borders with Kwara State (north), Osun State (east), Ogun State (south), and the Republic of Benin (on the west). It is characterized by a tropical climate with two distinct seasons: a rainy season (April-October) and a dry/harmattan season (November- March). Based on the vegetation classification of Nigeria, the study area falls into Sudan's savanna climate. The monthly mean temperature records show a range from 21 to

26.46 ºC, with an average annual rainfall of 850 - 954 mm. The relative humidity ranged from 71 to 80% in August and decreased to 16 to 16.8% in December.

Fig 1: Map of Oyo State showing the sampling points [10]

Sample collection

The samples were collected from three districts: North, South, and Akinyele. The boiled, fried, and spicy soy cheese samples were randomly bought from three different producers each in Ibadan, Agbeni, Bodija, and Akinyele markets in Ibadan. A total of four freshly prepared samples of boiled, fried, spicy boiled and fried soy cheese samples were collected. All the samples were collected in clean polyethylene bags and taken immediately to the laboratory for proximate and microbiological analyses.

Preparation of the soy cheese sample

In this research, chemical, microbial estimation, and statistical analyses were determined.

Chemical analysis

The proximate composition of the soy cheese samples was determined using the AOAC method [11]. Moisture content was determined by oven drying the samples at 105 °C until a constant weight was achieved. Total protein content was determined by the kjeldahl method, which

involved digestion of the samples followed by titration. Extracting lipids from the samples using ethanol or methanol solvent, followed by gravimetric analysis determined fat content. Ash content was determined using a dried sample obtained in the process of moisture content determination and were heated in a muffle furnace at 550 °C for several hours. The percentage of ash was calculated by subtracting the weight of ash from the initial weight [22]. Crude fiber was determined by the enzymatic gravimetric method. Total carbohydrate content was calculated by difference, subtracting the sum of moisture, protein, fat, ash, and fiber from 100%.

Microbial eestimation

Microbial hazards associated with the soy cheese samples were assessed by enumerating total viable counts (TVC), yeast, mould, and *Escherichia coli* (*E. coli*) using standard microbiological methods. For TVC, samples were serially diluted in sterile saline solution, plated onto appropriate agar media (Plate Count Agar), and incubated at an optimal temperature (typically 37 °C) for 24-48 hours. Yeast and *E. coli* were enumerated using selective agar media, MacConkey Agar and Eosin Methylene Blue Agar, followed by incubation at 37 °C for 24 hours. Microbial colonies were counted, and results were expressed as colony-forming units per gram (cfu/g) of the sample.

Quality assurance

All analyses were conducted by standard protocols and quality assurance procedures. Sterility and cleanliness were maintained throughout sample collection, handling, and analysis to prevent cross-contamination and ensure the accuracy of results. Calibration of equipment and validation of analytical methods were performed regularly to ensure the reliability and reproducibility of data.

Statistical analysis

Data obtained from proximate composition and microbial estimation were analyzed. Descriptive statistics including mean, standard deviation, and range were calculated for proximate composition parameters and microbial counts. Inferential statistical tests, ANOVA, and t-tests were performed to assess differences between sample groups.

RESULTS AND DISCUSSION

The proximate composition of soy cheese foods obtained within Ibadan metropolis was presented in Table 1. The moisture content ranged from 5.22– 26.47% in all four fried and boiled

samples. Boiled soy cheese had the highest moisture content 26.47 % w/w while fried spicy soy cheese had the lowest moisture content 1.04% purchased from all locations. There is a significant difference in the moisture content of all the fried samples.

Table 1: Mean proximate composition of soy cheese foods within Ibadan Metropolis

Proximate Analysis (%)	Locations	BSC	FSC	SBSC	SFSC
Moisture content		26.47	6.10	6.80	5.22
Carbohydrate		1.79	26.55	0.61	0.61
Crude protein		19.18	6.10	0.41	17.12
Fat	Bodija	22.82	19.6	0.04	21.81
Ash content		2.18	2.22	0.41	2.18
Fibre content		7.55	4.80	0.00	4.62
Lipid		1.02	1.94	11.71	1.00
Moisture content		5.22	4.19	24.73	7.23
Carbohydrate		48.22	3.21	75.83	74.06
Crude Protein		2.60	9.43	0.74	3.52
Fat	Akinyele	12.82	11.04	2.25	6.78
Ash content		2.20	1.81	0.19	4.32
Fibre		3.79	6.55	0.73	3.51
Lipid		1.48	1.70	1.56	0.41
Moisture content		6.81	5.22	5.64	1.04
Carbohydrate		16.31	28.22	7.82	1.32
Crude protein		2.56	2.56	5.43	4.32
Fat	Agbeni	2.30	1.04	9.85	7.42
Ash content		9.42	2.20	0.22	0.32
Fibre content		3.79	6.55	9.06	4.02
Lipid		1.90	1.80	4.90	2.40

BSC = Boiled Soy cheese; FSC = Fried Soy Cheese; SBSC=Spicy Boiled soy cheese; SFSC= Spicy Fried Soy cheese. Mean ± Standard deviation of values (n=3). Mean within columns with the same Super Scripts are not significantly different (P>0.05).

Moisture content, which is the percentage composition of water in food samples, is pertinent in the human diet [12] because it regulates the body temperature and gives an account of the shelf life of food samples. The higher the moisture content, the lower the shelf life. Boiled soy cheese is a protein-rich food sample that has a low carbohydrate content.

The result of this research shows a mean protein concentration of 0.41 ± 0.01%. The protein content ranged from 0.41 – 19.18% w/w with boiled soy cheese and spicy-boiled soy cheese having the lowest protein content of 0.41% w/w and boiled soy cheese having the highest protein content of 19.81% w/w. All the boiled samples are protein-rich while the remaining

samples of fried are carbohydrate-rich. The result of this research revealed that the mean protein concentration of 0.41± 0.01 % w/w. Boiled soy cheese is the richest in protein with a mean protein concentration of 19.18 ± 0.40 %. This is because the protein quality of a diet is usually a measure of the ability to promote growth. This makes soy cheese nutritionally balanced when consumed with foods which is low protein content but high carbohydrate content [13]. Animal protein is seldom affordable to the poor in developing countries [14, 15]. Plant sources like soy cheese provide a cheap source of protein. The World Health Organization (WHO) [16] estimated the average daily protein requirement for adults to be 52.5 g. However, the amount of protein derivable from these fried soy cheese food samples was estimated at 0.41 – 9.31 g/100g. The implication of this is that consumption of these fried soy cheese and spicy fried soy cheese food samples without any other protein supplements will be grossly inadequate to meet the significant role of protein in the human diet because during the process of frying all the protein is wiped away with deep-frying [17]. Therefore, in fried soy cheese samples, the amount of protein is reduced because of roasting which reduces the amount of protein content in these food samples. Protein is very important for the body's growth and cell differentiation [18].

It was reported by Nworu *et al* [19] that fat contributes to the absorption of fat-soluble vitamins, and act as structural elements of cell walls, in addition to being a concentrated source of energy. High intake of fats has associated risks such as obesity, type 2 diabetes, cancer and coronary heart disease. The fat content ranged from 0.04 – 22.82% in all the four food samples. In all three locations, boiled soy cheese and spicy fried soy cheese have the lowest mean fat content with values being at 0.04 ± 1.04% and 1.04 ± 0.43 % respectively while spicy boiled soy cheese and boiled soy cheese had the highest mean fat concentration at 22.82 ±0.26% and 19.60 ± 1.04% respectively. Soybeans contain about two to three percent fat and no cholesterol unless they are processed or prepared with other ingredients.

The lower ash content in the spicy boiled soy cheese and spicy fried soy cheese samples when compared to other studies is indicative of low mineral content and influences its quality [21].

The crude fiber content was not detected in spicy boiled soy cheese and was lower than the 9.06% in the study of Effiong *et al* [22]. The fiber content is beneficial as fiber in food helps eliminate bile acids, lower body cholesterol, and creates variation in feacal bulk and transit. High fiber diet intake prevents diet-related diseases like cardiovascular disease, cancer of the colon, and diabetes [23]. Diets with high fiber content have been used for weight control and fat

reduction as they provide satiety and thereby reduce the amount of energy-given food that would be consumed [24]. This could be an advantage as boiled and fried soy cheese is sold in Ibadan market.

Carbohydrates are the body's main source of energy and they comprise 40-80% of total food energy intake. The carbohydrate content ranged from 2.32– 75.83% w/w. Spicy boiled soy cheese has the highest mean carbohydrate content 75.83 ± 1.43% while spicy fried soy cheese has the lowest mean carbohydrate content 2.32 ± 0.28% w/w. It was also estimated by Bueno *et al.* [25] that the percentage of soybeans contain high carbohydrate content, which is about 30-35g/ 100 g. The results also showed spicy boiled soy cheese contained a high carbohydrate content of 75.83± 2.32 %.

The lipid contents were 1.02 ± 0.10%, 2.27 ± 0.20%, 4.90±2.40%, and 11.71 ± 4.64% for the boiled soy cheese, fried soy cheese, spicy boiled soy cheese, and spicy fried soy cheese respectively. High lipid content with high moisture as seen in the fried soy cheese in this study increases the chances for rancidity and thus decreases the shelf life of the food.

The ash content of a feedstuff is the inorganic residue remaining after the organic matter has been destroyed by combustion in the muffle furnace [26].

Table 2: Proximate composition of soy cheese within Ibadan Metropolis

Food Items	Proximate Composition						
	Moisture	Carbohydrate	Protein	Fat	Ash	Fibre	Lipid
Boiled soy cheese	Mean ± SD	Mean ± SD	Mean ± SD	Mean± SD	Mean ±SD	Mean ±SD	Mean ±SD
	5.86±0.33^{d}	4.98±0.03^{aa}	9.43±0.17^{ab}	1.82±0.61^{e}	1.66±0.01^{f}	10.28±0.15^{ac}	11.41±0.24
Fried soy cheese	0.71±0.05^{a}	1.82±0.01^{c}	60.07±0.02^{a}	0.48±0.06^{a}	1.12±0.18^{c}	1.46±0.01^{a}	4.124±0.081
Spicy boiled cheese	3.18±0.19^{c}	8.83±0.80^{e}	1.99±0.10^{f}	1.91±0.71^{d}	2.45±0.02^{b}	3.82±1.61^{e}	1.78±0.25
Spicy fried cheese	19.28±10.84^{f}	78.49±1.62^{b}	3.58±0.49^{c}	7.78±0.45^{e}	2.25±0.20^{c}	1.48±0.12^{d}	2.39±0.04

The ash content of the fried and spicy food samples ranged from 0.32 – 9.42% with spicy fried soy cheese having the highest ash content while spicy boiled soy cheese had the lowest mean ash content.

The microbial load counts, microbiological hazards analysis and the description of microorganisms in the soy cheese samples are presented in Tables 3-5 respectively.

Table 3: Microbial load counts (cfu/mL) of soy cheese food

MHA	Location	BSC (cfu\mL)	FSC (cfu\mL)	SBSC (cfu\mL)	SFSC (cfu\mL)
TVC	Bodija	$4.1x10^5$	$7.1x10^5$	$2.8x10^5$	$1.8x10^8$
TYC		$2.1x10^6$	$8.9x10^5$	$1.7x10^7$	$1.6x10^4$
TVC	Akinyele	$4.1x10^5$	$2.4x10^6$	$4.9x10^8$	$2.0x10^6$
TYC		$5.6x10^5$	$1.2x10^6$	$1.6x10^4$	$6.8x10^5$
TVC	Agbeni	$2.8x10^5$	$3.8x10^6$	$1.2x10^2$	$8.2x10^6$
TYC		$2.4x10^7$	$3.5x10^7$	$3.3x10^8$	$1.3x10^4$

TVC: Total Viable Count: TYC: Total Yeast Count: Mean ± Standard deviation of values (n=3). Mean within columns with the same rows with the same superscripts are not significantly different (P>0.05).

Table 4: Microbiological hazard analysis of the soy cheese samples

Food Items	Microbial Composition ($\times10^3$ cfu/mL)	
	THF	THB
Boiled soy cheese	3.40	2.80
Fried soy cheese	1.33	1.78
Spicy boiled soy cheese	2.34	5.01
Spicy fried soy cheese	3.10	2.55

THF = Total Heterotrophic Fungi, THB = Total Heterotrophic Bacteria

Table 5: Description of microorganisms in soy cheese samples

Microorganisms	Boiled soy cheese	Fried soy cheese	Spicy boiled soy cheese	Spicy fried soy cheese
Streptococcus spp	+	+	+	+
Lactobacillus spp	+	+	+	+
Staphylococcus aureus	+	+	_	+
Penicillium spp	+	+	-	-
Aspergillus niger	+	+	+	+
E.coli	-	+	+	+
Klebsiella sp	+	-	+	+
Vibrio cholera	+	+	+	+

It was found by Kechero *et al.* [28] that several microorganisms such as feacal coliform bacteria, and Salmonella species which have public health concerns have been implicated in street foods sold in some African countries. These street foods include soy cheese, meat pie, *akara, moin-moin, suya* and cheese, which is the focal point of this research.

Table 4 showed that spicy boiled soy cheese has the highest mean heterotrophic bacteria count of 5.01 $\times 10^3$ cfu/ml, followed by boiled soy cheese at 3.40×10^3 cfu/ml while fried soy cheese has the lowest mean heterotrophic bacteria count of 1.78 $\times 10^3$ cfu/ml. Table 4 also showed that boiled soy cheese has the highest mean heterotrophic fungi count at 3.40 $\times 10^3$ cfu/ml, followed by spicy fried soy cheese at 3.10 $\times 10^3$ cfu/ml while fried soy cheese has the lowest mean heterotrophic fungi count at 1.33 $\times$ 10^3 cfu/ml. The WHO standards for Total Heterotrophic Bacteria count is 10 – 16 cfu/ml of which the microbial loads of the boiled food items were far higher than the standards of fried foods. The high bacteria counts could be a result of the food items being processed with water from sources that are not treated [29]. The presence of bacteria and fungi in high amounts in these boiled food items could pose health risks to consumers. Factors that could have contributed to the high bacteria and fungi counts are as follows: exposure of raw and uncooked boiled food items to the environment, poor hygienic practices such as inadequate washing of hands and utensils, and poor food preparation handling.

The high microbial count recorded in the food samples could be linked to several factors such as improper handling and processing conditions, use of contaminated water during cooking, cross contamination of raw materials used during production, use of dirty processing utensils, and unhygienic nature of food vendors [30]. The mean microbial count from the study is unacceptable as it exceeds the recommended standard of 10^5 cfu/g for ready-to-eat foods [31]. The microorganisms isolated in this study were in agreement with the studies of Opeolu et al [32] and Akinnibosun [33]. *E.coli* strains pose food safety problems as they are all enter toxigenic and cause gastroenteritis [20]. Staphylococcus aureus was the most prevalent microorganism and its presence in the food is an indication of excessive human handling. Contamination of ready-to-eat by *Staphylococcus aureus* can be prevented using latex gloves to reduce excessive humans.

CONCLUSIONS

This study investigated the proximate composition and microbial estimation of soy cheese samples sourced from various producers in Ibadan, Oyo State, Nigeria. The findings provide valuable insights into the nutritional adequacy, safety, and potential for commercialization of soy cheese as an alternative to traditional dairy-based cheese products. The findings of this study underscore the potential of soy cheese as a viable alternative to conventional dairy-based cheese products, offering nutritional benefits, versatility, and safety assurances. By promoting the

adoption of soy-based alternatives in the local food, industry and its can contribute to sustainable food systems, address dietary preferences, and improve public health outcomes in Nigeria and beyond. Moving forward, further research is warranted to explore optimization strategies for soy cheese production, including ingredient selection, processing techniques, and packaging methods, to enhance its nutritional quality, sensory attributes, and shelf-life. Additionally, consumer acceptance studies and market analyses are needed to gauge the demand for soy cheese products and identify opportunities for market expansion and product diversification.

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