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# PROXIMATE PROPERTIES AND MICROBIAL LOAD OF MEATLESS MEAT PRODUCED FROM THE BLENDS OF COW MILK AND COCONUT MILK

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## ABSTRACT

Meat is one of the primary sources of dietary protein, widely acknowledged for its high-quality protein and nutritional value. However, due to various dietary and health concerns surrounding red meat, there's a growing need for palatable and nourishing alternatives. This study evaluates the proximate composition and microbial load of meatless meat produced from a blend of cow's milk and coconut milk. Four dehusked coconuts weighing 540 g, 543 g, 550 g, and 555 g were processed to extract coconut milk using three litres of warm water filtered through a cotton cloth. The extracted coconut milk was blended with raw cow's milk at varying proportions (90:10, 80:20, 70:30, and 60:40). Cheese produced from each blend was sliced, seasoned with spices, coloured using hibiscus flower extract to simulate the appearance of red meat, and deep-fried to produce the meat analogue. A sample containing 100% red meat served as the control. Results showed that yield decreased as the proportion of coconut milk increased, while processing time increased. The 90:10 cow milk–coconut milk blends produced the highest yield (486 g) with the shortest processing time (8 minutes). Proximate analysis revealed moisture (36.30–49.81%), ash (4.47–6.42%), crude fibre (13.93–22.91%), crude protein (17.98–29.13%), and carbohydrate (5.25–15.75%), with significant differences ($p < 0.05$) among samples. Microbiological analysis indicated the absence of coliform contamination. Overall, the cow milk–coconut milk blend demonstrates potential as a safe, nutritious, and innovative meat substitute with promising yield and functional properties.

**Keywords**: Meat Analogue, Gastronomy, Proximate Value, Food Innovation

## INTRODUCTION

One of the leading sources of dietary protein is meat, which is known to be high-quality, nutritious, and to possess desirable sensory qualities such as flavour and texture. Nevertheless, with several ethical, dietary, and health issues associated with red meat, there is an increased demand for alternatives that are not only palatable but also nourishing. Those with dental caries or who are lacto-vegetarians tend to be unable to eat traditional meat due to dietary preferences or a need for soft-textured food (Nieman et al., 2022).

Meatless meat consists of food that is not produced from red meat. The so-called Meatless meat often refers to the products that look, have the texture, taste, and colour of meat, but do not include any meat (Bakhsh et al., 2021). There are many other names used to refer to meatless meat, such as meat replacers, meat substitutes, imitations, non-meat protein substitutes, man-made meats, artificial meats, and meat-like meats, meat analog, and mock meats (Zahari et al., 2022).

There is a considerable prospect in the novel of healthy protein substitutes that have the ability to imitate the flavor, taste, texture, color, and nutritional value of red meat (Bakhsh et al., 2021). Milk is a common food because it has a high nutritional value in that it contains proteins, lipids, lactose, vitamins, and minerals that facilitates the growth of tissues and organs (Nwaeze et al., 2020) The composition of milk contains about 25 percent protein, 20 percent lipids, 3 per cent carbohydrates, 2 per cent ash, and 50 per cent moisture (Guetouache et al., 2022).

The coconut milk is a nutritionally high food substance with not too high or too low levels of protein and minerals and quite high fat proportions, which is why it is applicable in a variety of diets, including vegetarian, vegan, and lactose-free ones (Arya et al., 2017). With its soft texture and pleasing flavor, coconut milk, combined with cow milk's high-quality protein, presents a prospective element for creating a meat substitute (Paul et al., 2020).

This meat substitute, prepared from a blend of cow's milk and coconut milk, will be a good alternative for lacto-vegetarians and individuals with dental caries. While current literature focuses on meat substitutes derived from legumes, soy, and fungi, there's a gap in investigating dairy and plant-based milk blends like cow milk and coconut milk for creating a viable red meat substitute. This study evaluates the proximate and microbial loads of meatless meat made from this blend.

## MATERIALS AND METHODS

Cow milk was purchased from Kushe at Ilaro, and the milk was aseptically collected into the 10-liter keg. The coconut, coagulum (Sodom apple), meat, vegetable oil, zobo leaf (dry hibiscus flower), pepper and seasoning were purchased from Sayedero market at Ilaro, Ogun state.

### Sample Preparation

Four coconuts that had been dehusked and weighed 540g, 543g, 550g, and 555g each were split in half. To extract the meat from the shell, the split coconut was deshelled using knife. After being cleaned, the coconut meat was sliced into smaller pieces. In order to extract the coconut milk, the sliced coconut meat was grated with a greater, three litres of warm water were added, and the mixture was filtered through a cotton cloth using the method described by (Ekanem & Ojimelukwe, 2017).

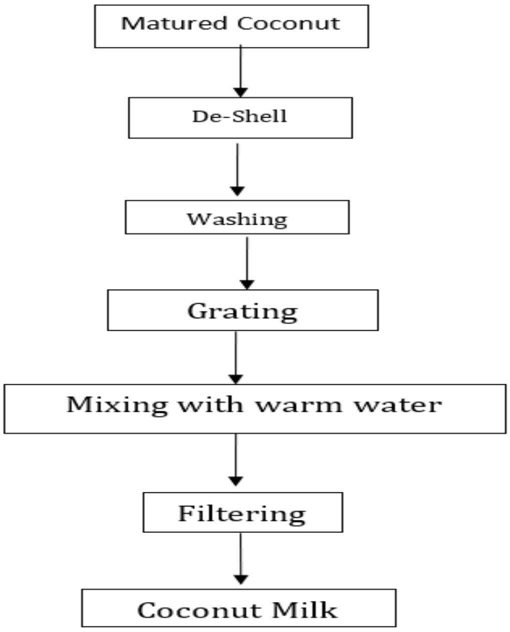


Figure 1: Shows the Process Flow Chart of Coconut Milk Production (Ekanem & Ojimelukwe, 20

**Proportion Ratio of Meat Substitute**
The fresh portions of cow milk and coconut milk were measured according to the required ratio, while red meat was used as a sample control.

**Table 1: Proportion Ratio of Meat Substitute**

| Specimen | Red meat | Cow milk | Coconut milk |
|---|---|---|---|
| A (Control) | 100% | 0 | 0 |
| B | 0 | 90 | 10 |
| C | 0 | 80 | 20 |
| D | 0 | 70 | 30 |
| E | 0 | 60 | 40 |

**Production of Meat Substitute**
The same procedure followed by Ekanem & Ojimelukwe (2017**)** was adapted with some slight modifications to create a meat substitute, cheese. Fresh leaves and stems of the Sodom apple were mashed using a pestle and mortar. Label sample B, C, D, and E in four sterilised pots. Three litres of blend of milk were then measured and each pot was placed on low heat. A minute of reaction of the enzymes in the leaves and stem of the plant was allowed following the addition of 26g of crushed Sodom apple stem and 9g of crushed Sodom apple leaf to the heated milk. This mixture was kept at low temperature ranging between 32 and 38 o C. This was done by swirling the milk to make sure that it was thoroughly mixed and this took approximately one minute. It was evidently divided into whey and curd shortly after shaking. The curd was then strained and allowed to rest a period of fifteen minutes so as to separate the cheese and whey further. The cheese was sliced into manageable portions seasoned with spices and cooked with hibiscus flower as a means of making the meatless meat take on the colour of red meat and then deep fried in oil. The fried meat alternative was strained off oil and stored to undergo further analysis.

**Proximate Analysis**
The moisture, ash, protein, fat, fibre and carbs were measured using the AOAC (2005) method. To conduct a gravimetric analysis of the moisture content, two grammes of the sample were dried in the air oven at 105 ℃ in five hours. The crude protein concentration was determined by the use of the macro Kjeldahl technique. To ascertain the crude fat content, approximately 5 grammes of the sample were extracted using petroleum ether and the Soxhlet extraction method. Using the muffle furnace, 2grams of the sample was ashed at 600 ℃ to determine the ash content. The crude fibre content was ascertained using the acid/detergent wash method. Following thorough removal of all soluble materials from the approximately 0.5g of residue left over after the extraction process using a 1.25% $H_2SO_4$ and 1.25% NaOH solution, the residue was cleaned, and the weight difference was noted. The difference between crude fibre and total carbohydrates was then calculated.

**Method of Data Analysis**
SPSS version 20.0 was used to statistically examine the data from the laboratory and proximal analyses. Following data analysis using an analysis of variance (ANOVA), Duncan's multiple range test was used to find substantially different means.

**RESULTS AND DISCUSSION**
The results of the meat alternative yield using cow and coconut milk blends are displayed in Table 2. As evident from the table, the yield of the meat substitute decreased progressively as the proportion of coconut milk increased,

while the preparation time also increased. Sample B, which contained 2700 ml of cow milk and 300 ml of coconut milk, produced the highest yield (486g) of meat alternative in the shortest period of time (8 minutes). As the level of coconut milk increased from 400 ml to 500 ml and 600 ml in Samples C, D, and E, respectively, this led to a gradual reduction in product yield (439g, 330g, and 315g) and a gradual increase in the preparation time (15, 17, and 20 minutes), respectively. This suggests that higher inclusion of coconut milk reduces the product's yield and extends the processing time, possibly due to differences in the physicochemical properties of cow milk and coconut milk.

**Table 2: Meat Substitute Yield**

| Samples | Meat | Cow Milk (Milliliter) | Coconut Milk (Milliter) | Total milk used (Milliter) | Yield of product (g) | Time used in preparation |
|---|---|---|---|---|---|---|
| A | 100% | 0 | 0 | 0 | 0 | 0 |
| B | 0 | 2700 mil | 300 mil | 3000 mil | 486g | 8 min |
| C | 0 | 2600 mil | 400 mil | 3000 mil | 439g | 15 min |
| D | 0 | 2500 mil | 500 mil | 3000 mil | 330g | 17 min |
| E | 0 | 2400 mil | 600 mil | 3000 mil | 315g | 20 min |

Key
Specimen A = 100% meat, Specimen B = 90% cow milk, 10% coconut milk, Specimen C = 80% cow milk, 20% coconut milk, Specimen = 70% cow milk, 30% coconut milk, Specimen E = 60% cow milk, 40% coconut milk

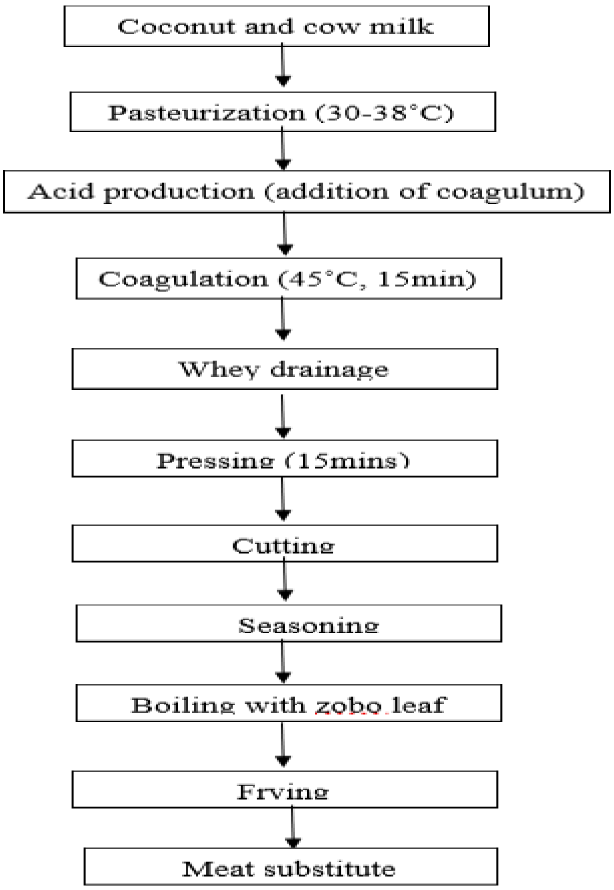


Figure 2: Shows the Process Flow Chart for Meat Substitute Production (Khanal et al., 2019)

The meat substitute samples' proximate composition is displayed in Table 3; Sample E had the highest moisture content (49.81 ± 0.03%) and Sample A had the lowest (36.30 ± 0.04%). Sample A had the highest ash concentration (6.42 ± 0.01%), whereas Sample E had the lowest (4.55 0.02%). Sample E had the lowest protein value (17.93 ± 0.01%), whereas Sample A had the highest value (29.13± 0.03%). Additionally, Sample A had the highest fat level (22.91 ± 0.04%), whereas Sample E had the lowest (13.93 ± 0.03%). Sample A had the lowest carbohydrate content (5.25 ± 0.04), while Sample E had the highest (15.73 ± 0.05%)

**Table3: Proximate Composition**

| Sample | Moisture (%) | Total Ash (%) | Crude Fat (%) | Crude Protein (%) | Total Carbohydrate (%) | Fiber |
|---|---|---|---|---|---|---|
| A | 36.30 ± 0.04[e] | 6.42 ± 0.01[a] | 22.91 ± 0.04[a] | 29.13 ± 0.03[a] | 5.25 ± 0.04[e] | Nil |
| B | 36.63 ± 0.04[d] | 5.43 ± 0.02[b] | 20.06 ± 0.01[b] | 27.58 ± 0.02[b] | 10.31 ± 0.06[d] | Nil |
| C | 40.44 ± 0.02[c] | 5.21 ± 0.04[c] | 17.23 ± 0.02[c] | 24.59 ± 0.03[c] | 12.55 ± 0.05[c] | Nil |
| D | 43.98 ± 0.03[b] | 4.47 ± 0.03[d] | 14.22 ± 0.02[d] | 21.61 ± 0.03[d] | 13.74 ± 0.09b | Nil |
| E | 49.81 ± 0.03[a] | 4.55 ± 0.02[e] | 13.93 ± 0.03[e] | 17.98 ± 0.01[e] | 15.73 ± 0.05[a] | Nil |

Data shown as mean ± SD (duplicate measurements). Significant differences ($p < 0.05$) are indicated by different superscripts within rows

Table 4 shows the microbial load of the sample, indicating the absence of coliform growth.

**Table 4: Microbial Analysis of Fried Meat Alternatives Samples**

| Specimen | TOTAL COLIFORM COUNT (TCC) ($X10^1$Cfu/g) |
|---|---|
| A | 0.00 |
| B | 0.00 |
| C | 0.00 |
| D | 0.00 |
| E | 0.00 |

Remark: No coliform count growth was observed

**Discussion**

The yield of the meat substitute product was calculated with the weight of the coagulated milk product (in grammes). The meat alternative was produced through the process of coagulation of cow and coconut milk proteins as indicated in Table 1. As it is observed in Sample B (2700 mL: 300 mL), the addition of 300 mL of coconut milk increased the content of cow milk as shown in the table. Conversely, the 400 mL of coconut milk quantitative addition to 600 mL of coconut milk led to a reduction in the manufacturing of the meat analog. It means that the relationship of a greater protein concentration and a greater yield of the final product is clear (Amar et al. 2017).

This can be demonstrated by sample B (2700 mL cow milk: 300 mL coconut milk) having a yield of 486g, which is significantly higher than that of Sample E (315g) (2400 mL cow milk: 600 mL coconut milk). Increased cow milk percentage significantly added to the increased yield of Sample B, which is in line with the results of Halim et al. (2022), who reported that in their examination of coconut milk production into cheese and its organoleptic traits, the production yield decreased through the percentage of coconut milk, with maximum results at 37.96%. The low protein content and the poor functional quality of coconut milk could have led to the reduction in the yield of cheese to high levels of coconut milk (Amar et al. 2017). In addition, the table indicates that the coagulation time used the longer, the more the coconut milk used.

The result of proximate composition of the meat substitute samples revealed significant differences ($p < 0.05$) in the moisture, protein, ash, fiber, fat, and carbohydrate content of the cow milk and coconut milk substitute blends.

The moisture content gradually increased from sample A (36.30%) to sample E (49.81%). This is in line with the findings of Hussein et al. (2016), who found that, in the study of the chemical composition and sensory qualities of West African soft cheese (warankashi) made from blends of cow milk and soy milk, the moisture content increased from 45.12% to 58.30% as the proportion of soy milk increased. Moreover, this finding is in line with the conclusions of Ekanem and Ojimelukwe (2017) who also state that the moisture content rose from 57.75% to 66.90% as the coconut milk rose in the experiment of Potentials of coconut milk as a substitute of cow milk in cheese making.

Additionally, this result is consistent with the findings of Balogun et al. (2019), who examined the chemical composition and sensory characteristics of soy-tigernut cheese and found that the moisture content increased as the amount of tigernut milk increased from 61.11% to 65.21 percent for cheese made from 100% soy milk and 75:25% soymilk-tigernut milk blend, respectively. The precipitate of the coconut milk obtained after filtration of the grated coconut kernel could be the reason why the moisture content had increased across the entire sample made.

In general, beef has a lower moisture content because of its solid muscular structure, while meat alternatives made from milk-based products have a higher moisture content since cow milk and coconut milk both contain a lot of water ( Williams,2007; Swing et al., 2021).

The moisture content of the foods indicates the water activity of the food and the development of microbes can adversely affect the shelf stability in the case of excess moisture content. The higher the percentage of coconut milk the higher was the moisture content.

Similar tendencies in terms of fat reduction were also noted by He et al. (2020) in a survey of research about plant-based meat alternatives where the percentage of fat content had decreased to 5.11 with a starting percentage of 22.12. Sample A had a high fat content of 22.91 percent and the level gradually decreased with the formulated samples up to 13.93 percent in sample E. Moreover, the same finding was aligned with the results of Hussein et al. (2016), who studied the chemical makeup and sensory attributes of the West African soft cheese (warankashi) obtained with the mixtures of cow milk and soy milk. They discovered that the fat level reduced with the rise in the content of soy milk to 11.30% percent. This reduction in sampled fats level might be because an ingredient was added or simply because coconut milk was mixed with water, and thus it could have lowered already existing fats (Lee et al. 2020). Since red meat tends to be higher in fats, particularly with the selection of the cut, sample A (100% meat) is fattier (Balogun et al. 2019; Swing et al 2021). Cow and coconut milk contain fat in different levels.

The ash content that was used to determine the mineral content was measured in the samples and varied between 4.55

per cent and 6.42 per cent. Sample E registered the lowest including the lowest value of the mineral content and Sample A registered the highest amount. These results were in tandem with the ranges given by Ekanem & Ojimelukwe (2017) in their experimentation on the possibility of using coconut milk rather than cow milk to prepare cheese. He stated that when the percentage of coconut milk rose, the percentage of ash content dropped from 1.80% to 1.45%; the reason these two data line up could be that the same substance was used. An estimate of the sample's overall mineral composition can be obtained from the ash content. Minerals are essential for many bodily functions, including as the operation of the neurological system, cell functions, and structural systems like the skeleton Sultan et al. (2024). However, as the amount of coconut milk increased, the amount of ash dropped.

The protein content of the meat substitute ranged between 17.98% and 29.13. Sample E and sample A contained the least and the most protein respectively. This finding is in line with the study that found that the content of proteins present in coconut milk was low compared to cow milk, since animal products contain significantly more protein in 100g of food (William 2007 ; Lee et al. 2020).

Herrmann et al (2024) state in their study titled A Comparative Nutritional Life Cycle Assessment of Processed and Unprocessed Soy-Based Meat and Milk Alternatives including Protein Quality Adjustment, that the protein content is 16.3-30.1. These results were similar to that research. Also, it aligns with the study by Hermann et al. (2024), who discovered in a study on plant-based meat substitutes that the protein level of the cheese made with soy-coconut milk decreased when the proportion of coconut milk was raised; the cheese began at 22.67% and reduced to 16.37% as the proportion of coconut milk increased. This was also similar to what Matin et al. (2020) did when they studied the effect of adding coconut milk to the physicochemical, proximate, microbial, and sensory characteristics of Dahi (Indian food), and discovered that the protein content varies between 2.98 to 3.13 percent when the coconut is added. The protein content decrease in all the formulation samples may be attributed to the low protein content of coconut milk. Protein is necessary for cell division, growth, and system maintenance. In addition to being a solid source of high-quality protein, meat has all the essential amino acids required for hormone production, immunological response, and muscle repair (Lort et al. 2023). The higher protein content in the beef ,due to its dense muscle tissue, contracts with the lower protein content in cow milk and coconut milk , which have higher water content, potentially contributing to the sample formulation's overall protein drop.

The meat substitute's carbohydrate content varied from 5.25% to 13.74%, mainly rising as the percentage of coconut milk increased. Sample E contained the most carbohydrates, while Sample A contained the fewest. Given that meat has very little carbohydrate, the natural sugars in milk and coconut milk, as well as potential component breakdown during processing, can be blamed for the formed samples' increased carbohydrate content (William, 2007; Sultan et al. 2024). It is well known that carbohydrates aid in fat metabolism and provide energy to the central nervous system (Hermann et al. 2024)

The microbiological investigation of the meat substitute samples revealed no coliform counts was found. The microbial load analysis's lack of coliform growth indicates that the meat analog made from a combination of cow's and coconut milk has good hygienic quality and is probably safe to eat. A class of bacteria known as coliforms is frequently used to identify contaminated feces and unsanitary conditions. Their absence implies that the product was handled and processed under sanitary conditions, minimizing the risk of pathogenic contamination.

## CONCLUSION

This study concludes that meatless meat with a reasonable nutritional value and safety can be hygienically produced from blends of cow milk and coconut milk to serve as an alternative for people who avoid meat for health, religious, or dental reasons, and suggests more research into the mineral, vitamin, and sensory qualities of meatless meat.

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