

Effect of Different Coagulants on the Quality Characteristics of Cheese Produced from Cow Milk and Coconut Milk Blend

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Abstract

This research involved the production of cheese from cow milk supplemented with coconut milk using four different types of coagulants (lime, lemon, vinegar and calcium chloride). The effect of these coagulants on the physicochemical, nutritional and microbiological qualities of cheese was assessed. Fresh cow milk was blended with coconut milk at equal ratios of 50:50 and divided into four samples, each treated with a different coagulant. Results showed that the different coagulants had significant ($p < 0.05$) effect on the quality parameters of cheese. Values ranged from 0.03 – 0.16% for TTA; 5.04 – 6.60 for pH; and 110.00 – 211.50 sec for coagulation time. Cheese yield ranged from 19.53 – 25.09% with calcium chloride giving the most yield. Proximate composition of cheese was also significantly influenced by the coagulants. Mineral contents of cheese showed maximum values of 19.21 mg/100g for calcium, 14.01 mg/100g for magnesium, 17.91 mg/100g for potassium and 13.21 mg/100g for iron for cheese sample with calcium chloride as coagulant. Microbiological analysis showed that the cheese samples were safe for human consumption.

Keywords: Cheese, Coagulants, Cow Milk, Coconut Milk, Calcium Chloride, Lime.

Introduction

Cheese is a concentrated dairy made by curdling milk with acid or rennet, then processing the curd through stirring, heating and draining, followed by shaping and pressing. The final step involves allowing the cheese to mature by ripening, curing or aging to enhance its flavour and texture (Balogun *et al.*, 2016). Typically, cheese is produced from pasteurized cow milk, although it can also be made from the milk of other mammals. In many developing nations, home-based cheese production is a widespread practice that helps extend the shelf life of milk, thereby preserving its nutritional value (Orhevba and Taiwo, 2016). The production of most cheese involves the use of rennet that causes the casein micelles in milk to coagulate, forming curds and separating from the whey (Gonzalez *et al.*, 2017) and adding a starter culture which triggers the production of lactic acid (Kongo and Malcata, 2016). Rennet or a coagulating agent is commonly used to coagulate milk, a crucial step in the cheese-making process. Alternatives to traditional coagulants include using

acidic substances like acetic acid, citric acid, vinegar, or lemon juice to curdle milk (Chikpahs *et al.*, 2014).

The basic ingredients required to make cheese are milk, coagulants, bacterial cultures and salt. The coagulant triggers the milk proteins to clump together, gradually turning liquid milk into a semi-solid, gel-like state. Cheese is a nutrient-dense food that provides a rich concentration of many of the nutrients found in milk. The production of cheese is controlled by several key factors, including the temperature, acidity level, and calcium content of the milk, among other variables (Ayeeni *et al.*, 2014). The combination of the cheese's formulation and the production process ultimately determines its texture and functional properties, and optimal cheese quality is typically attained by carefully balancing the composition of the cheese with the conditions under which it is made (Yu and Gunasekaran, 2005).

The meltability (ability to soften and flow when exposed to heat) of cheese can be directly impacted by various compositional factors, including its calcium, fat and moisture contents, pH and nitrogen fractions (Machuca *et al.*, 2015) while the stretchability (the ability to stretch and form strings when subjected to tension and heat) can be affected by various factors throughout its production, from the milk used to the conditions after manufacturing, with the curdling process playing a key role in creating the linearity of protein chains in its structure (Ismail *et al.*, 2011). Cheese, similar to other dairy products, is a nutrient-dense food that provides minerals, particularly calcium and phosphorus, protein, vitamins, fat, and carbohydrates (Dhuol and Hamid, 2014).

Coconut (*Cocos nucifera* of the *Family Palmae*) is widely grown in Nigeria and is commonly consumed as a snack for pleasure. It is also a good source of fibre and iron as well as other minerals, making it an ideal raw material for creating dairy alternatives and similar products (Balogun *et al.*, 2016). Coconut milk is derived from the grated flesh of coconut (Balogun *et al.*, 2016). The distinctive colour and rich taste of coconut milk are due to its high concentration of oil and the majority of the fat is saturated fat. Coconut milk is cholesterol-free and rich in various vitamins, minerals and electrolytes (Amarasiri and Dissanayake, 2006; Ntukidem, *et al.*, 2019). It helps to build up the body's immune system amongst other uses (Mensink *et al.*, 2003). It is a significant source of lauric acid, a type of saturated fat that can help raise blood cholesterol levels (Balogun *et al.*, 2016).

In many parts of tropical Africa, milk and milk products are scarce and unaffordable to the majority of the populace (Ayodeji *et al.*, 2020). The high and unaffordable cost of cow milk in some developing countries has made it necessary to source less expensive plant products that could be used as substitutes for milk products or to augment the use of milk products for effectiveness in fighting protein malnutrition (Okon and Ojimelukwe, 2017).

The objective of this study was to assess the effect of using lime, lemon, vinegar and calcium chloride as coagulants on the quality characteristics of cheese produced from a blend of cow milk and coconut milk.

Materials and Methods

Procurement of raw materials

Cow milk was purchased from Nasarawa Market, aseptically collected and stored in a refrigerator. Coconut and coagulants (lime, lemon, vinegar and calcium chloride) were purchased from Itam Market in Itu Local Government Area, all in Akwa Ibom State, Nigeria.

Preparation of coconut milk

Coconut milk was prepared following the method described by Balogun *et al.* (2016) with slight modification. 5 clusters of coconut were processed by removing their shells, cleaning them, and then shredding them with the use of a traditional coconut grater. Coconut milk was extracted by blending (Smart Gring, Black and Decker, Towson, MA, USA) the shredded coconut pulp with an equal weight (1:1) of warm distilled water (60 °C), and then straining the mixture through a double-layered cheesecloth. The cheesecloth was then squeezed and twisted by hand to press out as much milk as possible. The extracted milk was pasteurized and stored at 30°C before cheese production, which occurred within 24 hours of milk extraction.

Preparation of coagulants

Lime and Lemon Juice: Lime and lemon fruits (10 of each) were cleaned, peeled, halved and then manually squeezed to extract their juices, which were collected in separate containers. The extracted juices were strained using a sieve and then stored for further use.

Calcium Chloride (CaCl₂): 0.2% of CaCl₂ was prepared from the Calcium Chloride salts by dissolving 4.44g of CaCl₂ in 200 ml of distilled water. The prepared solution was stored for further use.

Vinegar with 4.5 % (W/V) acetic acid (pH of 2.6) was prepared with traditional preferences from the local market.

Sample formulation

Table 1 shows the blending ratio of cow milk and coconut milk used in the production of cheese and the coagulant used for each sample. Four (4) samples were formulated and designated as A (Lime) (50:50), B (Lemon) (50:50), C (Vinegar) and D (CaCl₂) (50:50).

Table 1: Blending Ratios of Cow Milk and Coconut Milk for Cheese Production and Coagulant Used

Sample	Coagulant	Cow Milk (%)	Coconut Milk (%)
A	Lime	50	50
B	Lemon	50	50
C	Vinegar	50	50
D	Calcium chloride	50	50

Production of cheese

Cheese was produced using the method described by Olorunisomo *et al.* (2016). One (1) litre of each milk (cow milk and coconut milk) was placed in four different stainless steel pots. The milk samples were individually heated and stirred on a magnetic stirrer until boiling point was reached. Every 5 min, 5 mL each of the coagulants (lime, lemon, vinegar and calcium chloride) was added every to the boiling milk. The milk was boiled until it formed curds. After boiling, the pots were taken off the heat, cooled in a water bath for 15 min, and then the curds were drained of whey through a muslin cloth. The curds (Cheese) were then packaged and stored in the refrigerator for further use.

Methods of Analysis

Determination of total titratable acidity (TTA)

Total titratable acidity was determined using the AOAC (2005) method.

$$TTA = \frac{N(NaOH) \times \text{titre value} \times \text{lactic acid value} \times \text{dilution factor} \times 100}{10}$$

Where N = Normality of NaOH (0.01)

Lactic acid value = 0.09

Dilution factor = 10

Determination of pH

pH was determined using a pH meter (Unicam 9450, Cambridge, UK).

Determination of percentage yield

Percentage yield of cheese was determined by the method described by Igyor *et al.* (2006). The yield of cheese from Cow milk and coconut milk was determined by the calculation as follows:

$$\text{Yield of Cheese (\%)} = \frac{W_2}{W_1} \times 100\%$$

W_1 = Weight of Cow milk and coconut milk blends.

W_2 = Weight of Cheese produced.

Determination of coagulation time

Coagulation time was determined using a stop watch and was measured as the time it took the milk samples to coagulate after the different coagulants had been added (Ezeama and Dobson, 2019).

Determination of proximate composition

The method described in AOAC (2005) was followed for the determination of moisture, ash, fiber, protein, fat and carbohydrate contents of the cheese.

Determination of caloric value

The caloric value was calculated using Atwater factor as described by Osborne and Voogt, (1978) using the following formula;

$$\text{Caloric value} = \text{crude protein} \times 4 + \text{crude fat} \times 9 + \text{carbohydrate} \times 4$$

Determination of mineral content

Calcium, potassium, magnesium and iron contents were determined using atomic absorption spectrophotometer as described by Fraga *et al.* (2004).

Microbiological analysis

The method of Ahemen *et al.* (2018) was employed in determining the total bacterial count and the total fungal count of the cheese samples.

Statistical analysis

Statistical analysis was carried out using Analysis of Variance (ANOVA). The means were separated with the use of Duncan New Multiple Range Test (DMRT) using the Statistical Package for the Social Sciences (SPSS) 23.0 software.

Results and Discussion

Physicochemical properties of cheese made from cow milk and coconut milk blends using lime, lemon, vinegar and calcium chloride as coagulants

The physicochemical properties of cheese made from cow milk and coconut milk blends using lime, lemon, vinegar and calcium chloride as coagulants is shown in Table 2. The results showed that the physicochemical properties of the cheese were significantly affected ($P < 0.05$) by the ratio of cow milk to coconut milk as well as the coagulants used.

The pH of the cheese samples ranged from 5.04 in sample A (Lime+50% Cow Milk+50% Coconut Milk) to 6.60 in sample D (CaCl_2 +50% Cow Milk+50% Coconut Milk). The increase in acidity could be attributed to the acidity levels of the different coagulants used. These results were similar to the findings of Ayodeji *et al.* (2020) who reported a pH value ranging from 4.16 – 6.90 for cheese produced from cow, soy and coconut milk blends with rennet, lime and lemon as coagulants and Elijah *et al.* (2020) who reported a pH value in the range of 6.40 – 6.69 for pH of cheese produced from goat and coconut milk. There was no significant difference ($P > 0.05$) in the pH values of sample A (Lime+50% Cow Milk+50% Coconut Milk) and sample B (Lemon +50% Cow Milk+50% Coconut Milk).

The TTA of the cheese samples ranged from 0.03% in sample D (CaCl_2 +50% Cow Milk+50% Coconut Milk) to 0.16% in sample A (Lime+50% Cow Milk+50% Coconut Milk). The TTA was lower in sample D (CaCl_2 +50% Cow Milk+50% Coconut Milk) than in the rest of the samples. This could be because calcium chloride is a salt and presumably due to the absence or low amount of lactic acid bacteria in the sample. Total titratable acidity represented the level of lactic acid present in the cheese. This result was relatively lower than those of Balogun *et al.* (2016) who reported TTA levels of 0.20 – 0.29% for cheese produced from cow and

coconut milk blends. Dari and Appiah (2023) reported lower TTA values (0.0072 – 0.0096%) for cheese produced from cow milk with rennet, lime and sodom apple as coagulants.

Percentage yield and coagulation time of cheese made from cow milk and coconut milk blends using lime, lemon, vinegar and calcium chloride as coagulants

The percentage yield and coagulation time of cheese made from cow milk and coconut milk blends using lime, lemon, vinegar and calcium chloride as coagulants is shown in Table 2.

The percentage yield of the cheese samples ranged from 19.53% in sample A (Lime+50% Cow Milk+50% Coconut Milk) to 25.09% in sample D (CaCl₂+50% Cow Milk+50% Coconut Milk) while the coagulation time of the cheese samples ranged from 110.00 sec in sample A (Lime+50% Cow Milk+50% Coconut Milk) to 211.50 sec in sample D (CaCl₂+50% Cow Milk+50% Coconut Milk). The difference in coagulant type significantly affected coagulation time and percentage yield of the cheese samples. This might be due to differences in the pH of the coagulants used. Lime which has the lowest pH (2.15), coagulates milk faster when compared with lemon, vinegar and calcium chloride (CaCl₂) with pH of 2.25, 2.53 and 6.33 respectively. This may have also affected the cheese yield since it had been reported by Johnson and Steele (2013) that a coagulant with a longer coagulation time results in a higher moisture content of cheese, ultimately leading to a greater cheese yield. Calcium chloride which took a longer period for coagulation was observed to have the highest percentage of cheese yield. Differences in milk source had a significant effect on the coagulation time and the cheese yield.

Variations in milk composition, particularly pH, protein and fat contents, may have been responsible for this, as these factors significantly influence both coagulation time and cheese yield (Ayodeji *et al.*, 2020). For cheese manufacturers, cheese yield has significant economic implications, as even slight variations in yield can result in substantial differences in profitability (El-Gawad and Ahmed, 2011). Ayodeji *et al.* (2020) reported a similar range of values (12.40 – 28.70%) for percentage yield but had lower coagulation time (27 – 147 sec) for cheese produced from cow, soy and coconut milk blends with rennet, lime and lemon as coagulant.

Table 2: Physicochemical Properties, Percentage Yield and Coagulation Time of Cheese made from Cow Milk and Coconut Milk Blends using Lime, Lemon, Vinegar and Calcium Chloride as Coagulants

Parameter	Sample A	Sample B	Sample C	Sample D
pH	5.04 ^c ± 0.01	5.15 ^c ± 0.03	5.66 ^b ± 0.02	6.60 ^a ± 0.04
TTA (%)	0.16 ^a ± 0.02	0.13 ^a ± 0.02	0.07 ^a ± 0.01	0.03 ^a ± 0.03
Percentage Yield (%)	19.53 ^d ± 0.02	20.59 ^c ± 0.04	23.59 ^b ± 0.01	25.09 ^a ± 0.01
Coagulation Time (sec)	110.00 ^d ± 1.41	140.00 ^c ± 2.83	188.50 ^b ± 4.95	211.50 ^a ± 6.36

Values are means $\pm$ SD (standard deviation) of duplicate determinations. Means on the same row with different superscripts are significantly different at $P < 0.05$.

KEY:

Sample A = Lime-(50% Cow Milk, 50% Coconut Milk)

Sample B = Lemon-(50% Cow Milk, 50% Coconut Milk)

Sample C = Vinegar-(50% Cow Milk, 50% Coconut Milk)

Sample D = CaCl_2 -(50% Cow Milk, 50% Coconut Milk)

Proximate composition and energy value of cheese made from cow milk and coconut milk blends using lime, lemon, vinegar and calcium chloride as coagulants

The proximate composition and energy value of cheese made from cow milk and coconut milk blends using lime, lemon, vinegar and calcium chloride as coagulants is shown in Table 3. The results showed that the proximate composition of cheese was significantly affected ($P < 0.05$) by the milk blends as well as the coagulants used. The moisture content of the cheese samples significantly increased ($P < 0.05$) from 47.61 – 57.22% with sample D (CaCl_2 +50% Cow Milk+50% Coconut Milk) having the highest value and sample A (Lime+50% Cow Milk+50% Coconut Milk) the lowest. The variations observed in the moisture content of the cheese samples may be attributed to the coagulating strength of the selected coagulants used in the current study. A higher level of moisture in cheese can create an environment where microorganisms can thrive; ultimately leading to a shorter shelf-life (Orhevba and Taiwo, 2016). Ayodeji *et al.* (2020) reported similar results (42.64 – 62.44%) for the moisture content of cheese produced from cow, soy and coconut milk blends with rennet, lime and lemon as coagulants.

The protein content of the cheese samples significantly increased ($P < 0.05$) from 15.03 – 17.20% with sample D (CaCl_2 +50% Cow Milk+50% Coconut Milk) having the highest value and sample A (Lime+50% Cow Milk+50% Coconut Milk) the lowest. Similar values were reported by Balogun *et al.* (2015) (13.75 – 15.33%) for cheese produced from cow and coconut milk while higher protein values (18.61 – 26.30%) were reported by Adeniyi *et al.* (2020) for soft cheese from cow milk with sodom apple, lime and calcium chloride as coagulants. The differences in protein content among the samples may be due to the incorporation of plant-based protein sources in the cheese, which can help address protein deficiencies commonly found in impoverished countries (Udoh, 2017).

The highest fat content (10.70%) was seen in sample A (Lime+50% Cow Milk+50% Coconut Milk), while the lowest fat content (9.01%) was obtained in sample D (CaCl_2 + 50% Cow Milk + 50% Coconut Milk). Higher fat content (30.15 – 40.41%) was reported in the findings of Adeniyi *et al.* (2020) for soft cheese from cow milk with sodom apple, lime and calcium chloride as coagulants. Ayodeji *et al.* (2020) reported a fat content of 5.12 – 11.97% for cheese produced from cow, soy and coconut milk blends with rennet, lime and lemon as coagulants. In addition to boosting energy density, fat in food also serves as a carrier for fat-soluble vitamins (Udoh *et al.*, 2024).

The ash content of the cheese samples ranged from 1.17 – 1.49%. The highest ash content was obtained in sample D (CaCl_2 + 50% Cow Milk + 50% Coconut Milk) while the lowest ash

content was obtained in sample A (Lime+50% Cow Milk+50% Coconut Milk). Ash is an indication of mineral content in food materials (Ogbonna *et al.*, 2024); therefore, sample D is expected to possess the highest amount of minerals. Balogun *et al.* (2016) reported lower ash content (0.32 – 1.02%) for cheese produced from cow and coconut milk blends while Ayodeji *et al.* (2020) reported higher ash content (1.56 – 2.32%) for cheese produced from cow, soy and coconut milk blends with rennet, lime and lemon as coagulant.

The crude fibre content ranged from 1.06 – 1.36%. Sample A (Lime+50% Cow Milk+50% Coconut Milk) had the highest value while sample D (CaCl₂ + 50% Cow Milk + 50% Coconut Milk) had the least. Similar values (0.87 – 1.32%) were reported for cheese produced from cow, soy and coconut milk blends with rennet, lime and lemon as coagulants (Ayodeji *et al.*, 2020).

The carbohydrate content ranged from 14.02 – 24.13%. Sample A (Lime+50% Cow Milk+50% Coconut Milk) had the highest value while sample D (CaCl₂ + 50% Cow Milk + 50% Coconut Milk) had the least. The carbohydrate content of the samples depended on other parameters as it was calculated by subtracting known components from the total. Similar carbohydrate values (12.72 – 17.10%) were observed in the findings by Ibrahim *et al.* (2018) for cheese from soy milk. Lower values (2.82 – 9.60%) and (5.29 – 21.79%) were reported by Balogun *et al.* (2016) and Adeniyi *et al.* (2020) for cheese produced from cow and coconut milk, and cow milk with sodom apple, lime and calcium chloride as coagulants respectively. The caloric (energy) value of the samples ranged from 205.97 – 253.02 Kcal/100g. Sample A (Lime+50% Cow Milk+50% Coconut Milk) had the highest value while sample D (CaCl₂ + 50% Cow Milk + 50% Coconut Milk) had the least. The protein, fat and carbohydrate constituents contributed to the calculated caloric value of the samples with fat as the major contributor.

Table 3: Proximate Composition and Energy Value of Cheese made from Cow Milk and Coconut Milk Blends Using Lime, Lemon, Vinegar and Calcium Chloride as Coagulant

Parameter	Sample A	Sample B	Sample C	Sample D
Moisture (%)	47.61 ^d ± 0.01	50.01 ^c ± 0.01	54.62 ^b ± 0.00	57.22 ^a ± 0.01
Protein (%)	15.03 ^d ± 0.01	15.62 ^c ± 0.00	17.02 ^b ± 0.02	17.20 ^a ± 0.01
Ash (%)	1.17 ^d ± 0.00	1.28 ^c ± 0.01	1.37 ^b ± 0.00	1.49 ^a ± 0.01
Fibre (%)	1.36 ^a ± 0.01	1.23 ^b ± 0.00	1.18 ^c ± 0.01	1.06 ^d ± 0.01
Fat (%)	10.70 ^a ± 0.00	10.67 ^a ± 0.00	9.81 ^b ± 0.01	9.01 ^c ± 0.01
Carbohydrate (%)	24.13 ^a ± 0.00	21.19 ^b ± 0.01	16.00 ^c ± 0.06	14.02 ^d ± 0.01
Caloric value (Kcal/100g)	253.02 ^a ± 0.06	243.27 ^b ± 0.06	220.37 ^c ± 0.04	205.97 ^d ± 0.03

Values are means ± SD (standard deviation) of duplicate determinations. Means on the same row with different superscripts are significantly different at P<0.05.

KEY:

Sample A = Lime-(50% Cow Milk, 50% Coconut Milk)

Sample B = Lemon-(50% Cow Milk, 50% Coconut Milk)

Sample C = Vinegar-(50% Cow Milk, 50% Coconut Milk)

Sample D = CaCl_2 -(50% Cow Milk, 50% Coconut Milk)

Mineral content of cheese made from cow milk and coconut milk blends using lime, lemon, vinegar and calcium chloride as coagulants

Table 4 shows the mineral content of cheese made from cow milk and coconut milk blends using lime, lemon, vinegar and calcium chloride as coagulants.

The values for calcium content ranged from 11.68 – 19.21 mg/100g. The calcium was higher in sample D (CaCl_2 + 50% Cow Milk + 50% Coconut Milk) than in the rest of the samples. This could be due to the high calcium content of cow milk as well as the coagulant used (calcium chloride) for the coagulation process. Adeniyi *et al.* (2020) reported values ranging from 22.74 – 31.90 mg/L for soft cheese from cow milk with sodom apple, lime and calcium chloride as coagulants. Calcium plays a crucial role in the growth and development of bones and teeth, as well as the production of blood and various bodily fluids, both inside and outside of cells (Mahan and Escott-Stump, 2004).

The magnesium content ranged from 4.63 – 14.01 mg/100g. Magnesium serves as a catalyst for numerous enzyme functions and helps regulate the electrical impulses in nerve cells (Odimegwu *et al.*, 2019). Magnesium collaborates with calcium to facilitate muscle movement blood clotting, blood pressure control and proper lung functioning (Odimegwu *et al.*, 2019). Similar values (2.00 – 8.10 mg/100g) were reported by Elijah *et al.* (2020) for cheese produced from goat and coconut milk. The magnesium content was higher than the USRDA requirement (2–5 mg/100 g).

The potassium content ranged from 8.01 – 17.91 mg/100g. The values were lower than the values (25.95 – 50.94 mg/L) reported by Adeniyi *et al.* (2020) for soft cheese from cow milk with sodom apple, lime and calcium chloride as coagulants. An increased potassium level could be an added advantage to the product since it is crucial for regulating the balance of fluids and maintaining the body's delicate acid-base equilibrium (Chima *et al.*, 2019).

The iron content ranged from 6.36 – 13.21 mg/100g. Iron is an important part of the hemoglobin in red blood cells (Oyegoke *et al.*, 2020). The results were higher than values of 3.23 – 3.63 mg/100g reported by Babarinde *et al.* (2014) for cheese from cow-soy milk blends with sodom apple, alum and fermented maize liquor as coagulants. The iron values in this study were lower than the US RDA (10–15 mg/100 g) requirement. Symptoms of iron deficiency include fatigue, weakness, and shortness of breath (Odimegwu *et al.*, 2019).

Table 4: Mineral Content of Cheese made from Cow Milk and Coconut Milk Blends Using Lime, Lemon, Vinegar and Calcium Chloride as Coagulants (mg/100g)

Parameter	Sample A	Sample B	Sample C	Sample D
C a l c i u m	11.68 ^d ± 0.00	13.25 ^c ± 0.02	16.73 ^b ± 0.01	19.21 ^a ± 0.00
P o t a s s i u m	8.01 ^d ± 0.01	11.61 ^c ± 0.01	14.22 ^b ± 0.00	17.91 ^a ± 0.01
M a g n e s i u m	4.63 ^d ± 0.01	8.82 ^c ± 0.00	10.67 ^b ± 0.00	14.01 ^a ± 0.00
I r o n	6.36 ^d ± 0.01	9.60 ^c ± 0.00	11.71 ^b ± 0.02	13.21 ^a ± 0.01

Values are means ± SD (standard deviation) of duplicate determinations. Means on the same row with different superscripts are significantly different at $P < 0.05$.

KEY:

Sample A = Lime-(50% Cow Milk, 50% Coconut Milk)

Sample B = Lemon-(50% Cow Milk, 50% Coconut Milk)

Sample C = Vinegar-(50% Cow Milk, 50% Coconut Milk)

Sample D = CaCl_2 -(50% Cow Milk, 50% Coconut Milk)

Microbial quality of cheese made from cow milk and coconut milk blends using lime, lemon, vinegar and calcium chloride as coagulants

The microbial quality of cheese made from cow milk and coconut milk blends using lime, lemon, vinegar and calcium chloride as coagulants is shown in Table 5. The result showed that the total heterotrophic bacterial count (THBC) was higher in sample D (CaCl_2 +50% Cow Milk+50% Coconut Milk) than in all the other samples. The THBC ranged from 1.50×10^3 cfu/g to 2.50×10^3 cfu/g. The total fungal count ranged from 3.10×10^2 cfu/g to 7.10×10^2 cfu/g. TFC was higher in sample D (CaCl_2 +50% Cow Milk+50% Coconut Milk) than in all other samples. This showed that sample D (CaCl_2 +50% Cow Milk+50% Coconut Milk) would be the least shelf-stable of all the samples. The microbial load may be due to factors such as the moisture content of the milk samples in the blend, the nutrient composition of the cheese samples, environmental factors, storage conditions, the differences in the pH and titratable acidity of the cheese products and milking process, milk collection and cheese making process as stated by Oladipo and Jadesimi (2012). Ayodeji *et al.* (2020) reported a total bacterial count of $2.50 \times 10^2 - 3.10 \times 10^3$ cfu/g and a fungal count of $3.10 \times 10^2 - 7.10 \times 10^2$ cfu/g for cheese from cow, soy and coconut milk blends with rennet, lime and lemon as coagulants. The study however, revealed that all samples were microbiologically safe for human consumption since the microbial loads did not exceed the acceptable limits of $>10^5$ recommended by the International Commission of Microbiology Specifications of Foods (Korshima *et al.*, 2019).

Table 5: Microbial Quality of Cheese made from Cow Milk and Coconut Milk Blends Using Lime, Lemon, Vinegar and Calcium Chloride as Coagulants (cfu/g)

Parameter	Sample A	Sample B	Sample C	Sample D
THBC	1.50×10^3	1.70×10^3	1.60×10^3	2.50×10^3
TFC	5.10×10^2	3.10×10^2	6.10×10^2	7.10×10^2

Values are means $\pm$ SD (standard deviation) of duplicate determinations. Means on the same row with different superscripts are significantly different at $P < 0.05$.

KEY:

Sample A = Lime-(50% Cow Milk, 50% Coconut Milk)

Sample B = Lemon-(50% Cow Milk, 50% Coconut Milk)

Sample C = Vinegar-(50% Cow Milk, 50% Coconut Milk)

Sample D = CaCl_2 -(50% Cow Milk, 50% Coconut Milk)

THBC = Total heterotrophic bacterial count

TFC = Total fungal count

Conclusion

The result of the study has shown that the production of cheese from cow and coconut milk blends using lime, lemon, vinegar and calcium chloride had varying effect on their physicochemical, nutritional and microbiological qualities. It also shows the potential of lime, lemon, vinegar and calcium chloride to be used as replacements for rennet in cheese production. All the cheese samples were microbiologically safe for human consumption. The use of coconut milk as a substitute for cow milk as well as the use of local materials as coagulants will go a long way to reducing dependency on cow milk and rennet and improve the utilisation of these crops and materials as well as their economic value.

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