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Potentials of Coconut Milk as a Substitute for Cow Milk in Cheese Making

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Authors' contributions

This work was carried out in collaboration between both authors. Author PCO designed the study, performed the statistical analysis and wrote the first draft of the manuscript. Author EGO conducted the analyses of the study and managed the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

Aim: The project aimed at producing cheese products by partial substitution of cow milk with coconut milk and evaluating the nutrient content and sensory properties of the products.
Experimental Design: The experimental design was a randomized complete block (RCBD).
Methodology: This experiment was conducted at the University of Uyo, Nigeria. Coconut milk was extracted with water (1:1 ratio) and mixed with fresh raw cow milk at varying proportions (10:90; 20:80; 30:70). The control was 100% cow milk. They were used to produce cheese. The control and the partially substituted cheeses were stored in a refrigerator and examined for sensory quality, microbial quality and nutrient composition.
Results: The yield of cheese showed significant ($p < 0.05$) decrease from 27.20% (control sample) to 15.30% in the cheese product containing 30% coconut milk. No coliforms were found in the fermented products suggesting that they were safe for consumption. The protein content of the cow-coconut cheese blends increased ($p < 0.05$) from 15.82% to17.14% (at 10%-30% substitution of coconut milk), while the control sample had 15.11%. There was also an increase in fat content from

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12.06 - 13.87% (10% - 30% substitution of coconut milk), with the control sample having 11.65%. There was a decrease in the carbohydrate content of the cheese blends which ranged between 12.44% -0.54%, with the control sample having 16.64%. There was a significant decrease ($p<0.05$) in the ash content of the cow-coconut cheese blends, with the control sample having 1.80% ash. There was no significant difference observed in the colour, taste, texture, and overall acceptability as influenced by addition of coconut milk. The blend with 10% coconut milk and 90% cow milk was most acceptable by panelists in terms of aroma. Acceptable cheeses with improved nutritional value and consumer acceptability could be made from 1:9 ratio of coconut milk and cow milk.

Keywords: Local cheese-Warankasi; coconut milk; substitution; quality characteristics.

1. INTRODUCTION

Traditionally fermented milk products in Nigeria include Kindirmo, Nono and Warankasi [1,2,3,4]. Warankasi popularly referred to as "Wara" is an un-ripened West African soft cheese produced using plant products as the source of coagulants. [5]. In many parts of tropical Africa, milk and milk products are scarce and unaffordable by the majority of the populace [6]. The high and unaffordable cost of milk in some developing countries like Nigeria 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. Coconut is much cheaper than cow milk and using it for substitution will reduce the cost of the cheese product. Coconut milk is a sweet rich tasting, nutrient dense white fluid derived from the meat of the coconut fruit. It is rich in oil, protein and sugars [7]. It is cheaper than cow milk and has the potentials to act as a cow milk complement in traditionally fermented milk products. Chymosin is a natural enzyme that has been used extensively in the clotting of milk for cheese making [8]. This natural enzyme is relatively expensive Acids, such as acetic acid, citric acid and vinegar and lemon juice are also capable of precipitating the casein in milk [8] and they are cheaper. Juice extracts from plant products which contain proteases are also used to coagulate milk and add special flavours to the formed cheeses [9]. Of the several plant extracts used for milk coagulation, *Calotropis procera* (Apocynaceae) is the coagulant of choice [10].

However, the use of these plant extracts has been observed to increase the microbial load of wara [11]. Substitution of cow milk with coconut milk will diversify cheese products when successfully coagulated and fermented. The present research investigated the effect of substitution of coconut milk on the quality of this traditionally fermented milk product.

2. MATERIALS AND METHODS

2.1 Sample Collection and Preparation

Cow milk was bought from Nasarawa market at Calabar- Itu highway in Uyo. The fresh milk was aseptically collected into 5 litter transparent bottles and stored in a refrigerator. The coconut used was bought from Akpanandem market in Uyo. The coagulum (*Calitropis procera*) was sourced from a village in Ogbomoso L.G.A in Oyo state.

2.2 Production of Coconut Milk

Coconut was unshelled and the meat washed and grated using a traditional coconut grater, the shredded pulp was mixed with an equal weight of warm distilled water (60℃) in a blender, filtered through a double layer cheese cloth, and manually squeezed with a twisting motion to extract most of the milk.

2.3 Milk Formulation

The portion of the fresh cow milk and coconut milk was measured according to the needed ratio, 100% cow milk, 90:10, 80:20, and 70:30 cow milk and coconut milk respectively. The 100% cow milk Warankasi was produced from 500 ml of fresh cow milk and used as the control sample.

2.4 Production of Warankasi

The method of Ashaye et al. [12] was adopted with some modifications to produce "wara" cheese.

Fresh Sodom apple leaves and stems were washed and crushed in a mortar with a pestle. Five hundred (500) ml of fresh milk was added to 50 g of the crushed Sodom apple. The mixture was allowed for 20 minutes after which the milk

was filtered. Six hundred (600) ml of the blended milk at different ratios was heated to a temperature of 55℃. At this temperature, 50ml of the stock was added. The milk was stirred and the temperature gradually raised to 85℃, five minutes after stirring, after a clear separation of the whey and visible curd formation, stirring was repeated to break the curd into pieces. The temperature was raised to 95℃ and maintained for seven minutes with stirring. The pieces of curd was collected into cheese cloth, tightened and hung to allow the whey to drain by gravity for an hour. After an hour of hanging, the mass of the curd was comminuted into pieces and 0.03 g of salt added; the salt was mixed well with the comminuted curds. The pieces of curd was repacked into the cheese cloth, then squeezed and pressed with 5 kg weight for 30 minutes for further removal of whey. The curd was finally removed from the cheese cloth and stored for further analyses.

2.5 Analyses of Warankasi

2.5.1 Determination of percentage yield

The yield was determined by a method described by Igyor et al. [13]. The yield of Warankasi from the cow milk-coconut milk blends/mix and the whole cow milk was determined by the calculation given as follows:

$$\text{Yield of Warankasi (\%)} = \frac{X_2 \times 100}{X_1}$$

Where

X_1 = volume (ml) of cow milk-coconut milk or whole cow milk used.
X_2 = weight (g) of Warankasi (either from blends or whole cow milk) produced.

2.6 Proximate Analysis of Warankasi

2.6.1 Determination of moisture content

Method described by AOAC (2000) was used in the determination.

Procedure: Crucibles were washed and dried to a constant weight in an air oven at 100℃. They were later removed and cooled in a desiccator and weighed (w_1). Two (2 g) of the sample was placed in it and weighed (w_2). The crucible containing the sample was kept in oven at 100℃ for 3 hours to ensure a constant weight (w_3) and the moisture content was calculated as;

$$\% \text{ moisture} = \frac{(w_2 - w_1)}{(w_2 - w_1)} \times 100$$

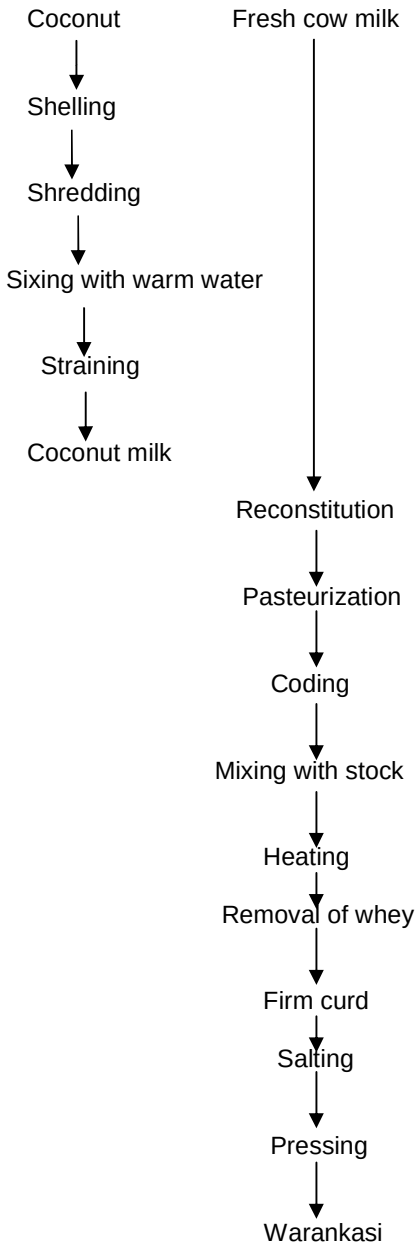

Fig. 1. Production of cow-coconut milk Warankasi

2.6.2 Determination of ash content

The method by AOAC (2000) was used. A clean crucible was dried in an oven, cooled and weighed (w_1). Exactly 0.5 g of the sample was placed in the crucible and the crucible was reweighed (w_2). It was then transferred into a furnace, which was set at 550℃ and left for 8 hours to ensure proper ashing. The crucible containing the ash was then removed, cooled

and weighed (w_3). Ash content was calculated as follows;

$$\% \text{ ash} = \frac{w_3 - w_1 \times 100}{w_2 - w_1}$$

2.6.3 Determination of lipid content

The lipid content was determined as in the method of AOAC [14]. Two round bottom flasks were washed and few anti-bump granules were added to prevent bumping. Petroleum ether of (40-60℃) boiling point and volume (300 ml) were poured into the flask. These were fitted into the soxhlet extraction units. Extractor thimbles were weighed and 2 g of sample were added. The thimbles were fixed into the soxhlet extraction unit and the cold water circulation was also put on. The heating mantle was switched on and solvent refluxing was adjusted at a steady rate. Extraction was carried out for 8 hours. The thimble was removed and dried to constant weight in an oven at 70℃ and was weighted (w_2). The extractible lipid content of the sample was determined as follows;

$$\% \text{ lipid} = \frac{\text{Weight of lipid extracted x 100}}{\text{Weight of dried sample}}$$

2.6.4 Determination of crude protein content [15]

Exactly 0.2 g of the samples was weighed using an electronic balance (JA 2003; made in China) into 100 ml Kjedahl rack and few anti-bump granules was added. One gram of catalyst (K_2SO_4 and $CuSO_4$) was added to speed up the reaction. The flask was placed on a Kjedahl rack and heated until a clear solution was obtained. At the end of digestion, the flask was quantitatively transferred to a 100 ml volumetric flask and made up to the mark with distilled water. After cooling, 10 ml of the digest was pipetted into Markham semi-micro nitrogen still and 40% sodium Hydroxide solution was added. The sample was steam distilled liberating ammonia into a 100 ml conical flask containing 10 ml of 40% Boric acid and 2 drops of methyl red indicator. Distillation was continued until the pink colour of the indicator turned greenish. The control was titrated with 4% boric acid with end point indicated by a change from greenish to pink colour. The volume of the acid for each sample distillate was noted as well as that of blank. The percentage (%) total nitrogen (N) per sample was calculated as;

$$\% \text{ crude protein} = \frac{V_1 - V_o \times M \times 14 \times 100 \times 10}{0.2 \times 1000 \times 10 \times 1}$$

V_o = Vol. of HCl required for blank
V_1 = Vol. of the HCl required for 10ml sample solution
M = Molarity of acid (0.1M)
14 = Atomic weight of N_2
100 = Total volume of digest
100 = % conversion
0.2 = Amount of sample taken in gram
1000 = Total convert to liter

The crude protein was calculated as % crude protein (P) = 6.25 × N.

Note: protein contains 16% N. This makes the general conversion factor (for casein) to be 6.25.

2.6.5 Determination of crude fibre

The method described by AOAC [14] was used. Two grams of the cheese (C_1) was put into a round bottom flask, 100 ml 0f 0.25M H_2SO_4 was added and the mixture boiled for 30 minutes. The hot solution was quickly filtered. The insoluble residue was washed with hot water until it was base free and was dried to constant weight in an oven at 100℃ cooled in a desiccator and weighed (C_2). The weighed sample was incinerated in a furnace at 550℃ for 4 hours, cooled and reweighed (C_3). The crude fiber was calculated as the loss in weight on ashing.

$$\% \text{ crude fiber} = \frac{C_2 - C_3 \text{ x } 100}{C_1}$$

2.6.6 Determination of carbohydrate

This was determined by difference.

% carbohydrate = 100 – (% protein + % ash + % lipid + % crude fiber)

2.7 Microbiological Analysis of Warankasi

The Standard method of Harrigan and McCance [16] was employed. Exactly 1 g of the cheese sample was aseptically weighed using a weighing balance and carefully introduced into 9 ml of sterile distilled water. This was shaken manually in order to have a homogeneous suspension. 1 ml of this was taken and introduced into the second tube, followed with series of dilutions up to 10^{-10} dilution. One ml was taken from 10^{10} dilution and introduced into

sterile plates and molten agar (50℃) added by pour plate method using the following agar and incubation periods:

Nutrient Agar was used for the determination of total viable bacteria in the sample. The plates were incubated at 37℃ for 48 hours.

MacConkey Agar was used for the enumeration of total coliform organisms in the sample. The plates were incubated at 35℃ for 48 hours.

Sabouraud dextrose Agar was used for the enumeration of mould and yeast in the sample. The plates were incubated at 30℃ for 24 hours for yeasts and 3 days and examined for mould growth.

Calculation:

$$\frac{DF \times N}{W}$$

Where

DF = dilution factor
N = number of colony
W = weight of sample used

2.8 Physico-chemical Analyses

2.8.1 Total titratable acidity

It was determined using the AOAC [14] method. Ten grams of the sample was dissolved in 30 ml of distilled water in a beaker and stirred. The mixture was then filtered into a 100 ml standard volumetric flask. The filtrate was made up to 100 ml. Ten (10) ml of the filtrate was pipetted into a beaker and 1 drop of phenolphthalein was added. The mixture was then titrated against the standard 0.01 N sodium hydroxide solution until a light pink colour was attained. The reading of the burette was recorded. This was done in triplicate and calculated as shown:

Calculation:

N (NaOH) × titre value × lactic acid value × dilution factor × 100/10

Where

N = normality of NaOH (0.01)
Lactic acid value = 0.09
Dilution factor = 10

2.8.2 pH determination

About 1 g of the cheese sample was dissolved in 10 ml of distilled water in a beaker and stirred. The pH was determined using the pH meter (Unicam 9450 Model). The pH meter was standardized using standard buffer of pH 4.0 and 7.0.

2.8.3 Determination of vitamin A content

One (1) g of each of the cheese samples was poured into a beaker with 10ml of chloroform solution added to extract the vitamin A using pasture pipette the chloroform layer was taken in another test tube. This was tested with Antimony Trichloride reagent to develop a blue colour. The spectrophotometer was adjusted to read absorbance at 620nm against chloroform/$SbCl_3$.

The result is calculated as;

$$\frac{\text{Abs of test} \times \text{Conc. of Std} \times \text{D.F.}}{\text{Abs of Std} \times \text{Volume of Sample}} = \text{mg/1 of Vit. A}$$

2.8.4 Mineral analysis of samples

The analysis of minerals was done according to the AOAC [14] procedures. The quantitative determination of minerals (Ca, Fe, Na, and K) were done using the single beam atomic absorption spectrometer (AAS), and the data was obtained in parts per million (ppm), (1 ppm = 1 mg/100 g). Working standards was used to establish calibration curve for each of the element to be determined.

Two (2.0) g of the samples were accurately weighed into a clean dry crucible. This was then transferred to a hot plate in a fume cupboard and charred to burn off all the organic material until no more smoke was given off. It was then transferred using a pair of tongs into the muffle furnace at a temperature of 500℃ unit it was fully ashed for 8 hour. The sample (ash) was leached with 5ml of 6 M HCl into a 100 ml volumetric flask and the volume was made up to 20 cm^3 with distilled water. Also, the blank determination was also carried out in a similar manner. The solution was then filtered, through a Whatman No. 1 filter paper and transferred into the AAS auto sampler vial for analysis of Calcium (Ca), Iron (Fe) Sodium (Na) and Potassium (K).

2.8.5 Total solid

Two (2) g of grated cheese was oven dried at a constant temperature of 100℃ for 3 hours to a

constant weight. The weight of the sample after drying was expressed as % weight.

2.9 Sensory Evaluation

Sensory evaluation was conducted using a semi-trained panel consisting of 20 members that are familiar with Warankasi. The panelists was instructed to evaluate the coded samples for appearance, taste, texture, aroma, flavor, consistency and overall acceptability. Each sensory attribute was rated on a 9- point hedonic scale (9 = like extremely and 1 = dislike extremely) (Ihekoronye and Ngoddy, 1985).

2.10 Statistical Analysis

SPSS 20.0 was used to statistically analyze the data obtained from triplicate determinations. Significant differences among the sample means were detected using the Duncan's Multiple range test.

3. RESULTS AND DISCUSSION

3.1 Proximate Composition of Cheese Products

Table 1 shows the proximate composition of the cheese samples.

The sample containing 30% coconut milk had the highest fat content which was significantly different ($p<0.05$) from fat content of others. The fat contents differed significantly with increased substitution of coconut milk (see values in Table 1). Protein content also increased ($p<0.05$) with increase in the level of substitution of coconut milk. Substitution with coconut milk led to 13% increase in protein content (at 30% substitution level). Ash content deceased with an increase in the level of substitution of coconut milk. There were no significant differences in ($p<0.05$) in the ash content of samples substituted with 20% and 30% coconut milk. Fibre content of 100% cow milk was significantly lower than that of samples substituted with coconut milk but there were no significant differences ($p>0.05$) in the fibre contents of samples containing coconut milk. Moisture increased with increased substitution of coconut milk and carbohydrate content decreased with increased level of inclusion of coconut milk.

The proximate composition of cow milk was improved by the addition of coconut milk. Fat, protein and fibre and moisture increased in direct proportion with the increase in the quantity of coconut milk. However, ash and carbohydrate contents decreased as more coconut milk was added to cow milk. Coconut meat has relatively low amounts of ash and carbohydrates. This explains why the inclusion of coconut milk to cow milk reduced the two nutrients. Adegoke [6] had reported values of 61.7% moisture, 13.3% protein; 15.6% fat and 1.5% ash for "Wara". Sanni et al. [17] observed 12.46% protein; 15.85 fat and 1.68% ash for "Wara" samples from Southwest Nigeria. These values are slightly lower than the values obtained for "Wara" products from the present research.

Vitamin A content of the cheese sample increased with the addition of coconut milk (see Table 3). NDC [18] documented the vitamin A content of a soft cheddar cheese produced from cow milk as 68–71mcg. Increase in vitamin A content in this product could be attributed to the increase in inclusion levels of coconut milk.

Also, this result shows that a vegetable source of protein (such as coconut milk) should be encouraged, as its consumption would help eliminate protein deficiencies and it is also a cheaper source when compared to 100% whole milk cheese [19].

Table 1. Proximate composition

Samples	Fat	Protein	Ash	Fibre	Moisture	Carbohydrate
A	11.65^{d}±0.05	15.11^{d}±0.01	1.80^{a}±0.05	0.05^{b}±0.01	54.75^{d}±0.05	16.64^{a}±0.04
B	12.06^{c}±0.04	15.82^{c}±0.02	1.70^{b}±0.05	0.08^{a}±0.02	57.90^{c}±0.02	12.44^{b}±0.02
C	13.03^{b}±0.03	16.58^{b} ±0.02	1.65^{b}±0.02	0.09^{a}±0.01	61.00^{b}±0.05	7.65^{c}±0.01
D	13.87^{a}±0.03	17.14^{a}±0.02	1.45^{c}±0.01	0.10^{a} ±0.02	66.90^{a}±0.05	0.54^{d}±0.04

**Values are means ± SD of triplicate determinations. Means in the same column with different superscript are significantly different at P< 0.05: A = 100% cow milk (control): B = 90% cow milk and 10% coconut milk = 80% cow milk and 20% coconut milk: D = 70% cow milk and 30% coconut milk*

3.2 Mineral Content of Cheese Products

Table 2 shows the mineral content of samples. The iron (4.87% in 100% cow milk to 11.51% in 30% coconut milk substitution), calcium, (9.43-17.71%) sodium (2.96-3.33%) and potassium (6.37 -15.46) contents of milk samples increased with an increase in the level of substitution of coconut milk.

3.3 Physico - Chemical Properties of Cheese Products

Table 3 shows the physico chemical properties of cheese samples. Titratable acidity pH (6.65-6.76), and vitamin A content increased with an increase in the level of substitution coconut milk. Total solids and percentage yield decreased with an increase in the level of substitution of coconut milk.

Total titratable acidity of the milk increased with the addition of coconut milk. pH also increased in the same manner. There were no significant differences in the pH of samples containing coconut milk, but their pH values were significantly higher than that of the sample containing only cow milk. The yield of cheese was observed to reduce with the inclusion of coconut milk. Igyor et al. (2006) reported a decline in the yield of cheese as soymilk inclusion increased in cheese (30.50% -15.50% for 100% cow cheese and cheese with 75% soymilk supplementation). However, Fashakin and Unokiwedi [20] reported that the percentage yield remained relatively constant with levels of soy substitution. This suggests that available enzymes for the curdling process may remarkably influence the yield of cheese.

3.4 Microbial Load of Cheese Products

Table 4 shows the microbial load of the produced cheeses.

The total plate count for microorganisms from the cheese sample was low (0.5 -3.5 x 10^1). No coliforms, yeasts and moulds were identified. Fresh samples were not grossly contaminated. The results indicated that the fermented soft cheeses were wholesome.

3.5 Organoleptic Properties of Cheese Products

Table 5 shows the sensory properties of the produced cheeses. There were no significant differences in the appearance, taste consistency and general acceptability of all the samples (whether substituted with coconut milk or not). The aroma of cheese made from 80 cow milk and 20% coconut milk was less preferred to that of other samples except sample B which contained 90% cow milk and 10% coconut milk.

Table 2. Mineral content of samples

Sample	Fe	Ca	Na	K
A	4.87^{d}±0.03	9.43^{d}±0.03	2.96^{d}±0.04	6.37^{d}±0.03
B	7.70^{c}±0.05	11.20^{c}±0.03	6.60^{c}±0.03	9.50^{c}±0.05
C	9.90^{b}±0.02	14.63^{b}±0.03	8.35^{b}±0.02	12.27^{b}±0.03
D	11.51^{a}±0.01	17.71^{a}±0.01	12.33^{a}±0.03	15.46^{a}±0.04

***Values are means ± SD of triplicate determination. Means in the same column with different superscript are significantly different at P< 0.05: A = 100% cow milk (control): B = 90% cow milk and 10% coconut milk; C = 80% cow milk and 20% coconut milk: D = 70% cow milk and 30% coconut milk*

Table 3. Physico-chemical properties and vitamin A content of samples

Sample	TTA	TS	pH	% Yield	Vitamin A (mcg)
A	0.25^{c}±0.05	45.25^{a}±0.05	6.65^{b}±0.05	27.20^{a}±0.10	68.00^{b}±2.00
B	0.28^{bc}±0.02	42.10^{b}±0.02	6.70^{ab}±0.03	26.50^{b}±0.05	69.00^{ab}±3.00
C	0.33^{b}±0.02	39.00^{c}±0.01	6.71^{ab}±0.01	20.30^{c}±0.03	71.00^{ab}±1.00
D	0.45^{a}±0.02	33.10^{d}±0.03	6.76^{a}±0.04	15.30^{d}±0.03	72.00^{a}±1.00

***Values are means ± SD of triplicate determination. .A= 100% cow milk; B= 90% cow milk and 10% coconut milk; C= 80% cow milk and 20% coconut milk and D= 70% cow milk and 30% coconut milk. TTA + Total titratable acidity; TS = Total solids;*

Means in the same column with different superscript are significantly different at P< 0.05. A = 100% cow milk (control): B = 90% cow milk and 10% coconut milk

C = 80% cow milk and 20% coconut milk: D = 70% cow milk and 30% coconut milk

Table 4. Microbiological load of coconut/Warankasi cheeses

Type of analyses	Colony forming unit /g x 10^1			
	A	B	C	D
Total plate count	5.0	3.5	1.8	0.5
Coliform count	<1.0	Nil	Nil	Nil
Mould and yeast	Nil	Nil	Nil	Nil

A = 100% cow milk; B = 90% cow milk and 10% coconut milk; C = 80% cow milk and 20% coconut milk; D = 70% cow milk and 30% coconut milk

Table 5. Sensory properties of samples

Sample	Appearance	Taste	Aroma	Consistency	General acceptability
A	6.20^a±1.70	6.35^a±1.38	6.75^a±1.33	6.55^a±1.59	6.45^a±1.39
B	6.35^a±1.30	6.25^a±1.61	6.25^{ab}±1.29	6.65^a±1.46	6.20^a±1.05
C	6.50^a±1.46	5.85^a±2.00	5.45^b±1.82	5.95^a±1.70	6.35^a±1.95
D	6.70^a±0.92	6.65^a±1.53	6.85^a±1.49	6.15^a±1.66	6.90^a±1.33

**Values are means ± SD of triplicate determination. Means in the same column with different superscript are significantly different at P< 0.05: A = 100% cow milk (control): B = 90% cow milk and 10% coconut milk C = 80% cow milk and 20% coconut milk: D = 70% cow milk and 30% coconut milk*

The inclusion of coconut milk into cow milk at 10%, 20% and 30% levels did not cause any adverse effects on the sensory properties of cow milk soft cheese (Warankasi).

4. CONCLUSION

In conclusion, substitution of coconut milk into cow milk (up to 30% level of inclusion) yields a nutritious, wholesome product with good sensory properties. There is need to establish the effect of inclusion of coconut milk on the shelf stability of the unripened soft cheese (Warankasi).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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