Journal of Agriculture and Agricultural Technology 11(1):23-30, 2020

QUALITY ASSESSMENT OF CHEESE FROM COW MILK SUPPLEMENTED WITH TIGERNUT MILK AND COCONUT MILK

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ABSTRACT
Cow milk was supplemented with tigernut milk and coconut milk in the percentage ratio of 25:25:50; 25:50:25; 50:25:25; 75:25:0; 75:0:25 for cow milk-tigernut milk-coconut milk respectively (v/v) to produce cheese. The shelf life and sensory attributes of the cheese samples were examined. The samples were analyzed using standard methods. The percentage yield of the cheese samples ranged from 13.43 to 17.33%. An increase in the percentage inclusion of tigernut milk resulted to an increase in percentage yield while an increase in coconut milk results in a lower yield. The total titratable acidity decreased significantly ($p<0.05$) with decrease in percentage cow milk in the blend with the values ranging from 0.30 to 0.23%. The moisture content increased significantly ($p<0.05$) from 53.18% to 59.66% with increase in coconut milk. The protein content differed significantly ($p<0.05$) with values ranging from 18.77 to 14.59%. The fat content ranged from 21.49 to 12.90% with an increase in coconut milk. The total ash content ranged between 3.03 and 1.47% while the carbohydrate content ranged from 10.72 to 2.81%. Significant ($p<0.05$) difference was observed in the fungal and bacterial counts at different levels of storage period. Sample $C_{25}S_{50}N_{25}$ and $C_{75}S_{25}N_0$ showed the highest number of both bacterial and fungal counts respectively. There was significant ($p<0.05$) difference in color, texture, aroma and overall acceptability of the samples. The taste shows no significant difference. The study recommended that tigernut milk and coconut milk could be used either alone or as a mix to supplement cow milk. However, 25% supplementation proved to be the best blend based on consumer general acceptability.

Keywords: Cheese, cow milk, tigernut milk, coconut milk, supplementation

INTRODUCTION

Milk is a major constituent of the diet and is considered essential to the welfare of a community (Marimuthu *et al.*, 2013). It is a perishable commodity and also an excellent medium for microbial growth (Ogunlade *et al.*, 2017). In Nigeria, milk production is mainly produced by the Fulani. Fulani women do process the surplus fresh milk into unripened cheese called "warankasi" or "wara" due to lack of refrigeration facilities (Omotosho *et al.*, 2011).

Tigernut (*Cyperus esculentus*) are often used in various ways in traditional Nigerian cuisine. Tigernut milk has great potentials to supplement cow milk; it contains high quality protein and essential amino acids, essential minerals, vitamins, unsaturated fatty acids, soluble and insoluble dietary fibres, and isoflavones whose presence in everyday diet is very important. Unlike cow milk, tigernut contains no cholesterol and can be consumed by lactose intolerant individuals. (Hussein *et al.*, 2016).

Coconut (*Cocos nucifers*) milk is the liquid that comes from the grated meat of a brown coconut. Coconut milk contains approximately 3% protein, 17% - 24% fat,2% carbohydrate, many vitamins, minerals and electrolytes, including potassium, calcium and chloride as well as cholesterol free (Balogun *et al.*, 2016). Coconut milk is being used by confectionaries, bakeries, biscuits and ice cream Industries worldwide to enhance flavor and taste of various products (Adejuyiyan *et al.*, 2014).

According to Balogun *et al.* (2016), cheese is a dairy product made by coagulating either whole milk, part-skim (low fat) milk, skim milk, or cream by removing much of the liquid portion while retaining the coagulum and the entrapped milk solids. It is an excellent source of protein, fats and minerals such as calcium, iron and phosphorus, vitamins and essential amino acids, thus making it an important food in the diet of both old and young people (Oladipo and Jadesimi,2013).

'Warankashi' is processed by coagulating pasteurized milk at a specific temperature, pH and processing time with an appropriate coagulant. The preferred coagulant comes from Sodom apple leaf extract (*Calotropis procera*) because the cheese made with this coagulant has a sweeter flavour and a higher protein content compared to the cheese made with the other coagulants (Omotosho *et al.*, 2011).The coagulated milk is poured

into a small basket or strainer in order to drain and to give the cheese the desired shape and size (Adetunji and Salawu, 2008). So many types of cheeses are produced based on their different characteristics and method of productions. Their styles, textures and flavours depend on the origin of the milk (including the animal's diet), whether they have been pasteurized or not, the butterfat content, the bacteria and the mold, the processing and aging. Herbs, spices or wood smoke may be used as flavouring agents (Fankhauser and David, 2007)

The manufacture of soft cheese (*wara*) is widespread in developing Africa countries and was thought to have originated in the Northern region of Nigeria due to the traditional cattle rearer (*Fulani*) access to fresh milk from cattle rearer. However, many factors such as shortage of good quality milk, poor processing and preservation methods, poor hygiene practices, poor packaging and storage facilities have contributed to poor utilization and availability in areas where it might have been useful in alleviating protein and other nutritional deficiency (Omotosho *et al*., 2011). This often leads to importation of milk and milk products such as cheese which may adversely affect the nutrition and the socio-economic well-being of people especially low income earners and rural dwellers. Thus, there is a need to find alternatives making the use of plant milk supplementations a research field.

Coconut utilization in Nigeria is very low as it is mainly eaten as a snack or shredded and fried to make a coconut candy. Coconut oil is still being used however, the milk is under-utilized in the country (Balogun *et al*., 2016). Blend of cow milk, tigernut milk and coconut milk for the production of cheese will not only give a food product of improved quality but also a product which can be consumed by lactose intolerant individual, people with low fertility and more so consumer who intend to improve his immune system and prevent cardio- vascular diseases, inflammatory, diabetes and cancer.

Little research attention and inconsistency in research findings have been major challenges on the production and blending ratio of cow milk to vegetable sourced milk such as tigernut milk, coconut milk, soy milk and Bambara nut milk. Therefore, this study is to evaluate the chemical composition and sensory qualities of West African soft cheese 'warankashi' produced from blends of cow milk, tigernut milk and coconut milk, documenting its keeping quality and also increase the utilization of blends of plant milk for the production of good quality cheese product.

MATERIALS AND METHODS

Material Collection and Preparation

Sodom apple leaves (*Calotropis procera*) and fresh cow milk were obtained from a nomadic settlement located within Ikole Ekiti, Nigeria. The fresh cow milk was collected from a cow aseptically, packaged in a sterile white container, and placed in a cooler containing ice crystal. The tiger nut and coconut were purchased from King's Market, Ikole Ekiti, Nigeria and processed using the method described by Belewu and Belewu (2007) and Balogun *et al.* (2016) respectively.

Production of Cheese (Warankashi)

The portion of the sieved milk for warankashi production from the cow, tigernut and coconut were measured. The variation in the measurement was done according to the method described by Balogun *et al.* (2016) with modifications. Cheese samples were produced using 1000ml as standard with formulation by partial substitution of cow milk with coconut milk and tigernut milk at varying proportions as presented in Table 1.

ANALYSIS

The proximate compositions were carried out on the cheese samples using the AOAC (2010) method. The percentage yield and total titratable acidity were carried out using methods described by Balogun *et al.* (2016), AOAC (2006) and AOAC (1996) respectively.

The method described by Adegoke (2004) was used for microbiological analysis. The analysis was repeated for three days of the studies to determine the effect of storage on the spoilage organisms of the samples.

Sensory Evaluation

1. Instrument for Data Collection: The samples were coded and validated questionnaire made up of quality evaluation for flavor, texture, color and overall acceptability was used. Quality ratings were based on a 9-point descriptive hedonic scale with 9 (like extremely) being the highest score and 1(dislike very much) the least score (Ihekoronye and Ngoddy, 1985).

2. Panel of Judges: The population was made up of ten (10) students of Food Science and Technology, Federal

University Oye Ekiti, Ekiti State, Nigeria. The purposive sampling technique was adopted in the selection of the panel of judges because the students have better knowledge of food than other students and would therefore give better interpretation on what would be required from them.

Statistical Analysis

Means were compared using test of significant difference (Steel and Torrie, 1980). Test of significant ($P<0.05$) difference among the treatments were determined by Analysis of Variance (ANOVA) as described by Steel *et al.* (1997).

RESULTS AND DISCUSSION

Proximate composition of cheese produced from cow-tigernut-coconut milk blends

The result of proximate composition is presented in Table 2. There were significant ($p<0.05$) differences in all the parameters (Moisture, Protein, Fat, Ash and Carbohydrate) evaluated. This difference could be attributed to the addition of coconut milk and tigernut milk at different levels and the resultant difference in the proportion of cow milk present in the samples. The moisture content of cheese (*warakanshi)* samples ranged from 53.92% to 56.66% with samples $C_{75}T_0CC_{25}$ having the lowest value while sample $C_{25}T_{25}CC_{50}$ had the highest value. This result shows that the blending of cow-tigernut-coconut milk significantly ($p<0.05$) influenced the moisture content of cheese (*warankashi)* products. The moisture content increases with addition of vegetable sourced milk. This can be further proved from samples with lowest moisture content having zero percent in either coconut milk, tigernut milk or both as observed in samples $C_{75}T_0CC_{25}$, $C_{75}T_{25}CC_0$; and C_{100}. The result agrees with the findings of Balogun *et al.* (2016) who reported increase in moisture content as the level of coconut increases.

The protein content ranged from 14.59% to 18.77% with sample $C_{25}T_{25}CC_{50}$ having the lowest value while $C_{75}T_{25}CC_0$ have the highest value. The lowest protein content value in sample $C_{25}T_{25}CC_{50}$ may be attributed to the high amount of coconut milk in the blend since coconut milk contains the least amount of protein of all the three milk used,. This result agreed with the findings of Balogun *et al.* (2016) who reported that sample with 75:25% of cow-coconut cheese has the highest protein content. Hussein *et al.* (2016) also reported increase in the crude protein as the proportion of tigernut milk is increased in the blend for the cow- tigernut cheese production. The differences in the findings may be due to many factors such as differences in the species of tigernut used, the maturity and nutrient composition of the tigernut and coconut as well as the amount of protein available in the milk after the extraction process.

The fat content value ranged from 12.90% to 21.49% with sample $C_{75}T_{25}CC_0$ having the lowest value while sample $C_{25}T_{25}CC_{50}$ have the highest value respectively. The fat content of the samples can be seen to be dependent on the proportion of cow milk and coconut milk in the samples. This is in agreement with Balogun *et al.* (2016) who reported that the fat content increases with increase in the coconut milk as a result of the high fat content of the milk.

The ash content ranged from 1.47 to 3.03% with sample $C_{25}T_{25}CC_{50}$ having the lowest value while sample $C_{75}T_{25}CC_0$ had the highest value. Thus it can be deduced that increase in the percentage cow milk (i.e. above 50%) leads to increase in the ash content. This is supported by the findings of Balogun *et al.* (2016) who reported decreased in the ash content of cheese with addition of coconut milk. The increased in ash content with the addition of 25% of tigernut implies that it is a good source of minerals.

No value at all for crude fiber. Total carbohydrate content of the cheese samples ranged from 2.81 to 10.72% with sample $C_{25}T_{25}CC_{50}$ having the lowest value while sample $C_{75}T_{25}CC_0$ had the highest value. The result indicates that the total carbohydrate content is dependent on the tigernut milk.

Percentage yield and total titratable acidity of cow-tigernut-coconut cheese

The percentage yield and titratable acidity of the samples are presented in Table 3. The percentage yield ranged from 13.43% ($C_{25}T_{25}CC_{50}$) to 17.33% ($C_{25}T_{50}CC_{25}$).The variations may be attributed to the nutrient composition of the blends, the nature and specie of the food materials and the quantities of the materials used in the production. The highest yield was recorded in sample $C_{25}T_{50}CC_{25}$ and this was in agreement with the findings of Adedokun *et al.* (2013) who reported an increase in percentage yield of cheese as bambara milk inclusion is increased in the blends. The relatively low value of the percentage yield in the cheese produced from the higher proportion of cow milk may be due to the specie of the animal, age, sex,

feeding habits and type of feeds given to the animal as well as the time and season of milking.

It can be deduced from the findings that the percentage yield may depend on the available protein for curdling by enzyme. Thus, it can be said that increase in the amount of protein rich materials used in supplementations in the production of cheese will lead to increase in the percentage yield of the cheese as observed in this research and also the findings of Adedokun *et al.* (2013). Balogun *et al.* (2016) also reported that percentage yield decreases with increase in the percentage coconut milk in the blend. However as reported by Balogun *et al.* (2016) the principles of cheese making involves the removal of water from milk with a consequent six to ten-fold concentration of protein, fat, minerals and vitamins by the formation of protein coagulum which further shrinks to expel whey. Therefore, the decline in the percentage yield of the cheese sample $C_{25}T_{25}CC_{50}$ can be attributed to the high proportion of the coconut milk which is also in agreement with the findings of Balogun *et al.* (2016).

The total titratable acidity (TTA) was found to be between 0.23% and 0.30% for sample $C_{25}T_{50}CC_{25}$ and $C_{75}T_{25}CC_0$ respectively. The significant ($p<0.05$) differences between the samples can be attributed to the differences in the ratio of the cow milk in the blend as the samples with 25 percent cow milk as observed in samples with $C_{25}T_{50}CC_{25}$ and $C_{25}T_{25}CC_{50}$ have lower titratable acidity compared to samples with cow milk of 50 percent and above. This is supported by the findings of Abdel *et al.* (2012) who reported that cheese samples produced from cow milk has higher titratable acidity than those produced from goat milk or the mixtures of both milk. Changes in pH and total titratable acidity depend on the impact of cheese ripening and condition of storage after the production.

Microbiological quality of cow-tigernut-coconut cheese

The resultof the bacteria count is presented in Table 4. The growth rate increased as the storage period increased with sample $C_{25}T_{50}CC_{25}$ having the highest bacteria growth throughout the storage period. This may be due to the highest ratio of the tigernut milk used in the blend as tigernut milk contains high amount of nutrients than enhance microbial growth (Dauda, 2017). Moreover, the increase in the number of microorganism in the samples may partially result from the curdling and partially from the retention of these microorganisms in the curd as the whey is run off couple with other factors such as environmental factors, milking unit operations, storage condition, the differences in the pH and titratable acidity of the cheese products may attribute to proliferation of microorganisms in the product.

It can be deduced from the finding that cheese produced from blends of cow milk with tigernut milk or other milk from plant sources get spoilt easily and thus preservation methods such as drying, frying, refrigeration and use of chemicals can be employed to maintain the quality and enhance the shelf life of the product.

There was significant ($p<0.05$) difference in the total fungal count of the cheese samples with increase in storage period (Table 5). The increase could be attributed to addition of tigernut milk

and coconut milk in the sample. The control sample C_{100} has a value of 1.67 which is low compared to sample $C_{75}T_{25}CC_0$ which has a greater value of 100. Sample $C_{75}T_{25}CC_0$ shows increase in spoilage over the storage period while also having the highest number of fungal growth on a daily basis. Decrease in fungal growth with increase in coconut milk was observed as sample $C_{50}T_{25}CC_{25}$ showed a steady value of having the least number of growths during the storage periods.

Table 6 shows the colony forming unit per gram of the cheese sample with the control samples 100% cow milk cheese having a fungal count of 1.7×10^4, 7.3×10^5 and 9.3×10^5 cfu/g for the three days of storage these findings was in contrast with the findings of Dauda. (2017) who reported no fungal growth for storage at day one although this may be due to the difference in samples as the report was on fried cheese. The increase in the fungal count as the storage days increases is also in line with the findings of Dauda. (2017) who also reported that increase in the fungal growth could be due to favorable environmental condition and the acidity of the cheese samples at storage. Sample $C_{75}T_{25}CC_0$ has the highest fungal growth with values ranging from 1.0×10^6 cfu/g, 1.7×10^6 cfu/g and 1.7×10^6 cfu/g for the three days of storage respectively. However, growth was constant in days 2 and 3. The study showed that tigernut supplemented cheese is very prone to both bacterial and fungal spoilage and refrigeration temperature alone is not enough to maintain its quality and enhance its keeping period. Thus there is need for combined preservation methods to increase the shelf life, maintain the quality and enhance the safety and wholesomeness of the cheese product.

Sensory evaluation of cheese produced from blends of cow-tigernut-coconut milk

The mean sensory scores are shown in Table 7. There was no significant difference in the taste of all the six samples of cheese provided thus the taste was very palatable and acceptable by the consumers. There was significant ($p<0.05$) difference in colour, texture, aroma and overall acceptability aiming the samples. The sample with highest percentage of tigernut milk ($C_{25}T_{50}CC_{25}$) was rated lowest in colour with a value of 5.80. This could be attributed to the present of tigernut milk in the cheese analogue which may result in a slight brownish discoloration observed in the samples

The texture of the control sample (C_{100}) was rated highest (6.65) score. The result supports the findings of Balogun *et al.* (2016) who reported that 100% cow milk has the best texture.

In terms of aroma the sample $C_{75}T_{25}C_0$ had the highest (6.45) 6.45 score. Samples $C_{75}T_{25}C_0$ had the highest overall acceptability (7.00) while sample $C_{25}T_{25}CC_{50}$ had the least (5.40) value. This denotes that samples with coconut and tigernut milk supplements are generally accepted by the consumer and can be used for commercial production of cheese.

The result from this study shows increase in the yield, protein, moisture content, fat and ash content with increasing proportion of the coconut and tigernut milk at different levels in the blend formulation and this shows high possibility of using a milk analogue from a vegetable source such as coconut milk and tigernut milk in cheese production. The increase in yield of the supplemented cheese makes it economical and cost effective. The results of the microbiological evaluation showed that samples at day one of production with tigernut milk and coconut milk supplements have high bacteria and fungal count at day one thus very prone to spoilage. The result of consumer oriented test from this study shows that 75:25:0% cow-tigernut - coconut milk 'warankashi' was most accepted by the consumer. Therefore tigernut milk and coconut milk can be used alone and collectively to supplement cow milk up to 50 % without much adverse effect on the chemical properties, nutrients and acceptability of the final product. However 25% of supplementation proved to be the best blend based on consumer acceptability and hereby recommended.

Table 1: Blend formulation for the production of cow-tigernut-coconut cheese

Sample	Cow milk (%)	Tigernut milk (%)	Coconut milk (%)	Sodom Apple leaves (%)
C_{100}	100	0	0	15
$C_{75}T_0CC_{25}$	75	0	25	15
$C_{75}T_{25}CC_0$	75	25	0	15
$C_{50}T_{25}CC_{25}$	50	25	25	15
$C_{25}T_{50}CC_{25}$	25	50	25	15
$C_{25}T_{25}CC_{50}$	25	25	50	15

Key: C_{100}: 100% cow milk; $C_{75}T_0CC_{25}$: (75% cowmilk+0% tigernut milk+25% coconut milk) $C_{75}T_{25}CC_0$: (75% cowmilk + 25% tigernut milk+0% coconut milk) $C_{50}T_{25}CC_{25}$: (50% cow milk + 25% tigernut milk + 25% coconut milk) $C_{25}T_{50}CC_{25}$: (25% cow milk +50% tigernut milk + 25% coconut milk) $C_{25}T_{25}CC_{50}$: (25% cow milk + 25% tigernut milk+ 50% coconut milk).

Table 2: Proximate composition of cow-tigernut-coconut cheese

Samples	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Carbohydrate (%)
C_{100}	$55.18^{c}\pm0.25$	$16.75^{b}\pm1.58$	$19.51^{b}\pm0.74$	$2.52^{c}\pm0.02$	$6.06^{bc}\pm1.06$
$C_{75}T_0$ CC_{25}	$53.92^{c}\pm0.81$	$17.25^{ab}\pm0.00$	$20.46^{ab}\pm0.53$	$2.72^{bc}\pm0.16$	$5.67^{c}\pm0.12$
$C_{75}T_{25}CC_0$	$54.59^{c}\pm0.01$	$18.77^{a}\pm0.16$	$12.90^{d}\pm0.22$	$3.03^{a}\pm0.14$	$10.72^{a}\pm0.06$
$C_{50}T_{25}CC_{25}$	$59.32^{a}\pm1.10$	$16.53^{b}\pm0.74$	$13.84^{d}\pm1.42$	$2.84^{ab}\pm0.17$	$7.49^{b}\pm0.91$
$C_{25}T_{50}CC_{25}$	$57.49^{b}\pm0.00$	$15.48^{bc}\pm0.43$	$15.71^{c}\pm0.01$	$1.92^{d}\pm0.15$	$9.42^{a}\pm0.29$
$C_{25}T_{25}CC_{50}$	$59.66^{a}\pm0.13$	$14.59^{c}\pm0.14$	$21.49^{a}\pm0.57$	$1.47^{e}\pm0.64$	$2.81^{d}\pm0.53$

Values are mean ± standard deviation .Means with same superscript across a columns are not significantly ($p<0.05$) different.

Key: C_{100}: 100% cow milk; $C_{75}T_0CC_{25}$: (75% cowmilk+0% tigernut milk+25% coconut milk) $C_{75}T_{25}CC_0$: (75% cowmilk + 25% tigernut milk+0% coconut milk) $C_{50}T_{25}CC_{25}$: (50% cow milk + 25% tigernut milk + 25% coconut milk) $C_{25}T_{50}CC_{25}$: (25% cow milk +50% tigernut milk + 25% coconut milk) $C_{25}T_{25}CC_{50}$: (25% cow milk + 25% tigernut milk+ 50% coconut milk).

Source: Data Analysis, 2019

Table 3: Percentage yield and total titratable acidity of cow-tigernut-Coconut cheese

Samples	Yield (%)	TTA (%)
C_{100}	14.32^{bc}±0.90	0.29^{a}±0.02
$C_{75}T_0CC_{25}$	15.33^{b}±1.53	0.27^{a}±0.02
$C_{75}T_{25}CC_0$	14.33^{bc}±0.61	0.30^{a}±0.02
$C_{50}T_{25}CC_{25}$	13.38^{c}±0.58	0.30^{a}±0.03
$C_{25}T_{50}CC_{25}$	17.33^{a}±0.83	0.23^{b}±0.01
$C_{25}T_{25}CC_{50}$	13.43^{c}±0.67	0.24^{b}±0.03

Values are mean ± standard deviation. Means with same superscript across a columns are not significantly ($p<0.05$) different.

Key: C_{100}: 100% cow milk; $C_{75}T_0CC_{25}$: (75% cowmilk+0% tigernut milk+25% coconut milk) $C_{75}T_{25}CC_0$: (75% cowmilk + 25% tigernut milk+0% coconut milk) $C_{50}T_{25}CC_{25}$: (50% cow milk + 25% tigernut milk + 25% coconut milk) $C_{25}T_{50}CC_{25}$: (25% cow milk +50% tigernut milk + 25% coconut milk) $C_{25}T_{25}CC_{50}$: (25% cow milk + 25% tigernut milk+ 50% coconut milk).

Source: Data Analysis, 2019

Table 4: Bacteria count of cow- tigernut-Coconut cheese during storage

Samples	Storage period (days) 1 (cfu/g)	2 (cfu/g)	3 (cfu/g)
C_{100}	83.33^{cd}±5.77	193.33^{c}±11.55	793.33^{ab}±17.10
$C_{75}T_0CC_{25}$	66.67^{d}±11.55	293.33^{bc}±83.27	733.35^{ab}±24.13
$C_{75}T_{25}CC_0$	125.33^{bc}±18.90	266.67^{bc}±130.13	786.67^{ab}±61.10
$C_{50}T_{25}CC_{25}$	133.33^{b}±23.09	353.33^{ab}±50.33	793.33^{a}±57.74
$C_{25}T_{50}CC_{25}$	180.00^{a}±20.00	450.00^{a}±86.60	840.00^{a}±69.28

Values are mean ± standard deviation. Means with same superscript across a columns are not significantly ($p<0.05$) different

Key: C_{100}: 100% cow milk; $C_{75}T_0CC_{25}$: (75% cowmilk+0% tigernut milk+25% coconut milk) $C_{75}T_{25}CC_0$: (75% cowmilk + 25% tigernut milk+0% coconut milk) $C_{50}T_{25}CC_{25}$: (50% cow milk + 25% tigernut milk + 25% coconut milk) $C_{25}T_{50}CC_{25}$: (25% cow milk +50% tigernut milk + 25% coconut milk) $C_{25}T_{25}CC_{50}$: (25% cow milk + 25% tigernut milk+ 50% coconut milk).

Source: Data Analysis, 2019

Table 5: Fungal count of cow-tigernut-coconut cheese during storage

Samples	Storage period (Days) 1 (cfu/g)	2 (cfu/g)	3 (cfu/g)
C_{100}	1.67^{c}±1.53	73.33^{b}±20.8	293.33^{c}±5.77
$C_{75}T_0CC_{25}$	12.00^{c}±2.00	76.67^{b}±15.82	106.67^{c}±11.55
$C_{75}T_{25}CC_0$	100.00^{a}±20.00	166.67^{a}±30.55	173.33^{a}±23.09
$C_{50}T_{25}CC_{25}$	10.00^{c}±2.00	16.00^{c}±5.29	20.00^{d}±2.00
$C_{25}T_{50}CC_{25}$	5.00^{c}±1.00	53.33^{b}±6.11	184.00±14.42
$C_{25}T_{25}CC_{50}$	43.33^{b}±5.77	80.00^{b}±20.00	133.33±11.54

Values are mean ± standard deviation Means with same superscript across a columns are not significantly ($p<0.05$) different

Key: C_{100}: 100% cow milk; $C_{75}T_0CC_{25}$: (75% cowmilk+0% tigernut milk+25% coconut milk) $C_{75}T_{25}CC_0$: (75% cowmilk + 25% tigernut milk+0% coconut milk) $C_{50}T_{25}CC_{25}$: (50% cow milk + 25% tigernut milk + 25% coconut milk) $C_{25}T_{50}CC_{25}$: (25% cow milk +50% tigernut milk + 25% coconut milk) $C_{25}T_{25}CC_{50}$: (25% cow milk + 25% tigernut milk+ 50% coconut milk).

Source: Data Analysis, 2019

Table 6: Colony forming of cow-tigernut-coconut cheese during storage

Samples	Storage period (Days) 1 (cfu/g)	2 (cfu/g)	3 (cfu/g)
C_{100}	1.7×10^4	7.3×10^5	9.3×10^5
$C_{75}T_0CC_{25}$	1.2×10^5	7.7×10^5	1.1×10^6
$C_{75}T_{25}CC_0$	1.0×10^6	1.7×10^6	1.7×10^6

$C_{50}T_{25}CC_{25}$	1.0×10^5	1.6×10^5	2.6×10^5
$C_{25}T_{50}CC_{25}$	5.0×10^4	5.3×10^4	8.4×10^5
$C_{25}T_{25}CC_{50}$	4.3×10^5	8.0×10^5	1.3×10^6

Values are mean ± standard deviation. Means with same superscript across a columns are not significantly ($p<0.05$) different

Key: C_{100}: 100% cow milk; $C_{75}T_0CC_{25}$: (75% cowmilk+0% tigernut milk+25% coconut milk) $C_{75}T_{25}CC_0$: (75% cowmilk + 25% tigernut milk+0% coconut milk) $C_{50}T_{25}CC_{25}$: (50% cow milk + 25% tigernut milk + 25% coconut milk) $C_{25}T_{50}CC_{25}$: (25% cow milk +50% tigernut milk + 25% coconut milk) $C_{25}T_{25}CC_{50}$: (25% cow milk + 25% tigernut milk+ 50% coconut milk).

Source: Data Analysis, 2019

Table 7: Sensory properties of cow-tigernut-coconut cheese

Samples	Colour	Texture	Taste	Aroma	Overall acceptability
C100	7.00a±1.41	6.65a±1.09	5.15a±1.90	5.40ab±1.85	6.10ab±1.86
C75T0 CC25	6.80ab±1.28	6.50ab±1.70	5.35a±2.13	5.20ab±1.96	6.30a±1.75
C75T25CC0	7.00a±1.56	6.50ab±1.61	6.05a±1.67	6.45a±1.99	7.00a±1.45
C50T25CC25	6.25ab±1.48	6.45ab±1.57	5.85a±1.95	6.00ab±1.89	6.10ab±1.77
C25T50CC25	5.80b±1.61	6.00ab±1.86	5.35a±2.16	5.50ab±1.85	5.75ab±1.83
C25T25CC50	5.95b±1.64	5.30b±2.72	4.80a±2.19	5.05b±2.16	5.40ab±1.85

Values are mean ± Standard deviation. Means with same superscript across a columns are not significantly ($p<0.05$) different.

Key: C_{100}: 100% cow milk; $C_{75}T_0CC_{25}$: (75% cowmilk+0% tigernut milk+25% coconut milk) $C_{75}T_{25}CC_0$: (75% cowmilk + 25% tigernut milk+0% coconut milk) $C_{50}T_{25}CC_{25}$: (50% cow milk + 25% tigernut milk + 25% coconut milk) $C_{25}T_{50}CC_{25}$: (25% cow milk +50% tigernut milk + 25% coconut milk) $C_{25}T_{25}CC_{50}$: (25% cow milk + 25% tigernut milk+ 50% coconut milk).

Source: Data Analysis, 2019

CONCLUSION

The result from this study shows increase in the yield, protein, moisture content, fat and ash content with increasing proportion of the coconut and tigernut milk at different levels in the blend formulation and this shows high possibility of using a milk analogue from a vegetable source such as coconut milk and tigernut milk in cheese production. The increase in yield of the supplemented cheese makes it economical and cost effective. The results of the microbiological evaluation showed that samples at day one of production with tigernut milk and coconut milk supplements have high bacteria and fungal count at day one thus very prone to spoilage. The result of consumer oriented test from this study shows that 75:25:0% cow-tigernut - coconut milk 'warankashi' was most accepted by the consumer. Therefore tigernut milk and coconut milk can be used alone and collectively to supplement cow milk up to 50 % without much adverse effect on the chemical properties, nutrients and acceptability of the final product. However 25% of supplementation proved to be the best blend based on consumer acceptability and hereby recommended.

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