THE EFFECT OF SUPPLEMENTATION OF COW MILK WITH TIGER NUT MILK ON THE YIELD AND QUALITY OF SOFT CHEESE

BADMOS, A. A.[1]; SALAMI, K. O.[2]; AHMED-EL IMAM, A.[3]; YISA, Y.[2]; & LAWAL, A. O.[4]
[1] Department of Animal Production, University of Ilorin, Ilorin, Nigeria.
[2] Department of Home Economics and Food Science. University of Ilorin, Ilorin, Nigeria.
[3]Department of Microbiology, University of Ilorin, Ilorin, Nigeria.
[4]ITAD Ltd, Hove, U.K.
E-mail: badmos111@yahoo.com **Phone No:** +234-806-555-0095

Abstract
This study determined the yield and quality of West African soft cheese produced when cow milk was blended with 0 to 50 % graded percentage tigernut milk as substitute, using six treatments of five replicates each in a Completely Randomised Design. The results revealed that cheese pH was reduced with increasing tigernut supplementation. Cheese yield, calcium, lactose content and cheese protein decreased (p<0.05) with increasing tigernut supplementation of milk while cheese fat and cheese ash increased accordingly. Cheese taste, flavor and texture were rated highest for the ten percent tigernut milk at 3.15, 2.80 and 3.05 respectively while the control cheese was generally most acceptable. This study concludes that cow milk can be supplemented with tigernut milk to fifty percent, but the cheese produced from ten percent supplementation of cow milk with tigernut milk was of highest quality.

Keywords: *acceptability, milk blending, percentage supplementation.*

Introduction
Cheese is an excellent source of protein, and essential nutrients. It is a globally important food item (Raheem, 2006, Badmos *et al*., 2018). The cheese quality, nutritive value and flavour depends on the cheese coagulation procedure and the source of milk. The effect of different coagulants on the properties of cheese has been severally reported in literature (Adetunji *et al*., 2007; Adetunji and Babalobi, 2011; Badmos and Joseph, 2012; Augustine *et al.,* 2014). These studies reported the effect of sodom apple, lemon juice, almond (*Terminalia cattapa*) extract and other coagulants on cheese quality and nutritive value. In addition to coagulants however, cheese quality and properties also depend on the type and source of milk. The various sources of milk include the milk from cow (Chikpa *et al*., 2016; Belewu, 2019) sheep (Derar and El Zubeir, 2014; Cipolat-Gotet *et al*., 2016; Nguyen *et al*., 2019; Renes *et al*., 2019), buffalo (Bontempo *et al*., 2019; Da Silva *et al*., 2019) and goats (Darnay *et al*., 2019; Leclercq-Perlat *et al*., 2019). The differences in milk from these sources would affect cheese quality, nutritive value and flavour. According to Mason (2008), Vegetable based sources used as milk supplements enriches the content of milk and milk products. The increasing awareness of the health implication of high fat diets has led to increasing demand for vegetable-based milk and milk products. Belewu and Belewu (2007) compared the nutritive values of milk from tiger nut, soybean and coconut for inclusion as blends in dairy and confectionery products. The authors concluded that the resulting milk blends are nutritive and valuable for human consumption. Abdulkareem (2019) produced cheese from vegetable-based coagulants, including tigernut milk and coconut milk. Tiger nut has been recognized for its health benefits as it is high in fiber, protein and neutral sugars. It has a high content of soluble glucose and oleic acid, along with high energy content (starch, fats, sugar and protein), is rich in vitamins E and C and contains minerals such as phosphorus potassium, calcium, magnesium and iron that are necessary for bones, tissue repair, muscles, the blood stream and for body growth and development. It is recommended for those who suffer from indigestion, flatulence and diarrhoea because it provides digestive

enzymes like the catalase, lipase, and amylase (Mohamed *et al*., 2005). Tiger nut drink actually contains more iron, magnesium and carbohydrate than the cow's milk (Rita, 2009). There are however, scanty works reported on the effect of variations in cow milk constituents on cheese quality. This study was designed to determine the effect of supplementing fresh cow milk with tiger nut milk on the physico-chemical and sensory properties as well as the yield of cheese.

Materials and Methods

Source of Materials: Fresh cow milk was obtained from cattle herd at Oke - ose, adjacent to the University of Ilorin teaching Hospital. Fresh tiger nut was purchased from Ipata market in Ilorin while pack of sodom apple leaves was obtained along Bank road, University of Ilorin.

Preparation of Tigernut Milk: Tigernut was sorted, cleaned, soaked for 12 hours, wet milled and sieved with muslin cloth to obtain tigernut milk (Rita, 2009). This was blended with cow milk as in the treatment plan as shown in Table 1.

Table 1: Treatment plan of blends

Treatments	Cow milk (%)	Tigernut milk (%)
T1	100	0
T2	90	10
T3	80	20
T4	70	30
T5	60	40
T6	50	50

Preparation of Cheese: Cow milk of 200 ml (T1) was measured separately into five vessels, which were arranged in a water bath and in similar fashion, vessels of T2, T3, T4, T5 and T6 were arranged. Thus, six vessels (replicates) containing 200 ml milk of each treatment (T1 to T6) in the proportion outlined in the treatment plan (thirty vessels in all) were arranged in a water bath and heated to 35^0 C. Sodom apple (*Calotropis procera*) leaf extract of 6 ml was then added to the content of each vessel and gentle heating continued. The temperature was held between 65 and 70 ^{0}C for fifteen minutes, after which coagulation began (Badmos *et al.,* 2017), and there was visible separation of the curd and the whey. The heat source was removed and the cheese was ladled into raffia basket for drainage before being weighed.

Proximate Analysis: Method of Association of Official Analytical Chemists (AOAC, 2000) was used to estimate the pH, moisture, crude protein, crude fat, the ash content as well as the mineral composition of cheese samples.

Data Collection

Determination of Yield: Percentage yield of cheese samples was determined by the method by Igyor *et al.* (2006), thus: Yield of cheese (%) $= \frac{X_2 \times 100}{X_1}$

Where;
X_1 = Volume (ml) of blended cow milk - tigernut milk used
X_2 = weight (g) of cheese produced from blended cow milk - tigernut milk

Lactose Content Determination: This method is based upon the reaction of lactase with methylamine in hot alkaline solution to form a red complex which absorbs at 540nm (Amutha *et al.,* 2010) and included:

(i) addition of 1 ml of ZAPT reagent to 8.0g of well mixed cheese sample, dilution to 10 ml and filtration after 10 minutes using Whatman No. 1 filter paper.
(ii) addition of 0.5 ml of NaOH solution to 0.5 ml of the filtrate, dilution to 10ml and filtration using Whatman No. 1 filter paper
(iii) dilution of 5ml of the filtrate to 10 ml.
(iv) pipette of 5 ml each of working standard lactose and unknown solution into 25ml test tubes. Addition of 5 ml of glycine NaOH buffer, 0.5 ml of methylamine solution and 0.5 ml of sodium sulphite solution into each test tube and thorough mixing. Heating the test tubes in a thermostatically controlled water bath at 65°C for 25 minutes and cooling immediately in an ice water bath for 2 minutes to stop the reaction. The absorbance was read against blank at 540 nm spectrophotometer.

Sensory Evaluation: After the production of the cheese samples, sensory evaluation was carried out to determine the most acceptable blends (treatment) of cheese. This was done using a five-point hedonic scale questionnaire described by Sugri and Johnson (2009) with some modifications. The taste, flavour, appearance, texture and overall acceptability of cheese samples were examined independently by thirty (30) trained panelists, the average of which was computed.

Statistical Analysis: SPSS 16.0 was used to analyze the data obtained from the study. The results of the experiments were subjected to Analysis of Variance to determine significant differences among the samples, and the means were separated using Duncan Multiple Range Test (Steel *et al.,* 1997).

Results

pH: The results for the variation in pH were presented in Table 2. The pH values obtained for all the samples ranges between 6.1 and 6.5. There was a gradual decrease ($p \leq 0.05$) in pH with increasing tigernut milk content of cheese.

Cheese Yield: The percentage yield of cheese samples as shown in Table 2 decreased significantly ($p<0.05$) from 22.18 % for control sample (100 % cow milk) to 15.53 % for the cheese produced with 50:50 proportion of (cow – tigernut) milk blend.

Cheese Nutritive Value: The results of the proximate composition of cheese samples are presented in Table 3. The moisture content values ranged between 59.40 (T1) and 65.86 % (T6); the protein content ranged between 14.93 % (T1) and 8.32 (T6); the fat content ranges between 8.55 and 11.90 %; the ash content ranged between 1.10 and 1.80 % and the carbohydrate content ranged between 12.11 and 16.02 %.

Cheese Mineral Composition: The results of the mineral compositions are presented in Table 4. The values obtained for calcium ranges from 20.04 to 22.07 mg/kg, the potassium content values ranged from 1.72 (T6) to 3.14(T1) mg/kg, the sodium content values ranges from 16.34 (T6) to 24.47 (T1) mg/kg, the iron content values ranges from 1.25 to 2.17 mg/kg, the magnesium content values ranges from 20.03 (T6) to 25.42 (T1) mg/kg, and the zinc content values ranges from 1.82 (T1) to 2.83 (T6) mg/kg.

Cheese Lactose Content: The results of the lactose content of the samples are presented in Table 5. The value ranges between 30.10 (T1) and 17.45 (T6) mg/g.

Cheese Sensory Qualities: The mean sensory scores for cheese samples produced with varying proportions of added tigernut milk are shown in Table 6. Significant differences ($p<0.05$) were observed in appearance, taste, flavour, texture and overall acceptability. The overall sensory ratings of the control cheese was highest and except for T2 which had high taste, flavor and texture scores, sensory acceptability decreased with more tigernut milk substitution. The rating of cheese appearance however showed an opposite trend.

Discussions

The pH for control cheese (no tigernut) was highest, but decreased ($p<0.05$) with increasing tigernut milk content. The interaction of calcium and other minerals with the protein complex during milk coagulation might be responsible. Pastorino *et al.* (2003) reported cheese pH to be closely related to calcium solubilization and protein to protein interactions. The pH range of 6.1 to 6.5 observed in the present study are within the range of 5.2 to 6.5 earlier reported by Belewu *et al.* (2005) for cheese treated with different preservatives as well as the range (5.7- 6.9) earlier reported for cheese manufactured with the leaf extract of *Calotropis procera* (Adegoke *et al.*, 1992). Similar figures were reported by Gbadamosi (1994) as well as Olorunnisomo and Ikpinyang (2012) for cheese precipitated with sodom apple, ascorbic acid and sweet orange juice. Ihekoronye and Ngoddy (1985) earlier stated that pH is a parameter useful in food handling, processing, selection of packaging material and condition of storage.

The result of the percentage yields of cheese samples ranged from 22.18-15.53 %. The values decrease with increasing inclusion of the tigernut milk. The values were in agreement with the findings of Balogun *et al.* (2016) who reported a decline in the percentage of cheese yield as the percentage of coconut milk inclusion increased in cheese (from 26.71 % to 13.55 % for 100 % cow cheese and cheese with 30 % coconut milk supplementation respectively) but not in agreement with the findings of Adedokun *et al.* (2013) who reported an increase in percentage yield of cheese as the inclusion percentage of bambara milk increased in the cheese (from 28.05 % to 41.11 % for 100 % cow cheese and cheese with 50 % bambara milk supplementation respectively). This difference might be due to peculiar attributes of Bambara nuts. Fashakin and Unokiwedi (1992), corroborated by Balogun *et al.* (2016) reported that yield remained relative constant with levels of soy substitution. Observation on percentage yield may be due to the level of available protein for curdling by enzyme. Fox (1993) and Johnson (2017) asserted that principles of cheese making involves the removal of water from milk with a consequent six-to tenfold concentration of the protein, fat, minerals and vitamins by the formation of a protein coagulum that then shrinks to expel 'Whey'. The decline in percentage yield in this study can be attributed to the added tigernut milk which shows that tigernut milk has a partial potential to be used in the production of cheese.

There was an increase in moisture content of cow-tigernut milk cheese blends as the level of tigernut milk increased. This was observed to be within the range of 59.40 % and 65.86 %. 100% cow milk cheese (T1) had the lowest level of moisture content, while 50 % cow milk/ 50 % tigernut milk (T6) had the highest level of moisture content. This result agreed with that of Chikpah *et al.* (2016) who reported that the moisture content of cheese increases as the percentage of soy milk increases and disagreed with the result from Adedokun *et al.* (2013) who reported a decrease in the moisture as the percentage of bambara nut milk increases. Balogun *et al.* (2016) also reported an increase in the moisture content as the percentage of coconut milk increases. Smith (1990) stated that one of the main differences between processed cheese product and analogue is the level of moisture content in the product, which affects its rheological factor. The relatively high moisture contents of cheese may be attributed to the high percentage of water contained in the tigernut milk.

The crude protein contents of cheese products were significantly different ($p<0.05$) and the values ranged between 14.93 % and 8.32 %. Sample T1 (control or 100% cow milk cheese) had the highest protein content while sample T6 (50% cow milk and 50% tigernut milk) had the lowest protein content. This result implies that there was a decrease in the level of protein content as the level of tigernut milk increases. The differences in the percentage crude protein of cheese may be attributed to differences in chemical composition of the formulated raw milk samples. The result of this findings disagreed with Balogun *et al.* (2016) who reported an increase in protein content as the inclusion percentage of coconut milk increased in the cheese (13.75-15.33 %) and Adedokun *et al.* (2013) who also reported an increase in protein content as the inclusion percentage of Bambara nut milk increased in the cheese (7.86-13.61 %). The differences in the composition of the milk types might be responsible.

The fat content of cow-tigernut cheese blends were significantly different ($p<0.05$). The control sample had the lowest fat content of 8.55% while 50% cow milk and 50% tigernut milk (T6) had the highest fat content (11.90%). This result agreed with the results from Balogun *et al.* (2016) who also reported an increase in fat content of cheese as the inclusion percentage of coconut milk increases (8.94-9.64%) and disagreed with Adedokun *et al.* (2013) who reported a decrease in fat content of cheese as the inclusion percentage of Bambara nut milk increases (13.59-9.21 %).

The ash content in foodstuff is a measure of mineral elements in food. The ash content of the cheese samples varied significantly ($p<0.05$). The control sample had 1.10% while cheese with added tigernut milk increased from 1.25-1.80 % of ash content (10 % and 50 % proportions of added tigernut milk respectively). This result agreed with the results of Adedokun *et al.* (2013) who reported an increase in ash content of cheese as the inclusion percentage of Bambara nut milk increases (0.58-2.35 %). Balogun *et al.* (2016) however reported a decrease among the cheese samples with increasing proportion of coconut milk. The difference in mineral composition between Bambara nut and Coconut milk might be responsible for the ash content differences of the cheese. The control sample had 1.02 %, while the cheese with added coconut milk decreased from 0.88% - 0.32% (5 % and 30 % proportions of added coconut milk respectively).

Total carbohydrate (determined by difference) ranged between 12.11-16.02 % among the samples with added tigernut milk. The result disagreed with the results from Adedokun *et al.* (2013) who recorded an increase in the total carbohydrate content (13.82%-23.81 %) as the bambara nut milk substitution increased. The investigation on proximate composition in this study has showed the potential influence of added tigernut milk as a plant source in improving the nutritional value of cheese.

The mineral composition of the samples shows that there is presence of calcium, potassium, magnesium, sodium, iron and zinc in the cheese produced. The mineral content of cheese examined showed the range of 20.04 to 22.07 mg/kg calcium. The calcium content increases as the percentage of tigernut milk increases. Adedokun *et al.* (2013) reported a decrease in calcium content of the cheese from 44.79 mg/kg (control) to 17.90 mg/kg (50% Bambara nut milk). Zinc content increases with a range of 1.82 to 2.83 (mg/kg). This result agreed with results of Adedokun *et al.* (2013) who reported an increase in zinc content as the level of Bambara nut milk increases. The potassium content of the cheese shows a decrease and ranges from 3.14 to 1.72 (mg/kg). This is perhaps due to the potassium content of tigernut juice being lower than that of cow milk. Zamberlain *et al.* (2012) reported that cow milk contains 144 to 178 mg potassium per 100g cow milk disagreed, while Adgidzi (2010) reported that potassium can be as low as 6.4 mg in 100 g tigernut milk. Magnesium content of cheese also shows an increase and ranges from 20.03 to 25.42 (mg/kg). Sodium content of cheese shows an increase and ranges from 16.34 to 24.47 (mg/kg). This is at variance with sodium content of cheese from soymilk which decreased with increase in the level of soymilk (Chikpah *et al.,* 2016). The disagreement might be due to the differences in sodium content of soymilk and tigernut milk. Iron content of cheese also shows an increase and ranges from 1.25 to 2.17 (mg/kg). This result is similar to the report from Adedokun *et al.* (2013) that an increase in iron content as the level of bambara nut milk increases (0.98-6.08%). The increase in calcium, magnesium and iron content of the cheese with increase in the percentage of tigernut milk may be due to the high content of these minerals contained in tigernut (Traders, 2012) as compared with bambara nut and soyabean.

The changes in minerals content may be the result of different percentages of tigernut milk used for supplementation. Onyeka (2008) reported that mineral elements are inorganic matters that play important roles in human nutrition and their inadequacy may result into nutritional disorder.

The concentration of lactose was higher in the control sample - T1 (30.10%) which reduces as the percentage of tigernut milk increases (24.70-17.45%). This may be as a result of the tigernut not containing lactose (Traders, 2012). The result shows that the cheese samples produced will be suitable to people that are lactose intolerant.

The cheese sensory properties are attributable to the varying proportions of tigernut milk and cow milk used in cheese preparation. The T2 cheese blend (90:10) of fresh cow milk and tigernut milk with mean scores of 2.10 (appearance); 3.15 (taste); 2.80 (flavour); 3.05 (texture); and 3.30 (overall acceptability) was most preferred cheese sample next to the control sample (100% cow milk cheese). Many of the sensory panelists are apparently more familiar with the taste of cow milk cheese than tigernut milk cheese. The relationship between familiarity and sensory acceptability has been earlier reported by Badmos *et al.* (2018).

Conclusions and Recommendations

The blending of cow milk with tigernut milk had significant effect on yield, nutrient content and sensory properties of cheese. Fresh curd yield reduced significantly with increase in tigernut milk content. The moisture, ash and fat of the cheese increased with increasing proportions of tigernut milk. The colour, flavour, taste, texture and overall acceptability of cheese were significantly affected by the content of tigernut milk. Treatment 6 (50% cow milk and 50% tigernut milk) had the lowest lactose content. The result of this work showed that cow milk can be supplemented with tigernut milk up to 50% but the best cheese quality (in terms of cheese yield, reduction in lactose content and sensory properties) could be obtained by Treatment 2 (90% cowmilk, 10% tigernut milk).

As a strategy to mitigate the effects of milk shortages and to reduce the lactose content of cheese (making it suitable for people who are lactose intolerant), it is recommended that tiger nut milk should be blended with cow milk. A blend of ten percent tigernut milk in cow milk should be adopted for the production of good quality cheese as recommended above. It is also recommended that further research be conducted to determine the quality of cheese produced with milk blend of lower content (five percent) tigernut milk in cow milk.

Appendices

Table 2: Effect of Tigernut Milk Supplementation on Cheese Yield and pH

Treatments	Cheese Blends	Yield (%)	pH
T1	100%C; 0%TN	22.18^{a}	6.5^{a}
T2	90%C; 10%TN	21.55^{b}	6.4 ^{a}
T3	80%C; 20%TN	20.68^{c}	6.4 ^{a}
T4	70%C; 30%TN	19.67^{d}	6.3 ^{ab}
T5	60%C; 40%TN	17.33^{e}	6.3 ^{ab}
T6	50%C; 50% TN	15.53^{f}	6.1^{c}
P-value		0.001	0.020
SEM		1.05	0.15

*Values represent means of five duplicate samples
**abc*: Mean scores with same superscripts along the column are not significantly different (p>0.05)
*%C; %TN is the blending ratio (percentage) of cow milk and cow milk and tigernut milk.

Table 3: Effect of Tigernut Milk Supplementation on Cheese Proximate Composition

Trt	Moisture (%)	Protein (%)	Fat (%)	Fibre (%)	Ash (%)	CHO (%)
T1	59.40±0.06^{d}	14.93±0.45^{a}	8.55±0.59^{d}	0.00±0.00 ^{a}	1.10±0.10^{c}	16.02±0.30^{a}
T2	61.65±1.30^{c}	13.33±1.29^{b}	9.02±0.10^{cd}	0.00±0.00 ^{a}	1.25±0.03^{bc}	14.75±0.27^{b}
T3	62.90±0.49^{bc}	11.02±0.61^{c}	10.00±0.48^{bc}	0.00±0.00 ^{a}	1.47±0.06^{ab}	14.61±0.31^{b}
T4	63.92±1.01^{abc}	10.45±0.44^{c}	11.02±0.72^{ab}	0.00±0.00 ^{a}	1.53±0.17^{ab}	13.08±0.13^{c}
T5	64.30±1.33^{ab}	9.64±0.07^{cd}	11.62±0.59 ^{a}	0.01±0.00 ^{a}	1.69±0.18^{a}	12.74±0.24^{cd}
T6	65.86±0.57^{a}	8.32±0.04^{d}	11.90±0.13 ^{a}	0.01±0.00 ^{a}	1.80±0.20^{a}	12.11±0.49 ^{d}
P-value	0.023	0.001	0.034	0.531	0.045	0.014
SEM	2.15	1.24	1.44	0.23	0.39	1.62

* Values represent means of five duplicate samples.
*Trt = Treatments: CHO= Carbohydrate
**abc*: Mean scores with the same superscripts letters along the column are not significantly different (p>0.05)
*T1 to T6 represent the milk blending variation (of cheese) from 100%C; 0%TN to 50%C; 50%TN

Table 4: Effect of Tigernut Milk Supplementation on Cheese Mineral composition

Trt	Ca (mg/kg)	K (mg/kg)	Na (mg/kg)	Fe (mg/kg)	Mg (mg/kg)	Zn (mg/kg)
T1	20.04±0.03^{c}	3.14±0.07^{a}	16.34±0.10^{e}	1.25±0.04^{d}	20.03±0.34^{e}	1.82±0.08^{c}
T2	20.52±0.42^{bc}	3.02±0.45^{ab}	17.49±0.35^{d}	1.47±0.07^{c}	22.45±0.45^{d}	1.95±0.17^{bc}
T3	20.73±0.49^{bc}	2.43±0.21^{ab}	19.03±0.77^{c}	1.59±0.17^{bc}	23.02±0.04^{cd}	2.34±0.13^{abc}
T4	21.23±0.49^{ab}	2.27±1.16^{ab}	22.14±0.58^{b}	1.73±0.06^{b}	23.94±0.17^{bc}	2.42±0.10^{ab}
T5	21.59±0.13^{ab}	1.84±0.06^{ab}	23.02±0.03^{b}	2.01±0.01^{a}	24.39±0.58^{b}	2.61±0.45^{ab}
T6	22.07±0.82^{a}	1.72±0.04^{b}	24.47±0.20^{a}	2.17±0.08^{a}	25.42±0.59^{a}	2.83±0.08^{a}
P-value	0.002	0.047	0.012	0.001	0.007	0.041
SEM	0.49	1.32	1.59	0.22	0.97	0.56

*Values represent means of five duplicate samples
**abc*: Mean scores with the same superscripts along the column are not significantly different (p>0.05)
*T1 to T6 represent the milk blending variation (of cheese) from 100%C; 0%TN to 50%C; 50%TN
*****Trt = Treatments: CHO= Carbohydrate
*Ca-Calcium, K-Potassium, Na-Sodium, Fe-Iron, Mg-Magnesium and Zn-Zinc

Table 5: Effect of Tigernut Milk Supplementation on Cheese Lactose Content

Treatment	Cheese blends	**Lactose(mg/g)**
T1	100%C; 0%TN	30.10^{a}
T2	90%C; 10%TN	24.70^{b}
T3	80%C; 20%TN	22.57^{c}
T4	70%C; 30%TN	22.20^{d}
T5	60%C; 40%TN	21.99^{e}
T6	50%C; 50% TN	17.45^{f}
P-value		0.026
SEM		0.23

*Values represent means of five duplicate samples.

**abc*: Mean scores with same superscripts along the column are not significantly different (p>0.05)

*%C; %TN is the blending ratio (percentage) of cow milk and cow milk and tigernut milk.

Table 6: Effect of Tigernut Milk Supplementation on Cheese Sensory Qualities

Cheese blends	Taste	Flavour	Appearance	Texture	Overall acceptability
T1	2.85±0.75^{a}	2.70±0.47^{a}	1.45±0.51^{b}	2.90±0.45^{a}	3.65±1.04^{a}
T2	3.15±0.37^{a}	2.80±0.52^{a}	2.10±0.31^{a}	3.05±0.61^{a}	3.30±0.57^{a}
T3	2.25±0.55^{b}	2.10±0.55^{c}	2.20±0.52^{a}	2.05±0.61^{b}	2.40±0.75^{b}
T4	2.30±0.57^{b}	2.45±0.67^{abc}	2.15±0.75^{a}	2.05±0.39^{b}	2.30±0.47^{b}
T5	1.35±0.67^{c}	2.25±0.85^{bc}	2.25±0.72^{a}	1.95±0.51^{b}	2.10±0.45^{b}
T6	1.45±0.99^{c}	2.35±0.81^{abc}	2.25±0.64^{a}	1.20±0.41^{c}	2.15±0.49^{b}
P-value	0.033	0.004	0.761	0.047	0.038
SEM	0.56	0.48	0.19	0.17	0.45

*Values represent means of five duplicate samples.

**abc*: Mean scores with same superscripts along columns are not significantly different (p>0.05)

*%C; %TN represent the blending ratio (percentage) of cow milk and cow milk and tigernut milk.

References

Abdulkareem, L. O. (2019). *Quality, sensory and storage attributes of cheese produced from cowmilk supplemented with tigernut and coconut milk.* Project submitted to the Department of Food Science and Technology, Federal University of Oye Ekiti, Ekiti State, Nigeria.

Adedokun, I. I., Okorie, S. U., Onyeneke, E. N., & Anoruo, S. A. (2013). Evaluation of yield, sensory and chemical characteristics of soft unripened cheese produced with partial incorporation of bambaranut milk. *Academic Journal of Food Research*, (1), 14-18.

Adegoke, G. O., Nse, E. N., & Akanni, A. O. (1992). Effects of heat, processing time, and pH on the microflora, aflatoxin content, and storability of wara, a soft white cheese. *Die Nahrung*; 36(3), 259–264.

Adetunji, V. O., & Babalobi, O. O. (2011). A comparative assessment of the nutritional contents of wara' a West African soft cheese using *calotropis procera* and *cymbopogon citratus* as coagulants. *African Journal of Food, Agriculture, Nutrition and Development*, 1(7), 5574-5585.

Adetunji, V. O., Alonge, D. O., Singh, R. K., & Chen, J. (2007). Production of *wara*, a west African soft cheese using lemon juice as a coagulant. *Journal of Food Science and Technology*, 3(4), 289-293.

Adgidzi, E. A. (2010). *Effect of processing methods on the yield and quality of aqueous extracts and yoghurt- like products from Tigernuts (Cyperus esculentus).* MSc Thesis submitted to the Department of Food Science and Technology. University of Agriculture, Makurdi. Benue State. P. 73

Akinloye, A. M., & Adewumi, O. O. (2014). Effects of local coagulants on the yield of cheese using cow and sheep milk. *International Journal of Development and Sustainability*, 3(1), 150-161.

Amutha, M., Arunachalam, R., Umamaheswari, M., Usharamalakshmi, A., Ramakrishnan, S., & Annadurai, G. (2010). Medicinal Use of *Camellia sinensis* on Lactose Intolerance. *Journal of Biological Sciences*, 10, 112-116.

AOAC. (2000). Association of Official Analytical Chemists: Official methods of analysis (15th ed.), Association of Official Analytical Chemists, Washingrton, DC.

Augustine, O. A., Opeyemi, A. A., & Oyinlola, M. O. (2014). The production of Wara cheese from locally sourced coagulants and its nutritional evaluation. *IOSR Journal of Environmental Science, Toxicology and Food Technology,* 8, 55-57.

Badmos, A. A., Ahmad-El Imam, A., Annongu, A. A., Yusuff, A. T., Kayode, R. M. O., Salami, K. O., Ahutu I. A., & Lawal. A. O. (2017). Preservative effects of aqueous and ether extracts of *Aframomum melegueta* on West African soft cheese. *Bangladesh Journal of Animal Science,* 46 (1), 51-56.

Badmos, A. A., & Joseph, K. (2012). Effect of fermented maize supernatant and sodom apple coagulant on the time, temperature and yield of coagulation of soft cheese. *Journal of Agricultural Research and Development,* 11, 327-332.

Badmos, A. A., & Abdulsalam, K. (2012). Comparative evaluation of Cheese samples treated with Honey and Thyme solutions. *Journal of Agricultural Research and Development*, 11(2), 313-318.

Badmos, A. H. A., Adeyemi, K. D., Akande, F. T., Oyeyinka, S. A., Ahmed, R. N., & Lawal, A. O. (2018). Effect of *Parkia biglobosa* husk extracts and honey blend on the chemical, sensory and bacterial attributes of traditional West African soft cheese. *Croatian Journal of Food Technology, Biotechnology and Nutrition*, 13(1-2), 19-23. Available online at https://hrcak.srce.hr/hcptbn

Balogun, M. A, Kolawole, F. L., Joseph, J. K., Adebisi T. T., & Ogunleye, T. T. (2016). Effect of fortification of fresh cow milk with coconut milk on the proximate composition and yield of *warankashi*, a traditional cheese. *Croatian Journal of Food Science and Technology*, 8 (1).

Belewu, M., & Abodunrin, O. (2006). Preparation of *Kunnu* from unexploited rich food source: Tiger nut (Cyperus esculentus). *World Journal Dairy Food Science*; 1(1), 19-21.

Belewu, M., & Belewu, K. (2007). Comparative physicochemical evaluation of tiger-nut, soybean and coconut milk sources. *International Journal of Agriculture and Biology*; 5, 785-787.

Belewu, M. A., Belewu, K. Y., & Nkwunonwo (2005). Effect of biological and chemical preservatives on the shelf life of West African soft cheese. *African Journal of Biotechnology*, 4(10), 1076-1079. ISSN 1684-5315.

Belewu, M. A. (2019). *A functional Approach to dairy science and Technology. Revised and enlarged edition*. Published by milkyinka publications, Ilorin, Kwara State, Nigeria. Pp 137-172.

Bontempo, L., Barbero, A., Bertoldi, D., Camin, F., Larcher, R., Perini, M., Sepulcri, A., Zicarelli, L., & Piasentier, E. (2019). Isotopic and elemental profiles of Mediterranean buffalo milk and cheese and authentication of Mozzarella di Bufala Campana PDO: An initial exploratory study. *Food Chemistry*, 285, 316-323

Chikpah, S. K, Ketor, H., & Ayitey, D. (2016). Effect of different blends of cow -soy milk on yield, nutritional and organoleptic characteristics of West Africa soft cheese (Wagashie) *Ghana Journal of Science, Technology and Development*, 4(1).

Cipolat-Gotet, C., Cecchinato, A., Pazzola, M., Dettori, M. L., Bittante, G., & Vacca, G. M. (2016). Potential influence of herd and animal factors on the yield of cheese and recovery of components from Sarda sheep milk, as determined by a laboratory bench-top model cheese-making*. International Dairy Journal*, 63, 8-17.

da Silva, D.D., de Lima, M. d. S.F., da Silva, M.F., da Silva, G.R., Campos, J.F., Albuquerque, W.W.C., Cavalcanti, M.T.H., & Porto, A.L.F. (2019). Bioactive water soluble peptides from fresh buffalo cheese may be used as product markers. *LWT-Food Science and Technology;* 108, 97-105.

Darnay, L., Németh, Á., Koncz, K., Monspart-Sényi, J., Pásztor-Huszár, K., Friedrich, L., & Laczay, P. (2019). Effect of different O2/CO2 permeable foils on aging of semi-hard goat cheese. *International Dairy Journal,* 90, 114-118.

Derar, A., & El Zubeir, I. (2014). Compositional content of white cheese manufactured from mixtures of camel and sheep milk during storage. *Journal of Food and Nutritional Disorders,* 3(3),1-5, http://dx.doi.org/10.4172/2324-9323.1000145.

Ebing, P., & Rutgers, K. (2006). *Preparation of dairy products. Agrodok-series. Sixth Edition. ICCO, Interchurch Organisation for Development Co-operation*. Agromisa Foundation and CTA, Wageningen Netherlands; 36: 86.

Fashakin, J. B., & Unokiwedi, C. C. (1992). Chemical analyses of "warankasi" prepared from cow milk partially substituted with melon milk. *Nigerian Food*, 10, 103-110.

Fox, P. F. (1993). *Cheese in: Cheese Chemistry, Physics and Microbiology 2nd edition.* Volume 1. London.

Gbadamosi, A. D. O. (1994). *Yield and composition of wara from cow's milk coagulated with sodom apple leaf juice, ascorbic acid and sweet orange.* M.Sc. project, University of Ibadan, Ibadan.

Igyor, M. A., Igbian, E. K., & Iorbo, C. I. (2006). *Effects of soymilk supplement on the yield and Quality of 'Warankashi'. Nigeria Food Journal*, 24 (1), 92-97.

Ihekoronye, A. I., & Ngoddy, P. O. (1985). *Integrated food science and technology for the tropics.* Macmillan Publishers. London and Basingstoke.

Johnson, M. E. (2017). A 100-year review: Cheese production and quality. *Journal of Dairy Science*, 100 (12), 9952-9965.

Leclercq-Perlat, M., Saint-Eve, A., Le Jan, E., Raynaud, S., Morge, S., Lefrileux, Y., & Picque, D. (2019). Physicochemical and sensory evolutions of the lactic goat cheese Picodon in relation to temperature and relative humidity used throughout ripening. *Journal of Dairy Science*; 102(6), 5713-5725.

Mason, D. (2008). Tigernuts (online) National Vegetable Society, UK. .http://www.nvsuk.org.uk/growing_show_ vegetables_1/tiger_nut.php.

Mohamed, L. S., Mohsen, Z., & Maizum, K. I. (2005). Dietary supplementation with *Cyperus esculentus* L. (tigernut) tubers attenuated atherosclerotic lesion in a polipoprotein knockout mouse associated with inhibition of inflammatory cell responses. *American Journal of Immunology*, 1, 60-67.

Nguyen, Q. V., Van Le, H., Nguyen, D. V., Malau-Aduli, B. S., Nichols, P. D., & Malau-Aduli, A. E. (2019). Enhancement of dairy sheep cheese eating quality with increased n-3 long-chain polyunsaturated fatty acids. *Journal of Dairy Science*, 102(1), 211-222.

Oladele, A. K., & Aina, J. O. (2007). Chemical composition and functional properties of flour produced from two varieties of tigernut (Cyperus Esculentus). *African Journal of Biotechnology*; 6, 2473-2476, 2007.

Olorunnisomo, O. A., & Ikpinyang, E. A (2012). Chemical composition, sensory properties and yield of soft cheese precipitated with different coagulants. *Tropical Animal Production Investigation*, 15 (1), 15-18.

Onyeka, E. U. (2008). *Food and nutrition (2nd Edition).* Owerri, Nigeria: Charismatic Forum Publisher.

Pastorino, A. J., Hansen, C. L., & McMahon, D. J. (2003). Effect of pH on the Chemical Composition and Structure-Function Relationships of Cheddar Cheese. *Journal of Dairy Science,* 86 (9), 2751-2760.

Raheem, B. (2006). *Developments and Microbiological applications in African foods: Emphasis on Nigerian Wara cheese.* Doctoral Thesis, Department of Applied Chemistry and Microbiology, Faculty of Agriculture and Forestry. University of Helsinki, Finland.

Rita, S. (2009). The use of tiger nut (*Cyperus esculentus*), Cow's milk and their composite as substrates for yoghurt production*. Pakistan Journal of Nutrition*, 8(6), 755-758.

Robin, O., Turgeon, S., & Parquin, P. (1993). Functional properties of milk proteins. In *Dairy Science and Technology Handbook*, 1, 5-7.

Scott, R. (1986). *Cheese making practice. 2nd Ed.* London S29P: Elsevier Applied Science Publisher.

Smith, B. L. (1990). Codex Alimentarius: Abridged Version. Food and Agriculture Organization of the United Nations, Rome: 12.10-12.16

Steel, R. G. D., Torrie, J. H., & Dickey, D. A. (1997). *Principles and procedures of Statistics: A biometrical approach.* McGraw Hill Book Company, New York.

Sugri, I., & Johnson, P. N. T. (2009). Effect of two storage methods on the keeping and sensory qualities of four plantain varieties. *African Journal of Food, Agriculture, Nutrition and Development*, 9 (4), 1091-1109.

Traders (2012). Tigernut traders: S.L, *Bio tigernuts;* 2012. http://www.biotigernuts.com/organic.tigernuts-bio-tigernuts-biotigernuts.php

Walther, B., Schmid, A., Sieber, R., & Wehrmuller, K. (2008). Cheese in nutrition and health. *Dairy Science Technology.* Volume 88, No 4-5, pages 389-405. July-October 2008, 5th Symposium on Cheese Ripening. Agroscope Liebefeld- Posieux Research Station. ALP, 3003 Bernee, Switzerland.

Zamberlin, S., Antunac, N., Hauranec, J., & Samarzija, D. (2012). Mineral elements in milk and dairy products. *Mljekarstvo,* 62 (2), 111-125 113.