Comparative assessment of the nutritional contents and sensory evaluation of cheese produced from cow and sheep milk using local coagulants

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Abstract

The objectives of this study was to comparatively assess the dry matter, nutritive value and sensory properties of cheese produced from cow and sheep milk using three different local coagulants of plant origin: *Calotropis procera* leaf extract, *Carica papaya* leaf extract and lemon fruit juice. The following proximate and mineral compositions were assayed: dry matter, crude protein, ether extract, ash, carbohydrates, magnesium, copper, potassium, iron, zinc, calcium. Relative to that made with *Calotropis procera* and *Carica papaya*, cheese made with lemon juice was harder, less cohesive and gave a higher significant value ($P < 0.05$) of dry matter (48.04% - cow milk : 53.22% sheep milk) in both types of milk. The lowest dry matter content was observed in *Calotropis procera* processed cheese made from cow milk (40.02%). The crude protein (4.22%), ether extract (60.54%) and ash (6.00%) of *Calotropis procera* processed cheese made from sheep milk was significantly higher ($P < 0.05$) than cheese made from cow and sheep milk using *Carica papaya* and lemon juice. The lemon juice processed cheese made from sheep milk gave a significantly higher value ($P < 0.05$) of zinc (0.273%) and calcium (1.299%) than the cheese produced by the other two coagulants. Lemon juice processed cheese made from cow milk had the lowest content of crude protein (2.23%) and ether extracts (49.23%). With respect to carbohydrates, cheese made from cow milk using lemon juice had the highest ($P < 0.05$) value (41.21%) while it was lowest in *Calotropis procera* and *carica papaya* processed cheese made from sheep milk (28.34% and 28.40% respectively). However, ether extract was highest in cheese made from sheep milk using *Calotropis procera* extract (60.54%) and lowest in cheese made from sheep milk using lemon juice (49.69%). In terms of organoleptic evaluation, cheese processed from cow milk using *Calotropis procera* scored the highest insignificant ($P > 0.05$) overall acceptability (5.77). This study suggests that sheep milk and *Carica papaya* leaf extract have the potential to compete favourably well with the commonly used cow milk and *Calotropis procera* leaf extract.

Key words: *Calotropis procera*, *Carica papaya*, lemon juice, proximate composition, coagulant.

Introduction

Cheese a product from processing of milk and one of the most versatile foods in the world, of which over 500 varieties exist (Patrick and Fox, 1999), is known to be an excellent source of essential amino acids, carbohydrates, fats, vitamins and minerals such as calcium, iron and phosphorus. It has a shelf-life from 4 to 5 days up to five

years depending on the variety. Cheese therefore provides an ideal vehicle for preserving the valuable nutrients in milk and making them available throughout the year (O'Connor, 1993). The basic principles involved in cheese manufacturing have remained the same for over 1000 years and quality cheese production start from the milk composition, manufacture methods,

variation in standard techniques and the types of coagulant used (Tarakci and Kucukoner, 2006; Adetunju and Babalobi, 2011). In addition, the absence of standard processing methods explains the variations observed in the nutrient composition of cheese in developing countries (Turkoglu *et al.* 2003). The use of coagulants in cheese making determines to a large extent the yield and quality of cheese and several plant preparations have been shown to clot milk (Aworth and Muller, 1987; Tamer, 1993). However, most of the coagulants of plant origin have proved unsuitable for cheese production owing to their excessively proteolytic character which lowers cheese yield and produces bitter flavours in the final cheese. Moreover, their toxin content constrains their use as food (Sofia *et al.* 2008). Among those that have been reported to produce satisfactory final products, the proteases present in the flowers of *Cynara cardunculus* deserve special mention; aqueous extracts thereof have been used for centuries in the Iberian Peninsula for the manufacture, at the farm level, of ovine and caprine milk cheeses (Trujillo *et al.*, 1994). The use of vegetable extracts as milk coagulants in soft cheese processing has been known since antiquity. The first reference to the substitution of animal rennet by vegetable coagulants dates from experiments in 1935 (Christen and Virasoro, 1935) and later in 1961 (Veringa, 1961), 1992 (Guinee and Wilkinson, 1992), and 1994 (Garg and Johri, 1994). In recent development, Roseiro *et al.* (2003) stated that milk coagulants of plant origin have over-ridden the use of animal rennet. The reason being that animal rennet may be limited for diet (vegetarianism), religious reasons (Judaism and Islam) or being genetically engineered food, of which the Germans and the Dutch for example, forbid the use of recombinant

calf rennet (Roseiro *et al.*, 2003). Application of plant coagulants therefore, allows target cheese production, and hence contributes to improve the nutritional input of those populations on whom restrictions have been imposed by the use of animal rennet's (Gupta and Eskin, 1977). Traditional cheese makers in West Africa especially in Nigeria (mostly the Fulanis) and Republic of Benin use *Calotropis procera* (Sodom apple, which is referred to as bomubomu among Yorubas and tunfafia in Hausa language) extract as coagulant for cheese making. The leaf extract contains an organic acid called calotropin which has the ability to coagulate milk. Other plant sources whose extracts could be used as coagulants are pawpaw leaf, sun flower, *Cynara* species (cardoon), citrus lemon, *Garcinia indica* etc, (Aworth and Muller, 1987). O'Connor (1993) says cheese industry is rapidly growing in Nigeria and Africa. Also, the production of cheese in Africa countries has increased and about one third of the total volume of milk is used for this purpose (FAO, 1990). Despite the importance of *Calotropis procera* as coagulant, Adetunji and Salawu (2008), stated clearly that the plant is not being cultivated on a commercial level. Furthermore, on the increase is the awareness of taking cheese as a replacement for expensive evaporated and other types of milk which are unaffordable to average Nigerians. All these facts imply that there will be increase in demand of *Calotropis procera* and that the plant may go into extinction or become a scarce commodity with time; not only because it is the major source of plant coagulant in cheese making industry in Nigeria, but more importantly now that its medicinal usefulness is being unveiled to mankind day by day. This research project work was therefore carried out to assess the

nutritional contents and evaluate the sensory properties of cow and sheep milk using local coagulants.

Materials and Methods

Experimental site and materials

This research work was carried out at the Animal Production and Health laboratory of the Federal University of Agriculture, Abeokuta, Nigeria in 2012. Two of the three coagulants of plant origin, *Calotropis procera* (Sodom apple) and *Carica papaya* (pawpaw) leaves were obtained within the University campus while lemon fruits were bought at a local market in Abeokuta, Ogun State. Fresh whole cow milk was obtained through hand milking from White Fulani Cows at Alabata cattle ranch in Abeokuta, Nigeria while fresh sheep milk was obtained through hand milking from lactating West African Dwarf ewes at livestock farm, Federal University of Agriculture, Abeokuta.

Milk test (Basic properties of milk)

Methylene blue test, pH, taste, smell, colour, blue and red litmus paper test were conducted to test for basic property of milk. The methylene blue reduction test was done by placing 1ml of methylene blue in a test tube, followed by the addition of 10 mls of milk and then covered with a stopper. It was then placed in an incubator at 37°C until the blue colour disappeared to determine the quality of the milk.

Preparation of Lemon juice, *Calotropis procera* and *Carica papaya* leaf extracts

The Lemon juice extract was prepared by cutting eight medium size fruits and squeezing them into a clean bowl to extract the juice. The extracted content was sieved, measured with measuring cylinder and thoroughly mixed equal volume of fresh

clean water. Fresh Sodom apple leaves were weighed, finely chopped and thoroughly mixed with fresh clean water. The weight of the leaves and the volume of water used were in ratio 1:1. After five minutes, the mixture was sieved to collect the extract. The extracted volume and the pH value were recorded. The extract was allowed to sediment for 72 hours inside a refrigerator. The supernatant was carefully separated from the sediment into another container. This supernatant was used as the coagulant. Similar procedure was used to prepare pawpaw leaf extracts.

Preparation of cheese

Fresh 3 litres (3000 mls) of cow milk and 3 litres (3000 mls) of sheep milk were each divided into three equal portions (1000 mls) and poured into six different labeled pots. Each portion of cow and sheep milk was boiled in a separate metallic pot over an electric cooker in the open air to bring the temperature to 50°C. The leaf extracts of *Calotropis procera* and *Carica papaya* (100mls each) were added separately to the warmed milk. Heating continued with intermittent stirring until boiling point and the time the clotting began in each experiment was recorded. The heating of the curds continued and was maintained at boiling point for about 15 minutes until it fully coagulated and there were visible separation of cheese and whey. The loose curds were poured into sieves to facilitate whey drainage and also to mold into shapes. Draining of whey took about 15 minutes and measuring cylinder was used to measure the volume of extracted whey while electrical weighing scale was used to determine the weight of the extracted whey. The experiment was carried out thrice and the mean calculated. The flow chart for the recipe is shown in figure 1:

Fresh cow milk (1 liter each) in Plot A1-SA; A1-CP and A1-LJ

Fresh sheep milk(1/4 liter each) in pots B1-SA; B1-CP and B1-LJ

Heat (50°C)

Coagulation point

Coagulants

Add SAE in pot A1-SA; A1-CP and LJE in pot A1-LJ

Add SAE in pot B1-SA; CPE in pot B1-CP and LJE in pot B1-LJ

Separation of cheese curds and whey

Stirring thrice (few seconds each approximately 3 min. apart)

Heating point

Heat the mixture to 95°C until curd formation

Molding for whey drainage

Storage of cheese in whey at 28°C or 15°C

SA-Sodom apple extract, CP -*Carica papaya* extract, LJ -Lemon juice extract

A1- Cow milk, B1-Sheep milk

Fig. 1- Flow chart of coagulation of cow and sheep milk for cheese making

Determination of dry matter and moisture content

To determine the moisture content and dry matter, the weight of each sample of fresh cheese was taken and recorded before oven-drying. All the samples were dried at 70°C in a hot air oven until a constant dry weight was obtained for each sample. The final weight was deducted from the fresh weight

to determine the moisture and dry matter content.

Nutritional analysis

The six cheese samples were oven dried at 70°C for 3 day, milled and analysed. The proximate compositions (crude protein, ether extract, ash, fat, carbohydrates) were determined using the AOAC (1990). Major and trace mineral compositions such as

zinc, potassium, manganese, iron, copper and calcium were determined using Perkin-Elmer atomic absorption spectrophotometer-model 372.

Sensory analysis

The organoleptic properties of cheeses produced with three different coagulants were determined using the method of Potter, (1968). The organoleptic evaluation was done by three panelists (a panel per replicate). Each panel consists of 10 individuals who had one time or the other tasted 'wara' (West Africa soft cheese) or have it as part of their constant diet. The 6 different types of cheeses made were coded to eliminate biases. The coded values were evaluated at room temperature. The cheeses were assessed for aroma, taste, texture, colour and general acceptability on a seven-point. Hedonics scale using Potter (1968) procedure: 7- excellent; 6-very good; 5-good; 4-average; 3-fair; 2-poor; 1-very poor and the attribute mean score calculated.

Experimental design and statistical analysis

All the data generated were subjected to 2 x 3 (2 animal species -cow and sheep milk; and 3 coagulant types- *Calotropis procera*, *Carica papaya* and lemon juice) factorial arrangement in a completely randomized design and the significant different means

were separated with Duncan's Multiple Range Test of SAS (2005) package.

Results

The results in Table 1 showed that the pH of sheep milk (6.63) was slightly higher than cow milk (6.56). This was an indication that the milk used was slightly acidic. This was further confirmed by the use of litmus paper, which turned blue litmus paper to faint red for both types of milk. The methylene blue test (reductase test) carried out on both milk revealed that they were first class (excellent) milk because the milk decolourised in 8 hours. The pH value of *Calotropis procera*, *Carica papaya* and lemon juice extract were 6.83, 6.73 and 2.17 respectively (Table 2).

Table 3 indicated that there was no significant difference ($P > 0.05$) in the main effect of species and coagulants on the sensory evaluation of cheese except in cheese processed with lemon juice. The interaction effect in Table 4 showed that there were no significant differences ($P > 0.05$) in taste, aroma and general acceptability among the six types of cheese. However, there were significant differences ($P < 0.05$) in texture and colour between *Calotropis procera* and lemon juice processed cheese for both types of milk. Cheese processed from cow milk using *Calotropis procera* scored the highest

Table 1: Milk quality test

Parameters	Cow milk	Sheep milk
pH	6.56	6.63
Taste	Slightly sweet	Slightly
Colour	Creamy white	Creamy white
Smell	Aromatic flavour	Butter aromatic flavour
Litmus paper	Turn blue to faint red	Turn blue to faint red
Methylene blue test	Decolourised in 8 hours	Decolourised in 8 hours

Values represent mean of triplicate readings

Table 2: pH, volume and percentage of plant coagulant extracts

Plant coagulants	Weight(g)	Volume of water(mls)	Volume of Extract(mls)	Percentage of extract	PH	Colour
<i>Calotropis procera</i>	744.00	744 ^a	666 ^c	89.52 ^a	6.83 ^a	Green
<i>Carica papaya</i>	744.00	744 ^a	564 ^b	75.81 ^c	6.73 ^b	Deep green
Lemon juice	744.01	288 ^b	576 ^b	77.42 ^b	2.17 ^c	Yellowish
SEM	1.02	12.32	6.77	2.34	0.04	

Values represent mean of triplicate readings. Values with the different superscript along the same columns are significantly different ($P < 0.05$); values with similar superscript are not significantly different ($P > 0.05$)

SEM – Standard Error of Mean

Table 3: Main effect of animal species and coagulants on sensory evaluation

Factor	Taste	Aroma	Texture	Colour	Overall
Animal Species					
Cow	5.51	5.32	5.27 ^a	5.45	5.37
Sheep	5.67	5.56	5.04 ^a	5.97	5.56
SEM	0.27	0.19	0.26	0.23	0.18
Coagulants					
<i>Calotropis procera</i>	5.90	5.47	5.60 ^a	5.98	5.74
<i>Carica papaya</i>	5.62	5.52	5.50 ^a	5.67	5.55
Lemon juice	5.25	5.35	4.39 ^b	5.48	5.12
SEM	0.19	0.13	0.18	0.17	0.13

Values represent mean of triplicate readings. Values with the different superscript along the same columns are significantly different ($P < 0.05$); values with similar superscript are not significantly different ($P > 0.05$)

SEM – Standard Error of Mean

overall acceptability (5.77) while cheese made from cow milk using lemon juice scored the lowest mark (4.79)

As indicated in table 5 and 6, the dry matter content and moisture content of the cheese made from the two types of milk using three different coagulants were significantly different from one another ($P < 0.05$). Cheese made from sheep milk using lemon juice extract had the highest dry matter content (52.22%) while *Calotropis procera* processed cheese made from cow milk had

the lowest dry matter (40.02%) content. The pH readings showed a significant difference ($P < 0.05$) between the cheese processed with lemon juice and those processed with *Calotropis procera* and *Carica papaya* extracts in both types of milk. Cheese processed with sheep milk using *Calotropis procera* had the highest pH reading (6.6) while the lowest pH reading was recorded in cheese made from cow milk using lemon juice (5.47).

The main and interaction effects of animal

Table 4: Interaction effect of animal species and coagulants on sensory evaluation

Animals Species	Coagulants	Taste	Aroma	Texture	Colour	Overall
Cow	Calotropis	6.00	5.43	5.67 ^a	5.96 ^a	5.77
	Procera					
	Carica	5.57	5.40	5.67 ^a	5.80 ^a	5.56
	papaya					
Sheep	Lemon	4.97	5.13	4.47 ^{bc}	4.60 ^b	4.79
	Juice					
	Calotropis	5.80	5.50	5.52 ^{ab}	6.00 ^a	5.71
	procera					
	Carica	5.67	5.63	5.31 ^{abc}	5.55 ^{ab}	5.54
	papaya					
	Lemon	5.53	5.56	4.3 ^c	6.37 ^a	5.44
	Juice					
SEM		0.19	0.13	0.18	0.17	0.13

Values represent mean of triplicate readings. Values with the different superscript along the same columns are significant different ($P < 0.05$); values with similar superscript are not significantly different ($P > 0.05$)

SEM= Standard Error of Mean

Note -7- excellent; 6 – very good; 5 – good; average; 4- average; 3- fair; 2 – poor; 1- very poor)

Table 5: Main effect of animal species and coagulants on dry matter and pH

Factor	Dry matter (%)	pH
Animals Species		
Cow	44.46	6.10 ^a
Sheep	47.37	6.19 ^a
SEM	1.78	0.02
Coagulants		
Calotropis	40.92 ^a	6.53 ^a
procera		
Carica	46.20 ^a	6.40 ^b
papaya		
Lemon	50.63 ^a	5.50 ^a
juice		
SEM	1.56	0.03

Values represent mean of triplicate readings. Values with the different superscript along the same columns are significantly different ($P < 0.05$); values with similar superscript are not significantly different ($P > 0.05$); SEM= Standard Error of Mean

Table 6: Interaction effect of animal species and coagulants on dry matter and pH

Animals species	Coagulants	Dry Matter (%)	pH
Cow	Calotropis	40.02 ^c	6.47 ^b
	procera		
	Carica	45.34 ^{bc}	6.37 ^b
	papaya		
Sheep	Lemon	48.04 ^{ab}	5.47 ^c
	juice		
	Calotropis	41.82 ^{bc}	6.6 ^a
	Procera		
	Carica	47.07 ^{abc}	6.43 ^b
	Papaya		
	Lemon	53.22 ^a	5.53 ^a
	juice		
SEM		1.28	0.11

Values represent mean of triplicate readings. Values with the different superscript along the same columns are significantly different ($P < 0.05$); values with similar superscript are not significantly different ($P > 0.05$); SEM = Standard Error of Mean

species and coagulants on proximate composition of the dry matter of cheese (crude protein, ether extract, carbohydrate and ash) and mineral contents (manganese, copper, potassium, iron, zinc and calcium) are presented in Tables 7-10. There were significant differences ($P < 0.05$) in the crude protein content of the different types of cheese. The crude protein of *Calotropis procera* processed cheese made from sheep milk was significantly higher ($P < 0.05$)

than the other types of cheese. Furthermore, the ether extract of *Calotropis procera* processed cheese made from sheep milk was significantly higher ($P < 0.05$) than the other types of cheese. With respect to carbohydrates, cheese made from cow

milk using lemon juice extract was significantly higher ($P < 0.05$) when compared with the other types of cheese. The interaction effect in Table 6 and 8,

indicated the variations in values of both proximate compositions and mineral contents, ranging from the lowest to the highest crude protein (2.23%-4.22%), ether

Table 7: Main effect of animal species and coagulants on the proximate composition of cheese

Factor	Crude Protein (%)	Ether extract	Ash (%)	Carbohydrates (%)	Dry matter (%)
Animals species					
Cow	2.76 ^b	50.36 ^b	4.33 ^b	39.39 ^a	94.88
Sheep	3.33 ^a	55.87 ^a	5.00 ^a	32.57 ^b	95.11
SEM	0.22	1.17	0.23	1.50	0.31
Coagulants					
Calotropis procera	3.77 ^a	55.15 ^a	5.00 ^a	32.63 ^b	95.00 ^{ab}
Carica papaya	3.04 ^b	54.74 ^a	4.50 ^b	41.08 ^a	95.67 ^a
Lemon juice	2.31 ^c	49.46 ^b	4.50 ^b	41.08 ^a	95.67 ^a
SEM	0.15	1.50	0.30	1.71	0.30

Values represent mean of triplicate reading. Values with the different superscript along the same columns are significantly different ($P > 0.05$)

SEM- Standard Error of Mean

Table 8: Interaction effect of animal species and coagulants on the proximate composition of cheese

Animals species	Coagulants	Crude Protein (%)	Ether Extract (%)	Ash (%)	Carbohydrates (%)	Dry Matter (%)
Cow	Calotropis	3.33 ^b	49.77 ^c	4.00 ^a	40.91 ^a	94.67
	Procera					
	Carica	2.72 ^c	52.08 ^c	5.00 ^b	36.07 ^b	94.44
	Papaya					
	Lemon Juice	2.23 ^d	49.23 ^c	4.00 ^c	41.21 ^a	95.67
Sheep	Calotropis	4.22 ^a	60.54 ^a	6.00 ^a	28.34 ^a	95.33
	Procera					
	Carica	3.36 ^b	57.36 ^b	4.00 ^b	28.40 ^a	94.33
	Papaya					
	Lemon Juice	2.40 ^c	49.69 ^a	5.00 ^b	40.96 ^a	95.67
SEM		0.17	1.10	0.18	1.39	0.21

Values represent mean of triplicate readings. Values with the different superscript along the same columns are significantly different ($P < 0.05$); values with similar superscript are not significantly different ($P > 0.05$)

SEM - Standard Error of Mean

extract (49.23% - 60.54%) carbohydrates (28.34% - 41.99%) from *Carica papaya* processed cheese made from cow milk, while copper had the lowest value (0.0057%) from *Carica papaya* processed cheese made from sheep milk.

Discussion

Adetunji and Salawu (2008), reported that *Calotropis procera* cheese is the preferred type in terms of organoleptic taste and many nutritional values like fat, protein, sugar, zinc and copper when compared with

Table 9: Main effect of animal species and coagulants on mineral compositions of cheese

Factor	Manganese (%)	Copper (%)	Potassium (%)	Iron (%)	Zinc (%)	Calcium (%)
Animals species						
Cow	0.022 ^b	0.008 ^a	11.956 ^b	0.060 ^b	0.217 ^b	1.170 ^b
Sheep	0.024 ^a	0.007 ^b	12.580 ^a	0.068 ^a	0.222 ^a	1.228 ^a
SEM	0.00019	0.00059	0.86	0.0018	0.0875	0.0371
Coagulants						
Calotropis procera	0.026 ^c	0.007 ^b	12.008 ^b	0.068 ^a	0.213 ^b	1.258 ^a
Carica papaya	0.021 ^c	0.006 ^c	14.303 ^a	0.059 ^b	0.189 ^c	1.054 ^b
Lemon Juice	0.021 ^b	0.010 ^a	10.493 ^c	0.064 ^b	0.256 ^c	1.285 ^a
SEM	0.00093	0.00041	0.73001	0.00220	0.01030	0.01451

Values represent mean of triplicate readings. Values with the different superscript along the same columns are significantly different ($P < 0.05$); values with similar superscript are not significantly different ($P > 0.05$)

SEM - Standard Error of Mean

Table 10: Interaction effect of animal species and coagulants on mineral composition of cheese

Animals species	Coagulants	Manganese (%)	Copper (%)	Potassium (%)	Iron (%)	Zinc (%)	Calcium (%)
Cow	Calotropis procera	0.022 ^a	0.006 ^d	9.100 ^d	0.058 ^c	0.192 ^a	1.252 ^b
	Carica papaya	0.022 ^a	0.007 ^a	14.97 ^c	0.061 ^b	0.219 ^c	0.987 ^d
	Lemon juice	0.021 ^b	0.011 ^a	11.783 ^c	0.062 ^b	0.239 ^b	1.271 ^{ab}
	SEM	0.000915	0.000427	0.593615	0.0001753	0.008730	0.273030
Sheep	Calotropis Procera	0.019 ^c	0.006 ^d	13.620 ^b	0.058 ^c	0.158 ^c	1.121 ^a
	Carica Papaya	0.021 ^b	0.009 ^b	9.203 ^d	0.066 ^a	0.273 ^a	1.299 ^a
	Lemon juice	0.021 ^b	0.009 ^b	9.203 ^d	0.066 ^a	0.273 ^a	1.299 ^a
	SEM	0.000915	0.000427	0.593615	0.0001753	0.008730	0.273030

Values represent mean of triplicate readings. Values with the different superscript along the same columns are significantly different ($P < 0.05$); Values with similar superscript are not significantly different ($P > 0.05$)

SEM- Standard Error of Mean

Carica papaya processed cheese. Veringa (1961) also reported that mealy texture white cheeses made with extract from *Carica papaya* leaves showed flavour defect such as bitterness. However the results of this study stated otherwise in relation to organoleptic properties as there was no difference in the overall acceptability of both types of cheese. Presumably, this may be as a result of the supernatant of the extracts that were used in this study instead of the raw extracts (which probably contained higher concentration of bitter substances) used by the other authors. Thus, in terms of taste, aroma, colour and general acceptability, the three coagulants used can compete favourably well especially if the supernatant of the coagulants are used instead of raw extracts. In terms of texture, lemon juice processed cheese was not preferred. This may be as a result of the high acid content of the extract which made the cheese slightly sour, harder and inconsistent.

Lemon juice processed cheese gave the highest dry matter content while *Calotropis procera* processed cheese gave the lowest value of dry matter content for both of milk. This indicated that lemon juice extract had the highest coagulating strength when compared with the other two coagulants. This could also be an indication that the lower the pH of coagulant the higher the coagulating strength which was why the highest dry matter content was recorded in lemon juice processed cheese followed by *Carica papaya* processed cheese. The pH of cheese produced using *Calotropis procera* extract in this study was higher than the one reported by Adetunji and Babalobi (2011) which were 3.58 and 5.10-5.36 respectively. However, the range of pH values (5.70 – 6.90) reported by Adegoke *et al.* (1992) was in agreement with the findings of this work.

The variations in the chemical composition of cheese in this study could be due to different species of animal used, stage of lactation, health, climatic conditions and herd management which include feeding and general care. The results of this study agreed with the report of Worthinlton (2009), that milk consist of major nutrients, such as proteins, fats, carbohydrates, minerals and vitamins, as these nutrients reflected in the proximate composition of various cheese made. The crude protein values of cheese made from both cow and sheep milk were respectively lower than 3.29% and 5.95% reported by George (2011). The differences could have been due to heat (which denatures protein) that the milk was subjected to during processing (Fegan, 1979). Cheese made from sheep milk using *Calotropis procera* extract gave the highest protein value. This could be attributed to the likelihood that the protein content of this coagulant which was presumably higher than the other two coagulants might have been transferred to the cheese in addition to the fact that sheep milk have a higher protein content than cow milk (George, 2011). The protein content of *Calotropis procera* cheese reported by Omotosho *et al.* (2011), Adetunji and Salawu (2008), Belewu (2001) and Adegoke *et al.* (1992) which were 25.56%, 33.84%, 20.0%, 8.30% and 14.2% respectively were higher than the one obtained in this study. These differences could be attributed to lack of standardized techniques in the processing of cheese (Adetunji and Babalobi, 2011) and could also possibly be as a result of the supernatant of the extract that was used for this experiment instead of the raw extracts that were used by the other authors. Other variations in the proximate composition of the cheese could be attributed to the differences in the composition of the two

types of milk, the proximate composition of the coagulants used and the interactions between them during the processing periods. The higher value of manganese, potassium, iron, zinc and calcium of cheese made from sheep was an indication that sheep milk is richer in these compositions than cow milk. The highest calcium content observed in lemon juice processed cheese might have resulted from the fact that lemon juice is rich in vitamin C and calcium (Gulsen and Roose, 2001). In conclusion, the results of this experiment revealed that *Carica papaya* extract (supernatant) could compete well with *Calotropis procera* as coagulant in terms of sensory properties while *Calotropis procera* extract is still preferred to *Carica papaya* and lemon juice extracts in terms of nutritive values. Since sheep milk is better than cow milk in proximate composition, effort should be directed towards improving sheep for milk production and further work on refining of *Carica papaya* extract is still needed.

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