International Journal of Development and Sustainability
ISSN: 2168-8662 – www.isdsnet.com/ijds
Volume 3 Number 1 (2014): Pages 150-161
ISDS Article ID: IJDS12120102

Effects of local coagulants on the yield of cheese using cow and sheep milk

A.M. Akinloye *, O.O. Adewumi

Department of Animal Production and Health, College of Animal Science, Federal University of Abeokuta, Abeokuta, Nigeria

Abstract

Cheeses were produced from cow and sheep milk using three different local coagulants of plant origin, namely: *Calotropis procera* leaf, *Carica papaya* leaf and lemon fruit. The objective of this study was to determine the yield, texture, dry matter, whey volume, pH and cuddling time of cheese made from the aforementioned materials. The results for both types of milk revealed no significant difference (P > 0.05) between the yield of cheese using *Calotropis procera* and *Carica papaya* extracts (25.60 % and 24.16 % - cow milk; 30.41 % and 29.66 % - sheep milk, respectively); but showed a significant difference (P < 0.05) in the yield of cheese processed with lemon juice (18.31 % - cow milk and 23.52 % - sheep milk). The result of the main effect revealed a higher significant difference (P < 0.05) in the yield and cuddling time of cheese made from sheep milk (27.86 %) over that of cow milk (22.69%). In both types of milk the cheese produced using lemon juice was harder and had a higher significant value of dry matter (P < 0.05) than those processed with *Calotropis procera* and *Carica papaya*. In conclusion, this study suggests that sheep milk and *Carica papaya* extract could be good alternatives to commonly used cow milk and *Calotropis procera* extract in the cheese making industry.

Keywords: Calotropis procera; Carica papaya; Lemon juice; Extract; Cheese; Coagulants; Milk

Cite this article as: Akinloye, A.M. and Adewumi, O.O. (2014), "Effects of local coagulants on the yield of cheese using cow and sheep milk", *International Journal of Development and Sustainability*, Vol. 3 No. 1, pp. 150-161.

* Corresponding author. *E-mail address:* adegoke_akinloye@yahoo.co.uk

1. Introduction

Cheese, a nutritious food is one of the numerous products from processing of milk of cows, goats, sheep, buffalos, camels and yaks. It is produced by coagulation of the milk protein known as casein (Scott, 1986). Basically, cheese is product processed from milk by acidification, coagulation and (Fox et al., 2000). The shelf-life of cheese which varies from 4 days to 5 years depends largely on variety. Thus, cheese is a form of milk that is solidified to preserve its valuable nutrients (O'Connor, 1993). Cheese, an excellent source of protein, fat, vitamins and minerals such as calcium, iron and phosphorus is therefore an important food in the diet of human, both young and old (O'Connor, 1993).

One of the key ingredients in cheese making is coagulant, and rennet which serves as coagulants from animal origin is the commonest coagulant used (Roseiro et al., 2003). To a large extent, the yield and quality of cheese is determined by the quality of milk and the type of coagulant used, and several plant preparations such as *Cynara cardunculus* (Vieira and Barbosa, 1972), sun flower (Aworth and Muller, 1987), pineapple (O'Connor, C.B., 1993) and so on, have been used to clot milk (Domingos et al., 1997; Edwards and Kosikowski, 1983; Gupta and Eskin, 1997; Padmanabhan et al., 1993; Pozsar et al., 1969; Singh et al., 1973; Tamer, 1993).

In recent development, it has been observed 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 engineer food, of which the Germans and the Dutch for example, forbid the use of recombinant calf rennet (Roseiro et al., 2003).

In Nigeria and many parts of West Africa, the traditional cheese makers who are mostly *Fulanis* use *Calotropis procera* (Sodom apple, which is known as *ewe bomubomu* among Yorubas and *tumfafia* in Hausa language) extract as coagulant for cheese making. This leaf contains an organic acid called *calotropin* which has the ability to solidify/coagulate milk (Aworth and Muller, 1987). Other importance of Sodom apple include the use of the flowers and other parts of the plant to cure cold, coughs, catarrh, asthma, stomach pains, headaches and so on (Abbas et al., 1992). It is interesting to know however that despite the fact that *Calotropis procera* is very useful medicinally and in cheese making industry, it is not being cultivated commercially (Adetunji and Salawu, 2008). If *Calotropis procera* should therefore go into extinction or there is reduction in the population of the plant due to unfavourable weather, or there is higher demand because of its wide range of usefulness, or better still, if its other potentials and usefulness are discovered, there is definitely going to be a compulsion on cheese makers to source for alternative coagulants. It is therefore highly imperative to source for alternative (possibly better alternative) plants in West Africa that can be of suitable replacement for *Calotropis procera* should incase it becomes hard to get. A stitch in time saves nine.

2. Materials and Methods

2.1. Experimental site and materials

This research work was carried out in 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 Aboekuta, 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 also through hand milking from lactating West African Dwarf ewes at livestock farm, Federal University of Agriculture, Abeokuta, Nigeria.

2.2. Milk test (basic properties of milk)

The tests that were carried out on cow and sheep milk include: methylene blue reduction test, blue and red litmus paper test, pH, taste, smell and colour. The methylene blue reduction test was carried out by placing 1ml of methylene blue in a test tube, followed by the addition of 10 ml of milk and then covered with cotton wool. It was then placed in an incubator at 37^{0}C until the blue colour disappeared. The alkalinity and acidity of the test were done with the aid of litmus paper, while the sense organs of smell, sight and taste were used to judge the smell, colour and taste of the milk respectively.

2.3. 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 with equal volume of fresh clean water.

To prepare the Sodom apple extracts, fresh Sodom apple leaves were weighed, finely chopped by hand and thoroughly mixed with fresh clean water. The weight (g) of the leaves and the volume of water (mls) used were in ratio 1:1. After five minutes, the mixture was sieved to collect the extract and the volume of the extract and pH values were recorded. The extract was allowed to sediment for 72 hours inside a refrigerator. The supernatant of the extract 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.

2.4. Preparation of cheese

Fresh 3 liters (3000 mls.) of cow milk and 3 liters (3000 mls.) of sheep milk were each divided into three equal portions (i.e. 1000 mls.) and poured into six different metallic pots which were labeled A1-SA, A1-CP, A1-LJ, B1-SA, B1-CP and B1-LJ (A1- Cow milk, B1- Sheep milk, SA- Sodom apple, CP- *Carica papaya, LJ- Lemon juice).* 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 ^{o}C. 100 ml of Lemon juice and leaf extract (supernatant) prepared from *Calotropis procera* and *Carica papaya* were added separately to the warmed milk. With intermittent stirring heating continued until boiling point and the time the clotting began in each experiment was recorded. The heating of the curds was maintained at boiling point for about 10 minutes until it fully coagulated and there were visible separation of cheese and whey. The loose cords 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 weights (yields) of the different solidified cords/cheese were taking with electrical weighing scale. 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 Pots A1-SA; A1-CP and A1-LJ
Fresh sheep milk (1 liter each) in pots B1-SA; B1-CP and B1-LJ
Heat to 50 ^{o}C (coagulating point)

⇩

Add coagulants and stir intermittently
Add SAE into pot A1-SA; CPE into pot A1-CP and LJE into A1-LJ
Add SAE into pot B1-SA; CPE into pot B1-CP and LJE into B1-LJ

⇩

Heat the mixture to 95 ^{o}C until cord formation
(Separation of cheese curds and whey)

⇩

Whey drainage and molding
(Weigh fresh cheese to determine yield)

⇩

Oven dry at 70 ^{o}C
(Weigh dried cheese to determine dry matter)

A1- Cow milk; B1- Sheep milk; SA - Sodom apple; CP - Carica papaya; LJ- Lemon juice
SAE- Sodom apple extract; CPE- Carica papaya extract; LJE- Lemon juice extract

Figure 1. Flow chart showing process of cheese making

2.5. Determination of yield, dry matter and moisture content

The quantity of cheese produced from each experiment was weighed with electric weighing scale and recoded as yield. Yield percentage was calculated as shown in the Table below. To determine the moisture content and dry matter, the weight of each sample of fresh cheese was taken and recorded before oven-dry. All the samples were dried at 70 ^{o}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 content and dry matter.

$$\% \text{ of cheese yield} = \frac{\text{grams of cheese produced}}{\text{grams of milk used}} \times 100 \qquad (1)$$

2.6. Experimental design and statistical analysis

All the data generated were subjected to a two - way analysis of variance using 2 X 3 (2 animal species - cow and sheep milk; and 3 coagulant type - *Calotropis procera, Carica papaya* and lemon juice). Factorial arrangement was in a completely randomized design and the significant different means were separated with Duncan's Multiple Range Test of SAS (2005) package.

Table 1. Milk quality test

Parameters	Cow milk	Sheep milk
pH	6.56	6.63
Taste	Slightly sweet	Slightly sweet
Colour	Creamy white	Creamy white
Smell	Aromatic flavour	Butter aromatic flavour
Litmus paper	Turn blue to faint red , turn red to faint blue	Turn blue to faint red , turn red to faint blue
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 extracts (mls)	Percentage of extract	PH	Colour
Calotropis Procera	744.00	744^a	666^a	89.52^a	6.83^a	Green
Carica papaya	744.00	744^a	564^c	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 cheese yield, dry matter, cuddling time and pH

FACTOR	Milk weight (g)	Cheese weight (g)	Cheese Yield (%)	Dry matter (%)	Cuddling time (s)	pH
Animals species						
Cow	1015.87[b]	230.34[b]	22.69[b]	44.46	437.33[b]	6.10[b]
sheep	1026.68[a]	286.12[a]	27.86[a]	47.37	545.22[a]	6.19[a]
SEM	0.01	12.18	1.19	1.78	79.78	0.02
Coagulants						
Calotropis Procera	1021.27	286.27[a]	28.01[a]	40.92[b]	594.83[b]	6.53[a]
Carica papaya	1021.28	274.99[a]	26.91[a]	46.20[a]	700.83[a]	6.40[b]
Lemon juice	1021.27	213.44[b]	20.92[b]	50.63[a]	178.17[c]	5.50[c]
SEM	2.42	13.70	1.28	1.56	24.31	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 4. Interaction effect of animal species and coagulants on cheese yield, dry matter, cuddling time and pH

Animals species	Coagulants	Milk weight (g)	Cheese weight (g)	Cheese Yield (%)	Dry matter (%)	Cuddling time (s)	pH
Cow	*Calotropis Procera*	1015.87[b]	260.11[b]	25.60[b]	40.02[c]	523.67[d]	6.47[b]
	Carica papaya	1015.87[b]	245.45[b]	24.16[b]	45.34[bc]	617.00[c]	6.37[b]
	Lemon juice	1015.87[b]	185.45[c]	18.31[c]	48.04[ab]	171.33[f]	5.47[c]
sheep	*Calotropis Procera*	1026.68[a]	312.42[a]	30.41[a]	41.82[bc]	666.00[b]	6.6[a]
	Carica papaya	1026.68[a]	304.52[a]	29.66[a]	47.07[abc]	784.68[a]	6.43[b]
	Lemon juice	1026.67[a]	241.44[b]	23.52[b]	53.22[a]	185.00[e]	5.53[c]
SEM		1.31	10.75	1.03	1.28	56.86	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

Table 5. Main effect of animal species and coagulants on whey volume

FACTOR	Whey Volume(mls)	Whey weight (g)	Whey yield (%)
Animals species			
Cow	745.78[a]	760.44[a]	74.58[a]
Sheep	637.78[b]	650.89[b]	63.78[b]
SEM	11.58	11.58	1.16
Coagulants			
Calotropis Procera	666.50[b]	676.17[b]	66.65[b]
Carica papaya	679.50[b]	699.67[b]	67.95[b]
Lemon juice	729.33[a]	741.17[a]	72.93[a]
SEM	25.51	25.81	2.55

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).

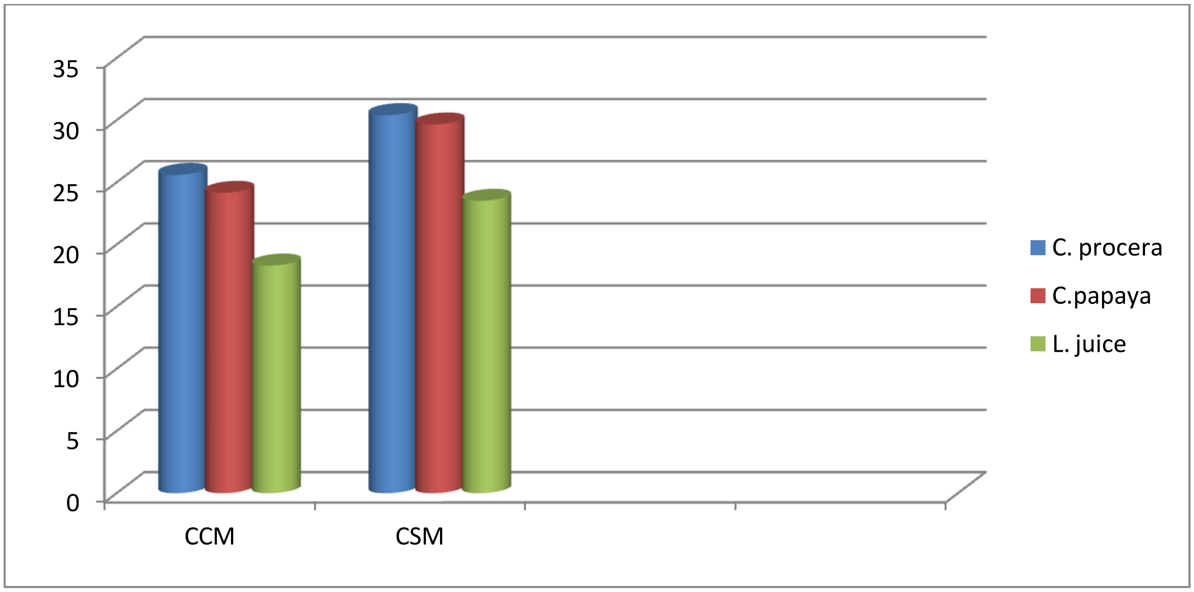
SEM- Standard Error of Mean

Table 6. Interaction effect of animal species and coagulants on whey volume

Animals species	**Coagulants**	Whey Volume (mls)	Whey weight (g)	Whey yield (%)
Cow	*Calotropis Procera*	724.67[b]	737.67[b]	72.47[b]
	Carica papaya	734.33[b]	749.33[b]	73.43[b]
	Lemon juice	778.33[a]	794.33[a]	77.83[a]
sheep	*Calotropis Procera*	608.33[d]	614.67[d]	60.83[d]
	Carica papaya	624.67[d]	650.00[cd]	62.47[d]
	Lemon juice	680.33[c]	688.00[c]	68.03[c]
SEM		15.33	15.49	1.53

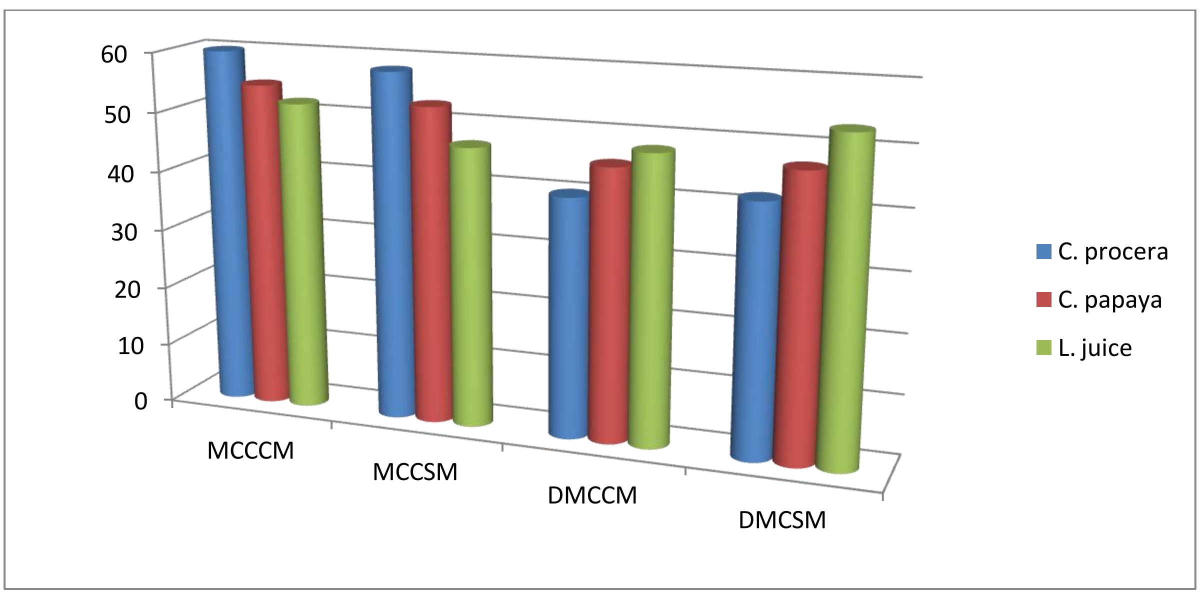
Values represent mean of triplicate readings. Values with the different superscript along the same columns are significantly different (P < 0.05); values with similar superscript are not significantly different (P > 0.05).

SEM- Standard Error of Mean



CCM- Cheese from cow milk; CSM- Cheese from sheep milk

Figure 2. The yield (%) of cheese processed from cow and sheep milk using three different coagulants



MCCCM - Moisture content of cheese made from cow milk
MCCSM - Moisture content of cheese made from sheep milk
DMCCM - Dry matter of cheese made from cow milk
DMCSM - Dry matter of cheese made from sheep milk

Figure 3. Moisture content and dry matter of cheese (%) processed from cow and sheep milk using three different coagulants

3. Results

The results in Table 1 show that the pH of sheep milk (6.63) was slightly higher than that of cow milk (6.56). This is 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 in 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. As shown in Table 2, the pH values of *Calotropis procera*, *Carica papaya* and Lemon juice extract were 6.83, 6.73 and 2.17 respectively.

The results in Table 3 show that there was no significant difference ($P > 0.05$) between the yield of *Calotropis* procera*, and Carica papaya processed cheese for both types of milk*. However, the yield of cheese from both types of milk using *Calotropis procera* and *Carica papaya* extracts were significantly higher ($P < 0.05$) than the yield of lemon processed cheese. The dry matter and moisture content of the cheese made from the two types of milk using the three different coagulants were significantly different from one another ($P < 0.05$). Similarly, the cuddling time in this study indicated that all the recorded values were significantly different ($P<0.05$). 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.

The interaction effects as shown in Table 4 and Figure 2, indicate that the yield of cheese made from sheep milk using *Calotropis procera* extract had the highest value (30.41 %), while cheese made from cow milk using lemon juice extract had the lowest value (18.31%). As shown in Figure 3, cheese processed from sheep milk using lemon juice extract had the highest dry matter content (52.22 %), while *Calotropis procera* processed cheese from cow milk had the lowest dry matter content (40.02 %). The moisture content was highest in *Calotropis procera* cheese made from cow milk (59.98 %) and lowest in lemon processed cheese made from sheep milk (47.78 %). The cuddling time was fastest in cow milk when lemon juice was used (171.33 sec.) and slowest in sheep milk when *Carica papaya* extract was used (784.67 sec). The pH value of cheese made from sheep milk using *Calotripis procera* extract was the highest (6.6), while that of cheese made from cow milk using lemon juice had the lowest pH value (5.47).

Table 5 shows that the volume and weight of whey extracted from cow milk using lemon juice extract were significantly difference ($P < 0.05$) when compared with those obtained in *Calotropis procera and Carica papaya* extracts. Similar trend was observed in the whey extracted from sheep milk. The interaction effect in Table 6 shows that whey extracted from cow milk using lemon juice had both the highest volume (778. 33 mls.) and the highest weight (794.33g), while the whey extracted from sheep milk using Calotropis procera extract had the lowest volume (608.33 mls.) and lowest weight (614g).

4. Discussion

The yield obtained from *Calotropis procera* cow cheese (25.59%) in this study was higher than the average yield suggested by O' Connor (1993), which was 20%; but lower than the one reported by Omotosho *et al*. (2011), which was 32.75%. The variation in values between the results obtained in this study and those of

Omotosho et al.(2011) and O' Connor (1993), could be as a result of the supernatant of the *Calotropis procera* that was used in this experiment instead of the raw extracts that were used by the other authors. The higher values of yield obtained in the cheese made from sheep milk when compared with that of cow milk may possibly be due to the fact that sheep milk has higher total solid fat and protein content than cow milk (George, 2001). There was no significant difference in the yield of *Calotropis procera* processed cheese and *Carica papaya* processed cheese for both cow and sheep milk. This suggests that with respect to yield as observed in this study *Carica papaya* extract could compete favourably well with *Calotropis procera* extract as coagulant of plant origin. On the contrary, lemon juice may not compete favourably well with *Calotropis procera* and *Carica papaya* extracts because the yield of cheese produced by using lemon juice extract were significantly lower than the other 2 coagulants. The results in this study showing moisture content of different cheese using different coagulants do not agree with the reports of Adetunji and Salawu (2008), that reported that the moisture content of *Carica papaya* processed cow cheese was higher than *Calotropis procera* cow cheese. However, the percentage of the moisture content of *Calotropis procera* cow cheese reported by these authors (61.70%) and the results of this project (59.98 %) were approximately the same. Adegoke *et al*. (1992), gave a similar close value of 61.7 % of *Calotropis procera* processed soft cheese obtained from Oyo in Nigeria, while Omotosho et al. (2011), reported 51% moisture content in their results. All the above reported values were lower than the 70.75% reported by Alalade and Adeneye (2006). These differences may be attributed to different processing methods adopted by these scientists. The differences could also be due to variation in the quantity of coagulants used. Furthermore, the variation in moisture content of the cheese could also be attributed to the coagulating strength (i.e. concentration of enzymes responsible for coagulation) of the leaves of the plants which were obtained at different times, of different species, from different locations and whose extracts were obtained through different methods and environment. It must be noted however that higher moisture content is not preferred because it could favour the growth and proliferation of microorganism, thus reduces the shelf - life of cheese (Adegoke et al., 1992).

Cheese processed with lemon juice gave the highest dry matter and lowest moisture content, while cheese processed with *Calotropis procera* extract gave the lowest value of dry matter content but highest moisture content in both types of milk . This could be attributed to the coagulating strength of the coagulants. The differences differences in the volume of whey is also complementary indication that the coagulating strength of the extracts used were different. The coagulant that produced the highest volume of whey (Lemon juice) could be said to have the strongest coagulating ability. Apart from the coagulating strength of the coagulants which determine to a large extent the yield of cheese and whey volume, it could also be explained that higher volume of whey which was extracted from cow milk buttresses the finding of Worthington (2009), who said that cow milk has a higher volume of water than sheep milk (Worthington, 2009).

The variations that were observed in the cuddling time during the processing line of cheese could as well be attributed to the strength/concentration of the coagulating enzymes that were present in the different types of the extracts used.

The highest pH value which was recorded for cheese made from sheep milk using *Calotropis procera* extract and the lowest pH value recorded for cheese made from cow milk using lemon juice was a reflection of the differences in pH values of the two types of milk in addition to the interaction effect between the pH of the coagulants (extract) and that of the milk during processing. The pH of cheese produced using *Calotropis procera* extract in this study is in agreement with the range values (5.70 - 6.90) reported by Adegoke *et al*. (1992).

In conclusion, it was established from this study that the supernatant extracts could be used as coagulants instead instead of raw extracts. *Carica papaya supernatant extracts* can be an alternative coagulant in cheese production because in term of yield and dry matter it competed favourably with the commonly used *Calotropis procera* extract. Further study may be required in order to improved on the yield of cheese using lemon lemon juice as coagulant, which has advantages of producing cheese with highest dry matter content and fastest cuddling time when compared with *Calotropis Procera* and *Carica papaya* extracts. Even though the quantity of sheep milk available for cheese making industry is small compared with cow milk which is known to supply vast majority of milk used for commercial production and consumption (Worthington, 2009), nevertheless the use of sheep milk in cheese production should be encouraged owing to the fact that it is better than cow milk with respect to yield, dry matter, nutritive value and cuddling time. Commercial small ruminant production should therefore be encouraged in West Africa. Another advantage of sheep milk is that it can be frozen and stored until a sufficient quantity of milk is available to sell or make cheese. Freezing does not affect the cheese making qualities of sheep milk (George, 2001).

More studies still need to be carried out to ascertain the exact/actual volume of *Calotropis procera* and *Carica papaya* supernatant extracts that could give the best yield of cheese in term of quality and quantity.

Acknowledgement

I acknowledge the efforts of Dr. (Mrs.) Ojo, Department of Pasture and Range Management, College of Animal Science, Federal University of Abeokuta, Abeokuta, Nigeria.

References

Abbas, B., El–Tayeb, A.E. and Sulleiman, Y.R. (1992), "*Calotropis procera*: feed potential for arid zones", Veterinary-Record, Vol. 131 No. 6, pp. 132.

Adegoke, G.O., Nse, E.N. and Akanni, O.O. (1992), "Effects of heat , processing time and pH on the micro- flora, aflatoxin content and storability of '*wara'*, a soft white cheese", *Die Nahrung,* Vol. 36, pp. 259 – 264.

Adetunji, V.O. and Salawu, O.T. (2008), "West African soft cheese 'wara' processed with *Calotropis procera* and *Carica papaya*: A comparative assessment of nutritional values, *International Journal of Dairy Science,* Vol. 6 No. 1, pp. 58 – 65.

Alalade, O.A. and Adeneye, J.A. (2006), "The effect of storage period on the chemical composition and coliform microflora of 'wara' cheese", *International Journal of Dairy Science, Vol.* 1 No. 2, pp. 126 - 130.

Aworth, O.C. and Muller, H.G. (1987), "Cheese making properties of vegetable rennet from Sodom apple (*Calotropis procera*)", *Food Chemistry journal, Vol.* 26 pp. 71-79.

Domingos, A., Avaria. F., Sousa, M.J., Malcata, F.X., Clemente, A., Brodelius, P. and Pais, M.S. (1997), "Degradation of caseins by purified extracts of Centaurea calcitrapa", Poster presented at 8th European *Congress on Biotechnology, Budapest, Hungary.*

Edwards, J. and Kosikowski, F.V. (1983), "Bitter compounds from Cheddar cheese", *Journal of Dairy Science,* Vol*.* 66, pp. 727-734.

Fox, P.F., Guinee, T.P., Logan, T.M. and Sweeney. P.L.H. (2000), "Fundamentals of cheese science", Aspen Publisher, Inc. Gaithersburg, MD.

George, F.W. (2001), "The nutritional value of sheep milk", *Sheep 101 info*., pp. 1-2

Gupta, C.B. and Eskin, N.A. (1997), "Potential use of vegetable rennet in the production of cheese", *Food Technology,* Vol. 5, pp. 62-66.

Omotosho, O.E., Oboh, G. and Iweala, E.E.J. (2011), "Comparative effects of local coagulants on the nutritive value, in vitro digestibility and sensory properties of '*wara*' cheese", *International Journal of Dairy Science,* Vol. 6 No.1, pp. 58 - 65.

O'Connor, C.B. (1993), "Traditional cheese making", *ILCA manual (International Livestock Centre for Africa), Addis Ababa, Ethiopia*, pp. 24.

Padmanabhan, S. Chitre, A, and Shastri, N.V. (1993), "Milk clotting protease isolated from Dieffenbachia maculate", *Die Nahrung,* Vol. 37, pp. 99-101.

Pozsar, H.K., Vamos, V.L., Nonn, S.H. and Hegedues, V.E. (1969), "Investigation of milk clotting enzymes from the point of view of cheese production -Selective inhibition of the proteolytic activity of plant proteases", *Elelmiszertudomany,* Vol. 3, pp. 55-70.

Roseiro, L.B., Barbosa, M., Ames, J.M. and Wilbey, R.A. (2003), "Cheese making with vegetable coagulants - the use of *Cynara* L. for the production of ovine milk cheeses", *International Journal of Dairy Technology,* Vol. 56 No. 2, pp. 76 - 85.

Scott, R. (1986), "Cheese making practice", 2nd Edition, *Elservier Applied Science Publisher, London,* pp. 529.

Singh, J., Chander, H., Bhalerao, V.R. and Dastur, N.N. (1973), "Studies on vegetable rennet from from Withania coagulants", *Journal of Food Science and Technology, India,* Vol. 10, pp. 16-19.

Tamer, I.M. (1993), "Identification and partial purification of a novel milk clotting enzyme from *Onopordum turcicum*", *Biotechnology Letters,* Vol. 15, pp. 427-432.

Vieira, S.F. and Barbosa, M. (1972), "Cheese-making with vegetable rennet from cardo- '*Cynara cardunculus' ", Journal of Dairy Research. Vol.* 39, pp. 335-343.

Worthington, R.B. (2009), "Milk", *Microsoft Encarta Encyclopedia*, 2009 edition.