NUTRITIONAL QUALITY OF SOFT CHEESE MADE FROM MILK OF WEST AFRICAN DWARF (WAD) DOES FED GUINEA GRASS (*PANICUM MAXIMUM*) SUBSTITUTED WITH LEAVES OF MULBERRY (*MORUS ALBA*)

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ABSTRACT

The aim of this study was to evaluate the quality of cheese made from milk of West African Dwarf (WAD) does fed diets containing guinea grass (Panicum maximum) substituted with leaves of mulberry (Morus alba) at varying levels. Sixteen lactating does of weight range between 15 to 19 kg were used for this experiment. The animals were divided into four groups consisting of four animals per group in a completely randomized design. The experiment lasted for eight weeks in which milk was collected from the animals and was used to produce cheese. The yield of cheese increased from 15.60 – 18.00% with increased M. alba leaves. Values ranged from 6.11 – 6.78 pH, 0.13 – 0.18% total titratable acidity, total solids declined from 28.79% in the control sample to 30.96% at 50% M. alba leaves proportion substituted cheese sample. Proximate composition of cheese was also influenced by increased substitution level of M. alba leaves in the diets of the does whose milk were used in the production of the cheese sampled. Moisture, protein, ash, and fat contents of cheese ranged from 69.04 – 71.21%, 11.59 – 18.89%, 1.08 – 2.15% and 1.43 – 1.98% respectively. There were significant differences (p<0.05) in mineral contents of cheese. Microbial analysis showed that the product was safe for consumption. Feeding of M. alba did not have any negative effect on the cheese produced from milk obtained from WAD goats.

Keywords: *Morus alba*, *Panicum maximum,* WAD goat milk cheese, Mineral composition, Proximate composition

INTRODUCTION

Goats are multifunctional animals and play an important role in the economy and nutrition of small farmers in most developing countries (Khan *et al*., 2007). Cattle are known to be the major source of global milk supply. Nevertheless, in Nigeria the milk production by local cattle breeds have been reported to be low due to poor quality, insufficient feeds, and feedstuffs especially during the dry season (Olafadehan and Adewumi, 2010). Milk can be obtained from other animals such as goat and sheep (Elbagermi *et al*., 2014). Goat milk is sweet, nourishing and medicinal than cow milk (Ojoawo and Akinsoyinu, 2014). The substance found in milk provides both energy and the building materials necessary for growth and development (Mahmood and Usman, 2010) for both young and old mammals.

Cheese can be defined as a solid milk product obtained from milk of cow, goat, sheep and other mammals obtained by curdling the milk using rennet addition, acidification, or a combination of rennet and acidification methods (Ogunleke *et al.*, 2015). Cheese production has been found to be one of the methods used in preserving and conserving the valuable nutrients in milk (Ibhaze, 2018) and serve as an excellent source of protein, fat, minerals, vitamins and essential amino acids. It has been reported by Beresford *et al.* (2001) that the most important ingredients in cheese making are milk and coagulants. The general principle involved in cheese manufacturing is heat treatment of milk, addition of starter or coagulant, and removal of whey as reported by Kelly *et al.* (2008) and FoodFaq (2022). Goat milk cheese provides a good source of protein for people in several countries (Seifu *et al.*, 2004) and was also used as a mode of preservation of milk by the nomadic Fulani women of Nigeria. Just a few majorities of Nigeria's population consume the cheese made from goat milk due to limited supply of raw goat milk and the unawareness of the nutritional benefits of the milk gotten from goat and its product, therefore, there is need to create awareness and meet up with protein demand of the people.

The coagulants used for 'wara' processing in Nigeria include the leaves and stem extracts of some plants. Among such are *Calotropis procera* W. T. Aiton (Gentianales: Apocynaceae) commonly called the apple of Sodom, *Carica papaya* L. (Brassicales: Caricaceae), *Moringa* Lam. (Brassicales: Moringaceae) seed, lime, lemon, mango fruit, pineapple juice, and latex of some plants of the Euphorbiaceae family (Olorunnisomo and Ibhaze, 2010; Oladipo and Jadesimi,, 2012; Mahajan and Chaudhari, 2014; Adewumi and Akinloye, 2015). Islam *et al.* (2009) stated that milk and milk products are highly susceptible to a variety of micro-organisms because of their high nutritive value. Adetunji *et al.* (2003) also reported that milk and milk products are also good medium for growth and transmission of several micro-organisms to humans. Due to the high consumption rate of soft cheese and in view of the way cheese is produced in Nigeria, there was need to determine the microbial quality which will be of greatest public health importance (Ogbolu *et al.*, 2014).

In most mulberry growing countries, mulberry foliage is used in feeding silkworms (Andallu *et al.*, 2014). Its leaf is also used for feeding cattle, goat and other animals including humans as it is highly nutritious and palatable to herbivorous animals (Sánchez-Salcedo *et al.*, 2017). The leaves have been reported to have high protein content (Adeduntan and Oyerinde, 2010; Venkatesh *et al.*, 2015) with negligible anti-nutritional factors (Venkatesh *et al.*, 2015). *Panicum maximum* Jacq. (Poales: Poaceae) is one of the most important grass in the tropics and is highly palatable to ruminant animals (Lawal-Adebowale, 2012).

The thrust of this study was to evaluate the nutritional quality of soft cheese precipitated with *C. procera* leaf extract, from fresh milk of goat fed guinea grass (*P. maximum*) substituted with leaves of mulberry (*Morus alba* L., Rosales: Moraceae).

MATERIALS AND METHODS

Description of Study Areas: The experiment was carried out at the Goat Unit, Teaching and Research Farm of the Federal University of Technology, Akure (FUTA), Ondo State, Nigeria, located on longitude 4.944055°E and 5.82864°E, and latitude 7.491780°N with annual rainfall ranging between 1300 mm and 1650 mm, maximum and minimum daily temperature of 38°C and 27°C respectively (Daniel, 2015).

Cheese production was carried out in the Nutrition Laboratory of the Department of Animal Production and Health, Federal University of Technology, Akure, Ondo State, Nigeria.

Procurement of Experimental Materials: Fresh mulberry (*M. alba*) leaves were collected from Ondo State Ministry of Agriculture Sericulture Centre, Akure while fresh *P. maximum* was sourced from the pasture within the FUTA campus. The experimental concentrate was formulated from dried crushed cassava-peel with other feed ingredients. Fresh goat milk was obtained through hand milking from lactating West African Dwarf goats at the livestock farm, Federal University of Technology, Akure, Ondo State, Nigeria. The coagulum (*C.*

procera) was sourced in Akure, Ondo State, Nigeria

Experimental Animal, Management, and Experimental Design: Sixteen (16) lactating WAD does of 2 years and weight of 17.00 ± 2.00 kg were used in this study. The goats were randomly distributed into four treatment groups of four goats per replicate using the completely randomized experimental design and each experimental diet was offered *ad libitum* and the concentrate was given at a constant rate (350 g/day). Freshwater was offered a*d libitum*. Four diets A, B, C and D were made to contain 75% *P. maximum* + 25% *M. alba* (P75M25), 50% *P. maximum* + 50% *M. alba* (P50M50), 25% *P. maximum* + 75% *M. alba* (P25M75) and 100% *M. alba* (P0M100) respectively.

Preparation of Cheese: The clarified raw goat milk (250 mL each) from each treatment was poured into four stainless steel pots and heated to a temperature of 50°C on a low-intensity burner and stirred intermittently. 25 grams of the *C. procera* leaf was washed and squeezed into the warm milk and heating of the milk continued with intermittent stirring until the milk formed into curds. The curds were poured into a sieve of 0.2 mm to drain out the whey. The curd formed was placed inside the muslin cloth and a weight of 500 g was placed on it for 30 minutes to expel more whey. The flow diagram for the cheese production is shown in Figure 1.

pH Determination: pH was determined using pH meter (Hanna instruments). 1.0 g of the cheese was dissolved in beaker containing 10 ml of distilled water and stirred. The electrode of the pH meter was dipped into the beaker and readings were obtained from the photodetector on the pH metre.

Determination of Peroxide Value of the Cheese: Peroxide value of the cheese was determined by titrimetric method of Siddique and Park (2018).

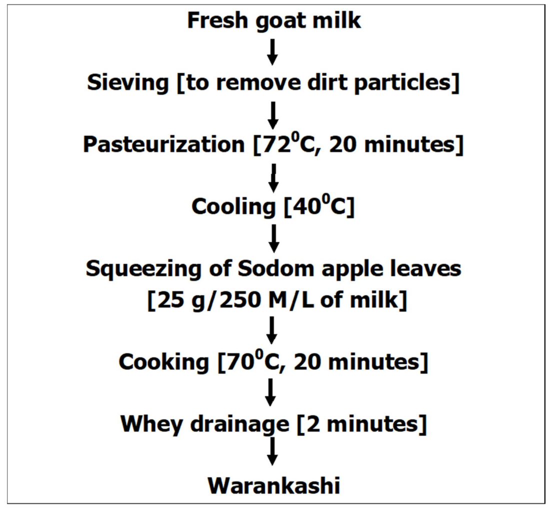

Figure 1: The flow diagram for cheese production (modified from Adetunji and Babalobi, 2011)

Determination of Total Titratable Acidity (TTA): TTA was determined according to the procedure of AOAC (2005). About 10 g of the sample was dissolved in 30 ml of distilled water in a beaker and stirred. The mixture was filtered into 100 ml standard volumetric flask. The filtrate was made up to 100 ml. A 10 ml sample of the filtrate was pipetted into a beaker and 1 drop of phenolphthalein was added. The mixture was titrated against standard 0.01 N sodium hydroxide solution until light pink colour was attained. The reading of the burette was recorded. TTA = N (NaOH) x titre value x lactic acid value x dilution factor x 100 / 10, where N = Normality of NaOH (0.01), Lactic acid value = 0.09 and Dilution factor = 10

Cheese Yield: The yield of cheese was calculated using the formula: Yield = $(W_1 \times 100) / (W_2 + W_3)$ as described by (Mahajan and Chaudhari, 2014). Where, W_1 was the weight of the cheese prepared, W_2 was the weight of the milk and W_3 was the weight of the coagulant used.

Proximate Composition of Cheese: Moisture, fat, protein, ash, were determined according to the procedure of AOAC (2005).

Mineral Determination: The analysis of minerals was done according to the procedure of AOAC (2005).

Microbiological Quality of Cheese: The method of Haddad and Yamani (2017) was employed. Exactly 1.0 g of the cheese was aseptically weighed and carefully introduced into 9.0 ml of sterile distilled water. This was shaken manually to have a homogenous suspension. One (1) ml of this was taken and introduced into the second tube followed with series of dilutions up to 10-2 dilutions. 1ml was taken from 10-2 dilution and pour plated on: (a) Nutrient Agar and incubated at temperature 37^{o}C for 48 hours; (b) MacConkey Agar was used for the enumeration of total coliform organisms in the sample, the plates were incubated at temperature 35^{o}C for 48 hours, while (c) Sabouraud Dextrose Agar was used for the enumeration of mould and yeast in the samples. The plates were incubated at temperature 30^{o}C for 24 hours for yeasts and 3 days for mould. Microbial counts were calculated as follows: DF x N / W, where DF = dilution factor, N = number of colonies and W = weight of sample used.

Statistical Analysis: The experimental design was completely randomized design. Data obtained were subjected to one-way analysis of variance and significant means were separated using Duncan's multiple range tests using SPSS (2017).

RESULTS

Physicochemical Properties of Cheese: The physicochemical composition of soft cheese produced from the milk of WAD does using *C. procera* as the coagulant indicated that there were significant differences ($p<0.05$) in TTA, pH, total solids, peroxide value, and yield among the cheese produced (Table 1). pH was significantly ($p<0.05$) higher (6.78) in cheese produced from the milk of goat fed 25% *M. Alba,* while the highest total solid and TTA values were 30.96 and 0.18% respectively in cheese produced from the milk of goat fed 50% *M. alba*.

The peroxide value of the cheese made from milk of goats fed 100% *M. alba* was the highest at 1.68 meqO_2/kg, while cheese produced from milk of goats fed 25, 50 and 75% *M. alba* leaves were 1.48, 1.43 and 1.58 meqO_2/kg respectively. Solid non fat was highest (29.52) in cheese produced from milk of goats fed 75% *M. alba leaves* and least (27.40) in cheese made from milk of goats fed 100% *M. alba* leaves.

Proximate Composition of Goat Milk Cheese: The percentage proximate composition of cheese produced using milk obtained from WAD does indicated that the peak value of moisture (71.21%) was recorded in cheese produced using milk of goat fed 100% *M. alba*. The moisture content of cheese ranged from 69.04 to 71.21%. Ash content of the cheese was higher (2.15%) in cheese made from milk obtained from goats fed 75% *M. alba* leaves but was the least (1.08%) in cheese made from milk obtained from goats fed 25% *M. alba* leaves (Table 2).

The highest value of fat (1.98%) was recorded in cheese made from milk obtained from goats fed 100% *M. Alba,* while the cheese produced from milk obtained from goats fed 25% *M. alba* leaves recorded the least (1.43%) value of fat. Protein was significantly high ($p<0.05$) in cheese produced using milk of goat fed 100% *M. alba* leave*s* with value of 18.89%, while 14.55 and 13.62% were recorded in cheese made from milk obtained from goats fed 75 and 25% *M. alba* leaves respectively (Table 2).

Lactose was highest in cheese made from milk obtained from goats fed 25% *M. alba* leaves with value of 16.37%, while cheese made from milk obtained from goats fed 100% *M. alba* leaves had the lowest value of lactose (Table 2).

Mineral Composition of Goat Milk Cheese: The results of the mineral compositions of cheese produced using milk obtained from WAD does fed guinea grass (*P. maximum*) substituted with leaves of mulberry (*M. alba*) is presented in Table 3. The result showed that there was significant difference ($p<0.05$) in mineral elements evaluated. Calcium and phosphorus content was significantly higher ($p<0.05$) in cheese produced from milk of goats fed 100% *M. alba* leaves with recorded values of 0.25 and 0.27% respectively.

Table 1: Physicochemical composition of cheese made from milk of WAD does fed guinea grass (*Pannicum maximum*) substituted with mulberry (*Morus alba*) leaves

Parameters	Samples			
	ML25	ML50	ML75	ML100
pH	6.78 ± 0.02^{a}	6.13 ± 0.02^{b}	6.12 ± 0.02^{b}	6.11 ± 0.02^{b}
Yield (%)	17.20 ± 0.02^{b}	15.60 ± 0.02^{c}	18.00 ± 0.02^{a}	18.00 ± 0.02^{a}
Total solid (%)	30.47 ± 0.02^{c}	30.96 ± 0.02^{a}	30.91 ± 0.02^{b}	28.79 ± 0.02^{d}
Total titratable acidity (%)	0.14 ± 0.02^{b}	0.18 ± 0.02^{a}	0.13 ± 0.02^{b}	0.14 ± 0.02^{b}
Peroxide Value (meqO_2/kg)	1.48 ± 0.02^{c}	1.43 ± 0.02^{d}	1.58 ± 0.02^{c}	1.68 ± 0.02^{a}
Solid Non Fat (%)	29.04 ± 0.02^{c}	29.37 ± 0.02^{b}	29.52 ± 0.02^{a}	27.40 ± 0.02^{d}

^{a,b,c,d} Means along the same column with different superscripts are significantly (p<0.05) different. ML25 = Cheese produced using milk of goat fed 75%Panicum maximum + 25% Morus alba (P75M25); ML50 = Cheese produced using milk of goat fed 50% Panicum maximum+ 50% Morus alba (P50M50); ML75 = Cheese produced using milk of goat fed 25% Panicum maximum + 75% Morus alba (P25M75); ML100 = Cheese produced using milk of goat fed 100% Morus alba (P0M100)

Table 2: Proximate composition of cheese made from milk of WAD does fed guinea grass (*Pannicum maximum*) substituted with mulberry (*Morus alba*) leaves

Parameters	Samples			
	ML25	ML50	ML75	ML100
Moisture (%)	69.53 ± 0.02^{b}	69.04 ± 0.02^{d}	69.09 ± 0.02^{c}	71.21 ± 0.02^{a}
Protein (%)	11.59 ± 0.02^{d}	13.62 ± 0.02^{c}	14.55 ± 0.02^{b}	18.89 ± 0.02^{a}
Fat (%)	1.43 ± 0.02^{d}	1.59 ± 0.02^{b}	1.51 ± 0.02^{c}	1.98 ± 0.02^{a}
Ash (%)	1.08 ± 0.02^{d}	2.15 ± 0.02^{a}	2.07 ± 0.02^{b}	1.98 ± 0.02^{c}
Lactose (%)	16.37 ± 0.02^{a}	13.60 ± 0.02^{b}	12.78 ± 0.02^{c}	6.53 ± 0.02^{d}

^{a,b,c,d} Means along the same column with different superscripts are significantly (p<0.05) different. ML25 = Cheese produced using milk of goat fed 75%Panicum maximum + 25% Morus alba (P75M25); ML50 = Cheese produced using milk of goat fed 50% Panicum maximum+ 50% Morus alba (P50M50); ML75 = Cheese produced using milk of goat fed 25% Panicum maximum + 75% Morus alba (P25M75); ML100 = Cheese produced using milk of goat fed 100% Morus alba (P0M100)

Table 3: Mineral composition of cheese made from milk of WAD does fed guinea grass (*Pannicum maximum*) substituted with mulberry (*Morus alba*) leaves

Parameters	Samples			
	ML25	ML50	ML75	ML100
Calcium (%)	0.20 ± 0.02^{b}	0.23 ± 0.02^{ab}	0.20 ± 0.02^{b}	0.25 ± 0.02^{a}
Phosphorus (%)	0.15 ± 0.02^{c}	0.20 ± 0.02^{b}	0.23 ± 0.02^{b}	0.27 ± 0.02^{a}
Magnesium (%)	0.15 ± 0.02^{c}	0.18 ± 0.02^{bc}	0.20 ± 0.02^{b}	0.25 ± 0.02^{a}
Potassium (%)	0.16 ± 0.02^{c}	0.20 ± 0.02^{b}	0.24 ± 0.02^{a}	0.24 ± 0.02^{a}
Sodium (%)	0.09 ± 0.02^{b}	0.12 ± 0.02^{ab}	0.14 ± 0.02^{a}	0.15 ± 0.02^{a}

^{a,b,c,d} Means along the same column with different superscripts are significantly (p<0.05) different. ML25 = Cheese produced using milk of goat fed 75%Panicum maximum + 25% Morus alba (P75M25); ML50 = Cheese produced using milk of goat fed 50% Panicum maximum+ 50% Morus alba (P50M50); ML75 = Cheese produced using milk of goat fed 25% Panicum maximum + 75% Morus alba (P25M75); ML100 = Cheese produced using milk of goat fed 100% Morus alba (P0M100)

The highest value of sodium (0.14 and 0.15%) was recorded in cheese made from milk obtained from goats fed 75 and 100% *M. alba* leaves respectively, while the cheese produced from milk obtained from goats fed 25% *M. alba* leaves substitution recorded the least sodium content (0.09%).

Microbial Analysis of Cheese: The result of the microbial load of goat milk cheese indicated significant difference (p<0.05) in the total bacteria counts of the cheese products. Microbial load in the cheese samples was low (Table 4).

DISCUSSION

The values obtained for pH of the cheese made from WAD does milk in this study (6.11 – 6.78) were within the range reported by Olorunnisomo and Ikpinyang (2012) for cheese precipitated with Sodom apple leaf extract,

Table 4: Microbial analysis of cheese made from milk of WAD does fed guinea grass (*Pannicum maximum*) substituted with mulberry (*Morus alba*) leaves

Parameters	ML25	ML50	ML75	ML100
Total coliform count (CFU/ml)	$3.00^{a} \times 10^{5}$	$2.50^{a} \times 10^{5}$	$1.80^{b} \times 10^{5}$	Nil
Organism identified	*Aeromonas* sp., *Salmonella* sp.	Nil	*Aeromonas* sp.	*Aeromonas* sp.
Total viable bacterial count (CFU/ml)	$2.50^{b} \times 10^{5}$	$2.00^{b} \times 10^{5}$	$1.80^{b} \times 10^{5}$	1.80×10^{5}
Organism identified	*Lactobacillus* spp., *Streptoccocus* spp.	*Lactobacillus* spp., *Streptoccocus* spp.	*Streptoccocus* spp.	*Lactobacillus* spp.
Total fungal count (CFU/ml)	$2.00^{c} \times 10^{5}$	$2.00^{b} \times 10^{5}$	$2.50^{a} \times 10^{5}$	1.80×10^{5}
Organism identified	*Aspergiillus* sp.	Nil	Nil	*Aspergiillus* sp.

[a,b,c,d] Means along the same column with different superscripts are significantly (p<0.05) different. ML25 = Cheese produced using milk of goat fed 75%Panicum maximum + 25% Morus alba (P75M25); ML50 = Cheese produced using milk of goat fed 50% Panicum maximum + 50% Morus alba (P50M50); ML75 = Cheese produced using milk of goat fed 25% Panicum maximum + 75% Morus alba (P25M75); ML100 = Cheese produced using milk of goat fed 100% Morus alba (P0M100)

pineapple fruit extracts, *Moringa* seed extract and lime fruit extract using cow milk. Also, the pH value of cheese produced in this study was within the range (4.98 – 7.44) reported by FoodFaq (2022) but higher than the values (6.36) obtained by Abiola *et al*., (2017). It can be deduced that cheese prepared in this study does not form at pH of 4.6 which was the isoelectric point of casein in the milk to get precipitated, which means that all the cheese made using Sodom apple leaf as the coagulant were enzymatic in nature and the proteolytic enzyme in Sodom apple made the cheese to be alkaline.

The yield (15.60 – 18.00%) obtained from *C. procera* leaves processed cheese in this study was comparable with 15 – 16% reported by Hayaloglu *et al*. (2017) when cow or goat milk was used, but lower than the values reported by (Oluwayemisi *et al*., 2017) when the same leaf was used as coagulants in the milk of sheep. The variation in values between the results obtained in this study and those of other researchers may be because of the Sodom apple leaves that were used in this experiment instead of the raw extracts that were used by the other author. Since milk coagulation may be achieved either by enzymatic activity or acidic reactions, it can be seen from this study that cheese yield obtained from Sodom apple leaves are higher which indicate that enzymatic activity produces more cheese (Olorunnisomo and Ikpinyang, 2012). It can be deduced from the findings that the percentage yield may depend on the available protein for curdling by enzyme following the report of Abdulkareem (2019). Thus, it can be said that increase in the amount of protein rich diets used in feeding the experimental animals that produces the milk used in the production of cheese may also lead to increase in the percentage yield of the cheese as seen in this research and in the findings of Adedokun *et al*. (2013). The total solids ranging from 28.79 – 30.96% respectively in this study were lower than 40.2% reported by Park (2010). The titratable acidity values range from 0.13 – 0.18% and were lower than the 0.67% and 1.20 – 1.28% lactic acid of cow milk cheese reported by Nazim *et al*. (2013) and Salih *et al*. (2020). This result is in agreement with the findings of Sulieman *et al*. (2012) who reported that cheese samples produced from cow milk has higher titratable acidity than those produced from goat milk and mixtures of both milk (0.23 and 0.13% for cow and goat milk in Mozzarella cheese respectively). The percentage of acid present in dairy products at any time is a rough indication of the age of the milk and the way in which it has been handled as reported by Igwegbe *et al*. (2015). It has also been reported by Adedokun *et al*. (2013) that changes in pH and TTA depend on the effects of cheese ripening and condition of storage after cheese production. The peroxide value of cheese obtained from milk of does fed the diets in the present study (1.43 – 1.68 meqO_2/kg) was less than 10 meqO_2/kg which is considered safe for human consumption (Sbihi *et al*., 2015).

Oluwayemisi *et al*. (2017) reported that higher moisture content will favour the growth and proliferation of microorganisms thus reduces the shelf-life of cheese as the moisture content is a measure of the water content and accounts for the texture of the cheese. Values obtained in this study were lower than 70.75% reported by Alalade and Adeneye (2010) except for the cheese made from milk of WAD does fed 100% *M. alba* leaves. These differences may be attributed to different processing methods adopted by the researchers, variations in the quality of coagulants used and the coagulating strength of the plants used. The protein values of 11.59 – 18.89% observed in this study were in comparison with 18.9% reported by Park (2010), but higher than 12.86% and 12.94 – 14.49% reported by Uaboi-Egbenni *et al*. (2010) and Elijah *et al*. (2020) respectively but lower than the values obtained by Oluwayemisi *et al*. (2017). This variation in high protein content of the samples in this study may be attributed to protein content in the diets which might have migrated into the milk and cheese samples. This result also showed that plant proteins should be encouraged in cheese production, as its consumption would help eliminate protein deficiencies (Adedokun *et al*., 2013). The ash values of 1.08 – 2.15% obtained in this study were comparable with the ash values obtained by Elijah *et al*. (2020) who worked on quality attributes of cheese produced from goat's milk supplemented with coconut milk. Also, the values were higher than the findings of Odewole *et al.* (2018) who gave ash of plain machine manufactured cheese to be 0.91%. The presence of ash is a measure of mineral elements in food stuff. Increase in ash would lead to high content of mineral elements and would therefore enhance the mineral intake of potential consumer. Uaboi-Egbenni *et al*. (2010) reported 0.6% ash content for fermented cheese sample. However, this study recorded over 1.0% and up to 2.08% of ash content in the cheese products. The value of 16.37% of lactose for cheese sample made from milk of WAD goat fed diet containing 25% *M. alba* in this study was higher than 6.53% for cheese sample made from milk of WAD goat fed diet having 100% *M. alba* substitution level. Values obtained for the different cheese samples in this study were higher than the findings of Adetunji and Salawu (2008) who gave lactose of cheese to be between 2.05 and 8.10% except for cheese sample made from milk of WAD goat fed diet containing 25% *M. alba* leaves.

The processed soft cheese contains essential minerals such as calcium, phosphorus, magnesium, potassium and sodium. Fresh cheese developed by *C. procera* had increased mineral content. This is due to the presence of minerals in the plant coagulant and in the experimental diets fed to the WAD does that produces the raw milk used in producing the cheese. The values obtained for calcium in this study was higher than the value reported by Adetunji and Babalobi (2011) and Omotosho *et al*. (2011). It was observed that the calcium content in the milk of WAD does in this study was lower than the values (0.27%) reported by Abiola *et al*. (2017). Adetunji and Babalobi (2011) and Abiola *et al*. (2017) reported 0.71% phosphorus content of Sodom apple cheese which was higher than the values (0.15 – 0.25%) obtained in this study. Omotosho *et al.* (2011) reported potassium content of Sodom apple cheese to be 22.5% which was higher than the values (0.16 – 0.24%), while Adetunji and Babalobi (2011) reported the potassium content of Sodom apple cheese to be 0.16% which was in comparison with the values reported in this study. The sodium content of cheese made using Sodom apple was 0.09 – 0.11% which was lower than the value reported by Omotosho *et al*. (2011) who reported the sodium content in apple cheese to be 16.98%, while Adetunji and Babalobi (2011) reported the sodium content of Sodom apple cheese to be 0.24% which was higher than the sodium content value obtained in the present study. The magnesium content in this study was lower than the values obtained by Adetunji and Babalobi (2011). The mineral concentrations varied between the cheese samples. The value reflected high concentration of most minerals. The variability of these macro elements may be attributed to contamination following milking, manufacturing process, animal species and environmental conditions as reported by Mustafa *et al*. (2013). In addition, Onyeka (2008) reported that mineral elements are significance in human nutrition, as lack of these elements may lead to nutritional malfunction, while Elijah *et al.* (2018) stated that mineral elements are involved in various body activities. Thus, mineral elements are essential for human development.

The possible sources of contamination of product are uncleaned hands of the manufacturers, poor quality water used in the manufacturing process and exposure of the product to open air during setting of curd following the report of Patel *et al*. (2017). The bacteria count achieved in this study were lower than the value reported (7.7×10^4 CFU/ml) by Tona *et al.* (2018) for the microbial characteristics of fresh white and red sorghum extract preserved West African soft cheese retailed in Ogbomosho, south-western Nigeria. Total coliform count was nil in soft cheese sample made from the milk of WAD does fed diet with 100% *M. alba* leaves. The total fungal counts were lower than the values reported by Tona *et al*. (2018). The low microbial count in the cheese produced may be attributed to the antimicrobial / antibacterial properties of the coagulant (Verma, 2014) and may also be attributed to the good manufacturing practice such as pasteurization of the milk, clean utensils and aseptically conditions observed during laboratory production. Hegazy and Mahgoub (2013) reported based on the recommendation of the European Commission (2004/24/EC and 852/2004/EC) standards, that microbial load in retailed cheese should range between 10^2 to $<10^5$ to be classified as average to satisfactory level. Thus, it was observed that the cheese samples produced in the current research with microbial counts range between 2.5×10^5 CFU/ml and 4.0×10^5 CFU/ml were of satisfactory to average hygiene quality. Hegazy and Mahgoub (2013) also reported the absence of coliform bacteria in some of the cheese sampled from Egypt. However, these counts were below the safety limit of 5.0×10^6 and may be rated to be within the acceptable grades. In another research, Oladipo and Jadesimi (2012) isolated *Pseudomonas* species and *Bacillus* species in some West African soft cheese samples. In a nutshell, the results of microbiological quality characteristics of soft cheese samples obtained in this study agreed with the standard set by Codex Alimentarius (1999).

Conclusions: It can be concluded from this study that goat milk can also be used to produce cheese (wara) of high quality. The result of this study showed that mulberry leaves (*M. alba*) inclusion in the diet of WAD does improved both the milk yield and nutritional properties of cheese. The inclusion of mulberry leaves in goat diets should be encouraged to obtained high quality milk for the production of cheese based on percentage yield and nutritional composition.

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