Wheat and White Sorghum Supernatants as Alternatives to Calotropis procera Extract in Making Cheese

Ayanniyi, N. N.¹, Adeyemi, S. A.², Gbanguba, U. A.¹, Akinleye, S. B.³, Alfa, M.¹, Eze, J. N.¹, Umar, A.¹ and Salihu, B. Z.¹

¹National Cereals Research Institute, Badeggi, Nigeria
²Department of Animal Science, Faculty of Agriculture, Al-Hikmah University, Ilorin, Nigeria
³Department of Animal Science, Faculty of Agriculture, University of Ibadan, Ibadan, Nigeria

Corresponding e-mail: newrain36@yahoo.com

Abstract

Plant coagulant, animal rennet and microbial coagulant are used as milk coagulating agents resulting in different cheese products. However, emphasis has been on the use of plant coagulant as opposed to that from animal source, rennet. Alternative milk coagulants are therefore investigated instead of animal enzymes. The use of vegetable extracts as milk coagulants has evolved in soft cheese processing. This study explored the potential of plant coagulants as an ideal choice in the production of cheese. Hence, the objective of this study was to evaluate the effects of the coagulants on the yield and proximate composition of cheese. To compare them with cheese coagulated with supernatants from fermented white sorghums (WSS) and wheat (WS) in the laboratory. The results were also compared with cheese coagulated with Calotropis procera leaf extract (CPE) in terms of yield, the percentage composition of total solids (TS), fat, protein, lactose ash and the pH of the cheeses. The same parameters were evaluated in the whey (by-product). The minerals, pH and the proximate components in WS and WSS were also compared. Maximum cheese yield was recorded at equal volumes of milk and coagulants. CPE was superior to these other two considering the constituents in all three cheeses. The chemical composition of CPE coagulant was superior to WS and WSS in terms of TS, fat, protein and ash but lower in moisture content compared with the other two. Protein content was higher in cheese prepared with CPE (22%) about six times the amount in raw milk and the least was WSS (12%). Moreover, the cheese made with CPE had the highest yield (31.76g) and differed significantly (P < 0.05) from WSS (28.87g) and WS (29.70g). Also, cheese made with WS (30.57g/ml) had the highest whey volume compared with WSS (28.11g/ml). However, increasing levels of each supernatant with a constant volume of raw milk (100ml) produced higher cheese yield at 100ml of the supernatant and 100ml of milk. Whey from WSS was the most acidic (5.85) of all the three produced but with increased acidity as the storage days increased. The study revealed that cheese with high nutritional quality can be produced with CPE, WSS and WS. The use of equal volume of coagulant (WSS or WS) to raw milk would give optimal cheese yield. This will promote the utilization of WSS and WS, which is naturally left as the waste product.

Keywords: White sorghums, Wheat, Calotropis procera extract, Coagulants, Cheese yield

Introduction

The majority of milk produced in Africa is processed into a variety of traditional milk products by small-scale processing units or the local food processors. The final products including fermented yoghurt-like milk, cheeses and butter, are produced with slight variations in processing depending on locality (Mattiello et al., 2018 and Owusu-Kwarteng et al., 2017). Dairy products are significant components in the diets of man and continue to play an important role in the diets of the growing population across the world (Fratkin, 2013). Cheese has been defined as a product made from milk by coagulating the casein with the help of rennet or similar enzymes in the presence of lactic acid produced by added microorganisms, from which part of the moisture is removed during cooking and pressing (Ogundiwon and Oke, 1983).
In Nigeria, extract from *Calotropis procera* containing Calotropin is used in milk coagulation. *Calotropis procera* is a plant widely distributed in tropical and subtropical regions of Africa and Asia with a long history of use in traditional medicine (O’connor, 1993). The production of cheese, is traditionally done using the extract from the fresh leaves and stems of *Calotropis procera* for coagulation (Oyewole, 1997). However, supernatants from cereal could equally be used in coagulating the raw milk. Vegetable extracts have been used as coagulants in cheese making since ancient times in the West African and southern European countries (Roseiro et al., 2003). The effects of plant coagulants extracted from *Ficus carica* latex and *Carica papaya* on bovine milk have been studied by comparing their milk-clotting properties and enzymatic proteolysis products to those of commercial calf rennet (Low et al., 2006).

Literature has over the years reported the use of some coagulants in sunflower, pineapple and several plant preparations of *Cynara cardunculus*, Calcium chloride for cheese preparations (Onatola, 2004). This study was designed to investigate the effects of extract from *Calotropis procera* leaf - CPE (also known as Sodom apple) and supernatants from wheat (WS) and white sorghum cereals (WSS) on finished cheese. The coagulants were compared in terms of coagulating strength and the nutritional values of the final cheese products.

**Materials and Methods**

**Milk collection**

The raw milk used for the experiment was obtained in June and July 2018 from the cattle section of the Lamidi Adesina International market, Akinyele Local Government, Oyo State.

**Milking processing**

Hand milking was done between 6.45-7.30am. Both the head and legs of the cow were tied to a big tree relatively far from the point of milking to prevent accidents and milk wastage. The cow was stimulated to let down its milk by allowing the calf to suckle the udder teat for 15-20 seconds after which the calf was withdrawn and tethered to a pole near the dam to sustain milk let down. The milker thereafter placed a clean bowl in-between its legs and sat on the right-hand side of the animal, massaging the teats of the udder up and down to complete the process. The milk was then hygienically sieved into a clean aluminium bowl and taken to the laboratory for cheese preparation and proximate analysis.

**Preparation of *Calotropis procera* extract (CPE)**

Eight to ten Sodom apple matured leaves were plucked from the *Calotropis procera* plants found within the Teaching and Research Farm of the University of Ibadan, Ibadan. The leaves were washed with 2-3 litres of water to remove dust or dirt. They were subsequently grounded with an enamel mortar and pestle to extract the juice. The crushed materials were squeezed manually through cheese cloth and the extract obtained used for cheese preparation.

**Preparation of supernatant**

Dried wheat and white sorghum grains of 2 kg each were soaked in 8 litres of warm water bowls at room temperature for twenty-four hours. Each of the soaked grains (Wheat and White sorghum) were later rinsed properly with 10 litres of fresh and clean water at ambient temperature twice and milled. Each milled product was then thoroughly mixed manually with five litres of clean, room temperature water, sieve with muslin cloth twice into a clean plastic bucket and left to stand for twenty-four hours during which the starch settled at the bottom while supernatant (decant) remained at the top. The supernatants were thereafter collected and used for cheese preparation.

**Cheese preparation**

Four litres raw milk procured from the herders was iced and quickly taken to the laboratory for the study. One hundred millilitres of wheat supernatant (WS) and white sorghum supernatant (WSS) were pipetted into clean aluminium cooking pots labelled A-F (WS) and G-L (WSS) respectively. The weights and pH of the supernatants and milk were determined by LCD digital electronic weighing scale (DH990) and portable pH meter (H199162). Similarly, a 300ml of raw milk was also collected and mixed with 1.5ml of CPE in a flask. In the preliminary study conducted 100ml - 300ml of the CPE could not neither precipitate, aggregate nor coagulate the raw milk given the
The same heat treatment to that of the two supernatants. However when the raw milk was left to stand for 24 hours at room temperature coagulation occurred but the appearance was entirely dark, tasteless and the aggregation of cheese was not compact. The cheese lack bulkiness as it was supposed to be. They appeared in form of small particulate droplets. As a result, a principle of following the conventional practice by the traditional cheese processors and it actually provided an opportunity to take 300ml of the raw milk with 1.5ml of the CPE and compare with the 100ml of each supernatant. Furthermore, the reason behind the use of 300ml of the raw milk was that it yielded highest alluding to the fact that cheese formation depends largely on the milk and not the coagulants at it were.

The mixtures were stirred gently with silver-spoon for 2-3 minutes, after which they were placed in a thermostatically regulated electric hot plate for heat supply until coagulation in 12-15 minutes at a temperature of 70°C. Each of the cheese was further cooked for 7-9 additional minutes to a temperature of 90-95°C which helped in the rapid release of whey from the coagulum (cheese curd). Then, the mixture was allowed to cool for 15 minutes and drained with cheese-cloth. The whey was poured into a graduated cylinder to determine the volume and the weight of the cheese was also determined. Samples from each treatment were weighed and taken for pH value determination and chemical analysis.

The total solids (TS %) = summation of fat, casein, lactose, crude protein and ash: While solid not fat (SNF %) is fat alone.

**Analysis of fat components**

Ten mil (10mls) of hydrogen sulphide (sulphuric acid) was run into a special Butyrometer graduated to 40 % for cheese. Three gram (3g) of freshly prepared cheese was dehydrated and ground well and thereafter mixed thoroughly with 6mls of distilled water and transferred into tube. About 2-3mls of distilled water later used to rinse the container and also transferred into the butyrometer tubes followed by the addition of 1ml of Amyl-alkanol. The stoppers were then firmly inserted and the contents mixed until no distinct particle of curd was left. The butyrometer tubes were then inverted 2-3 times and the tubes placed in a water bath at 65°C for 5 mins. The tubes were removed after 5 mins and transferred to a Gerger Centrifuge and whirled at a speed of 1,100 revolutions per minute for 5 mins and replaced in water bath at 65 °C for 5 mins. The percentage fat was thereby read off as in milk. Whey, and in both wheat and white sorghum supernatants Ihekoronye and Ngoddy (1985)

**Protein determination**

About 5mls of milk, whey, CPE, WS and WSS were put in a kjeldahl flasks while 2g of the samples were used for the solid samples. To each of the flask, 25ml of concentrated (Hydrogen sulphide) sulphuric acids was added together with 4 tablets of copper sulphate and 1 tablet of selenium. The flasks were then heated until digestion was completed. They were allowed to cool and the contents diluted with distilled water and transferred into a 250ml graduated flasks 5ml was then taken from each flask for the nitrogen determined by the micro kjeldahl method. The protein contents of the each of the component samples (cheese whey, CPE, WS and WSS) were given as the percentage. Nitrogen multiplied by a factor of 6.38 (%N x6.38) = Crude protein (ILCA, 1991)

**Lactose determination**

One gram (1g) of the samples (cheese or whey) were individually weighed in a beaker and transferred with distilled water to a 1000ml of flask. For the cheese, 1g of fresh cheese was taken and mixed with 10ml distilled water. This was transferred to 1000ml flask and was made up with distilled water. The flask was shaken vigorously. For the whey or milk, 10 ml of milk, whey and other samples was pipetted into 50ml flask each and lactose determined by the method of standard curve, following which a yellowish brown coloured substance was observed (ILCA, 1991).

\[ \% \text{lactose in the sample} = \frac{Y \times 1000 \times 100}{10000} \]

Where Y = reading from the graph in mg

**Ash**

100 ml of each samples milk, whey, WS, WSS and 1g of cheese was weighed into 300ml of Kjeldahl flask respectively but prior to weighing out, the
flasks were washed with perchloric acidchloric acid and glass distilled water. About 4ml of perchloric acid (A.R 60%), 25 ml of Concentrated Nitric acid were added and mixed by swirling. The mixture was heated gently over a small burner in the Kjeldahl flask. After 5 mins of heating, a dense brown fume would evolve, the flasks were then removed from the burner until initial vigorous reaction reduced. The flasks were placed on the burner and slowly heated until digestion was complete which was indicated by a dense white fume. The digestion continued until the digest became clearer.

The digest was allowed to cool and 40-50ml distilled water was added and boiled for about 30 seconds. This was later cooled and transferred into 100ml pyrex graduated flask and made up to volume. The content was filtered through a 9cm Watchman No 4 filter paper into 100ml volumetric flask (Ogundiwin and Oke, 1983)

**pH**

The pH of the samples was measured with a pH meter. A pH meter of H18424 model of Microcomputer Havanna Instrument was used

**Statistical analysis**

Data obtained were analyzed using the SAS program (release 6.10. SAS Institute, Inc., Cary, N.C., 2001). Least Significance Difference (LSD) of the same software was used for mean separation between the treatments.

**Results and Discussion**

Cheese yield is important tool to evaluate the potential use of a new coagulant. The yield of cheese at a constant volume of (100ml) raw milk coagulated with an increasing volume of the supernatants was evaluated as shown in Table 2. The yield of cheese made with WSS and WS using 100ml of coagulants had the significant highest values (22.4±0.25g and 21.43±0.23g) while cheese made with WSS and WS using 200, 250 and 300ml had the lowest values (16.23±0.23 and 16.22±0.19; 12.82±0.16 and 14.02±0.12; 10.02±0.02 and 11.47±0.24g, respectively). It was observed that the volume and weight of whey were directly proportional to the volume of the coagulum as shown in the table. The low values, 140.83±0.44ml and 145.35±0.68g at 100ml while the highest was 409.35±0.65ml and with a corresponding weight of 414.53±0.68g at 300ml. The increase in cheese yield is attributed to the higher concentration of whey proteins in the aqueous phase of cheese (Table 2). The work further showed that when the same volume (100ml) of milk was used with increasing volumes (100, 150, 200, 250 and 300mls) of each of the supernatants, the weight of cheese produced was inversely related to the volume of the supernatant used (Table 3). Cheese yields were lower as more of each supernatant was used. This suggested that it was not economical to use increasing volumes of any of the two supernatants with the same volume of milk for the cheese preparation. The results also confirmed findings that both WSS and WS had the coagulating ability on milk-producing higher yield at 100ml 100 by 100ml of the supernatants. The result from the study was similar to findings from Onatola (2004) who gave a range of 102 by 100ml ratio of the maize supernatant and the milk resulted in a higher yield.

**Cheese yield at an increasing volume of raw milk with a constant volume of the supernatants**

Different volumes of raw milk were coagulated at a constant volume (100ml) of each supernatant (Table 3). The cheese yield increased significantly (P<0.05) as the volume of raw milk increased. The cheese yields, 31.04±0.03, 29.67±0.33 for WS (at 300ml and 250ml respectively) and 30.35±0.33 for WSS (at 250ml and 300ml) were significantly the highest (Table 3). There was a direct relationship as expected since the cheese was produced largely from the protein and fat components of the milk. However, when cheese yields were compared across the treatment groups of 100ml, 200ml, 250ml and 300ml cheese from 200ml, 250ml and 300ml raw milk yielded less than two or three times the yield from 100ml of raw milk. Cheese yields only increased by 25.3% and 37.8% as well as by 12.12% and 19.10% when 200ml and 300ml of milk were used with 100ml of WSS and WS respectively. This showed that it is not scientifically economical to use an increasing volume of raw milk with a constant volume (100ml) of either the WS or WSS supernatants. Furthermore, since the percentage increase (25.3% and 37.8%) in cheese yields from 200ml and 300ml of milk with WSS as a coagulant were twice the (12.12% and 19.10%) increase in the
cheese yield with (WS) as a coagulant, the results suggested that (WSS) was superior to (WS) as a coagulant of milk in cheese production. The results showed that for the highest economic production of cheese, 100ml of WSS should be used to coagulate 100ml of raw milk allowing the milk aggregation in the production capacity of cheese preparation and cheese yield (Mistry, 2003). The additional non-fat solids that accompanied the increase in moisture would also contribute to an increase in the cheese yield. This finding is similar to the work of Pazzola et al. (2019) and Vacca et al. (2018) who submitted that the composition of raw milk and the technology adopted in its processing significantly influence the yield of cheese and nutrients recovery in curd.

Whey
In Table 3, whey yields were 28.33g and 25.20g when 100ml of WSS and WS respectively were used to coagulate 100ml raw milk. It declined significantly (P<0.05) to 20.61g respectively as 150ml was coagulated with WSS and WS using same volume of raw milk. This relationship was not unexpected as milk essentially is the chief determinant of the proportionality or otherwise of the cheese and whey yield. This result also corroborated with the work of Omojola (1990), Gbadamosi (1994) and Onatola (2004) who found that as the volume of raw milk increased, the yield of cheese and whey also increased.

Proximate analysis
pH
The pH value of WS 6.34±0.04 and WSS 6.32±0.16 were more acidic compared to 6.65±0.11 while that of CPE was the most acidic 6.01±0.02 (Table 4). In a controlled conversion of milk to fermented dairy products, a primary component of fermentation is the development of acidity by lactic acid bacteria. Acid is required to induce coagulation and promote syneresis. Therefore, acid development is the most important principle for the quality and safety of natural cheese.

Moisture content
Cheese made with CPE, WS and WSS contained 58.03%, 70.08% and 71.87% moisture respectively (Table 4). The moisture content from the present study was supported by the range of 56.80 to 76.6% reported by Ogundiwin and Oke (1983); Omojola (1990); Tayo and Adeneye (1997); Onatola (2004). The result showed that the use of CPE, WS and WSS as milk coagulants would produce soft but not semi-hard or hard cheeses. These differences might probably be due to the properties of coagulants used to process the Cheese. Cheese with high water content is not favourable because the water weakens the structure of casein tissue, therefore the cheese is less solid (Banks, 2007; Yasin and Shalaby, 2013). The reduced moisture content of the cheese made with CPE make it be easily preserved for a long time because high moisture content could cause quick deterioration and thereby promote rapid growth of microorganisms and a reduction in the shelf life of the product (Aisso et al., 2013). The higher moisture content in cheese is also an indication of relatively low fat and protein contents (Jung et al., 2013).

Total solids (TS)
The total solids (TS) of the cheese made with CPE, WS and WSS were 41.96%, 29.91% and 28.12% respectively (Table 4). These values differed (P<0.05) significantly from one another but were lower than 43.20% reported by Onatola (2004) for CPE made cheese who also utilized supernatant soaked and milled maize grains in making cheese. While Gbadamosi (1994) and Nwabudike (1991) reported lower total solids of 20.57 – 26.40%, findings from Omajoila (1990) with a range of 29.43% - 29.71% was similar to the TS obtained from the present study. This might be due to the inhibition of proteolytic and lipolytic activities of microorganisms by the coagulants (Nuser, 2001; Hayaloglu et al., 2005).

Fat
Cheese made with WS (13.98%) and WSS (13.78%) gave a similar fat content but lower than that prepared with CPE (14.71%). Hannon et al. (2006) reported that fat is important as a source of energy to the body since fat is a relatively good source of flavour, energy and fat-soluble vitamins, the result indicated that the cheese prepared with CPE would not only be more palatable but also contain higher calorie and more fat-soluble vitamins than the cheese produced with WS and WSS. Many consumers would probably prefer the
CPE cheese. The percentages of fat obtained in the present work fell within the range of 11.2%–21.9% as reported by Ogundiwin and Oke (1983) and Tayo and Adeneye (1997) while Gbadamosi (1994) reported a lower range of percentage fat (7.58%–10.02%) which could probably be due to seasonal variation or the type of diets served to the cow during lactation. The general analysis shows that the CPE, WSS and WS are important in cheese production because they increase the nutritional components in the raw milk.

**Protein**
The protein content of the cheese made with CPE coagulant had the highest value for crude protein (22.06±0.16) (Table 4) followed by cheese made with WS (14.00±0.58) and WSS (12.72±0.90). This variation in the protein content of cheese in this study may be attributed to protein content in coagulants which might have been added into the milk samples during coagulation. The variation could also be due to the technology of production of the cheese. The highest protein content of cheese made with CPE shows the importance of the plant Calotropis procera as a coagulant against the supernatants of WSS and WS. The protein content obtained in cheese from all the coagulants is slightly higher than that reported by Aisso et al. (2013) who found 13.66 for breed Girolando.

**Lactose**
The percentage lactose content in CPE cheese (2.86%) was higher than the others 0.44% for WS and 0.29 for WSS. The result for CPE agreed with 2.60 – 2.85% of Onatola (2004) however disagree with that of WS and WSS this was also lower than the result obtained by Okomanyi (1997) on sour cheese (0.38% and 0.36%). This result showed that cheese contains less lactose (0.29 – 2.86%) than the milk from which it is made (4.62%). It suggested that consumers who are allergic to lactose or lactose intolerant might prefer the WS and WSS coagulated cheeses to CPE. It also confirms the earlier report by FAO (1998) and Ebing and Rutgers (1991) that lactose, the fermentable carbohydrate in the cheese curd is easily drained into the whey during cheese production. Lactose retention in cheese is responsible for the significant increase in cheese yield. Indeed, cheese with high lactose content is prone to post-acidification, which could result in texture and flavour defects (Moynihan et al., 2016).

**Ash**
The ash content is an indicator of the total mineral content in the dairy product (Aisso et al., 2013). The ash content obtained from cheese made with CPE coagulant was significantly higher (2.33±0.08) than WS (1.40±0.07) and WSS (1.49±0.04). which is also significantly higher than the one obtained from milk (0.70±0.02). Thus, it can be then be concluded that the mineral is higher in cheese with different coagulants than milk.

**Titratable acidity (TTA)**
TTA plays important role in all milk coagulation phases, including aggregation rate of casein, syneresis rate and determines how easy the milk will be turned into cheese. The TTA highest average (0.17±0.02) was found in raw milk which was significant, followed by WSS with the average of TTA (0.04±0.01), CPE (0.02±0.01) WS (0.02±0.01) with no significant effect across the treatment group (P>0.05). A progressive lowering in acidity corresponds to an increase in the frequency of milk with low reactivity to the clotting enzyme (Mariani et al., 2002).

**Yield of cheese and whey obtained from coagulants using 300 ml of raw milk against 1.5ml Calotropis procera extract and 100 ml of each supernatant**
The average yield of cheese was affected by the kind of coagulants (Table 5). The average yield of cheese made by CPE was 31.76±1.25g followed by the cheese made by WS (29.70±1.51) and cheese by WSS (28.87±1.33). This might be due to the high volume of CPE in proportion to the WSS and WS. The higher yield in CPE was probably because of higher moisture content in it and not due to the higher total solids recovery. The result on table 5 revealed that there were significant differences (P>0.05) in the weight and volume of whey of each coagulant. Hence, WSS gave the highest weight and volume (30.57±0.41 and 25.24±0.27) while CPE (12.71±0.54 and 10.20±0.40) gave the least. The fact that there were significant differences (P>0.05) in the yield indicated that the various coagulants under
consideration substantially differ in their coagulating properties.

**Conclusion**
Coagulants have a positive impact on cheese yield and could be used as indicators of production. The study revealed that an acceptable cheese with high nutritional quality can be produced with CPE, WSS and WS. This reflected in the improved crude protein (22.06±0.16%) in samples of cheese produced with the coagulants. Cheese with 100ml of supernatants (WSS and WS) have the highest yield of cheese at 100ml of raw milk. At a constant volume of supernatants, the highest yield of cheese was recorded at 300ml of raw milk. Therefore, the inclusion of 100ml of WSS and WS to 100ml of raw milk should be encouraged in the production of cheese. This will promote the utilization of WSS and WS, which is naturally left as the waste product. This research would be of great influence to the fields of biotechnology and dairy technology, if further study can be done.

**Acknowledgement**
I owe the success of this work to the guidance of Professor Japhet A, Adeneye, formerly of the University of Ibadan, Ibadan who brought out the light when the darkness was frightening.

**References**

Aisso, R. C. B., Vahid Aïssi, M., Issaka Youssao, A. K., Mohamed, M. and Soumanou, A. S. (2013). Caractéristiques physico-chimiques du fromage Peulh produit dans les conditions optimales de coagulation à partir du lait de deux races de vaches du Bénin Revue « Nature & Technologie », B- Sciences Agronomiques et Biologiques, n° 14/ Janvier 2016, Pages 37 à 43

Banks, J. M. (2007). Flavour, texture and flavour defects in hard and semi-cheeses. In: P. L. H. McSweeney (ed.) Cheese Problems Solved. Woodhead Publishing Limited, Cambridge, England.

Ebing, P. and Rutgets, K. (1991). *The preparation of dairy products*. Agrodok-Series No.36. Agrmisc, Wagenering Netherlands. Pp:1-7.

FAO (1998). *The technology of tradition milk products in developing countries. Animal production and Health paper 85,163* and 211, Food and Agriculture, Rome.

Fratkin, E. (2013). *Seeking alternative livelihoods in pastoral areas. In Pastoralism and Development in Africa: Dynamic Change at the Margins New York*. Routledge: Abingdon, UK.

Gbadamosi, A. D. O. (1994). Yield and composition of cheese from cow’s milk coagulated with Sodom Apple leaf juice, ascorbic acid and sweet orange juice. M.Sc. Thesis, Department of Animal Science, University of Ibadan, Ibadan

Hayaloglu, A. A. (2015). Cheese: Microbiology of Cheese. Reference module in food sciences, *Elsevier*, pp.1–11. https://doi.org/10.1016/B978-0-08-100596-5.00675-2.ISBN: 9780081005965

Ihekoronye, A. I. and Ngoddy, P. O. (1985). *Integrated Food Science and Technology for the Tropics*. Macmillan Publishers Ltd; London, Pp: 293 – 300.

ILCA (1991). *Annual report and programme highlights*. International Livestock Centre for Africa (ILCA). Addis Ababa, Ethiopia

Jung, H. J., Ko, E. J. and Kwak, H. S. (2013). Comparison of physico-chemical and sensory properties between cholesterol-removed gouda cheese and gouda cheese during ripening. *Asian-Australas Journal of Animal Science*, 26: 1773 – 1780. [https://doi.org/10.5713/ajas.2013.13255](https://doi.org/10.5713/ajas.2013.13255)

Low, Y. H., Agboola, S., Zhao, J. and Lim, M. Y. (2006). Clotting and proteolytic properties of plant coagulants in regular and ultrafiltered bovine skim milk. *International Dairy Journal*, 16 : 335 – 343.

Mariani, P. (2015). La qualità casearia del latte di differenti razze bovine. La Razza Bruna n.1,p.713,2002.Available from: http://www.anisn.it/workgroup/progetto%20biodiversita/materiali%20didattici%20seconde%20ciclo_2011/CATANIA_21MARZO2011/Filiere%20zootecniche/La%20qualita%20casearie%20Mariani.pdf>. Accessed: Fev. 10, 2015.

Mattiello, S., Caroprese, M., Matteo, C. G., Fortina, R., Martini, A., Martini, M., Parisi, G., Russo, C. and Zecchini, M. (2018). Typical dairy products in Africa from local animal resources. *Italian
Journal of Animal Science, 17: 740 – 754.
Mistry, V. V. (2003). Membrane processing in cheese manufacture. Encyclopedia of Dairy Sciences. H. Roginski, J. W. Fuquay, and P. F. Fox (ed.). Academic Press, Amsterdam, the Netherlands. Pp: 300–306.
Moynihan, A. C., Govindasamy-Lucey, S., Molitor, M., Jaeggi, J. J., Johnson, M. E., McSweeney, P. L. H. and Lucey, J. A. (2016). Effect of standardizing the lactose content of cheesemilk on the properties of low-moisture, part-skim Mozzarella cheese. Journal of Dairy Science, 99: 7791 – 7802.
Nwabukide, A. U. (1991). The comparative yield and composition of (wara) from cow’s milk using young and old leaf juice extract of Soddom Apple plant (Calotropis procera) M Sc. Thesis, University of Ibadan, Ibadan.
Nuser, S. N. M. (2001). The effect of cooking and vacuum packaging on the quality of white soft cheese. M.Sc. Thesis University of Khartoum, Sudan.
O’Connor, C. (1993). Traditional cheese making in West Africa. Dairy Technology Paper, 3(2): 14 – 18.
Ogundewin, J. O. and Oke, O. L. (1983). Factors affecting the processing of ‘wara’ Nigerian soft cheese. Food Chemistry, 11: 1 – 13.
Okomanyi, O. A. (1997). Yield and composition of wara from raw, sour and fortified milk. M.Sc. Thesis, University of Ibadan, Nigeria.
Omojola, A. B. (1990). Influence of salting and season of the year on yield and composition of soft cheese from milk of Holstein cattle at Ibadan, M Sc. University of Ibadan, Ibadan.
Onatola, F. O. (2004). Unconventional preparation of ‘wara’ using maize starch supernatant (omidun) M Sc. University of Ibadan, Ibadan.
Owusu-Kwarteng, J., Akabanda, F., Johansen, P., Jespersen, L., Nielsen, D. S. and Nunu, A. (2017). West African Fermented Yogurt-Like Milk Product. In: Shah N. P. (ed). Yogurt in Health and Disease Prevention. Elsevier Academic Publisher; London, UK.
Oyewole, O. B. (1997). Lactic Fermented Foods in Africa and their Benefits. Food Control, 8(56): 289 – 297. Published by Elisevier Science Ltd.
Pazzola, M., Stocco, G., Dettori, M. L., Bittante G. and Vacca, G. M. (2019). Effect of goat milk composition on cheesemaking traits and daily cheese production. Journal of Dairy Science, 102(5): 3947 – 3955. DOI 10.3168/jds.2018-15397.
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, 56: 76 – 85.
SAS (2001). Statistical Analysis System User's Guide: Statistical. Version 9, 1st Edn., SAS Institute Inc., Cary, NC., USA.
Tayo, G. O. and Adeneye, J. A. (1997). Comparative yield and composition of soft cheese (wara) made from cow’s milk and extracts of different Calotropis procera plant parts. Nigerian Journal of Nutritional Sciences, 18: 35 – 38.
Vacca, G. M., Stocco, G., Dettori, M. L., Summer, A., Cipolat-Gotet C., Bittante G. and Pazzola M. (2018). Cheese yield, cheese making efficiency, and daily production of 6 breeds of goats. Journal of Dairy Technology, 101: 7817 – 7832.
Yasin, N. M. N. and Shalaby, S. M. (2013) Physiochemical and sensory properties of functional low fat cheese cake manufactured using cottage cheese. Annals of Agricultural Sciences, 58: 61-67. https://doi.org/10.1016/j.aoas.2013.01.009
White Sorghum Supernatant
Wheat Supernatant
White Sorghum Supernatant
Wheat Supernatant
White Sorghum Supernatant
Wheat Supernatant
White Sorghum Supernatant
Wheat Supernatant
White Sorghum Supernatant
Coagulants

Table 1: Comparative chemical compositions and pH of the Coagulants

| Parameters (%) | CPE       | WSS       | WS        |
|----------------|-----------|-----------|-----------|
| pH             | 6.30±0.04a| 4.63±0.06b| 4.72±0.02c|
| Moisture Content| 96.89±0.47| 98.16±0.23| 97.90±0.47|
| Total Solids   | 2.93±0.05a| 1.88±0.33b| 2.09±0.34b|
| Ether Extract  | 1.11±0.04a| 0.01±0.01b| 0.02±0.01b|
| Crude Protein  | 0.81±0.04b| 1.04±0.04a| 1.02±0.09a|
| Ash            | 1.01±0.07a| 0.84±0.03b| 0.89±0.12ab|
| Titratable Acidity | 0.21±0.04b| 0.32±0.02a| 0.24±0.04bc|

*a,b,c*: means within the same row with similar superscripts are not significantly different (P<0.05); CPE: *Calotropis procera* extract; WS: wheat supernatant; WSS: white sorghum supernatant and TTA: Total Titratable Acidity

Table 2: Yield of cheese and whey obtained from the different volume of supernatants against constant volume (100ml) of raw milk

| Coagulants                  | VC (ml) | VW (ml) | WW (g) | WC (g) |
|-----------------------------|---------|---------|--------|--------|
| White Sorghum Supernatant   | 100     | 145.83±0.83d | 147.83±0.50d | 22.40±0.25a |
| Wheat Supernatant           | 150     | 283.67±3.50c | 219.67±0.34c | 18.37±0.20b |
| White Sorghum Supernatant   | 200     | 290.03±0.03c | 360.85±0.83b | 16.23±0.23c |
| Wheat Supernatant           | 250     | 361.70±0.46b | 364.35±0.33c | 12.82±0.16d |
| White Sorghum Supernatant   | 300     | 409.35±0.65a | 414.53±0.29a | 10.02±0.02e |

*a,b,c*: means within the same column with similar superscripts are not significantly different (P<0.05); VC: Volume of Coagulants; VW: Volume of Whey; WW: Weight of Whey; WC: Weight of Cheese

Table 3: Yield of cheese and whey obtained from the constant volume of supernatants with different levels of raw milk (100-300ml)

| Coagulants                | VM (ml) | VW (ml) | WW (g) | WC (g) |
|---------------------------|---------|---------|--------|--------|
| White Sorghum Supernatant | 100     | 26.92±0.89d | 28.33±0.89a | 22.03±0.07d |
| Wheat Supernatant         | 150     | 20.62±0.28b | 20.61±0.18c | 25.37±0.37d |
| White Sorghum Supernatant | 200     | 22.02±0.02c | 22.06±0.06c | 28.05±0.25b |
| Wheat Supernatant         | 250     | 21.29±0.28b | 21.77±0.18b | 27.61±0.25c |
| White Sorghum Supernatant | 300     | 24.53±0.09b | 25.00±0.06b | 29.52±0.14 |

*a,b,c*: means within the same column with similar superscripts are not significantly different (P<0.05); VM: Volume of Milk; VW: Volume of Whey; WW: Weight of Whey; WC: Weight of Cheese

Table 4: Comparative chemical composition of cheese made with *Calotropis procera extract* (CPE), wheat supernatant (WS) and white sorghum supernatant (WSS)

| Parameters                | Raw milk | CPE       | WSS       | WS        |
|---------------------------|----------|-----------|-----------|-----------|
| pH                        | 6.65±0.11a| 6.01±0.02c| 6.32±0.16b| 6.34±0.04b|
| TTA                       | 0.17±0.02a| 0.02±0.01b| 0.04±0.01b| 0.02±0.01b|
| Total Solids              | 12.99±0.04d| 41.96±0.03a| 28.12±0.03c| 29.91±0.03b|
| Ether Extract             | 3.55±0.04d| 14.71±0.06a| 13.70±0.06b| 13.98±0.12b|
| Crude Protein             | 3.51±0.08d| 22.06±0.16a| 12.72±0.90b| 14.00±0.58b|
| Lactose                   | 4.62±0.04a| 2.86±0.13b| 0.29±0.08c| 0.44±0.10b|
| Moisture Content          | 87.01±0.86c| 58.03±2.88c| 71.87±2.12b| 70.08±0.80b|
| Ash                       | 0.70±0.02a| 2.33±0.08b| 1.40±0.07b| 1.49±0.04b|

*a,b,c*: means within the same row with similar superscripts are not significantly different (P<0.05); CPE: *Calotropis procera* extract, WS: wheat supernatant, WSS: white sorghum supernatant and TTA: Titratable Acidity
Table 5: Yield of cheese and whey obtained from Coagulants using 300 ml of raw milk against 1.5ml *Calotropis procera* extract and 100 ml of each supernatant

| Coagulants            | Cheese(g)   | Whey(ml)   | Whey(g)   |
|-----------------------|-------------|------------|-----------|
| *Calotropis procera* Extract | 31.76±1.25<sup>a</sup> | 10.20±0.40<sup>f</sup> | 12.71±0.54<sup>c</sup> |
| White Sorghum Supernatant | 28.87±1.33<sup>b</sup> | 28.05±1.19<sup>a</sup> | 30.57±0.41<sup>a</sup> |
| Wheat Supernatants   | 29.70±1.51<sup>b</sup> | 25.24±0.27<sup>b</sup> | 28.11±0.82<sup>b</sup> |

<sup>abc</sup> means within the same column with similar superscripts are not significantly different (<i>P</i>&gt;0.05); CPE: *Calotropis procera* extract; WSS: White Sorghum Supernatant; WS: Wheat Supernatant

Table 5: Level of ownership and costs of protective kits for herbicide application

| Protective Kits | Frequency (%) | Average costs (N) | Depreciation Cost |
|-----------------|---------------|-------------------|-------------------|
| Sprayer         | 133 (83)      | 8,146             | 815               |
| Rain boot       | 70 (44)       | 2,650             | 265               |
| Eye glasses     | 17 (11)       | 502               | 100               |
| Face Mask       | 76 (48)       | 195               | 97                |
| Gloves          | 39 (24)       | 350               | 70                |
| Long sleeve     | 132 (82)      | 1315              | 263               |
| Trousers        | 160 (100)     | 1210              | 242               |
| Cap/Hat         | 126 (79)      | 550               | 110               |

Table 6: Costs of herbicides usage for major crops of respondents

| Major Crops | Percentage (%) | Average herbicide Rate (Litre/Ha) | Cost of herbicide (N/Ha) | Cost of herbicide Usage (N/Ha) |
|-------------|----------------|----------------------------------|-------------------------|-------------------------------|
| Maize       | (87.5)         | 3.1                              | 4,664                   | 5,888                         |
| Sorghum     | (82.5)         | 3.0                              | 4,650                   | 5,874                         |
| Ground nut  | (65.6)         | 3.2                              | 3,635                   | 4,859                         |
| Beans       | (64.4)         | 3.2                              | 4,721                   | 5,945                         |
| Melon       | (43.1)         | 3.0                              | 3,998                   | 5,222                         |
| Millet      | (36.9)         | 3.5                              | 4,177                   | 5,401                         |
| Rice        | (35.6)         | 3.2                              | 5,805                   | 7,025                         |
| Cassava     | (14.4)         | 2.9                              | 3,857                   | 5,081                         |
| Soybean     | (10.6)         | 3.3                              | 4,702                   | 5,926                         |
| Yam         | (10.6)         | 2.5                              | 3,724                   | 4,948                         |
| Bambaranuts | (5.6)          | 3.1                              | 4,675                   | 5,899                         |
| Beniseed    | (2.5)          | 3.3                              | 4,375                   | 5,599                         |