ISSN: 2449 - 0539
BAYERO JOURNAL OF ENGINEERING AND TECHNOLOGY (BJET) VOL.13 NO.2, AUGUST, 2018

NUTRITIONAL ANALYSIS OF CHEESE MADE FROM A DEVELOPED CHEESE MAKING MACHINE

***Odewole, M.M.[1], Sunmonu, M.O.[2], Falua K.J.[3] and Aina, S.O.[4]**

[1,2] Department of Food Engineering, University of Ilorin, Nigeria.

[3,4]Department of Agricultural and Biosystems Engineering, University of Ilorin, Nigeria.

[*]Corresponding Author: [1]odewole2005@yahoo.com

ABSTRACT

This study focused on the evaluation of the nutritional compositions of cheese produced from a developed cheese-making machine. The electrically-powered cheese making machine was capable of reducing the drudgery, extended time and unhygienic characteristics of the traditional/local method of cheese production among medium and small scale cheese producers. The major components of the machine were the main frame, cheese processing and compression chambers. The processing chamber consists of the heating component, temperature regulator and a manually-driven stirrer. The compression chamber consists of a stirring rod and a perforated screen made of stainless steel. The performance evaluation of the machine was carried out using raw milk obtained from cow, and the lemon juice as coagulant. The results revealed that after coagulation, the machine produced a soft cheese with an average cheese formation time of 7.19 minutes, whereas, the local method used to take up to 20 minutes. The nutritional values of the cheese were analyzed and results showed an average value of fat (13.98%), crude protein (12.72%), carbohydrate (22.82%), moisture (50.03%), ash (0.91%), calcium (43.20mg/100g) and potassium (55.43 mg/100g). The nutritional values of the cheese produced with the machine and a locally produced cheese were compared and the results showed that values of fat, protein and carbohydrate, potassium and calcium of the machine produced cheese increased by 9.01%, 21.34%, 20.68%, 32.55% and 8.31% respectively. However, from positive perspective, the moisture and ash contents decreased by 14.52% and 9.90% respectively. The test of significance showed that there were significant differences in the values obtained at P<0.05 except for fat (0.059) and ash (0.217).

Keywords: Milk; cheese; cheese making machine; coagulant; nutritional values.

1. INTRODUCTION

Milk (the major raw material for making cheese) is one of the most consumed and highly nutritive food sources (Gemechu *et al.*, 2015) and considered as an indispensable food daily required by human because it contains essential requirements for growth. In others words, it could easily be described as an aqueous colloidal suspension of proteins, fat and carbohydrates having numerous vitamins and minerals such as calcium, phosphorus, sodium, potassium and magnesium (Vaclavik and Christian, 2008). Milk is obtained from different milking mammals with species, breed, feed nutrients, milking frequency, stage of lactation, number of lactations and season being some of the factors affecting milk composition (Løvendahl and Chagunda, 2011). Moreover, animals such as cow, sheep, buffaloes, camel, pig and goat have high tendency of milk secretion but cow milk is commonly utilized in various parts of the world (FAO, 2008). Plant-based source such as soy is another form through which raw milk could be obtained. Soymilk is a high-quality source of soy protein that serves as an alternate to dairy animal milk and available in variety of forms, including plain, vanilla, chocolate and it can be used to replace milk added to coffee, tea or cereal (Hajirostamloo, 2009). Soymilk contained a greater amount of iron (Fe) than cow milk, an amount which is ten times more than the iron (Fe) content in cow milk (Hajirostamloo, 2009). Moreover, soymilk not only provides protein but it is also a source of carbohydrate, lipid, vitamins and minerals (Chien and Synder, 1983). Soy milk is preferred also in milk processing because of perceived allergy or perhaps choice of milk sources by people which led to milk consumers preferring plant-based milk source such as soymilk as an alternative to milk obtained from animals. The derivatives of milk are butter, yoghurt, and cheese obtained through processing of milk and they are vital food for human foods.

Cheese, commonly called *wara* among some Nigerian natives, is a product of milk and serves as an excellent source of protein, fats, and minerals such as calcium, iron and phosphorus, vitamins and essential amino acids (Oladipo and Jadesimi, 2012). Although cheese production is not a major business in all parts of Nigeria, however, it is common among some Fulani pastoralists (Orhevba and Taiwo, 2016).

Cheese making is the process of concentrating the milk components, in particular fat and protein contents which are the determining factors of cheese yield (Banks *et al*., 1981). The principle of cheese making is based on the coagulation of the protein in milk, during which about 90% of the milk fat is encapsulated (Rebouillat and Ortega-Requena, 2015). The coagulated mass is called curd, and the remaining liquid is called whey. Curd consists mainly of milk proteins (casein) and milk fat; while whey mainly contains water, milk sugar (lactose), protein (serum proteins) and B-vitamins (Pauline and Karine, 2006). The curd obtained after coagulation of the milk is paramount and forms one of the desired goals of a cheese maker which in turn serves as a major determinant of cheese yield. Cheese yield is the amount of cheese, expressed in kilograms, obtained from 100 kg of milk (Abd El-Gawad and Ahmed, 2011). The factors dictating the cheese yield are the milk characteristics (contents of protein and fat, genetic variants of proteins, somatic cells, cheese making conditions), incorporation of whey proteins in the curd, homogenization of the fat, type of coagulant, use of different starters, curd firmness, type of vat, treatment of the curd (Lucey and Kelly, 1994).

Coagulants are substances used for converting liquid milk gel to curd. Traditionally, the coagulant used for cheese making is rennet extract from the abomasa of 10 to 30-day old milk-fed calves (Green, 1977) but recently, conducted researches employed different plant sources which served as alternative to rennet because of its scarcity (Roseiro *et al*., 2003). Plant sources such as sodom apple (*Calotropis procera*), pawpaw (*Carica papaya*) and lemon (*Citrus limon*) juice have been successfully utilized as alternative plant-sourced coagulants for cheese making.

Omotosho *et al.* (2011) investigated the effects of local coagulants on the nutritive value *in vitro* multienzyme protein digestibility and sensory properties of cheese. The researchers reported that no significant difference (P<0.05) in the yield of cheese (31.5-32.5%) from the different coagulants (sodom apple juice, steep waste water from pap, an aqueous solution of calcium chloride and an aqueous solution of alum). The protein (25.56%), manganese (0.23mg/100g), and zinc (1.9mg/100g) contents of *calotropis procera* coagulated cheese was significantly higher (P<0.05) than that of other coagulants but reported a low energy value (6.5 cal g^{-1}), potassium (26.04mg/100g), calcium (22.5mg/100g) and sodium (16.98mg/100g). Ogunlade *et al.* (2017) examined the percentage yield and proximate composition of cheese produced from sheep milk using different coagulants (*calotropis procera* leaves, *carica papaya* leaves, *citrus limon* juice and steep water from maize, millet and sorghum). The results showed that *calotropis procera* coagulated milk had the highest percentage yield of 25.60% while the cheese coagulated with steep water from maize had the lowest percentage yield of 3.80%. Other findings documented for local production of cheese are in Ojedapo *et al.*, *(*2014) and Adetunji *et al*. (2008). The aforementioned information showed that much quest have been triggered towards cheese making using milk from different animals and also coagulants from various plant

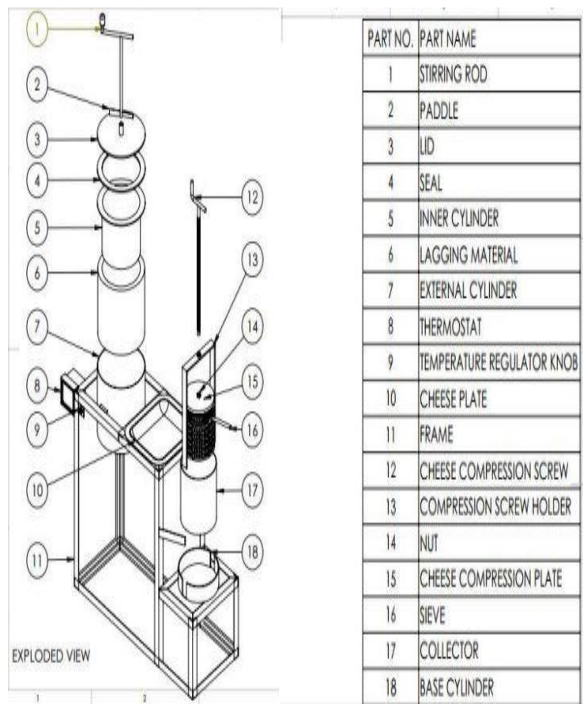
ISSN: 2449 - 0539
BAYERO JOURNAL OF ENGINEERING AND TECHNOLOGY (BJET) VOL.13 NO.2, AUGUST, 2018

and/or animal sources. However, focus has not been directed towards development of an adaptable technology (especially suitable machine for local cheese processors) for cheese making. The essence of an adaptable technology is to help in solving longer time spent in local production of cheese. Calandrelli (1997) observed that 1 ml of rennet can coagulate 10000 ml of milk at the temperature of 35°C in 40 minutes while the curd reaches the proper consistency, hardening could take up to 30-40 minutes. The traditional method of cheese making is characterized with longer time of formation of cheese, drudgery on human and unhygienic processing procedures. Therefore, the objectives of this study were to develop a cheese making machine and to carry out the nutritional analysis of the cheese produced.

2. MATERIALS AND METHODS

2.1 Description of the Machine

The machine consists of the frame (700 mm x 270 mm x 600 mm) made of mild steel angle iron (25 mm x 25 mm); the processing chamber (Ø160 x 380 mm) and the compression chamber (Ø130 x 170 mm) both of cylindrical cross sections and internally made of stainless steel. The processing chamber consists of the heating component (1000 W), the temperature regulator and a manually-driven stirring rod. The compression chamber consists of a compression screw which is driven manually, a cylindrical mesh which holds the cheese produced and base cylinder for collecting expelled water from the cheese. The temperature regulator is connected to the heat source which monitors and controls the temperature within the cheese processing machine to maintain the 90ºC preset value. The machine is powered by electricity. Figures 1 and 2 are the part list, orthographic and isometric views of the machine.



PART NO.	PART NAME
1	STIRRING ROD
2	PADDLE
3	LID
4	SEAL
5	INNER CYLINDER
6	LAGGING MATERIAL
7	EXTERNAL CYLINDER
8	THERMOSTAT
9	TEMPERATURE REGULATOR KNOB
10	CHEESE PLATE
11	FRAME
12	CHEESE COMPRESSION SCREW
13	COMPRESSION SCREW HOLDER
14	NUT
15	CHEESE COMPRESSION PLATE
16	SIEVE
17	COLLECTOR
18	BASE CYLINDER

Figure 1: Part List of the Machine

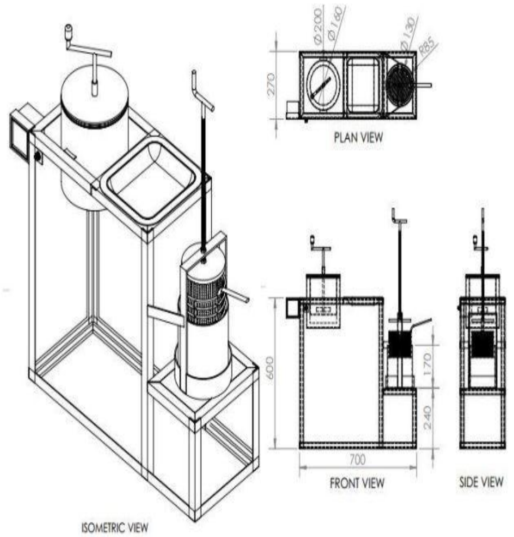


Figure 2: Isometric and Orthographic Views of the Machine

2.2 Working Principle of the Machine

The basic working principles of the machine are heat transfer (by conduction and convection) in the processing chamber and application of compressive force to dewater and harden the cheese produced in the compression chamber. The processing chamber makes use of electricity as its source of power and the milk is fed into the processing chamber. The stirring rod is a stainless steel shaft and was designed to ensure homogenous mixture of the coagulant and the milk.

2.3 Design Consideration

The engineering properties of milk with respect nutritional analysis were considered. The properties include milk quality and technology involved in its collection. Other factors considered relating to the developed machine were the strength of components, cost of construction, safety of operation, ease of maintenance and energy. Assumptions relating to the thermal constituent of the milk were specific heat capacity (3.93 kJ/kg.k) and thermal conductivity (0.550 W/m.k) (ASHRAE, 2006).

2.4 Design Calculation

2.4.1 Processing Chamber

The volume of the processing chamber is calculated using the formula stated by Agidi *et al.* (2014) for volume of a cylinder as expressed in Equation (1)

$$V = \pi r^2 h \quad \ldots \quad (1)$$

Where; V is the volume of the processing chamber (7640000 mm^3), h is the height (length) of the processing chamber (380 mm), r is the radius of the inner cylinder (80 mm).

2.4.2 Heat Transfer

Heat transfer through the walls of the processing chamber (without the milk) and the actual heat required for coagulation was calculated using Equation (2a) as stated by Rajput (2006).

$$Q_{pc} = M_s \times C_\rho \times \theta_{pc} \quad \ldots \quad (2a)$$

Where; Q_{pc} is the heat required in the processing chamber (without the milk) (7354.75 kJ), M_s is the mass of steel (58.838 kg), C_ρ is the specific heat capacity of stainless steel (500 J/kgK) and θ_{pc} is the temperature of the processing chamber (25°C)

Heat required to raise the temperature to coagulate the milk is given in Equation 2b as stated by Rajput (2006).

$$Q_{act} = M_s \times C_\rho \times \theta_{act} \quad \ldots \quad (2b)$$

Where; Q_{act} is the heat required in the processing chamber to raise the temperature to coagulate the milk is (1912.246 kJ), M_s is the mass of steel (58.838 kg), C_ρ is the specific heat capacity of stainless steel (500 J/kgK) and $\Delta\theta$ is the change in temperature (65°C) i.e. the difference between processing temperature (90°C) as suggested by Pal *et al.* (2008) and ambient temperature (25°C).

2.4.3 Total Heat Required

Since the objective was to heat the content (the milk) to 90°C, therefore, the total heat requirement of the cheese making machine Q_t is the summation of the heat energy required, Q_{act} is the heat required in the processing chamber to raise the temperature to coagulate the milk is (1912.246 kJ), Q_{ins} is the heat loss through the wall of the structure. The total heat required was calculated based on a modified formula by Bhatia (2013) as expressed in Equations (3) and (4)

$$Q_t = Q_{act} + Q_{ins} \quad \ldots. \quad (3)$$

$$Q_{ins} = \frac{K_{ins} \times A_s \times \Delta\theta}{L_{ins}} \quad \ldots \quad (4)$$

Where; Q_t is the total heat required (1912.272 kJ), Q_{act} is the heat required in the processing chamber to raise the temperature to coagulate the milk (1912.246 kJ), Q_{ins} is the heat loss through the wall of the structure (0.02584 kJ), K_{ins} is the thermal conductivity of insulating material (0.044 w/mk), L_{ins} is the Insulation thickness (0.03 m), A_s is the surface area of the processing chamber (0.271 m^2), $\Delta\theta$ is the change in temperature (65°C).

2.4.4 Stirring Rod (Shaft)

Shaft design involves analysis of strength and rigidity (Aremu and Ogunlade, 2016). For a solid shaft, torsional load could be obtained from ASME equation as reported by Hall *et al*. (1980). For a given solid shaft, the turning moment is given as expressed in Equation (5);

$$T = Fx \quad \ldots \quad (5)$$

Where: T is the turning moment (16 Nm), F is the force (100 N) (required by human for compression) as suggested by Reinhold (1986) and x is the distance (diameter of the inner cylinder) at which the rod would be turned (0.16 m).

2.5. Machine Fabrication and Assembly

After the design, the machine was fabricated and assembled according to designed specifications using workshop tools and machines, and standard procedures.

2.6 Performance Evaluation of the Machine

Raw milk obtained from milking cow was collected early in the morning from a Fulani pastoralist in the outskirt of Ilorin, Kwara state, Nigeria. Lemon juice was used as the coagulant for the performance evaluation experiment. The performance evaluation of the machine was done by first switching on the machine followed by weighing 250 ml of the raw milk using a beaker into the processing chamber. The milk was allowed to pasteurize at a temperature of 90°C before adding 15 ml of the coagulant (lemon juice). The stirring rod was turned five times at five (3) minutes interval to ensure proper homogenization. The cheese formed was transferred to the compressing chamber where the cheese compression screw was used to separate curds from whey and harden the cheese produced. The test was replicated four (4) times with experimental milk specimens of AC, DQ, BD, and AE. The performance index considered during the cheese making process was time of cheese formation. The time of cheese formation was deduced by intermittent opening of the processing chamber at two minutes interval. Also, nutritional analysis of the cheese produced was analysed using AOAC (2012) standard method. Furthermore, the data obtained was statistically analysed using Microsoft Excel (2013 version) at 5% level of significance.

3. RESULTS AND DISCUSSION

The results of the performance evaluation showed an average time of cheese formation of 7.10, 8.15, 9.22, 7.15 minutes for cheese specimens of AC, DQ, BD and AE respectively showing an average value of 7.91 minutes, a value lower than 10-40 minutes for cheese formation for locally produced cheese (Calandrelli, 1997). The nutritional values of the specimens showed an average value of fat (13.98%), crude protein (12.72%), carbohydrate (22.82%), moisture (50.03%), ash (0.91%), calcium (43.20mg/100g) and potassium (55.43 mg/100g) of the produced cheese. The values were compared with nutritional compositions of fat (12.72%), protein (9.66%), carbohydrate (18.10%), moisture content (58.53%), ash (1.01%), calcium (39.62mg/100g), and potassium (37.40mg/100g) of a locally produced cheese. The result showed that only fat (0.059) and ash (0.217) were not significantly different at $P<0.05$. Fig. 4 showed that the contents of fat, protein and carbohydrate increased by 9.01%, 21.34%, 20.68% respectively while moisture, ash contents of the produced cheese with the machine decreased by 14.52% and 9.90% respectively by calculation. Furthermore, the mineral compositions of potassium and calcium increased by 32.55% and 8.31% respectively. The significant increase could be attributed to processing conditions and techniques such as pasteurization temperature, and milk-coagulant (Abd El-Gawad and Ahmed, 2011; Orhevba and Taiwo, 2016). Comparison of the obtained nutritional values revealed that depending on volume of milk and coagulant used, processing time and temperature, mechanical way of cheese production offers positive contribution to fat, protein and carbohydrate contents but might cause decrease in moisture and ash contents. However, the decrease in moisture content and ash contents could be as a result of exposure of the milk to less production time during cheese making (Orheevba and Taiwo, 2016) Also, the result obtained is approximately similar to the findings of Orhevba and Taiwo (2016) in which it was reported that 1.00% of ash content was obtained for 50 ml milk volume. Furthermore, the mineral compositions of calcium (43.20mg/100g) and potassium (55.43 mg/100g) of the produced cheese with the machined showed a higher value than the findings of Omotosho *et al.* (2011) with a report of calcium (22.5mg/100g) and potassium (26.04mg/100g) for a cheese locally produced using cow milk and *calotropis procera* as coagulant. In summary, factors contributing to higher cheese yield, better proximate values could be as a result of volume of coagulant added during production (Ogunlade *et al.*, 2017), quality of milk, type of milk used and other processing conditions such as heating temperature, environmental conditions (Omotosho *et al.*, 2011). From Table 1, it could be deduced that significant difference exists in the obtained proximate values at $P<0.05$ except for fat (0.059 compare with value on Table 1) and ash (0.217). Table 1 shows the summary of the statistical analysis of the nutritional values. Figure 3 shows the comparison nutritional values of the cheese produced with the machine and the locally purchased cheese while Plate 1 shows the developed cheesemaking machine.

Table 1: Summary of the Statistical Analysis of the Performance Evaluation

Nutritional Composition	Mean	df	t-stat	t-critical	sig
Fat	13.978	3	2.974	3.183	0.059^{NS}
	(12.715)				
Protein	12.275	3	11.766	3.183	0.001*
	(9.655)				
Carbohydrate	22.816	3	9.646	3.183	0.002*
	(18.100)				
Moisture Content	50.028	3	-342.768	3.183	0.000*
	(58.525)				
Ash	0.913	3	-1.557	3.183	0.217^{NS}
	(1.005)				
Calcium	43.195	3	6.680	3.183	0.001*
	(39.620)				
Potassium	55.425	3	10.770	3.183	0.002*
	(37.400)				

Key: *a = cheese produced with the machine, b = locally produced cheese, NS = not significant,* = significant at 5%, Values in brackets are means of the locally produced cheese*

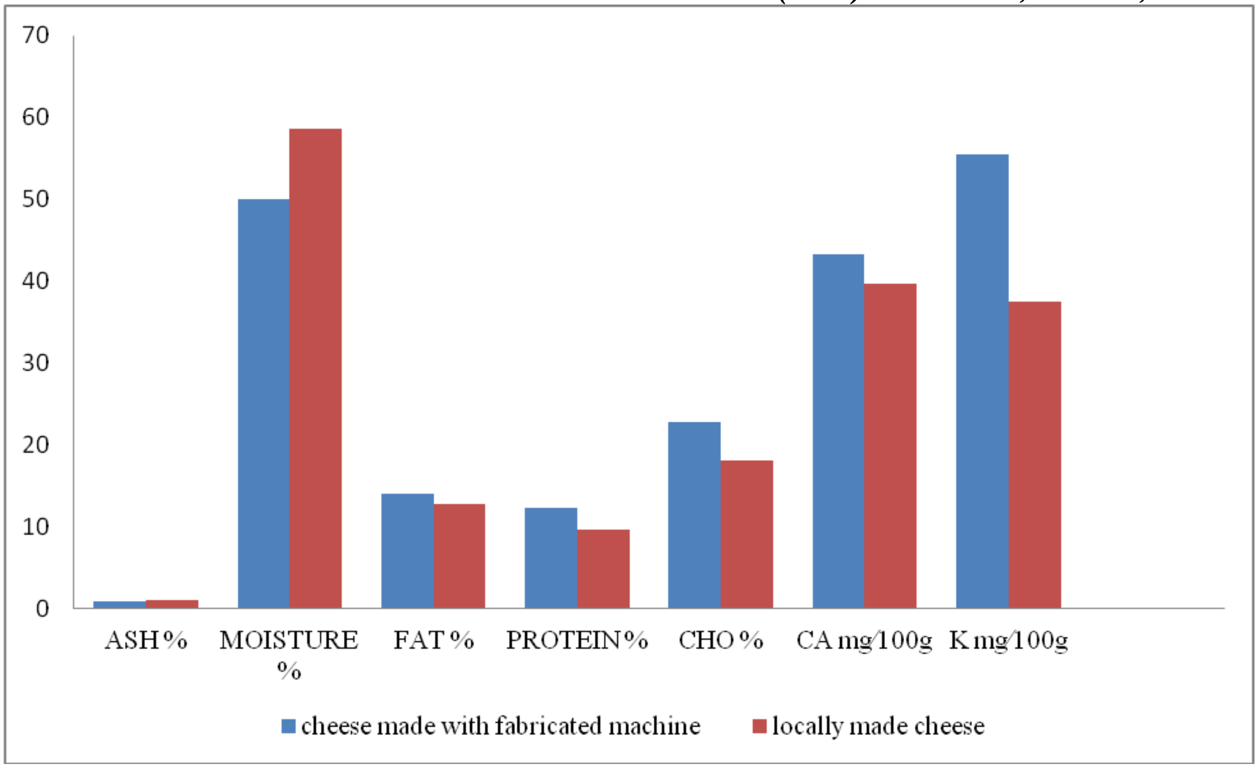


Figure 3: Proximate Analysis of the Locally Produced Cheese

Plate 1: Cheesemaking Machine

4. CONCLUSION

The design, fabrication and performance evaluation of a cheese machine was carried out. The machine produced a soft cheese and quicker cheese formation time of 7.19 minutes as compared with locally produced cheese which usually take about 10-20 minutes. In comparison with locally produced cheese, results of nutritional analysis showed the cheese produced with the machine had the contents of fat, protein and carbohydrate increased by 9.01%, 21.34%, 20.68% respectively while moisture, ash contents of the produced cheese decreased by 14.52% and 9.90% respectively. Furthermore, the mineral compositions of potassium and calcium increased by 32.55% and 8.31% respectively when compared with locally produced cheese.

REFERENCES

Abd El-Gawad, M.A.N., Ahmed, N.S. (2011). Cheese Yield as Affected by Some Parameters Review. *Acta Sci. Pol., Technol. Aliment*, 10(2): 131-153

Adetunji V.O., Alonge, D.O., Singh, R.K. and Chen, J. (2008). Production of wara, a West African soft cheese using lemon juice as a coagulant. *Journal of Food Science and Technology*, 41: 331–336.

Agidi, G., Liberty, J.T., Udekwe, M.O. and Ifere, M.P (2014). Design, Construction and Performance Evaluation of a Groundnut (*Arachis hypogaea*) Oil Clarifier. *International Journal of Engineering and Technology*, 4(1): 23-34

AOAC (2012). Official Methods of Analysis 20th Edition Association of Analytical Chemists Washington D.C. 46-80

Aremu A.K. and Ogunlade, C.A. (2016). Development and Evaluation of a Multipurpose Fruit Juice Extractor. *New York Science Journal*, 9(6): 7-14.

ASHRAE (2006). ASHRAE Handbook-Refrigeration (SI). Thermal Properties of Food, Chapter 9, pp 9.5-9.9. Accessed online at: http://www.cae.tntech.edu/~jbiernacki/CHE%204410%202016/Thermal%20Properties%20of%20Foods.pdf

Banks, J.M., Banks, W., Muir, D.D., and Wilson, A.G. (1981). Cheese yield: Composition does matter. *Diary Ind. Int.*, 46(5): 21-22

Bhatia, A. (2013). HVAC cooling load calculations and principles. Accessed online at https://www.scribd.com/document/348524502/Bhatia-Cooling-Load-Calculations-and-Principles-pdf. Assessed on 12/18/2017

Calandrelli, M. (1997). Manual on the Production of Traditional Buffalo Mozzarella Cheese. Milk Manual, Chapters 1-8. Accessed online at: http://www.fao.org/ag/againfo/themes/documents/milk/mozzarella.pdf. Retrieved on 16th April, 2018

Chien, J.T. and Snyder, H.E. (1983). Detection and control of soymilk astringency, *J. Food Sci*, 48: 438-440

FAO (2008). Gateway to diary production and products. Accessed online at http://www.fao.org/dairy-production-products/products/milk-composition/en/. Retrieved on 16th April, 2018

Gemech T., Beyene, F., and Eshetu, M. (2015). Physical and chemical quality of raw cow's milk produced and marketed in shashemene Town, Southern Ethiopia. *ISABB-Journal of Food and Agricultural Science*, 5(2): 7-13

Green, M.L. (1977). Review of the progress of Diary science: milk coagulants. *Journal of Diary Research, 44(1)*: 159-188

Hajirostamloo, B. (2009). Comparison of Nutritional and Chemical Parameters of Soymilk and Cow milk. *World Academy of Science, Engineering and Technology*, 57(1): 436-438

Hall, A.S., Holowenko, A.R., Laughlin, H.G. **(**1988). *Theory and problems of machine design, Schaum's Outline Series*. S.I. (Metric) Edition, McGraw-Hill Book Company, NewYork

Løvendahl, P. and Chagunda, M.G.G. (2011). Covariance among milking frequency, milk yield, and milk composition from automatically milked cows, *Journal of Dairy Science*, 94(11): 5381-5392

Lucey, J. and Kelly, J. (1994). Cheese Yield. *J. Soc. Diary Techn*., 47(1): 1-14

Ogunlade A.O., Oyetayo, V.O., Ojokoh, A.O. (2017). Percentage Yield and Proximate Composition of Cheese Produced from Sheep Milk Using Different Coagulants. *International Journal of Microbiology and Biotechnology*. 2(4): 171-175

Ojedapo L. O, Tona G. O, Amao S. R. and Adeneye J. A. (2014). Yield, composition and coagulation time of unsalted and salted soft cheese prepared from the milk of White Fulani cow. *International Journal of current Microbiology and Applied sciences,* 3(8): 378-383

Oladipo I.C. and Jadesimi P. D (2012). Microbiological Analysis and Nutritional Evaluation of West African soft cheese (*wara*) produced with different preservatives. *Am. J. Food. Nutr*, 3(1): 13-21

Omotosho, O.E., Oboh, G., and Iweala, E.E.J. (2011). Comparative Effects of Local Coagulants in the Nutritive Value in vitro Multienzyme Protein Digestibility and Sensory Properties of Wara Cheese. *International Journal of Diary Science*, 1-8

Orhevba, B.A., and Taiwo, A.D. (2016). Comparative Assessment of Wara (Local Cheese) Produced using Three Natural Additives as Coagulants. Research & Reviews. *Journal of Food and Dairy Technology*, 4(3):1-7

Pal, M.A., Malik, A.H., Wani, S.A., Salahuddin, M., and Bhat, A.S. (2008). Quality and yield of ewe milk paneer under the influence of various processing variables. *Bev Food World*. 35(8): 44–48.

Pauline E. and Karin, R. (2006). Preparation of dairy products. Sixth revised edition, Agromisa foundation and CTA, Wageningen. p10Rajput, R. K. (2006): Engineering Thermodynamics, 4^{th} or Later edition, Laxmi, Publications (P) Ltd. New Delhi, India

Rebouillat, S., and Ortega-Requena, S. (2015). Potential Applications of Milk Fractions and Valorization of Dairy By-Products: A Review of the State-of-the-Art Available Data, Outlining the Innovation Potential From a Bigger Data Standpoint. *Journal of Biomaterials and Nanobiotechnology*, 6: 176-203

Reinhold, V. N. (1986). Ergonomic design for people at work, Vol. 2, Eastman Kodak Company

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(2): 76 - 85.

Vaclavik V.A., Christian E.W. (2008). Milk and Milk Products. In: Essentials of Food Science. Food Science Texts Series. 4^{th} edition, New York, NY. Springer, 447p.