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Original Research

# Effects of Different Pasteurizers on the Nutritional Quality of Raw Milk Samples

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**Abstract**

The difference and changes in the nutritional components (Protein, fat an calcium) of local and exotic cow breeds (White Fulani, New Jersey and Mixture of the two breeds) were investigated before and after pasteurization of milk samples from the breeds in aluminium, stainless and galvanized steel pasteurizers that was designed and fabricated, at temperature-time combinations of $61^0$C for 30minutes, $66^0$C for 15minutes and $71^0$C for 15seconds as well as at an unquantified temperature. Chemical test carried out on the milk samples before and after pasteurization showed significant variation in protein, fat and calcium content ($p<0.05$) after pasteurization. The protein contents in the unpasteurized samples were 3.65%, 3.49% and 3.62% for White Fulani, New Jersey and heir mixtures respectively. These values decrease to 3.64% in White Fulani but increased to a range of 3.50%-3.64% in New Jersey and the mixture after pasteurization. The values of fat content obtained in the same order were 2.95, 2.85 and 2.85 % while those of calcium were 1227.70, 1117.30 and 1107.70 mg/Kg. Calcium values decreased significantly ($p<0.05$) with increase in temperature in White Fulani to a least value of 11140 mg/Kg at $71^0$C while it increased significantly as well to a value range of 1120.70 to 1134 mg/Kg in New Jersey and to a value range of 1110.30 to 1140.00 mg/Kg in the mixture at varying temperatures and material. This evaluation shows that the local breed has better nutritional composition than the foreign breed but the mixture of milk of the two breeds is a promising idea that should be further exploited.



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## INTRODUCTION

Milk is the lacteal secretion of the mammary glands of healthy mammals like cow, sheep, goat, etc (Hajirostamloo, 2009). It is slightly acidic having a pH of around 6.5 - 6.7 (Helmenstine, 2012). Milk is highly valued because it is a source of many nutrients essential for the proper development and maintenance of the human body (Wattiaux, 1994). It is a complex nutritious product containing more nutrients than any other single food (Wattiaux, 1994). Its exceptional nutrient profile includes water, protein, fat, carbohydrates, cholesterol, minerals, vitamins and energy (Anon, 2012). Hence, it is regarded as a complete diet (Anon, 2012). It is therefore recommended that every human being should consume a certain amount of milk to augment his or her nutritional deficit (Anon, 2012). To underscore the importance of milk, it is one of the most carefully tested and regulated foods (Anon, 2005).This is because it is easily contaminated by microbes leading to spoilage as a result of its mild acidic nature. It is easily affected by extremes of temperatures (Wattiaux, 1994). Different varieties of milk include whole milk, skimmed milk, flavored milk, evaporated milk, sweetened condensed milk, whole dry milk and many more (Holsinger *et al.,* 1997).

Raw milk is also referred to as whole milk. It is the freshly collected milk from the udder of any milk producing animal of choice. At the time milk is secreted, it is believed to be pure and uncontaminated until it probably gets to the udder of the animal where it can be contaminated by micro organisms in the udder due to the hygiene of the environment which the udder is exposed to. The fresh milk has an off white color, some worth yellowish indicating the presence of fat which after the milk is allowed to settle for some times covers the surface of the milk and is believed to be the breeding aid for the disease causing organisms.

'Nono' is the Hausa name for fermented milk which is sold along with butter, (mai shanu) a by- product of its production. It is commonly prepared by Hausa/ Fulani cattle rearers. It is mostly available in the northern part of Nigeria (Bankole, 1990). It is a crude cultured whole milk whose fermentation may be brought about by a number of bacterial species from various sources that contaminate the fresh milk (Atanda *et al.,* 1990). 'Nono' is locally produced in homes, especially in villages where shelf-life and safety of the product is not considered. Lactic acid bacteria are mostly associated with the production of fermented milk products. They play key role in producing desirable flavour, aroma and good physical appearance in fermented milk product. Lactic acid is the principal product of the fermentation but lesser amount of flavouring substance diacetyl is also being produced. Diacetyl is a major flavour compound in many cultured diary products.

Diacetyl is an essential property that contributes to the organoleptic quality of foods.

Pasteurization as one of the heat treatments have proven to be very effective as a means of preserving milk, it is undeniable that the intensities of heat applied will have certain effects positive or negative on the nutritional composition of the milk. The gravity of such heating effects at various pasteurizing temperatures needs to be examined. There is also the need to compare the nutritional compositions of the milk from foreign and local breeds of cows to know which contains a better quantity of certain nutrients and probably discover more interesting nutritional results from the mixture of the milk from the two breeds of cows.

## MATERIALS AND METHODS

The various material and devices used in this work and the basis of their selection as well as some of their standard properties are highlighted below.

### Aluminium Pasteurizer

This is one of the materials used to hold milk during pasteurization. In terms of its properties, aluminium is highly resistant to corrosion and has a thermal conductivity "k" of 99.99% for pure aluminium is 244 W/mK for the temperature range 0-100 $^0$C. Since this work is base on heat treatment, use of material that can easily transfer heat is necessary. Other properties of aluminium that is of interest include: density of, and approximate specific heat capacity of 900 J/kgK (Cobden, 1994).

### Stainless Pasteurizer

Its selection was base on its high corrosion resistance capability, good thermal conductivity (average of 15w/m$^0$C for all grades). It has a specific heat capacity of 500J/kgK on the average and a density of about 8.03 kg/m$^3$.

### Galvanized Steel Pasteurizer

Steel on its own is corrosive when if contact with water. Due to the high water content of milk, the galvanized steel pot is coated with Zinc-Aluminium alloy to prevent reaction of the milk with the steel. Steel has a thermal conductivity of 58.9W/mK, specific heat capacity of 420J/kgK and a density of 7900kg/m$^3$.

### Heating Medium

An electric stove with an AC voltage of 220V, a frequency of 50/60Hz and a thermal coil element rating of 1000w was selected for heating the milk at regulated temperatures. The cost of the stove is relatively cheap and it is available and can provide the desired power rating required.

### K-type Thermocouple

The thermocouple is a sensor attached to the material and connected to a temperature regulator. It senses the temperature of the milk and conveys this information to the regulator which then adjusts the temperature if necessary to a predetermined set point. The K-type (Chromel - Alumel) was selected because unlike other types of thermocouples (B, C, E, J, N, R, S, T types), it is well suited for oxidizing atmospheres; that is, it resist corrosion and has a useable temperature range of 95 to 1260 $^0$C. It is has a good degree of sensitivity of 39 μV/ºC, durable and readily available (Watlow, 2015).

### Temperature Controller

The temperature controller is a device used to maintain the desired temperature for the different pasteurization treatments of the milk. It was selected because of the need to main the different temperatures for specific periods. It works on the principles of a temperature control loop. The sensor (k-type thermocouples) measures the temperature of the milk to be controlled and converts the measured value into a travel signal. The information is received by the controller and compared the set point (pasteurizing temperature) and make adjustment when necessary.

### Pasteurization Procedure

There are basically three pasteurizers. Due to the type of pot material used, Each pasteurizer differs from the other. Generally, the pot is placed on a heater and attached to the pot is the thermocouple. The heater and the thermocouple are connected to the temperature controller and the controller is connected to a power source (Figure 1). The pasteurization is the carried out in the following steps:

1. The material (pot) is cleaned with cleaned water and placed on the heater.
2. Milk from a particular breed of desired quantity (500ml) is poured in the pot and covered.
3. The desired temperature (set point) is inputted on the controller.
4. Power is supplied from the heat source.
5. Milk is constantly stirred until the required time is reached.
6. The pot is dismounted from the heater and the power is cut off.
7. Milk is allowed to cool for a while and then poured into laboratory containers and immediately labeled.
8. The labeled samples are kept in the refrigerator (3-4$^0$C) until they are tested.

| PART LIST | |
|---|---|
| NUMBER | description |
| 1 | stirrer |
| 2 | cover |
| 3 | pastorizer |
| 4 | heat source |
| 5 | contorller |
| 6 | connecting cable |
| 7 | k-type thermocouple |
| 8 | power cable |

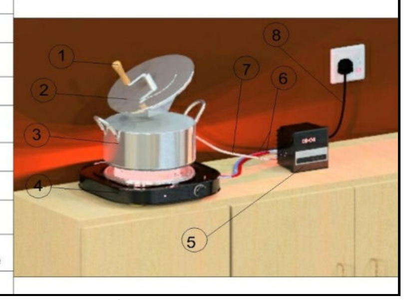


**Figure 1:** Pictorial view of experimental set-up

**Table 1:** Design layout for possible treatment combinations

| | | | | Materials | | |
|---|---|---|---|---|---|---|
| | | | | M1 | M2 | M3 |
| Temperature | T1 | Source of Milk | S1 | M1T1S1 | M2T1S1 | M3T1S1 |
| | | | S2 | M1T1S2 | M2T1S2 | M3T1S2 |
| | | | S3 | M1T1S3 | M2T1S3 | M3T1S3 |
| | T2 | | S1 | M1T2S1 | M2T2S1 | M3T2S1 |
| | | | S2 | M1T2S2 | M2T2S2 | M3T2S2 |
| | | | S3 | M1T2S3 | M2T2S3 | M3T2S3 |
| | T3 | | S1 | M1T3S1 | M2T3S1 | M3T3S1 |
| | | | S2 | M1T3S2 | M2T3S2 | M3T3S2 |
| | | | S3 | M1T3S3 | M2T3S3 | M3T3S3 |

Materials (M1=Aluminium, M2= Stainless, M3= Steel), Temperature (T1=71ºC, T2=61ºC, T3= 66ºC), and Spices (S1=White Fulani, S2=New Jersey, S3=Mixture)

**Determination of Nutritional Parameters**

After pasteurizing, the temperature of the milk samples were allowed to fall to room temperature and moved to the lab for necessary analyses. It was the refrigerated until there is need for it to be removed. The nutritional compositions of raw milk samples determined were pH, Protein, Fat, Calcium contents. They were determined using AOAC (1995), nutritional guidelines and a pH meter.

**Statistical Analysis**

The effect of different pasteurizing temperature on the amount of protein, fat and calcium in the raw milk sample were investigated using ANOVA at $p \leq 0.05$ and the level of significant means were further evaluated using Duuncan's Multiple Range Test (DNMRT). The analysis of variance test shows the effect of the measured parameters on nutritional qualities of pasteurized milk.The new Duncan multiple range test shows the different mean values of nutritional qualities across the breeds, applied temperatures and type of pasteurizer.

## RESULTS

The summary statistics on Table 2 show that depending on the materials and applied temperature being used, there exist variations in protein value of the milk from the various source 3.65, 3.49 and 3.62% for White Fulani, New Jersey and the Mixture. Similarly, variances were also observed in fat content of the milk from the different source along the various levels of applied temperature and materials 2.95, 2.85, and 2.85 %. Similar variations exist for calcium 1227.70, 1117.30 and 1107.70 mg/Kg and pH value 6.60, 6.70 and 6.60 all in the same order. These may imply that nutritional qualities of milk pasteurized using the selected applied temperature were not same in relation to the source. The analysis of variance test (Table 3) shows the effect of the measured parameters on nutritional qualities of pasteurized milk. The test shows that pasteurized milk using the selected materials under the three selected applied temperature had significantly different protein, fat and calcium content at 1% level. The new Duncan multiple range test on (Table 4) shows the different mean values of nutritional qualities across the breeds, applied temperatures and type of pasteurizer.

Figures 2, 3 and 4 show the graphical illustrations of the protein, fat and calcium contents respectively for the various milk source (White Fulani, New Jersey and their Mixture) along the levels of applied temperature for aluminum. Figures 5, 6 and 7 show the graphical illustrations of the protein, fat and calcium contents respectively for the various milk sources along the levels of applied temperature for stainless steel material. Figures 8,9 and 10 show the graphical illustrations of the protein, fat and calcium contents respectively for the various milk source (White Fulani, New Jersey and their Mixture) along the levels of applied temperature for galvanized steel material.

**Table 2:** Summary Statistics of the Data Generated

| Materials | Temperatures | Source | Protein g/100g | Fat g/100g | Calcium mg/Kg | pH |
|---|---|---|---|---|---|---|
| Aluminum | 61 | White Fulani | 3.65 | 2.94 | 1140.0 | 6.50 |
| | | New Jersey | 3.49 | 2.86 | 1122.0 | 6.30 |
| | | Mixture | 3.62 | 2.85 | 1105.7 | 6.20 |
| | 66 | White Fulani | 3.64 | 2.94 | 1146.0 | 6.60 |
| | | New Jersey | 3.49 | 2.85 | 1125.0 | 6.50 |
| | | Mixture | 3.62 | 2.84 | 1110.3 | 6.40 |
| | 71 | White Fulani | 3.64 | 2.93 | 1182.0 | 6.60 |
| | | New Jersey | 3.49 | 2.85 | 1134.0 | 6.50 |
| | | Mixture | 3.50 | 2.84 | 1113.3 | 6.40 |
| Stainless | 61 | White Fulani | 3.63 | 2.92 | 1193.3 | 6.40 |
| | | New Jersey | 3.56 | 2.85 | 1107.7 | 6.50 |
| | | Mixture | 3.63 | 2.92 | 1112.7 | 6.20 |
| | 66 | White Fulani | 3.65 | 2.95 | 1197.3 | 6.50 |
| | | New Jersey | 3.63 | 2.84 | 1114.3 | 6.40 |
| | | Mixture | 3.63 | 2.91 | 1120.3 | 6.30 |
| | 71 | White Fulani | 3.65 | 2.94 | 1219.7 | 6.50 |
| | | New Jersey | 3.49 | 2.85 | 1120.7 | 6.50 |
| | | Mixture | 3.53 | 2.91 | 1122.0 | 6.30 |
| Steel | 61 | White Fulani | 3.65 | 2.95 | 1117.3 | 6.30 |
| | | New Jersey | 3.49 | 2.85 | 1110.0 | 6.30 |
| | | Mixture | 3.64 | 2.93 | 1125.3 | 6.10 |
| | 66 | White Fulani | 3.63 | 2.92 | 1140.0 | 6.50 |
| | | New Jersey | 3.50 | 2.85 | 1109.3 | 6.30 |
| | | Mixture | 3.64 | 2.91 | 1130.0 | 6.30 |
| | 71 | White Fulani | 3.64 | 2.93 | 1209.7 | 6.40 |
| | | New Jersey | 3.49 | 2.84 | 1112.0 | 6.50 |
| | | Mixture | 3.63 | 2.92 | 1140.0 | 6.40 |
| Control | Raw | White Fulani | 3.65 | 2.95 | 1227.7 | 6.60 |
| | | New Jersey | 3.49 | 2.85 | 1117.3 | 6.70 |
| | | Mixture | 3.62 | 2.85 | 1107.7 | 6.60 |
| | Fermented | White Fulani | 3.49 | 2.85 | 1219.7 | 5.50 |
| | | New Jersey | 3.49 | 2.84 | 1117.7 | 5.60 |
| | | Mixture | 3.45 | 2.85 | 1202.00 | 5.30 |

**Table 3:** Multivariate analysis of variance for measured parameters

| Source | Dependent Variable | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| M | Protein | 0.022 | 2 | 0.011 | 10.376 | 0.000* |
| | Fat | 0.011 | 2 | 0.005 | 215.000 | 0.000* |
| | Calcium | 3346.741 | 2 | 1673.370 | 361.448 | 0.000* |
| T | Protein | 0.013 | 2 | 0.006 | 6.146 | 0.004* |
| | Fat | 0.000 | 2 | 0.000 | 8.450 | 0.001* |
| | Calcium | 8595.852 | 2 | 4297.926 | 928.352 | 0.000* |
| S | Protein | 0.235 | 2 | 0.117 | 112.703 | 0.000* |
| | Fat | 0.102 | 2 | 0.051 | 2075.000 | 0.000* |
| | Calcium | 50875.630 | 2 | 25437.815 | 5495.000 | 0.000* |
| MT | Protein | 0.008 | 4 | 0.002 | 1.944 | 0.116 |
| | Fat | 0.001 | 4 | 0.000 | 11.900 | 0.000* |
| | Calcium | 1167.185 | 4 | 291.796 | 63.028 | 0.000* |
| MS | Protein | 0.022 | 4 | 0.005 | 5.161 | 0.001* |
| | Fat | 0.027 | 4 | 0.007 | 276.650 | 0.000* |
| | Calcium | 13823.407 | 4 | 3455.852 | 746.464 | 0.000* |
| TS | Protein | 0.008 | 4 | 0.002 | 1.992 | 0.109 |
| | Fat | 0.000 | 4 | 0.000 | 1.475 | 0.223 |
| | Calcium | 6706.074 | 4 | 1676.519 | 362.128 | 0.000* |
| MTS | Protein | 0.029 | 8 | 0.004 | 3.493 | 0.003* |
| | Fat | 0.002 | 8 | 0.000 | 12.012 | 0.000* |
| | Calcium | 2802.000 | 8 | 350.250 | 75.654 | 0.000* |
| Error | Protein | 0.056 | 54 | 0.001 | | |
| | Fat | 0.001 | 54 | 0.000 | | |
| | Calcium | 250.000 | 54 | 4.630 | | |
| Total | Protein | 1044.329 | 81 | | | |
| | Fat | 678.285 | 81 | | | |
| | Calcium | 104700000.000 | 81 | | | |

*Significant at 5% level

**Table 4:** Multiple comparison using the New Duncan range Test

| | | Protein | Fat | Calcium | pH |
|---|---|---|---|---|---|
| Materials | Aluminum | 3.57a | 2.88a | 1130.90a | 6.444a |
| | Stainless | 3.61b | 2.90b | 1145.30b | 6.400a |
| | Steel | 3.59a | 2.90b | 1132.60c | 6.344a |
| Temperature | 61 | 3.60a | 2.90a | 1143.87a | 6.311a |
| | 66 | 3.60a | 2.89b | 1132.50b | 6.422b |
| | 71 | 3.57b | 2.89b | 1132.51b | 6.456b |
| Source | White Fulani | 3.64a | 2.94a | 1171.70a | 6.500a |
| | New Jersey | 3.52b | 2.85b | 1117.20b | 6.422b |
| | Mixture | 3.61c | 2.90c | 1120.00c | 6.288c |

Mean with the same alphabet are not significantly different from each other

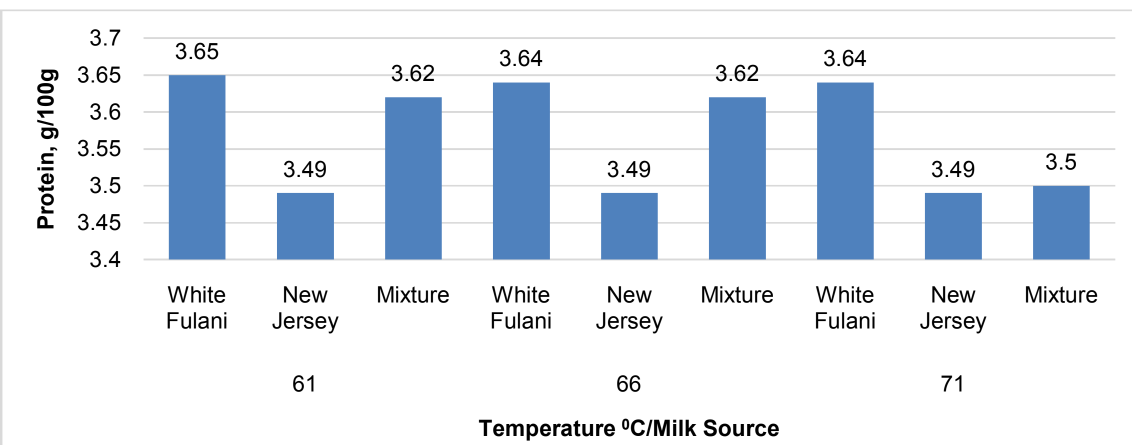


**Figure 2:** Chart showing the graphical illustration of the protein content in applied temperature and milk source for aluminum

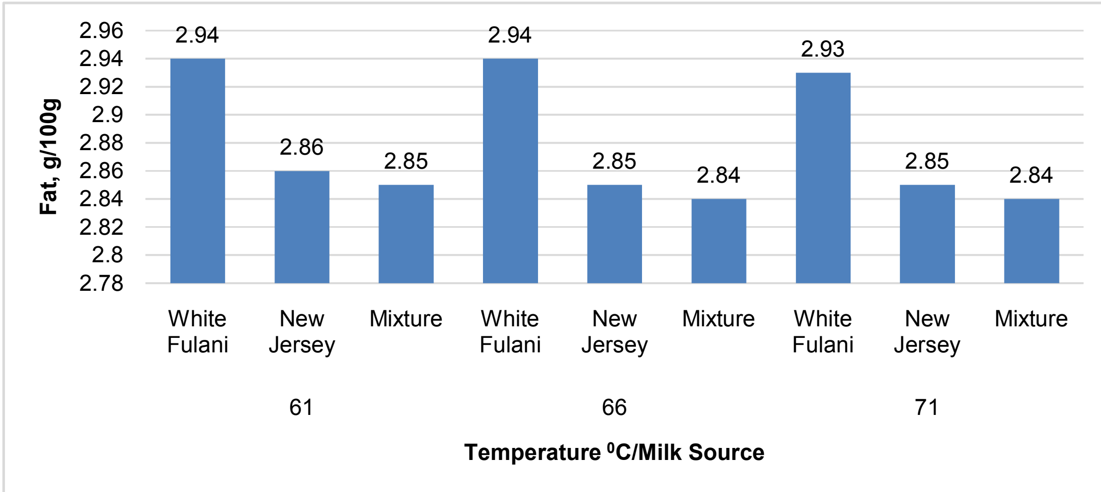


**Figure 3:** Chart showing the graphical illustration of the fat content in applied temperature and milk source for aluminum

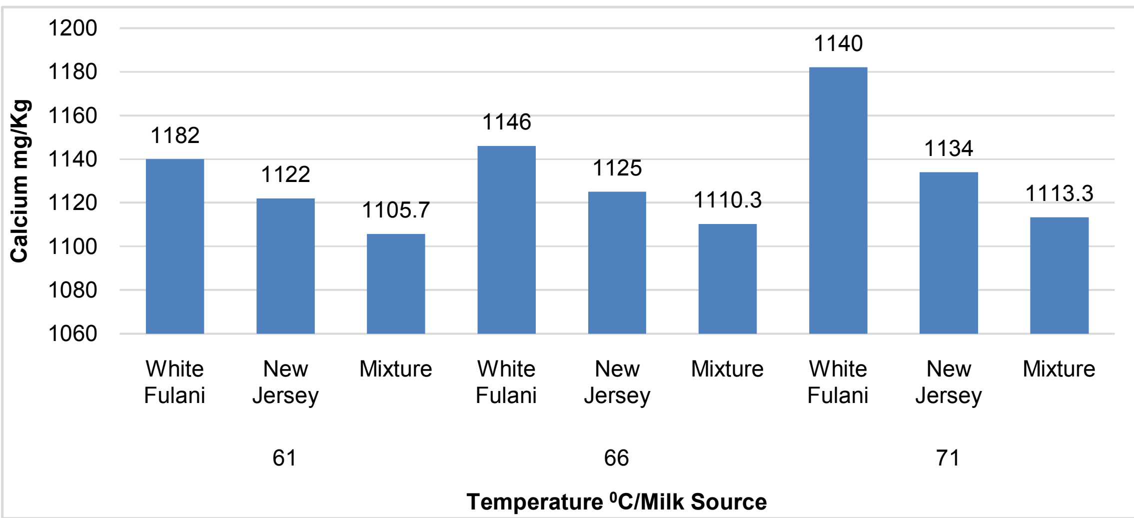


**Figure 4:** Chart showing the graphical illustration of the calcium content in applied temperature and milk source for aluminum

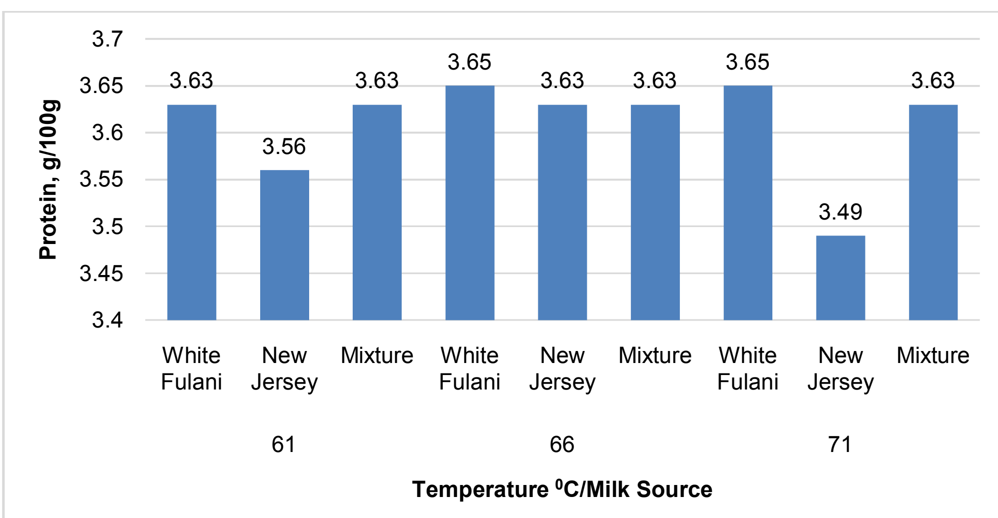


**Figure 5:** Chart showing the graphical illustration of the protein content in applied temperature and milk source for stainless material

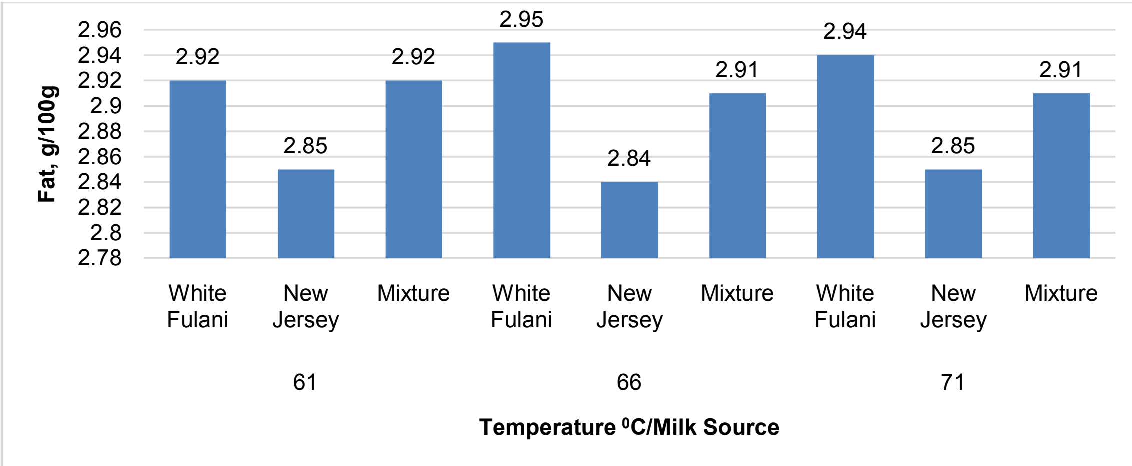


**Figure 6:** Chart showing the graphical illustration of the fat content in applied temperature and milk source for stainless material

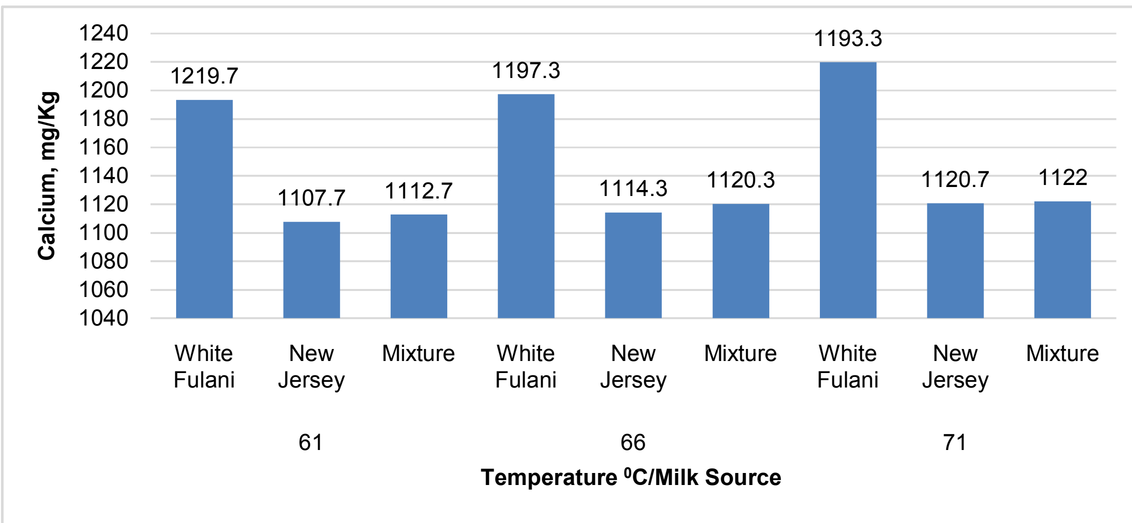


**Figure 7:** Chart showing the graphical illustration of the calcium content in applied temperature and milk source for stainless material

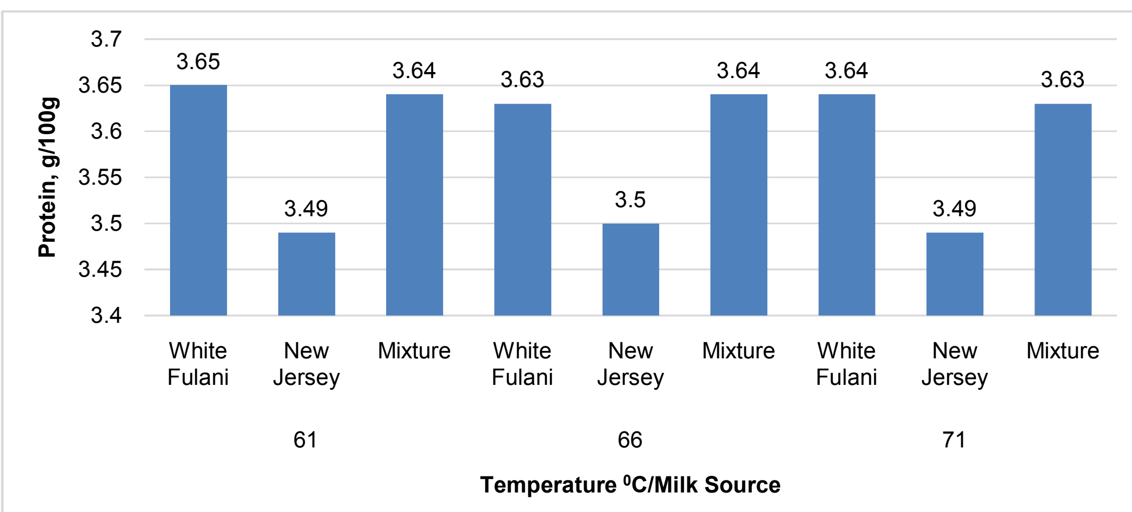


**Figure 8:** Chart showing the graphical illustration of the protein content in applied temperature and milk source for steel material

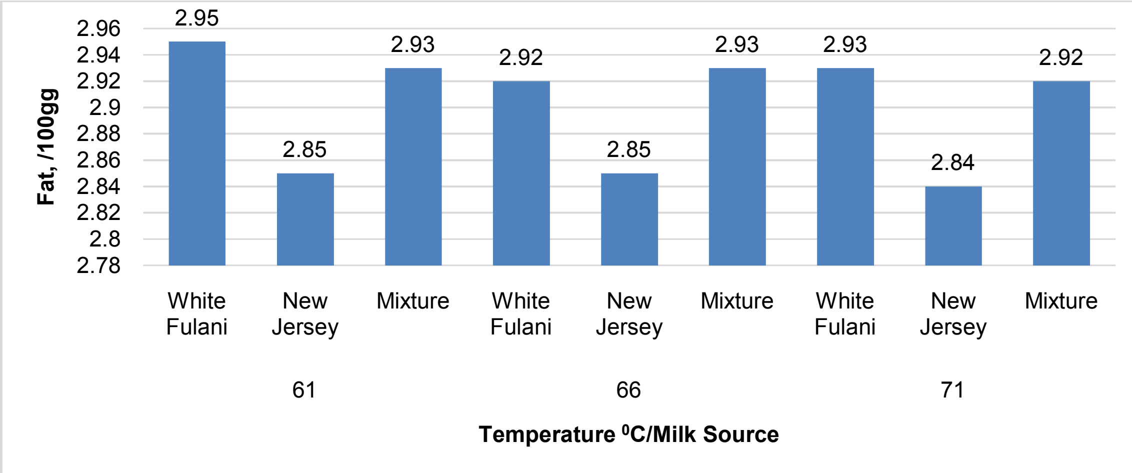


**Figure 9:** Chart showing the graphical illustration of the fat content in applied temperature and milk source for steel material

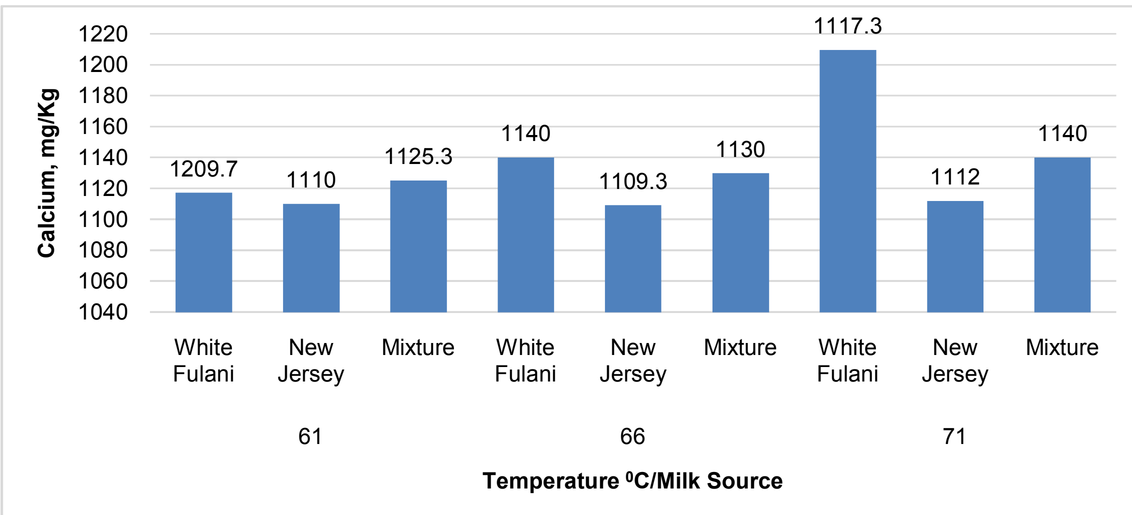


**Figure 10:** Chart showing the graphical illustration of the calcium content in applied temperature and milk source for steel material

## DISCUSSION

Variations were also observed in fat content of the milk from the different source along the various levels of applied temperature and materials 2.95%, 2.85%, and 2.85%. Similar variations exist for calcium 1227.70mg/Kg, 1117.30 mg/Kg and 1107.70 mg/Kg and pH value 6.60, 6.70 and 6.60 all in the same order. These may imply that nutritional qualities of milk pasteurized using the selected applied temperature were not same in relation to the source. Table 2 shows that protein content is highest in White Fulani milk having 3.65% (3.65g/100g) in the unpasteurized sample. This value however decreases insignificantly to 3.64% and 3.63% at 66$^0$C and 71$^0$C in stainless and steel pasteurizers. This can be attributed to the fact that heating of milk above 60$^0$C causes breakdown of proteins (Weight, 2008) this statement is further justified by the values obtained for the protein content of milk from mixture of the breeds at certain temperature (3.50% at 71$^0$C in aluminium and 3.53% at 71$^0$C in stainless) compared to the raw sample of the mixture having 3.62g/100g protein.

The test (Table 3) shows that pasteurized milk using the selected materials under the three selected applied temperature had significantly different protein, fat and calcium content at 1% level. As true as this is for white Fulani milk, protein values in New Jersey milk opposes these statements as an increase in protein content values above that of the raw sample (3.49g/100g) from this breed was recorded ranging from 3.50% at 66$^0$C in steel to 3.63% at 66$^0$C in stainless steel material. The fat content from the result of this study is highest in the local breed (2.95%) compared to the foreign breed and MMB (2.85%) gave a value lesser than that of WH but equal to NJ (2.85%) before pasteurization and values (2.91%, 2.93% etc) higher than that of NJ after pasteurization. Similar case was reported by Dandare *et al.,* 2014 , where WH recorded a value of fat (6.23±0.16) higher than that of the Holstein Friesian cow milk (5.96±0.21) and the resulting fat content from a cross breed of the two gave 6.8±0.62 fat content which is higher than that of Holstein Friesian. However, this increase in fat content of MMB is justified because milk protein percentage is positively correlated with the milk fat percentage. If one is high, the other is usually high (Ozrenk *et al.,* 2008). Furthermore, values obtained for fat in White Fulani, New Jersey and Mixture decreases with increase in temperature. White Fulani yet again has the highest calcium content followed by the Mixture then New Jersey with 1127.70mg/Kg, 1170.30mg/Kg and 1107.70mg/Kg respectively in their raw samples. Pasteurization is said to kills the natural enzymes and destroys the chemical make-up of calcium in raw milk (Edward, 2015) and soluble calcium and phosphorus subjected to such heat treatment decrease by not less than 5% or more . This explains the significant decrease in calcium content of the White Fulani milk to 1140.00 mg/Kg, 1193.30 mg/Kg, and 1117.30 mg/Kg at $71^0$C in each material when compared to the value for the raw samples from the results in table 2. New Jersey and Mixture values on other hand give significant increase in calcium content with increase in temperature as was witnessed in their protein content.

The pH of water ranges from 6.5-9.5 on the pH scale of 1-14 (WHO, 2003) and milk which is composed of approximately 90% water has a pH usually between 6.6 and 6.7 but it can be outside this range – for example 6.40–6.89. The pH obtained in this study conveniently falls within these ranges. However, the pH of milk heated at unquantified temperatures is more acidic with values of 5.50, 5.60, and 5.30 for White Fulani, New Jersey and Mixture respectively. This may be attributed to the fact that although milk pH falls during heat treatment, but this is largely reversible on cooling. Walstra and Jen-ness (1984) illustrated that pH could fall to below 6.0, when the temperature exceeds $100^0$C except in situations where high temperatures applied lead to water loss and causes severe chemical reaction

.

It can be inferred from Table 4 that the protein content of various pasteurized milk samples differs from that of raw milk and this applies to other nutritional components although not in the same pattern. Generally, the values obtained for protein in raw samples for the breeds in this study, is in contrast but within the range of those in other literatures. Previous studies reported various protein compositions in cow milk ranging from 3.3 ±0.22% (Mirzadeh *et al.,* 2010) and 3.73±0.68% (Ahmed *et al.,* 2007) for White Fulani milk to 3.7% for New Jersey milk. Similarly, variations occur in fat and calcium contents of these breeds from those recorded in previous studies. The variation in the fat content may be attributed to different genetics and physiological status of the cow breeds . These variations could also be as a consequence of type of feed, herd management, season or rate of milking of the cows (Dandare *et al.,* 2014).

The result (Figure 2) shows that irrespective of the applied temperature used, white Fulani and the mixture had higher protein content than the New Jersey except for applied temperature at 71°C where protein content seems to decrease but the same for New Jersey. The chart (Figure 3) shows that the milk from white Fulani has the highest fat content regardless of the heat applied followed by the milk from New Jersey. However, there is a decrease in the fat content in the breeds as the temperature increases. This implies that a high temperature affects the fat content although these decreases are insignificant. At $61^0$C (Figure 4), milk from White Fulani has the highest calcium content and same goes for calcium content at other two temperatures. A drastic fall in this nutritional component is witnessed in the white Fulani as the temperature increases. New Jersey and the mixture however show an increase in the calcium content as the temperature increases. It can therefore be said that if high calcium content is required from these samples, white Fulani milk pasteurized in an aluminium material, subjected to low temperature is the best followed by the new Jersey milk. This chart (Figure 5) shows that all types of milk have the highest protein content at $66^0$C. The White Fulani has it lowest protein content at $61^0$C while New Jersey has it lowest at $71^0$C. The mixture is not as affected by the temperature change but is best at $61^0$C. In all, moderate temperature of $66^0$C gives best protein content. The result (Figure 6) shows that moderate temperature of $66^0$C gives the highest fat content for White Fulani milk while higher temperature of $71^0$C gives the highest fat content for New Jersey which has the lowest fat content of the milk types. It appears from the fat content of the mixture that the fat content of the white Fulani milk boosts that of the New Jersey. The mixture gives the highest fat content of all the milk types at $61^0$C and is even higher at $66^0$C. Overly, White Fulani milk has the highest fat content followed by the mixture at same temperature of $66^0$C. Calcium in White Fulani is yet drastically affected by increase in temperature as it decreases with increase in temperature. The same decrease in calcium content with increase in temperature goes for the mixture except for New Jersey where highest temperature seems to favor the calcium content (Figure 7). Regardless of applied temperature, milk from White Fulani has the highest calcium content followed by that in the mixture. It can be deduced from the chart( Figure 8) that protein content in the milk types reduces with increase in temperature. Protein content in White Fulani is still the highest regardless of the applied temperature, having the same value with that in the mixture at $66^0$C while protein content in New Jersey is lowest at all levels of applied temperature. The result (Figure 9) shows that fat content in White Fulani milk is highest of all the types of milk followed by that in the mixture and reduces with increase in temperature. Fat in New Jersey milk is the lowest of the milk types regardless of temperature and it does not follow the pattern of decrease in fat content with increase temperature as the other two as it has it highest fat content at $66^0$C. It can also be said from the fat content in the mixture that fat in White Fulani boosts that of New Jersey. White Fulani milk has the highest calcium content regardless of applied temperature followed by the mixture then the New Jersey. There is again a drastic reduction in the calcium content of White Fulani with increase in temperature as well as in that of the mixture. New Jersey on the other hand has it highest calcium content at $66^0$C and is least favored by the lowest temperature (Figure 10).

## CONCLUSIONS

Protein to start with regardless of material of pasteurization or breed is highest at $61^0$C and in most but not all cases reduces with increase in temperature. $66^0$C however appears to be the most convenient temperature to enjoy a good protein content on the average for all three types of milk for whichever type of material is employed. In term of choice of milk for best protein content, it will be milk sourced from White Fulani cow, pasteurized at $66^0$C in a stainless steel material. For other milk types, it is the mixture pasteurized at $61^0$C in a steel material and lastly New Jersey milk pasteurized at $66^0$C in a stainless steel material.

Fat content generally at $61^0$C applied temperature on the average gives a convenient value regardless of breed or material of pasteurization. The highest fat content can be obtained in milk sourced from White Fulani cow, pasteurized at $66^0$C in a stainless steel material. For others, it is the mixture, pasteurized at $61^0$C in a steel material and lastly New Jersey milk pasteurized at $61^0$C in an aluminium material.

There was a severe decrease in calcium content of White Fulani milk with increase in temperature in all the material of pasteurization. The same was the case for other types of milk in most but not all cases. On the average, $61^0$C applied temperature appears to be the most convenient temperature for a good calcium content in all the types of milk and material. Best calcium content was however obtained in white Fulani, pasteurized at a temperature of $61^0$C in a stainless steel material. In others we have the mixture pasteurized at $61^0$C in steel material and then New Jersey milk pasteurized at $61^0$C in aluminium material.

It can also be concluded that the local breed of cow (White Fulani) regardless of the temperature and material for pasteurizing has higher nutritional values that the New Jersey bread and the mixture of milk from the two breeds is a welcome idea as it has no negative effect on the nutritional qualities tested for in this research. Best protein, fat and calcium content in different milk types were obtained instainless steel material appears to be the most reliable. High temperature of $71^0$C did more damage in most cases to the nutritional constituents of all the milk types than the other temperatures even though it was applied for a very short time.

### Conflict of Interest

Conflict of interest none declared.

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