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Comparative study of the physicochemical parameters goat, cow and camel's milk collected from Maigatari Town, Jigawa State, Nigeria

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Abstract
Fresh milk is nearly a complete food containing all the essential components in a nearly balanced form. This research investigated some key physicochemical parameters of milk samples from goat, cow and camel collected from Maigatari Town in Jigawa State, Nigeria. Fresh milk samples were collected and analyzed, and the results revealed the following: Goat milk: Temperature (34^{O}C); pH (6.45); specific gravity (1.05); titratable acidity (1.03%); total solids (12%); moisture content (88%); ash content (0.8%); crude protein (3.4%); fat content (5.6%); lactose content (3.9%) and solids-not-fat content (7.68%). Cow milk: Temperature (38^{O}C); pH (6.68); specific gravity (1.03); titratable acidity (1.04%); total solids (14%); moisture content (86%); ash content (0.6%); crude protein (3.6%); fat content (4.2%); lactose content (4.7%) and solids-not-fat content (9.16%). Camel milk: Temperature (36^{O}C); pH (6.1); specific gravity (1.04); titratable acidity (1.03%); total solids (13%); moisture content (87%); ash content (0.8%); crude protein (3.8%); fat content (3.8%); lactose content (3.3%) and solids-not-fat content (8.92%). It can be concluded that goat milk has the highest fat content, while cow milk has the highest lactose content, and camel milk is the richer in terms of the crude protein content.

Keywords: physicochemical parameters, goat milk, cow milk, camel milk

Introduction

Young mammals are fed with milk secreted from the mammary glands by their mothers, as such it can be said that milk itself is as ancient as mankind itself, since it is the substance used to feed the mammalian infants [1]. The milk is an important source of all basic nutrients required for nearly all mammals including human beings [2]. Mammals like sheeps, goats, cows, buffaloes and camels are producers of milk, and are used in various parts of the world for the production of milk for human consumption [1], and in the preparation of some nutritional products such as butter, milk cream, butter, yoghurt etc [2, 3, 4].

Because milk contains nearly all the essential nutrients, fats, proteins, minerals, vitamins and lactose, all in balanced ratio in comparison to other foods, fresh milk is regarded as a complete diet [5] and thus could be used throughout one's life. On another hand, milk is a source of macro and micro-nutrients, and contains a number of active compounds that play a significant role in nutrition and health protection [6], with its solid components (fat and protein) making it a nutritionally and economically important asset [7]. Compared to other biological fluids, milk is more widely influenced by genetic and environmental factors [8]. Other factors that may be responsible for variations in the milk composition may include breed of the cow, strain, interval between milking and completeness of milking, stage of lactation, feeding regime, health and age of the cow [7].

The major chemical components of fresh milk include water, fats, proteins, carbohydrates, minerals, vitamins, organic acids and enzymes [2], and in order to assess the quality of milk, milk samples including infant formulas, milk powder, milk from markets, fresh raw milk (unprocessed), human milk and animal milk from various countries such as Poland, Italy, USA, Canada, Lithuania, UK, Sudan, Ethiopia and Nigeria have been extensively studied [9. 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23]. Nutritionally rich milk and milk products with enhanced biological potential and without health risks are generally recommended [24, 25, 26].

In this study, the physical and chemical qualities of raw goat, cow and camel's milk collected from Maigatari town, Jigawa state, Nigeria were investigated and compared with some commercially available milk products.

Materials and Methods

Temperature of the Samples

The temperature of the fresh goat, cow and camel's milk samples were determined immediately at the collection point (immediately after milking) using thermometer (Thermco B200cws) based on the procedure reported by Gemechu *et al.*, [21].

pH of the Samples

The pH of the samples were determined in the laboratory using a digital pH meter (MT-103) based on the procedure described by O'Connor [27] as adopted by Gemechu *et al.*, [21].

Specific Gravity

Here a 100 mL capacity glass cylinder was filled with the fresh milk sample, and a lactometer was inserted, and then allowed to freely float until it reached equilibrium. The lower meniscus reading of the lactometer was recorded, and immediately a thermometer was inserted into the milk sample and the temperature was recorded as reported by O'Mahoney [28] as adopted by Gemechu *et al.,* [21]. The specific gravity was calculated using the following formula:

$$\text{Specific Gravity} = \frac{L}{1000} + 1$$

Where:
L = Corrected lactometer reading at a given temperature. That is, for every degree above 15.56^{O}C, 0.2 was added to the lactometer reading and for every degree below 15.56^{O}C, 0.2 was subtracted from the lactometer reading. This is based on the procedure reported by O'Mahoney [28] and adopted by Gemechu *et al.,* [21].

Titratable Acidity of the Milk Samples
The titratable acidities of the milk samples were determined according to the AOAC [29] procedures. Here 9 mL of the milk sample was pipetted into a beaker and 4 drops of 1% phenolphthalein indicator was added to it. The sample was then titrated with 0.1 N NaOH solutions until a faint pink color appeared. The titratable acidity was finally calculated using the following formula and expressed as % lactic acid.

$$\text{Titratable acidity (\%)} = \frac{0.1\ N\ NaOH\ (ml)\ x\ 0.009}{Weight\ of\ Milk\ Sample} X100$$

Total Solids of the Milk Samples
The AOAC [29] method of analyses was adopted for the determination of the total solids of the samples. Here 5 grams of the thoroughly mixed fresh milk samples was transferred into a pre-weighed and dried crucible. The milk samples were dried in a hot air oven (Lt-hao002) at 102^{O}C for 4 hrs. The dried samples were finally taken out of the oven and cooled at room temperature by placing it in a desiccator. The samples were weighed and the total solids were calculated using the following formula as reported by Richardson [30] and adopted by Gemechu *et al.,* [21].

$$\text{Total Solids} = \frac{(Crucible\ Weight + Oven) - Dried\ Sample\ Weight - Crucible\ Weight}{Sample\ Weight} X\ 100$$

Determination of Moisture Content
The moisture contents of the milk samples were determined by the difference between the known weights of the milk samples and the determined weights of the total solids after evaporating the liquid component of the milk samples on a hot plate [2].

$$\text{\% Moisture Content} = \frac{Sample\ Weight - Total\ Solids}{Sample\ Weight} X\ 100$$

Determination of Ash Content
The ash contents of the milk samples were determined gravimetrically in accordance with the procedure reported by Richardson [30] and adopted by Gemechu *et al.,* [21], where dried milk sample were used. Here the dried milk samples that were used for the determination of the total solid contents were ignited in a muffle furnace at a temperature of 550^{O}C for 4 hours until the samples were free from carbon. Heating continued until the ash residue appeared grayish, and then the samples were transferred to a desiccator to cool down. The ash content was finally calculated using the formula below.

$$\text{\% Ash} = \frac{Residue\ Weight}{Sample\ Weight} X\ 100$$

Crude Protein Determination
The total protein contents of the milk samples were determined by the Kjeldahl method [29]. To ensure digestion, 5 g of the milk sample each was warmed in water bath at a temperature of 38^{O}C and then transferred into a Kjeldahl flask. This was followed by the addition of 15 g potassium sulphate, 1 mL of copper sulphate solution and 25 mL of concentrated sulphuric acid, and then gently mixed. Digestion was carried out in a digestion block until a clear solution appeared, and then it was allowed to cool at room temperature.
To carry out distillation, the digestion flask was placed in the distillation equipment, then 30 mL of distilled water and 75 mL of 50% NaOH solution were added. Ammonia was then distilled and 50 L of 40% boric acid solution using bromocresol green indicator were until the color changed to blue. Lastly, the sample was titrated with 0.1 N HCl solution from a burette until a faint pink color solution was formed, and the burette reading was recorded to the nearest 0.01 mL. Using the same procedure, blank test was carried out using water instead of the test samples. The percentage nitrogen contents in the milk sample were calculated as follows (as adopted by Gemechu *et al.,* [29]:

$$\text{\% Nitrogen by Weight} = \frac{(Vs - Vb)HCl\ consumed\ x\ N\ HCl\ x\ 1.4007}{Sample\ Weight} X\ 100$$

$$\text{Percentage Crude Protein} = \text{\% N x 6.38}$$

Where:
Vs = Volume of HCl used for titration of the sample
Vb = Volume of HCl used for titration of the blank.

Determination of Fat Content
In this analysis, the Gerber method was employed in accordance with procedure reported by Richardson [30] and adopted by Gemechu *et al.,* [21]. Here 11 mL of each of the milk samples was mixed with 10 mL of sulphuric acid (specific gravity 1.82) into butyrometer and then 1 mL of amyl alcohol was added. The butyrometer was then closed with rubber cork, and the content was vigorously shaken until all the milk samples were digested by the acid. The butyrometer was then placed in a water bath at 65^{O}C for 5 minutes. The sample was centrifuged for five minutes, and then transferred back to the water bath at 65^{O}C for 5 minutes, and the percentage fat was recorded from the butyrometer.

Determination of Lactose Content
The lactose contents of the milk samples were determined by subtracting the percentage of the fat, protein and total ash from the percentage of the total solids, in accordance with the procedure reported by O'Mahonet [28] and adopted by Gemechu *et al.,* [21].

$$\text{\% Lactose Content} = \%\ Total\ Solids - (\%\ Fat + \%\ Protein + \%\ Total\ Ash)$$

Determination of Solids-Not-Fat Content
The solids-not-fat contents of the milk samples were determined by subtracting the percentage of the fat content

from the percentage of the total solids, in accordance with the procedure reported by Richardson [30] and adopted by Gemechu *et al.*, [21].

$$\% \text{ Solids} - \text{Not} - \text{Fat Content} = \% \textit{ Total Solids} - \% \textit{ Fat Content}$$

Results and Discussion

The results for all the physicochemical parameters analyzed are presented in Table 1.

Table 1: Physicochemical Parameters of the Goat, Cow and Camel Milk Samples

S/NO	Parameters	Goat milk	Cow milk	Camel milk
1	Temperature	34	38	36
2	pH	6.45	6.68	6.61
3	Specific Gravity	1.05	1.03	1.04
4	Titratable Acidity	1.03	1.04	1.03
5	Total Solids	12	14	13
6	Moisture Content	88	86	87
7	Ash Content	0.8	0.6	0.8
8	Crude Protein	3.4	3.6	3.7
9	Fat Content	5.6	4.2	3.8
10	Lactose Content	3.9	4.7	3.3
11	Solids-Not-Fat Content	7.68	9.16	8.92

Temperature

The temperature of the milk sample collected from goat was found to be 34^{O}C, and this is supported by similar report by Brown *et al.*, [31], while of cow was found to be 38^{O}C, and this agrees with report by Gemechu *et al.*, [21], and for camel the temperature of the milk sample was found to be 36^{O}C, and this agrees with result reported by Reinemann *et al.*, [32] and Gemechu *et al.*, [21]. Milk temperature is an important parameter for the assessment of the quality of milk, and may be affected by the health condition of the animal, the environment, the season and the frequency of milking [21]. Milk delivered at the proper temperature will stay fresher longer, with colder temperatures slowing or preventing the growth of the harmless bacteria that cause milk spoilage and also reduce the likelihood of other flavor defects. The warmer milk is allowed to get during collections, deliveries and subsequent handling, the longer it will take to cool back to its proper storage temperatures [32].

pH

The analyses of the pH of the fresh milk samples were conducted at the site of sampling. The results obtained showed the pH values of goat, cow and camel as 6.45, 6.68 and 6.61 respectively, and these results are in agreement to reports from some researchers [33, 34, 35, 36]. Measurement of the pH of milk is important in testing for signs of some infections, as well as adulteration, impurities and spoilages for milk products. The range of pH for fresh goat milk is 6.3-6.7, while for cow milk it is 6.4-6.8, while for camel milk it is 6.5-6.7 [37]. When the pH value of milk falls below the range of pH, it normally entails spoilage by bacteria from the class of the lactic acid bacteria (LAB) [38]. When the milk is too acidic, the milk may curdle or coagulate characteristic smell and sour taste [37]. However, when the pH value is higher than the range the milk may have come from an infected animal. Thus, a regular pH measurement offers a quick way to screen for infection among livestock [38].

Specific Gravity

The specific gravities of the milk samples analyzed in this study were found to be 1.05% for goat milk, 1.03% for cow milk and 1.04% for camel milk all at room temperature. All the specific gravities were found to be similar (for goat, cow and camel milks), and this finding is similar to that reported by Legesse *et al.*, [36] who reported similar specific gravities for milks from camel, cow and goat in Somali Regional State, Ethiopia. The result also agrees with similar finding reported by Asif and Sumaira [35]; Shamsia [39]; Sabahelkhier *et al.*, [40]; Elbagermi *et al.*, [41]. The specific gravity of milk bears a relationship of the butterfat and the total solids, as such it has been used as an aid to detecting possible adulteration and/or abnormalities from the average composition. [35, 42] The specific gravity of milk will decrease slightly with increasing temperature, partly because of the effect of temperature on the milk butter, and also because the contraction of the other solids that occur on mixing with water decreases slightly with increasing temperature. [42] Milk density is further influenced by other factors like history of the samples, biological differences of micelles and processing conditions of the milk, lactation stage [43], breed, feeding, milking system, milking frequency and age of the animal [44].

Titratable Acidity

The values of the titratable acidities of the milk samples studied were found to be 1.03, 1.04 and 1.03% for goat, cow and camel respectively. These values are found to be higher than the titratable acidities reported by Legesse *et al.*, [36] and Rehman and Salaria [45]. However, the results are in agreement with similar reports by Asif and Sumaira [35] and Haenlein and Wendorff [46]. Titratable acidity, the percentage (%) of lactic acid, is a very important test used to determine the quality of milk [47]. Titratable acidity has been used for many years to indicate whether milk has suffered from temperature abuse (heating), bacterial degradation (acid production) or whether the milk is aged [47]. Two major factors that are believed to impact the titratable acidity of milk are its age and protein content. Milk that is days old is prone to bacterial growth and this will subsequently decrease its quality, while higher protein content of milk tends to increase its titratable acid value [47].

Total Solids

The total solids contents of the milk samples collected from goat, cow and camel were found to be 12, 14 and 13% respectively, and these results are in agreement with similar findings by other researchers [33, 35, 36, 41, 48, 49]. Total solids content of milk is affected by the lactation status of the animal, with increasing lactation raising the total solids content. Total solids in milk are also affected by the season of the year, with the highest level observed during raining season [50].

Moisture Content

The moisture contents of the milk samples analyzed in this research were found to be very high, ranging from 88% for goat milk, 86% for cow milk, and 87% for camel milk. The results obtained in this study were found to agree similar researches [35, 36, 41, 49]. Milk is known to have moisture content, and with respect to this, milk is an excellent growth medium for microbial growth, with most microorganisms finding it difficult to survive and/or grow at reduced water activity [51]. Moisture content determination is one of the most important and most widely used measurements in testing and processing of milk and other foods. Since the amount of solid matter in milk is inversely related to its moisture content, then the moisture content is of direct economic importance to both the consumer and the processor of the milk. Of even greater significance, however, is the effect of moisture on the stability and quality of milk [51].

Ash Content

When the milk samples were heated to dryness and the residue incinerated at a low red heat, a white ash which contains the mineral substances remained. The values of ash contents goat, cow and camel milk samples were found to be 0.8, 0.6 and 0.8% respectively, with the ash contents of the three milk samples found to be nearly similar. These results are in agreement with findings reported by Rashida *et al.,* [1], Kanwal *et al.,* [33], Asif and Sumaira [35], Legesse *et al.,* [36] and Elbagermi *et al.,* [41]. Determining the ash content of milk is part of its nutritional evaluation, as well as an important quality attribute for some milk products; and it is also the first step in the preparation of the milk sample for elemental analysis. [52]

Crude Protein

The protein contents in milk samples collected from goat, cow and camel were found to be 3.4, 3.6 and 3.7% respectively, with protein content a little bit higher in camel. This result agrees with similar findings reported by Asif and Sumaira [35], Legesse *et al.,* [36] and Elbagermi *et al.,* [41]. The protein content of cow milk was similar with result reported by Kanwal [33] and Davide [53], while the amount of protein in camel milk was in agreement with that reported by Enb *et al.,* [34], with the protein content in goat milk higher than that reported by Kholif *et al.,* [48]. From the nutritional and biological activities points of view, protein content is an important component of the milk, owing to the fact that it acts as growth factors, hormones, enzymes, antibodies and immune stimulants. [54, 55, 56] The protein content usually differs between suckling and milking periods as reported by Gargouri *et al*., [57], who found that protein content in milking period was higher than the value in suckling period.

Fat Content

The fat contents of the milk samples collected from goat, cow and camel illustrated that the fat content for goat milk is 5.6%, for cow milk is 4.2%, and for the camel milk is 3.8%, and this agrees with similar findings reported by Ahmed and El-Zubeir [58]. From the result of this study, the fat content in cow milk was less than goat milk, but higher than camel milk, and this agrees with reports by Rashida *et al.,* [1], Kanwal [33], Enb *et al.,* [34], Asif and Sumaira [35], Legesse *et al.,* [36] and Elbagermi *et al.,* [41]. The values for the goat and cow fat contents in this study are quite similar to the finding of Hanjra *et al.,* [59], Foltys [60] and Banda [61]. Factors that may affect the fat content of animal include the following; genetic parameters [62, 63]; breed of the animal [64, 65]; the animal's individuality [66, 67]; parity or age of the animal [68, 69]; stage of lactation [70, 71].

Lactose Content

The results from this study, goat (3.9%), cow (4.7%) and camel (3.3%), were in agreement with other similar results reported by researchers [35, 36, 41]. Milk samples collected from camel showed the lowest lactose contents of 3.3%, while and that of cow showed the highest value of 4.7%), and this agrees with similar findings reported by Rashida [1]. The results are also supported by reports by Hanjra *et al.,* [58]. The lactose content of a dairy animal is affected by the species of the dairy animal, its age, breed, diet, the stage of lactation, parity (number of parturitions), physical environment, farming system and season [64, 65].

Solids-Not-Fat Content

The solids-nor-fat contents of the milk samples analyzed in this study were found to be 7.68, 9.16 and 8.92% for goat, cow and camel milks respectively, and these results are in agreement with reports by Ali *et al.,* [72] and Jaydeep *et al.,* [73]. Cow milk sample's solid-not-fat content compares with that reported by Abdel-Hameid [74]. The milk solids-not-fat comprises of lactose, caseins, whey proteins and minerals (ash content) of the product from which they were derived. They are an important ingredient for the improvement of the texture of milk, and may be a cheap source of total solids. The total solid-not-fat content may vary with respect to seasons, lactation stage, environmental conditions and breed of the animal [1].

Conclusion

There are some slight variations in the chemical compositions of the goat, cow and camel milk obtained from Maigatari Town in Jigawa state, Nigeria. The fat content was mostly higher in goat, making goat milk the most nutritious. Composition of animals' milk is influenced by numerous factors. The consumer should be aware about the kind of milk he consumes, and the authorities should adopt the policy of frequent inspection of the market to check whether the milk meets the minimum standards.

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