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Research Article

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Determination of the Chemical and Proximate Properties of Fresh Milk Samples from Small Holder Dairy Cows and Large Mechanized Dairy Cows in Parts of Kaduna State, Nigeria

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Abstract
The Chemical and Proximate composition of different raw fresh milk samples from small holder dairy cows and large mechanized dairy cows in Zaria and Kaduna in Kaduna State, Nigeria were determined using standard methods and EDRXF spectrophotometer. The mean values of the pH based on farm locations ranged between 6.71±0.03 – 6.81±0.02 and the titratable acidity ranged from 0.15±0.04 – 0.17±0.03. From the various farms, while the mean values of the proximate composition of milk from the various farms ranged from 86.30±0.01 – 87.94±0.04 for moisture up to 12.51±0.01 – 13.82±0.01 for Total solids. Based on the different farm management locations, the proximate values for moisture ranged from 86.38±0.01 –87.25±0.18 while that of Total solids ranged from 12.96±0.12 – 13.49±0.02. The statistical analysis of the obtained result at 0.05 probability value showed significant differences between pH values, between acidity values as well as in the values of the proximate characteristics from the different farm locations which were attributable to the differences in the farm management practices.

Keywords: Proximate Analysis, Small Holder Dairy Cattle, Large Mechanized Dairy Cattle, Milk, Kaduna

1. Introduction

The milk of domesticated animals (especially cow) is an important food source for humans, either as fresh fluids or processed into a number of dairy products such as yoghurt butter or cheese because it is nature's most nearly perfect food, deficient only in iron.

It is designed by nature to give a complete food to very young animals and therefore has exceptionally high nutritional value containing carbohydrate, fat, protein vitamins and minerals, which is equally an excellent culture medium for many kinds of microorganisms [1].

Milk has distinct physical, chemical and biological characteristics which justifies its high quality for consumption [2]. Nigeria, like other developing countries has its dairy industry facing a major problem of low demand for raw milk, this is partly because of public health concern over its safety and quality.

The chemical and proximate analysis of milk will help ascertain the product safety and quality. However, if efforts are made to produce safe and quality milk, it would not only protect public health, but also stimulate growth of the dairy industry in Nigeria.

2. Materials and Methods

2.1 Determination of the Chemical and Proximate Properties of Milk Samples

The fresh milk samples were analysed for pH, Titratable acidity, Moisure, Ash content, Protein, Fat, Carbohydrate, Crude fibre, Lactose and Total solids by the standard method of Association of Official Analytical Chemists [3].

2.2 pH

The pH of the milk samples were measured through electronic digital pH meter. Buffer solutions of pH 4 and 7 were used to calibrate the pH meter. Milk sample was taken in a beaker, electrode of pH meter was immersed in the sample to determine pH.

2.3 Titratable Acidity (as lactic acid)

Acidity was determined by taking 9ml of milk sample in a titration flask and 3 drops of 1% phenolphthalein indicator were added to it. The sample containing indiator was titrated against O.1 N Sodium hydroxide (NaoH) until light pink end point appeared. Volume of O.1 N NaoH used was recorded to determine acidity of milk in terms of lactic acid by using the expression:

% Acidity (as lactic acid) = (Volume of Na0H (ml) x 0.009)/(Vol of milk sample) x100

2.4 Moisture Content

A gram of milk sample was weighed into a clean dried porcelain evaporating dish, this was placed on an oven maintained at 1050C for 6h. The evaporating dish was cooled in desiccator to room temperature and then, this was reweighed and recorded. Weight of moisture was calculated by subtracting the weight of dried samples from the fresh.

2.5 Ash Content

A well mixed and homogenized milk sample (5ml) was taken in a crucible and the moisture was evaporated to dryness of sample on steam bath. Then the crucible containing the ash was placed in a desiccator for 30 minutes and weighed.

Ash (%) = (Residue weight)/(Sample weight) x100

2.6 Crude Protein

This was determined by Kjeldahl's method as China outlined by the AOAC 2000. One ml of milk sample was digested in digestion tubes using 2 digestion tablets and 20ml of sulphuric acid. Digested sample was distilled with 40% NaoH. The distillate was collected in 50ml 4% Boric acid solution and titrated against 0.1 N Hcl. The protein content in the milk was estimated by multiplying the percentage nitrogen with 6.38.

Protein = % N x 6.38

2.7 Fat/Lipid

Ten ml of sulphuric acid was dispensed into a butyrometer, to this, 11ml of milk and 1ml of amyl alcohol were added. It was closed with rubber cork and shaken severally until all the milk was digested by the acid. Then the butyrometer was placed in a water bath at 650C for 5 minute.

The sample was then centrifuged at 1100rpm for 5 minutes. Finally the sample was returned back to the water bath at 650C for 5 more minutes and the fat percentages was read from the butyrometer scale.

2.8 Carbohydrate (Bydifference)

This was determined by subtracting from 100, the sum of the percentage Moisture, Ash, Protein and Fat. The remainder value gave the Carbohydrate content.

Carbohydrate (%) = 100- (Sum of % moisture, protein, ash & fat)

2.9 Crude Fibre

Two grams of the milk sample was weighed into sterile container, this was then defatted. This defatted sample was boiled with 200ml (1.25%) H2S04 for 30m. It was further filtered and washed with boiling water until the washing was no longer acidic. The residue was boiled in a round bottom flask with 200ml (1.25%) NaoH for another 30m, filtered again and washed with boiling water until the washing was no longer alkaline.

The residue was scrapped into a previously weighed crucible and dried at 1000C. It was left in a desiccator to cool and then weighed. It was thereafter incinerated in a muffle furnace at 6000C, left in a desiccators to cool and then weighed from where the crude fibre content was calculated.

2.10 Lactose

Lactose was determined by the copper reduction method. A gram of milk was weighed into 250ml volumetric flask, it was diluted with hot water and allowed to stand for 30 minutes. It was then cooled and 4ml of carrez I solution was added, it was mixed and another 4ml of carrez II solution also added to it. Finally, it was diluted to the mark and then filtered. The lactose content was then determined by the Lane and Eynone's method, using standard Fehling solution.

2.11 Total Solids

Fresh cow milk sample was thoroughly mixed and 5g was transferred to a pre weighed and dried flat bottom crucible. The milk samples were dried in a hot air oven at 1200C for 3h. Finally the dried samples were taken out of the oven and placed in desiccators to cool down to room temperature. The samples were weighed again and total solids were calculated, using the relationship

Total Solids = (Crucible Wt + Oven dried sample Wt- Crusible Wt)/(Sample Wt)X 100

3. Results

3.1 Chemical and Proximate Composition of Milk Samples

The mean values of the chemical properties of the fresh milk samples were shown in Table 4.5. The pH values ranged from 6.71±0.03 which was the least in large mechanized dairy farm (LMDF) Kaduna, to 6.81±0.02 which was the highest small holder dairy farm, Kaduna. Anova showed a statistical significant difference between the pH values of fresh milk from different farm management types at $p \leq 0.05$.

The mean values of the acidity of the milk samples ranged from 0.15±.004 which was the least in both LMDF Kaduna and small holder dairy farm (SHDF) Kaduna, to 0.17±.003 which was the highest for LMDF Zaria. Statistical significant difference existed among the sampling points at $p \leq 0.05$.

The mean values of the physical properties i.e acidity and pH of the milk samples from various farms were shown in Table 4.6. There were significant differences at ($p \leq 0.05$) in the acidity in all the farm locations, but there was no significant differences ($p \geq 0.05$) in the pH of the different farm locations.

Table 4.7 is the mean values of the proximate composition of the milk samples. The values ranged from 87.27±0.01 – 87.94±0.04 for moisture, 0.84±0.01 – 0.89±0.01 for ash etc. significant differences existed ($p \leq 0.05$) in all the values of the proximate characteristics from all the farm locations. Anova was also used to test for the effect of farm management type/location on the proximate composition of the milk samples (Table 4.8) significant difference (at $p \leq 0.05$) existed in all the proximate parameters from the different farm management types, except in crude fibre where there was no significant difference (at $p \leq 0.05$). Farm management/location or sampling point has effect on proximate composition.

	Mean ± SEM					
Variables	**N**	**LMDF-Kaduna**	**SHDF-Kaduna**	**SHDF-Zaria**	**LMDF-Zaria**	**LOS**
pH	12	6.71±0.03b	6.81±0.02a	6.72±0.05b	6.73±0.06b	0.001**
Acidity	12	0.15±.004	0.15±.004	0.16±.003	0.17±.003	0.0005**
a, b= Means with different superscript in the same row differ significantly (*p<0.05; 0.05**p<0.01) SE						

Table 1: Mean values of the chemical properties of fresh milk samples

Key
SEM - Standard Error of Mean
N - Number of Samples Tested
LOS - Level of significance
LMDF - Large Mechanized Dairy Farm
SHDF - Small Holder Dairy Farm

	Farm Location	Acidity	pH
LMDF Kaduna	X1	0.14±0.01b	6.78±0.01
	X2	0.15±0.01ab	6.64±0.00
SHDF Kaduna	X3	0.15±0.01ab	6.52±0.01
	X4	0.15±0.01ab	6.64±0.01
	X5	0.16±0.01ab	6.96±0.02
	X6	0.16±0.01ab	6.75±0.01
SHDF Zaria	Y1	0.16±0.01ab	6.41±0.01
	Y2	0.17±0.01a	6.83±0.01
	Y3	0.17±0.01a	6.97±0.01
	Y4	0.16±0.01ab	6.72±0.01
LMDF Zaria	Y5	0.15±0.01ab	6.78±0.03
	Y6	0.14±0.01b	6.84±0.01
	Pvalue	7.76	0.53
	LOS	0.001**	0.67ns

Table 2: Mean (±SEM) Acidity and pH of fresh cow milk from different farms in Kaduna and Zaria

Means with different superscript in the same column differ significantly (*p<0.05; **p<0.01)

Key
SEM - Standard Error of Mean
LOS - Level of significance
ns - not significant
LMDF - Large Mechanized Dairy Farm
SHDF - Small Holder Dairy Farm

	Proximate parameters (%)								
	Farm Location	**Moisture**	**Ash**	**Protein**	**fat**	**Carbohydrate**	**Crude fibre**	**lactose**	**Total solids**
LMDF Kaduna	X1	86.43±0.01h	0.88±0.01ab	4.50±0.01b	4.06±0.01i	4.23±0.01f	0.28±0.01e	4.72±0.01d	13.41±0.01e
	X2	86.62±0.01f	0.86±0.00ab	4.32±0.00c	4.15±0.01j	4.41±0.01e	0.23±0.01f	4.58±0.01f	13.32±0.01f
SHDF Kaduna	X3	87.34±0.01d	0.84±0.01c	3.43±0.01g	4.42±0.01e	5.35±0.01d	0.16±0.01gh	4.43±0.01g	12.84±0.00h
	X4	87.45±0.01c	0.85±0.01c	3.37±0.01h	4.38±0.01f	5.68±0.01c	0.14±0.01h	4.34±0.01i	13.46±0.01c
	X5	87.28±0.01de	0.86±0.01bc	3.24±0.01i	5.61±0.01a	5.57±0.01c	0.34±0.01d	5.16±0.01b	12.75±0.00i
SHDF Zaria	X6	86.52±0.01g	0.85±0.00c	3.06±0.01j	4.34±0.01g	5.42±0.01d	0.42±0.01b	4.20±0.01j	13.82±0.01a

	Y1	87.24±0.01e	0.85±0.01c	3.41±0.01g	5.62±0.01a	6.61±0.01a	0.45±0.01a	4.40±0.01h	12.64±0.01j
	Y2	86.30±0.00j	0.86±0.01bc	3.38±0.01h	4.24±0.01h	5.40±0.01d	0.39±0.01c	4.61±0.01e	13.28±0.01g
	Y3	87.94±0.04a	0.86±0.01bc	3.52±0.01e	5.51±0.01b	5.32±0.01d	0.26±0.01e	5.35±0.01a	12.51±0.01k
	Y4	87.52±0.01b	0.84±0.01c	3.49±0.01f	4.90±0.01d	6.24±0.01b	0.17±0.01g	4.72±0.01d	13.42±0.01de
LMDF Zaria	Y5	86.40±0.01ih	0.89±0.01a	4.62±0.01a	4.03±0.01k	4.51±0.01e	0.26±0.01e	4.83±0.01c	13.53±0.01b
	Y6	86.36±0.01ij	0.88±0.01ab	3.81±0.01d	5.41±0.01c	4.47±0.01e	0.28±0.01e	4.63±0.01e	13.44±0.01dc
	Pvalue	3.13	17.09	60.96	4.00	39.20	3.35	1.21	3.45
	LOS	0.001**	0.001**	0.001**	0.001**	0.001**	0.001**	0.001**	0.001**

Table 3: Mean values (± SEM) of the proximate composition of fresh milk samples

Means with different superscript in the same column differ significantly (*p<0.05; **p<0.01) Significant differences in means were separated using Turkey HSD test

Key
SD - Standard Error of Mean
LOS - Level of significance
LMDF - Large Mechanized Dairy Farm
SHDF - Small Holder Dairy Farm

Farm Management type/location					
Parameters	**LMDF Kaduna**	**SHDF Kaduna**	**SHDF Zaria**	**LMDF Zaria**	**LOS**
Moisture	86.53±0.04b	86.38±0.01b	87.15±0.11a	87.25±0.18a	0.0004**
Ash	0.87±0.01b	0.89±0.01a	0.85±0.01c	0.85±0.01c	0.0001**
Protein	4.41±0.04a	4.22±0.18ab	3.27±0.04b	3.45±0.06b	0.0001**
Fat	4.11±0.02c	4.72±0.31b	4.69±0.16b	5.08±0.17a	0.02*
Carbohydrate	4.32±0.04d	4.49±0.01bc	5.50±0.04a	5.89±0.17b	0.0001**
Crude fibre	0.26±0.01	0.27±0.01	0.27±0.04	0.32±0.03	0.51
Lactose	4.65±0.08b	4.73±0.11a	4.53±0.11b	4.77±0.11a	0.03*
Total solid	13.37±0.02b	13.49±0.02a	13.22±0.13b	12.96±0.12c	0.03*

Table 4: Mean values (± SEM) of the proximate composition of fresh milk samples from different points in Kaduna and Zaria

Means with different superscript in the same row differ significantly (*p<0.05; **p<0.01)
Significant differences in means were separated using Turkey HSD test

Key
SEM - Standard Error of Mean
LOS - Level of Significance
LMDF - Large Mechanized Dairy Farm
SHDF - Small Holder Dairy Farm

4. Discussion

4. 1 Chemical and Proximate Composition of Milk Samples

The mean pH values of fresh cow milk samples obtained from farms in Kaduna and Zaria ranged from 6.71±0.03 to 6.81±0.02, these values were within the normal pH range of fresh cow milk which according to should be in the range of 6.6 -6.8 [4].

Milk pH gives an indication of the milk hygiene as, according to pH values higher than 6.8 indicates mastitic milk while pH values below 6.6 indicates acidity due to bacterial multiplication. However in other studies, various rates of pH readings were reported for raw cow milk as between 6.44±0.030 – 6.98±1.2 [5-7]. The pH values in this study were within the range reported by those other researchers.

The test of acidity is important in milk hygiene because the percentage of acid present in milk is a rough indicator of its age and the manner in which it has been handled [8]. Normal fresh milk should have an apparent acidity of 0.14 - 0.16% as lactic acid. The mean titratable acidity values in this study ranged from 0.14±0.01 – 0.17±0.04 for milk samples from Kaduna and Zaria, these values were relatively high, this high titratable acidity values obtained suggests bacterial contamination and subsequent multiplication during handling and transportation. Nevertheless, in a similar study, reported a higher total acidity of 0.23±0.01 for milk samples in Ethiopia [9].

In proximate analysis, the values of the main milk constituents/composition are known to vary considerably depending on the individual animal i.e it's genetic make-up, Its breed, stage of lactation, age, Feed, health status, herd management practices and environmental conditions.

The mean values of the moisture content varied from 86.30±0.00 – 87.94±0.04 in the different farms sampled in Kaduna and Zaria. These values were lower than the 89.30% reported by in Nasarawa state [10]. The difference may be due to differences in diet or environmental conditions. Water is the main constituent of milk and much milk processing is designed to remove water from milk or reduce the moisture content because a high moisture content implies high water activity which supports mirobial growth and consequently reducing the shelflife of the milk sample [11].

The mean ash content of the milk samples differed significantly (p≤0.05) from each other based on the different sampling points, ranging from 0.84±0.01 – 0.89±0.01. The FAO/WHO 2007 recommended standard for milk ash lies at 0.90±0.10 – 1.00±0.01. The values from this findings therefore fall below the recommended standard. Other researchers have reported different ash values e.g higher values of 1.0 and 1.2% by Ethiopia and in Abeokuta, Nigeria and relatively lower value of 0.73 by Ethiopia [12]. The differences may be due to differences in experimental locations or feeding. The ash value is an empirical measurement of the mineral constituents of foodstuff volatile component which is very essential in nutrition, in essence, the ash content is the reflection of the mineral composition of the milk.

The crude fibre content of all the samples did not differ significantly (p≤0.05) from each other. According to the crude fibre contributes to the health of the gastro intestinal` system and metabolic system in man such as prevention of constipation [13].

The mean carbohydrate values ranged from 4.23±0.01 – 6.61±0.01. This is rather low when compared to those of other workers who reported mean carbohydrate values of 10.56±1.56 – 13.20±2.48. The low carbohydrate values could be attributed to bacterial contamination which helped to breakdown some of the carbohydrate during metabolism.

The values for protein ranged from 3.06±0.01 – 4.62±0.01. The FAO/WHO, 2007 standard for protein in raw fresh milk is 4.00±0.10 most of the values obtained in this work were below the standard. This could also be attributable to protein metabolism from bacterial contamination of the milk samples. However, the values were within the range of 3.25 – 4.05% reported by Mohammed [14-16].

Results of the mean fat content on this study revealed a reasonably high fat content in the milk samples, ranging from 4.03±0.01 – 5.61±0.01 as the United States Public Health Services (USPHS) milk ordinance and code recommended a minimum of 3.25% butterfat milk fat for fluid whole milk [17]. The high fat content could be due to the environment or stage of lactation in the cattle, because, fat content of milk has been found to vary considerably with stage of lactation. Fat of milk is the most valuable constitution of milk. Milk having a fair amount of fat is more valuable as a food than milk which is poor in fat [18].

According to the European union standard, lactose content of fresh raw cow milk should not be less than 4.2%. The lactose content of milk samples in this study ranged in value from 4.20±0.01 – 5.35±0.01. The analysed milk samples are therefore within the recommended standards. Generally the lactose content of milk is usually less subject to variations.

The mean total solid component of the analysed milk samples ranged from 12.51±0.01 – 13.53±0.01. This is in proximity to the 13.5% and 13.7% reported by Olafadehan and Adewunmi (2010) but higher than the 10.48% reporte [19]. Differences in nutrition and herd management could influence the variation in percentage total solids in milk.

The European Union established quality standard stipulated that total solid content of raw cow milk should not be less than 12.5% (FAO/WHO, 2007). Therefore the values in the present study were still within the recommended level [20-25].

5. Conclusion

The knowledge of the chemical & proximate composition of milk is very important in order to know the milk with the right quality because a contaminated milk usually have values that differ from recommended levels and is unsuitable for consumption and may be discarded; as it tends to endanger public health from the infectious agents causing disease conditions leading to the changes and the resultant antibiotics used in treatment.

Milk that is abnormal or contaminated with antibiotics is unsaleable; there are veterinary and antibiotic costs; a higher culling rate and occasional fatalities. The milk processing industry also incurs losses because of problems that result from antibiotics in milk and the reduced chemical and bacterial quality of mastitic milk which affects the suitability of milk for processing.

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