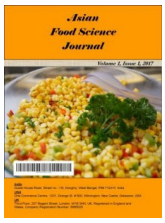

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Determination of Micro and Macro Minerals and Some Biochemical Parameters in Fresh Cow Milk from Different Locations in Maiduguri Metropolis, Borno State, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author PA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors FBA and PA managed the analyses of the study. Author LL managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Milk is an essential nutritional substance required for growth and development as well as food supplement to humans and animals. However, milk and milk products are considered as an essential source of dietary minerals for consumers. Four fresh cow milk two each were randomly collected from two different farms, Kasuwan Shanu samples A and B and Bulumkutu Kasuwa samples C and D within Maiduguri metropolis of Borno State, Nigerian. In this present study the concentration of the micro (Zn, Cu, and Mn) and macro (Na, Ca, and Mg) minerals were quantitatively determined using Atomic Absorption Spectrometry (AAS) (Model 9190 Pyeunicam UK), while the biochemical constituents, such as fats and protein in the fresh cow milk were analyzed using the standard methods. The results showed milk sample C and D from Bulumkutu Kasuwa had the highest sodium content (49.06±0.02 and 41.01±0.01 mg/L) respectively, while

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Kasuwa Shanu samples A and B has the lowest sodium concentrations (36.27±0.09 and 31.61±1.05 mg/L respectively. Calcium levels were highest (2.15±0.05 mg/L) in sample B, followed by (1.81±0.01 mg/L) in sample D and lower (1.48±0.03 mg/L and 1.40±0.09 mg/L) in samples C and A respectively. Mg, Zn, Cu and Mn were detected in all the fresh cow milk samples from the two farms Kasuwan Shanu, and Bulumkutu Kasuwa and their concentrations were within the National Agency for Food and Drugs Administration Control) (NAFDAC) Standard values. The biochemical constituents; Protein content ranges from (6.32±0.03% to 7.11±0.11%) in samples B and A respectively of Kasuwan Shanu and (6.33±0.11% to 7.57±0.16%) in samples D and C respectively of Bulumkutu Kasuwa. The highest protein content was recorded in sample C of Bulumkutu Kasuwa and the lowest was recorded in samples B and D respectively. The fat levels range from ((1.36±0.08% to 8.46±0.05%) in samples B and A respectively of Kasuwan Shanu and (4.57±1.00% to 3.55±0.13%) in D and C respectively of Bulumkutu Kasuwa. From the results, it was observed that significant difference existed in protein and fat values while there is no significant difference in the values of micro and macro elements of the cow milk samples from the studied farms. However, the protein contents in the cow milk samples are significantly within the NAFDAC standard values. The high-fat content in sample A is a source of worry and concern and necessitates further monitoring in other areas and some caution in the rampant consumption of such milk.

Keywords: Micro and macro minerals; biochemical parameters; fresh cow milk; Maiduguri and Nigeria.

1. INTRODUCTION

Milk is an essential nutritional substance required for the growth and development as well as food supplement to humans and animals. The worldwide contamination of milk with undesirable substances through soil and water pollution of milk by heavy metals, animal feeds, mycotoxins, dioxins and similar pollutants is considered to be a great source of concern and worries to public health due to their toxic effects on humans and animals especially in the Northern Nigeria where the consumption of cow milk is prevalent [1]. Milk and milk products are an essential source of dietary minerals for consumers. Milk products are very important human nutrients and their consumption has increased in recent years. According to several reports, milk is an excellent source of calcium, magnesium, zinc and provide very small amount of Fe and Cu. In addition milk products are the main constituents of human daily diet, especially for vulnerable groups such as infants, school-age children as well as old aged people [2,3,4]. Fresh cow's milk contains 4.5% fat, 3.8% protein, 4.9% lactose, 0.72% ash and 13.91% total solids [5]. Report according to [6] indicated that milk is also known to be an ideal source of macronutrients and micronutrients, all present at certain concentration. The macronutrients are essential for normal growth of the various body system of human beings in amount greater than 50mg day-1 and while trace elements are needed in amounts less than 50mg day-1 and ranges of their biochemical action have been elucidated [7] [3]. Several studies indicated that the content of micro and macro elements in fresh cow milk depends upon the content of these elements in soil, water and animal feed, which varied considerably among and within different places [1]. Report according to [8] indicated that good quality measurements of cow milk are very important in order to control and often play a vital role in maintaining products and processes quality, in both manufacturing, trading and in research. Consumption of milk particularly fresh cow milk is associated with beneficial health effect beyond its pure nutritional value. Several reports indicated that low-fat milk consumption could reduce risk of arterial hypertension, coronary heart disease, colorectal cancer and obesity [1][9]. Report according to [10] showed that apart from the essential benefits derived from consuming cow milk, contamination of milk also arises from industrial pollutants in the environment, modern Agricultural practices, animals feeds and use of sewage sludge and polluted water in Agriculture which is increasing on daily basis and required urgent attention. Environmental conditions are responsible for most of the toxic metal content of milk and milk products. The contamination of soil and water pollution by heavy metals exposes man and grazing animals to health risks, as such it becomes paramount to determine and monitor the concentration of toxic metals such as Pb, Cu, Zn etc. in milk, because this can significantly influenced human health. The presence of heavy metals in milk is source of worry and concern because milk is largely consumed by infants, children and as well as old aged people. However, the presence of these heavy metals in

milk are responsible for many pernicious effects on human health such as immune – depression and skin diseases caused by copper and zinc contamination [11]. Biochemical parameter such as fat and protein are also very important and essential constituents required by humans. The aim of this study was to determine the level of micro and macro minerals, and some biochemical parameters such as fat and protein in fresh cow milk in two different locations in Maiduguri metropolis, Borno State, Nigeria.

2. MATERIALS AND METHODS

2.1 Study Area

Maiduguri is a city found in Borno State, Nigeria. It is located 11.85 latitude and 13.16 longitudes and it is situated at elevation 325 meters above sea level. Maiduguri has a population of 1,112,449 making it the biggest city in Borno. It operates in the WAT time zone.

2.2 Sample Collection

Fresh cow milk samples were collected from four cows at two different farms. Two cows C and D from Bulumkutu Kasuwa farm and two cows A and B from Kasuwan Shanu farm of Maiduguri metropolis, Borno State, during the morning milking period directly into sterile 1 liter screw polythene bottles. The cow nipples were also sterilised using cotton wool diluted with ethanol prior to milking. The collected milk samples were kept in an ice box and transported to the laboratory and immediately analysed for micro and macro elements and biochemical parameters. Three replicate determinations were carried out on each sample.

2.3 Sample Digestion

Microwave digestion system was used for acid digestion of all the samples.

All glassware were washed with detergent and distilled water, then rinsed with distilled water severally, the glassware were soaked in 10% HNO_3 (v/v) for 24 hours. This solution was discarded and the glassware rinsed again severally with distilled water and then dried.

Cow milk samples were dried at 70°C in an oven until the dry weight was obtained. 0.5 g of the sample was measured and transferred into a clean 250 ml dry digestion flask. 10ml of 65% nitric acid was added, followed by the addition of 3.0 ml of 30% hydrogen peroxide. The digestion flask was heated gently until frothing subsided. The sample was heated to dryness, dissolved in

Fig 1. Map of Nigeria showing Maiduguri the study area

30 ml distilled water and filter with No. 42 Whatman filter paper. The solution was made up to the volume in a 100ml flask and store in a special screw container ready for analysis [1] [12].

2.4 Elemental Analysis

All reagents and chemicals were of analytical grade obtained from Merck (Darmstadt, Germany, www.merck.de**)**. Standard solutions of Ca, Zn, Cu, Mg, Na and Mn were prepared from 1000ppm standard stock solution. Calibration curves were prepared for the six metals using different absorbance from atomic absorption spectrophotometer (Model 9190 Pyeunicam UK). Extrapolation obtained the concentration of each metal from the standard curve [12,1].

2.5 Determination of Biochemical Parameters

2.5.1 Proteins

Total proteins content were determined by Micro-Kyeldahl method which was based on quantification of nitrogen [12]. A factor of 6.38 was used to obtain the final values of the sample. 5mL milk sample was warmed at 38°C and digested in 25mL H_2SO_4, using 1mL $CuSO_4 \cdot 5H_2O$ as catalyst with 15g K_2SO_4 as boiling point elevator, to release nitrogen from protein and retain nitrogen as ammonium salt. Concentrated NaOH was added to release NH_3, which is distilled, collected in H_3BO_3 solution, and titrated. Total nitrogen was converted to 'protein' by using a factor of 6.38.

2.5.2 Fats

Fat content was determined by gravimetric method [12,1]. 10g milk sample was weighed and transferred into a Mojonnier extraction tube. The lipid content was exhaustively extracted from the cow milk using petroleum ether at 40 to 60°C for 3 hours. The extractant (petroleum ether) was distilled off and the flask was reweighed. The percentage lipid was calculated.

2.6 Statistical Analysis

The statistical analysis was performed using analysis of variance (ANOVA). There were no significant difference in the concentrations of the micro and macro elements in the studied samples, $P>0.05$. The values are mean ± Standard deviation of three replicate determinations.

3. RESULTS AND DISCUSSION

3.1 Results

The results of the concentrations of the micro and macro mineral elements (Na, Ca, Mg, Zn, Cu, and Mn) in fresh cow milk from two different farms in Maiduguri metropolis of Borno State, Nigeria was presented in Table 1. The mean concentration of Na, Ca, Mg, Zn, Cu, and Mn in

Table 1. Elemental compositions of fresh cow milk samples (mg/L)

Sample	Na	Ca	Mg	Zn	Cu	Mn
A	36.27±.10	1.40±0.10	0.51±0.01	0.40±0.02	1.24±0.04	0.14±0.02
B	31.61±1.05	2.15±0.05	0.67±0.03	0.60±0.05	3.10±0.10	0.15±0.03
C	49.06±0.02	1.48±0.03	0.51±0.01	0.59±0.02	0.29±0.02	0.04±0.01
D	41.31±0.01	1.81±0.01	0.55±0.05	0.48±0.02	0.23±0.03	0.04±0.02
NAFDAC Standard	200	75	50	5.0	2.00	0.2

Results are presented as mean ± SD of three replicate determinations
A and B: Samples from Kasuwa Shanu farm, C and D: Samples from Bulumkutu kasuwa farm.

Table 2. Proteins and fats content in fresh cow milk

Sample	Protein%	Fat%
A	7.11±0.11	8.46±0.5
B	6.32±0.32	1.36±0.08
C	7.57±0.16	4.57±1.00
D	6.33±0.11	3.55±0.13
NAFDAC Standard	2.7-10	3.0 -5.0

Results are presented as mean ± SD of three replicate determinations
A and B: Samples from Kasuwa Shanu, C and D: Samples from Bulumkutu Kasuwa farm.

the fresh cow milk samples collected from Kasuwan Shanu (sample A) were 36.27 ± 0.09, 1.40 ± 0.09, 0.51 ± 0.01, 0.40 ± 0.02, 1.24 ± 0.04 mg/L and 0.14 ± 0.02 mg/L respectively. While sample B of the same location recorded the following concentrations Na (31.61 ± 1.05 mg/L); Ca (2.15 ± 0.05 mg/L); Mg (0.67 ± 0.03 mg/L); Zn (0.60 ± 0.05 mg/L); Cu (3.10 ± 0.10 mg/L); and Mn (0.15 ± 0.03 mg/L). The highest concentration of sodium was recorded in samples A. However, all the elemental compositions investigated in this study are below the recommended NAFDAC standard values. The mean concentrations of Na, Ca, Mg, Zn, Cu, and Mn in Bulumkutu Kasuwa sample C were as follows: 49.06 ± 0.02 mg/L, 1.48 ± 0.03 mg/L, 0.51 ± 0.01 mg/L, 0.59 ± 0.02 mg/L, 0.29 ± 0.02 mg/L and 0.04 ± 0.01 mg/L respectively. Finally, the mean concentration of Na, Ca, Mg, Zn, Cu and Mn in Bulumkutu Kasuwa (sample D) were in the following order 41.31 ± 0.01 mg/L, 1.81 ± 0.01 mg/L, 0.55 ± 0.05 mg/L, 0.48 ± 0.02 mg/L, 0.23 ± 0.03 mg/L and 0.04 ± 0.02 mg/L respectively. Sample C from Bulumkutu Kasuwa contained the highest level of Na and samples B of Kasuwan Shanu contained the lowest level. However, there was no significant difference in the concentration of Ca, Mg, Zn, Cu and Mn in the samples collected from Kasuwan Shanu and Bulumkutu Kasuwa. Table 2 represents the results obtained for the biochemical parameters. The results showed that fat value in the studied milk, sample A was higher than the NAFDAC standard values, but the protein content was within the NAFDAC standard values. The mean protein content in the two locations ranges as follow: samples A (7.11 ± 0.11%); B (6.32 ±0.32%); C (7.57 ± 0.16%) and D (6.33 ± 0.11%). Sample C of Bulumkutu Kasuwa has the highest percentage while sample B and D recorded the same values.The results from Table 2 showed that sample A of Kasuwa shanu has the highest fats content compared to the other studied areas. This high fat content in this sample is a source of worry and concern and also necessitates further monitoring in other area and some caution in the rampant consumption of such milk.

3.2 Discussion

The average mean concentration of Zn in the analyzed fresh cow samples were, A (0.40 ± 0.02 mg/L,), B (0.60± 0.05 mg/L); C (0.59± 0.02 mg/L); D (0.48± 0.02 mg/L). These concentrations were lower than those reported for goat milk 32.10 mg/L [13], in raw bovine milk (0.29- 4.96 ppm) [14]; and fresh cow milk (0.98 ppm) [8]. However, Zinc is such a critical element in human health of which, a minor deficiency is detrimental to health. The deficiency of Zinc is always characterized by growth retardation, loss of appetite and impaired immune function. Many reports have shown that zinc deficiency in most cases results to hair loss, diarrhea, delayed sexual maturation, impotence, hypogonadism in males, eye and skin lesions [15].

However, the mean concentration of Cu recorded in this study are in line with reports given by other authors [1,2,3,4]. The low concentrations of Cu observed in the analysed samples could be attributed to Zn contained in food that interferes with the copper absorption system; this explains the presence of low levels of this metal in milk [16]. According to [17], copper (Cu) is a cofactor of many cuproenzymes and several proteins are involved in its metabolism. Although the concentration of Cu in bovine milk as reported in the literature is very variable (<0.13–737.6) [14,18]. The concentration of Cu among the values of analysed samples in this present work was within the reported values in literature, (<0.13–737.6) [14,18].

Based on reports, manganese (Mn) is also a cofactor of mutase antioxidant enzyme and its elevated content could reduce Fe absorption. In this present study the average concentration of Mn is found in an order of magnitude lower than that reported in the literature (5.2–95 ppm) [18].

The average mean range obtained for sodium in this study was (31.61±1.05 - 49.06±0.02 mg/L). These values are higher than those reported in other research papers [19]. Sodium is needed for osmotic pressure regulation, acid-based balance, body fluid balance and nutrient transport. Sodium is needed for heart function; sodium is also an important compound of the ruminant buffering activity of saliva [20].The concentration levels of Mg (0.51 -0.67 mg/L) in fresh cow milk investigated in this study are lower than those observed in raw goat milk: 151-167 ppm [21] and fresh cow milk 214 ppm reported by [8].

Fat content in fresh cow milk varied greatly from the two locations with samples A having highest concentration, higher than the NAFDAC value. The values obtained from other samples were within permissible range [22]. However, in Northern Nigeria milk is sold on the basis of fat content for example butter fat. Fat is known as a source of high energy for humans. According to

[23], excessive intake of milk with high fat values are however not desirable. Skimmed milk is preferred alternative.

Milk collected from sample C Bulumkutu Kasuwa had highest protein content. Although the values recorded in this study were higher than values obtained in [1], and in agreement, when compared with the results obtained by [24]. Fresh milk is the most important source of protein most especially to infants and individuals that are vegetarians. This protein source contains high levels of essential amino acids and is also desirable for consumption [25].

It is very necessary to have a routine analysis of heavy metals and some biochemical parameters in dairy products especially from cow milk, because presence of heavy metals in cow milk can significantly influence human health. The results from this study showed that the concentrations of the micro and macro elements from all the studied locations were all within the NAFDAC standard values and also in line with those reported by other authors that had worked on cow milk [1,2,8]. There is no significant difference as the values obtained are closely related irrespective of sample locations at $P>0.05$. Routine macro and micro mineral analysis and other valued chemical parameters in dairy products are essential. Cow milk either fresh or fermented is a common dietary component of communities in Northern Nigeria. There is an increase incidence of different diseases among rural populace. Such problems could be associated with their dietary habits among which could be high fat intake. Protein content in the fresh cow milk varied only slightly from the two locations. The values obtained were within permissible range. Fresh milk is the most important source of protein to infants and individuals that are vegetarians. This protein source contains high levels of essential amino acids and is desirable for consumption. While milk is sold on the basis of fat content for example butter fat. Fat is a source of high energy for humans. Excessive intake of milk with high fat values are however not desirable, skimmed milk is preferred alternative.

4. CONCLUSION

Fresh cow milk from the study areas contains micro and macro elements which are an important source of our daily dietary diet. Na, Ca, Mg, Zn, Cu and Mn were all analysed in the fresh cow milk with sodium having the highest concentration in all the studied samples, but there is no significant difference in the values of micro and macro elements of the studied areas while significant difference existed between the values of protein and fat. However, the protein content in studied samples is significantly within the NAFDAC standard values while the fat content in sample A is higher than the NAFDAC standard values. The calcium content analysed was below the standard limits. The results showed a high-fat content in most of the milk samples except sample B ($1.36 \pm 0.08\%$) which recorded lower concentration. This high concentration of fat is a source of concern and needs further monitory to ascertain that cow milk consumed by the populace is safe for consumption. From this study, it was concluded that cow milk in the studied areas is safe for human consumption.

ETHICAL APPROVAL

As per international standard or university standard written ethical permission has been collected and preserved by the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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