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RAD designed the study, performed all the conducted experiments, did statistical analysis, and wrote both first draft of the manuscript and protocol as well as informed others of the decision to publish. Authors RSUW supervised collection and arrangement of the obtained data for the study and Authors MSI, KA and SU have offered invaluable help with some literature, and have further proofread. All authors managed literature searches, arrange tables. All authors have read and approved the final manuscript.

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Raw Milk Proximate Composition Analyses for Some Camels (*Camelus dromedarius*) in Sokoto, Nigeria

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Abstract:
Camel milk (CM) known traditionally for its medicinal application, but analysis of its mineral contents and proximate composition especially for domesticated camels around Sokoto metropolis of northern Nigeria was not fully elucidated. In this study, five samples of raw camel milk obtained by hand milking of five domesticated female camels (*Camelus dromedarius*) at Kwakwalawa village of Sokoto, Sokoto State, Nigeria were analyzed for their proximate composition using standard methods. These raw camel milk samples (M1- M5) were obtained during morning after thorough sterilization of camel udders. Results of composition analyses of the collected raw camel milk samples based on percentages (w/v) revealed that 11.7% is total dissolved solids (TDS), 90.8% is moisture, 1.3% is fats, 1.5% is crude proteins, 0.7% is total ash and 5.7% is crude carbohydrate. Mineral nutrient analyzed by photometric methods revealed Na^+ is 45.0 mg/L, K^+ is 315 mg/L, Ca^{2+} is 0.6 mg/L, Mg^{2+} is 0.6mg/L and P is 2.1mg/L. In conclusion, the proximate composition of the camel milk samples analyzed showed average nutrient quality content.

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INTRODUCTION

Milk was described to be that excellent medium repository of all macronutrients, such as carbohydrates, proteins, and fat that are together in excellent proportion to each other, but which also contain several vitamins and minerals that are important for the body (Lambrini *et al*., 2021). A total, comprehensive, full and uninterrupted milking of a dairy female that is fully nourished, which is in good health, and not overworked are what leads to milk production; which must be collected properly without any colostrum content (Leseur and Melik, 1990). The global consumption of human diet substantially constitute of milk and milk products as part and parcel of the overall food and nutrition because of its richness in various nutrients (Pal *et al*., 2021).

Dromedary camels were acknowledged in producing more milk of high nutritional quality for longer period than any other animal within their hostile environment of drought, extreme temperature and lack of pasture (Khan and Iqbal, 2001). Camel milk with an estimated production of about 6 L/day-^{1}/camel-^{1}, is mainly consumed as raw milk or traditional fermented milk by the local population (Ismaili *et al*., 2019). For many centuries, camel milk was utilized as medicinal drink by many cultures in Middle Eastern, Asian and African countries (Levy *et al*., 2013; Yagil, 2013; Nikkhah, 2014). Camel milk was used earlier in successful treatment of some autoimmune and metabolic diseases (Al-Fartosi *et al*., 2011).

Dogondaji et al. (2023) have reported about some past and recent immediate conducted several studies on some samples of raw camel milk among others; which focused on vast array of determined properties in some of the studied samples including its established chemical composition, physicochemical characteristics, functionality and its microbial quality (Khalil *et al*., 2011; Al Haj and Al Kanhal, 2010; Rahli *et al*., 2013; El-Ziney and Al-Turki, 2007; Omer and Eltinay, 2007).

Despite all the many factors that affect milk composition such as breed variation (within a species, or herd to herd), feed considerations, seasonal variation, geographic locations, stage of lactation, and rations; camel milk is still recognized as highly nutritious (Park and Haenlein, 2006), and all those aforementioned factors may alter the proportion of milk constituents to some extent (Adugna and Asrerie, 2014).

The gross composition of virtually any milk is affected by genetic and environmental factors, including the breed, stage of lactation, individuality of animals, frequency and completeness of milking, maternal age, health and type of feed (Bhardwaj *et al*., 2020). Milk's physicochemical compositions from different animals usually vary based on their feeding condition, breed and locality (Tadesse *et al.,* 2014).

In the fourth millennium BC in North Africa; domesticated camels were used as dairy animals to provide milk in central Arabia and the Peninsula (Peters, 1997).

To the best of our knowledge information about camel milk composition, establishing and assessing its nutritional value although available worldwide; is still scanty in this part of sub-Saharan Africa, which is Sokoto, Sokoto state, Nigeria. Within this contextual framework in mind, in this study we analyzed the proximate composition of camel milk to establish and assess its nutritional value.

MATERIAL AND METHODS

Materials and chemicals

All the chemicals and reagents used in this research were of purest quality available and were all of analytical grade.

Raw CM samples collection

Five (5) healthy domesticated lactating female camels (*Camelus dromedarius*) aged 7-10 years old were identified and tracked at Kwakwalawa village along the main road to the permanent site of Usmanu Danfodiyo University, Sokoto between May to July 2021 have provided raw milk samples used in the research. The milk was collected by hand milking of camel udders by experienced and skilled camel attendant that wore hand gloves after thorough cleaning and sterilization of their udders in the morning time using an aseptic technique. A gallon-full (5 liters) of milk was separately collected from each camel and appropriately labeled A-E. The samples were immediately transported via the ice-cold medium in vaccine carriers to the Postgraduate research laboratory of the Usmanu Danfodiyo University, Sokoto, and refrigerated thereafter at -20°C until required for subsequent use.

Proximate composition analyses

Proximate analyses of the samples for moisture, crude fat, and ash were determined as described by AOAC (2005) procedure with petroleum ether serving as a solvent for crude fat determination. Crude protein and total dissolved solids were determined by the methods of Pearson (1976). The nitrogen content of the sample was determined by the Kjeldahl (1883) procedure. The obtained nitrogen value was then multiplied by 6.25 to give an estimate of the crude protein content. The content of carbohydrates was determined by calculation using the weight difference method; while mineral contents were determined by atomic absorption spectrometry, flame photometry, and spectrophotometry in accordance with AOAC (2003) methods.

Statistical analyses

Statistical analysis was conducted using SPSS software (IBM Corp. Released 2012). Results obtained were expressed as Mean ± standard error of the mean (SEM). ANOVA and Tukey's tests were used for multiple comparisons of means to examine effect of sampling time on raw milk composition (Mudgil *et al.,* 2022). Differences were considered statistically significant at $p < 0.05$ and or when the chi-square approximation value is less than 0.0001 (<0.0001) respectively.

RESULTS

The result of proximate composition analyses of five raw camel milk samples is shown in Table 1.

Table 1. Proximate composition analysis of five raw camels' milk.

Parameter % (w/v)	Determined Value
TDS	11.7±9.3
MC	90.8±0.4
CP	1.5±0.03
CF	1.3±0.1
Ash	0.7±0.05
CC (wd)	5.7±0.4
N	0.2±0.004

Key:- TDS:-Total Dissolved Solids; MC:-Moisture content; CP:-Crude protein; CF:- Crude fat; CC (wd):-Crude carbohydrate by weight difference; N:-Nitrogen.
Values are mean±SEM (n=5).
Values with statistically significant difference, p<0.05 are asterisked *

The amount of some mineral nutrients determined in the raw camel milk samples is presented in Table 2.

Table 2. Some mineral composition determined in raw camel milk samples.

Mineral element (mg/L)	Determined Value
Na^{+}	45.0±1.3
K^{+}	314.6±37.4
Mg^{2+}	0.6±0.04
Ca^{2+}	0.6±0.05
P	2.1±0.1

Key:- Na+-Sodium ion; K+:- Potassium ion; Ca2+:-Calcium ion; Mg2+:-Magnesium ion; P:-Phosphorous.
Values are mean±SEM (n=5).
Values with statistically significant difference, p<0.05 are asterisked*

Comparison of proximate composition values for some of the domestic animals is presented in Table 3.

Table 3. Proximate composition values of milk of some domestic animals.

Parameter	Value	Animal	Reference
Moisture	90.95 ±0.42	Donkey	(Tadesse *et al.,* 2014)
	88%	Cow	(Kataoka *et al.,* 1991)
	86.99%	Cow	(Damtew and Gebre, 2020)
Ash	0.36 ±0.03	Cow	(Pal *et al.,* 2021)
Ash	0.63±0.07	Cow	(Ponka *et al.,* 2013)
TDS	9.5 g/100 mL	Cow	(Pal *et al.,* 2021)
Crude Protein	0.56±0.02	Cow	(Tadesse *et al.,* 2014)
Crude Fat	1.68±0.06	Cow	(Tadesse *et al.,* 2014)
Crude Carbohydrate	6.6±0.1	Cow	(Tadesse *et al.,* 2014)

DISCUSSION

In this research, proximate composition and mineral nutrients of milk samples obtained from five female camels were determined in accordance with AOAC 2005 described standard procedures. Analyzed were the four dominant quantitative components of milk; which as affirmed by Guetouache et al. (2014) comprised of water, protein, fat, and lactose; while its minor components are minerals, enzymes, vitamins, and dissolved gases. Results of investigation in this study showed raw milk of camel is enriched with not only high amounts of water and total dissolved solid particles which were the highest determined quantitative components but the milk sample also has adequate amount of crude carbohydrate, crude protein and crude fat, ash as well as nitrogen in that decreasing order. The research nitty-gritty found total dissolved solids as 11.7% (w/v) which completely agreed in toto with Alhaj and Al-Kanhal (2010) who reported similar value for raw camel milk in his research and it had near equal agreement on ash content, reporting 0.8% there and here it was 0.7% (w/v). On this note of determined ash content this research finding agreed with (Konte, 1999) whom found and reported (0.7%/100g).

The composition of any milk which is considerable resource product varies depending on many contributing factors. Milk proteins that were described as important component of milk, which gives major impact on its nutritional value while milk fat is major substance defining milk’s energetic value and offers major contribution to the milk’s nutritional properties, and both milk proteins and fats confers their technological suitability to bear (Gizachew *et al*., 2014). Crux of this research finding were the determined moisture content, crude protein and crude fat in that descending order. Moisture content of this research (90.8% w/v) is little bit higher than the same parameter value for camel milk (87.7 g/100g) reported by (Konte, 1999) studies and it (90.8% w/v) was also higher than reported values of the same parameter in raw milk of cow, goat and sheep which were (87.2), (86.5) and (82.7) respectively in the same (Konte, 1999) research. Also, moisture content of this research (90.8%) was slightly higher than mean value for cow’s milk moisture content (87.92%) in year 2020 research in Ethiopia. This finding slightly differs with (Konte, 1999) in not only the moisture content as pointed out above, but also for the protein, and fat compositions.

Similarly findings on total solids in this research also totally agreed with similar proximate composition parameters of camel milk in earlier studies reported by Sawaya et al. (1984) and that of other several investigators that includes Haddadin et al. (2008) in Jordan and Ismaili et al. (2019) in Morocco among many others but with slight variations.

Within different raw milk from different regions around the world, it is one of the richest source of micro and trace elements as there was reported about 38 of such components contained in it (Damtew and Gebre, 2020). Mineral elements analyses of raw milk of camel in this study revealed appreciable concentrations of potassium followed by sodium and phosphorus in that decreasing pattern while calcium and magnesium trailed behind them with similar amounts each. Total ash nutritional value

(0.7%) in this research is higher than goat milk's 0.5% and even cow's milk mean values (0.53%) for a research conducted in Ethiopia in 2020 on different samples of cow milk's collected from different areas and regions that aimed to determined physicochemical quality, minerals and nutrient composition of different cow's milk. This same total ash content and moisture found in this research for some few raw camel milk samples collected and analyzed were similarly higher than the one found for different breeds of cow's milk that are reared and grown in Adamawa and Taraba States of Nigeria in another 2020 conducted study reported by Adamu et al. (2020) (0.7% ash and 90.8% w/v) were higher than the mean values (0.41, 0.39 and 0.43 ash contents of 3 breeds of cows' that were White Fulani (WF), Red Bororo (RB) and Sokoto Gudali (SG) breeds respectively. While the moisture is between 83.52-84, 82.3-84 and 83-84 for the 3 different breeds of cows studied respectively. Also the determined values for calcium (0.6 mg/L), Magnesium (0.6 mg/L), and Phosphorous (2.1 mg/L) are also higher when compared to goat milk's calcium (0.1), magnesium (0.2) and phosphorus (0.08) present in g /100 g of the goat milk respectively (Cayot, 1998; Amitot *et al*., 2002). The main mineral compounds of milk are calcium and phosphorus, which are substantial for bone growth and proper development of newborns (Gizachew *et al*., 2014). The high bioavailability of these minerals influences the unique nutritional value of milk, of which camel milk is the richest in these minerals (Al-Wabel, 2008).

Differences in values of macro-minerals levels reported by various research groups might be as a result of environmental conditions such as feed and soil or due to breed differences (Gizachew *et al*., 2014). Camels' different breeds have different capacities to deposit minerals in their milk (Wangoh *et al*., 1998). Thus, raw camel milk offers a better advantage than goat milk in terms of the stated nutritional content.

These research results revealed the dominant quantitative components of milk. The nutritional value of milk is particularly high due to the balance of the nutrients that compose it. The composition varies among animal species depending on the period of lactation and diet and also depending on breeds even within the same species, and also from one dairy to the other (Guetouache *et al*., 2014).

CONCLUSION

The present study based on its findings showed that raw camel milk's moisture, crude protein, crude fat, crude carbohydrate, and some determined minerals to be relatively adequate and higher than goat's raw milk.

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CONFLICT OF INTEREST

Authors hereby declare that they have no conflict of interest.

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