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Full Length Research Article

Fatty Acids and Mineral Content in Milk of Locally Reared Ruminant in Sokoto

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ABSTRACT
The nutritional content of milk is determined by its protein, free fatty acids, and essential mineral contents which are indicators of high-quality dairy. This work aimed to evaluate some nutritional indices of milk obtained from locally reared Sokoto Red goats, Yankasa sheep, and Red Fulani cows. Milk samples were collected from each group of five breastfeeding goats, sheep, and cows. Crude protein and percent ash contents were determined using the Kjeldahl method while free fatty acid and mineral contents were determined using Gas Chromatography (GC) and Atomic Absorption Spectroscopy (AAS), respectively. The results obtained show that the percent crude proteins of cows, sheep, and goats were 7.00 ± 0.10, 9.60 ± 0.10, and 25.50 ± 0.10 %, respectively. The percent abundance of free fatty acids show that saturated fatty acids (SFA) were 54.70, 46.19, and 32.28 %, monounsaturated fatty acids (MFA) were 54.96, 47.76, and 35.94 %, while polyunsaturated fatty acids (PFA) were 1.71, 6.04, and 2.99 %, respectively for cow, goat, and sheep. The content of zinc, potassium, and magnesium in the samples were 24.30, 35.50, and 15.70 mg/L, and 11.20, 61.30, and 23.20 mg/L; and 85.20, 97.3, and 86.30 mg/L, respectively for cow, goat, and sheep milk. Results also showed that there is significant difference ($p < 0.05$), between goat's milk which had high percent crude protein, zinc, magnesium, and potassium when compared with sheep and cow milk. Interestingly, sheep milk contained the important essential fatty acids arachidonic acid and nervonic acid in cow's milk. Quantitatively, goat and sheep milk MFA and PFA contents are superior to that in cow milk. While goat milk is rich in zinc, potassium, and magnesium, and significant presence of arachidonic acid in sheep milk, no significant difference was observed in the tested constituents of goat and sheep milk.
Keywords: Milk; Monounsaturated, Polyunsaturated; Crude protein, Zinc, Magnesium

INTRODUCTION
Food has been defined as a substance consisting essentially of protein, carbohydrate, fat, and other nutrients used in the body of an organism to sustain growth and vital processes and to furnish energy (Menrad, 2003). Milk is one of such food that contains several important nutrients for human health. Major shifts in dietary patterns have been occurring, even in the consumption of basic staples toward more diversified diets, and these changes are accompanied by food consumption at a global and regional level and have considerable health consequences (Kearney, 2010). Furthermore, healthy nutrition coupled with physical activity has a positive impact on metabolic health, and the immune system, and lowers the risk of chronic illnesses and infectious diseases (Chooi *et al*., 2019). Milk serves as a good source of nutrients such as fatty acids (FAs), proteins, lactose, and minerals. The rearing of goats and sheep contribute about 17 % of the total meat and 12 % of milk production in Africa (Lebbie, 2004) and this play a significant role in the improvement of human nutrition (Adam *et al*., 2010). Goat milk rarely consumed in this part of the world however, there is a growing awareness of the nutritive importance of goat milk to humans (Nwachukwu and Berekwu, 2020). Significant variation has been observed in ruminant feed utilization where goat was reported to have higher feed conversion efficiency to meat and milk than cattle, sheep, and buffaloes (Lebbie, 2004; Nwachukwu and Berekwu, 2020). Globally, goat milk is more widely produced and accepted than sheep milk according to a report by Nwachukwu and Berekwu (2020). In addition, sheep milk shows an advantage in cheese production compared to cow milk (12.6%), and their large population size, and wide adaptability to climates make sheep much more widely accepted and have greater potential than the cows, and also its minerals such as calcium, phosphorus, potassium, magnesium, sodium, and vitamins (Jensen, 2002; Balthazar *et al*., 2017; Hirahatake *et al*., 2020).

In Africa, it has been shown that sheep and goats play significant roles in the food chain and overall livelihoods of rural households, where they are largely owned by women and their children (Lebbie, 2004). Data from FOASTAT, (2022) indicates that there is an increase in cattle, goats, and sheep production from 2015 to 2020 in sub-Sahara Africa. With an increase between 2.5 to 5.0 fold for cattle, goat and sheep.

Goat, sheep, and cow milk contain triglycerides, which constitute the short-chain (C4-C10), medium-chain (C12-C16), and long-chain (C18-C20) fatty acids (Alonso *et al*., 1987; Alonso, 1993). The long-chain fatty acids are originated directly from the fatty acids of the blood plasma, while the short-chain fatty acids are biosynthesized in the mammary glands while the medium-chain are derived from both ways (Alonso *et al*., 1999). Several factors influence the composition of fatty acids in milk including feed stock (Bank and Muir, 1981; Black, 1985; Clapperton and Banks, 1985), genetics (Gaunt, 1980; Grummer, 1991; Hargrove *et al*., 2004) and seasonal factors (Juárez *et al*., 1992). Medium-chain triglycerides (MCT) have also been shown to be unique in their usefulness (Babayan, 1981; Babayan and Rosenau, 1991; Haenlein and Wendorff, 2006). Pirsi *et al*., (2000) reported that milk proteins are comprised of caseins, and

whey proteins beta-lactoglobulin, alpha-lactalbumin, serum albumin, and immunoglobulins.

The composition of milk in different animal species yield milk of different quality in terms of nutritional value as determined by FA, protein and fat contents. It is interesting to note that the species-specific milk composition determines the rate of growth of an organism's offspring (Melnik, 2015). Thus, study therefore was designed to analyze the FA profiles and mineral content of milk produced by locally reared Sokoto Red Goats, Yankasa sheep, and Red Fulani cows.

MATERIALS AND METHODS

This work was carried out at Usmanu Danfodiyo University, Sokoto-Nigeria from September 2016 through February 2017.

Chemicals and Reagents

Sodium hydroxide (40%), Hydrogen chloride (10%), potassium hydroxide (50%), Dilute Sulphuric acid, Boric acid (BDH, Chem. England), Petroleum ether, Methanol (BDH, England), 0.5% Ascorbic acid, Methyl red and Kjeldhal tablet.

Apparatus and Equipment

Water bath (Gerten and George Ltd, Britain), Round bottom flask, Separating funnel, Volumetric flask, Test tubes, Burettes, Pipettes and Volumetric flask desiccators (Pyrex, Britain), Rotary Evaporator, Centrifuge, Hamilton syringe, Gems, Crucibles (Halde Wanger, Germany), Atomic Absorption Spectrophotometer and GC – MS Gas chromatography (Agilent Technologies Intuvo 9000, Germany).

Animal Feed and Samples Collection

The animals were kept in free open range and were fed on grass, wheat and Guinea corn husk, and supplied with clean drinking water. Five breastfeeding Fulani red cows, Sokoto red goats, and Yankasa sheep of an average age of between 1 to 5 years were randomly selected for milk sample collection.

Sample Preparation

Milk samples collected during the first month of lactation from sheep, Sokoto red goat, and white Fulani cows were homogenized and 10 g aliquot each was preserved separately in a polyethylene tube and kept frozen at -20ºC until required for analysis.

Extraction of Milk Sample

Into different separating funnels containing the saponifiable aliquots (10 g), 5mL of distilled water and 30 mL of petroleum ether was added and mixed gently for several minutes then vortexed to give two layers. The aqueous phase was recovered in a round-bottom flask while the ether phase transferred into a separate flask. The procedure was repeated and fractions were combined after which the ether fraction was evaporated to dryness in a rotary evaporator set at 45 ºC. After cooling, the residue was transferred into a test tube into which 5 mL methanol was added, mixed and centrifuged at 4000 *rpm* for 5 minutes. The extracted portions were kept for fatty acid analysis and mineral determination.

GC-MS Analysis

An Agilent Technologies Intuvo 9000 GC System with 5977B Mass Selective Detector (MSD) coupled with 4513A Automatic Liquid Sampler (ALS) was applied for the GC-MS combination. The column used was Agilent 1909IS – 483UI – INT capillary column with the specification HP – 5MS UI 30m, 0.25 mm, 0.25 µm, Intuvo. The carrier gas, Helium (99.999%, Yara-Rjukan, Norway) was used at a constant pressure set to 90 kPa. A 10 µL injection needle was used to inject 1 µL of extracted sample into the inlet valve. The GC oven temperature was programmed from 70 ºC (2 min) to 150 ºC at a rate of 30 ºC/min, held at 150 ºC for 0.5 min, then to 172 ºCat a rate of 28C /min, held at 172 ºC for 12 min, then to 195 ºCat a rate of 58C/min, held at 195 ^{0}C for 0.5 min, then to 210 ^{0}C at a rate of 20 ºC /min, held at 210 ºC for 15 min, and finally to 230 ºC at 80 ºC/min. The total run time was 49 min. The injection temperature was at 250 ºC. The instrument was operated in SIM mode. The MSD transfer line was at 250 ºC. The source temperature was 230 ºC and MS Quad at 150 ºC. The ionization mode used was electron ionization at 70 eV. Total Ion Count (TIC) was used for compound identification and quantification. The spectrum of the separated compound was compared with the database of the spectrum of known compounds in the NIST17 Reference Spectra Library. Data analysis and peak measurement were carried out using Agilent MassHunter software. Relative response factors were used for the quantitation of the FAs as described by Devle *et al*. (2009). The results were transformed to percent FA "area% under the curve" (AUC) of the injected sample.

Determination of Percentage Ash Content

The milk was dried using a method by AOAC (1990). Briefly, the milk was evaporated to remove the moisture, thereby determining the % moisture content in a water bath at a temperature of 40 – 45 ºC, and the total solid remained was subjected to extraction as described above. To obtain the % ash content, exactly 500 mg of each sample was weighed into a pre-weighed crucible and placed in Gallen Kamp muffle furnace at 600 ºC for six (6) hours. The ash was weighed in the crucible and the weight of the ash content was obtained by the difference and calculated as a percentage of the initial dry weight of the sample using the relationship:

$$Weight\ of\ Ash \Big/ Weight\ of\ original\ sample \; x100\% = \%Ash \quad ---1$$

Determination of Crude Protein (Kjeldhal's Method)

Exactly 2 g of each sample was weighed into a pre-weighed crucible, then transferred into a 250 cm^3 conical flask and a digestion tablet (a mixture of K_2SO_4 and $CuSO_4$) was placed and 10 mL of conc. H_2SO_4 was added. The mixture was placed on a digestion block for 3 hours. After digestion, the sample was made up to the

50 mL mark with distilled water. Exactly 20 mL boric acid mixed with ammonia (colour change from dark red to dark green) was used as indicator for endpoint titration against 0.01N H_2SO_4. Crude protein content was calculated as follows:

$$T.Vx\ \frac{Conc.of H_2SO_4(0.01N)x\ 0.014x50mL}{WOS(2g)xamountofaliquot(10mL)}\ x\ 100\ \% = N_2 \ldots\ldots \mathbf{2}$$

Where *T.V* = Titre value, *WOS* = weight of the original sample; % Crude protein = % $\mathbf{N_2}$***6.25** (conversion factor for protein)

Statistical Analysis

Data are presented as mean ± SD where replicate determinations were carried out. The SPSS statistical software (IBM SPSS statistics for windows version 20 IBM Corp) was used for One-way Analysis of Variance (ANOVA). Multiple range analyses were used to compare means and p values less than 0.05 were considered statistically significant.

RESULTS AND DISCUSSION

Figure 1 presents the percentage areas (% Area) of fatty acid methyl esters (FAMEs) of milk samples. The result shows that the Sokoto Red goat milk has 36.67%, sheep milk had 37.77% while cow milk had 25.56% of the total free fatty acid (FFAs) which comprised the short-chain (C3 – C12), medium-chain (C13 – C17), and long-chain length (C18 - C25) fatty acids, respectively. Furthermore, analysis based on cumulative aggregates on individual FA classes; saturated, monounsaturated, and polyunsaturated fatty acids reveal significant variation amongst the analyzed milk samples.

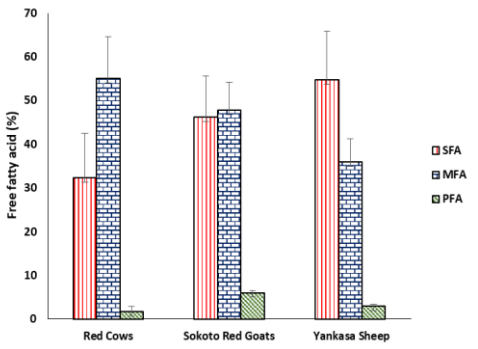

Figure 1: Percentage Abundance of Free Fatty Acids in Milk Samples of Locally Reared Ruminants.
Values are mean ± SD of triplicate determination. **SFA** = Saturated fatty acids, **MFA** = Monounsaturated fatty acid; **PFA** = Polyunsaturated fatty acid

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Fatty acid compositions of milk samples collected from the selected ruminant are presented in Tables 1, 2 and 3. Palmitic acid constituted about 55.80% of the total saturated fatty acids in sheep milk, 64.48% in cow milk, and 35.44% in Red Sokoto goat, while margaric acid identified in both goats and sheep milk were 36.06% and 45.33% of the total saturated fats. The saturated fatty acids (SFAs) were composed of the medium-chain fatty acids capric acid (C10:0) and lauric acid (C12:0); long-chain fatty acids tridecylic acid (C13:0), myristic acid (C14:0), pentacyclic acid (C15:0), palmitic (C16:0), margaric acid (C17:0) and stearic acid (C18:0).

Studies have shown that saturated fatty acids in ruminant milk account for about 60% to 70% of fatty acids (Shingfield *et al*., 2008; Jóźwik *et al.,* 2010). Research has shown that the main SFA in milk fat of the majority of mammals is C16:0 (Mayer and Fiechter, 2012). These studies agreed with the current study, which shows that the saturated percent abundance of C16:0 was between 36.06%, to 64.48% in cow's milk as represented in Tables 1, 2, & 3. Similar reports have shown that fat present in sheep and goat milk is a good source of medium-chain fatty acids. In goat milk, for example, these include; C6:0, C8:0, and C10:0 fatty acids (Schmidely and Andrade, 2011). This corroborates well with the current study where C10:0 and C12:0 was found in both goat and sheep milk.

The pool of FA composition in goat milk has been reported to be more than twice as high as found in cow milk (Strzałkowska *et al*., 2009). As shown in Table 1, the FA in goat milk was more than that of cow milk. The characteristic trait distinguishing goat milk from cow and sheep milk could be observed in the composition of the medium-chain saturated fatty acids such as lauric C12:0 and capric C10:0 acids (ranging between 0.5 – 1% in cow milk) and this could serve as an important indicator for detecting adulteration of either goat or cow milk (Strzalkowska *et al*., 2009). A high concentration of the medium-chain fatty acids capric, caprylic, and caproic in sheep and goat milk in comparison to cow's milk are responsible for the characteristic aroma in the milk of these ruminants (Tudisco *et al*., 2010). Furthermore, these medium-chain fatty acids have been shown to have human health-promoting effects including inhibition of bacterial growth and assisting in cholesterol disposition thereby preventing arteriosclerosis and cardiac heart attack (Schuster *et al*., 1980; Sun *et al*., 2002; Sun *et al*., 2003)

Table 1: Percentage composition of free fatty acid methyl esters in milk of Sokoto red goat

ω-n	Common/other Name	Systemic Name	Δ^n	Area (%)	Structural Formula
	Capric acid	n-decanoic acid	C10:0	0.45	$CH_3(CH_2)_8COOH$
	Lauric acid	n-dodecanoic acid	C12:0	2.50	$CH_3(CH_2)_{10}COOH$
	Tridecylic acid	n-tridecanoic acid	C13:0	9.75	$CH_3(CH_2)_{11}COOH$
	Myristic acid	n-tetradecanoic acid	C14:0	1.00	$CH_3(CH_2)_{12}COOH$
	Pentadecyclic acid	n-pentadecanoic acid	C15:0	35.44	$CH_3(CH_3)_{13}COOH$
	Palmitic acid	n-hexadecanoic acid	C16:0	36.06	$CH_3(CH_2)_{14}COOH$
	Margaric acid	n-heptadecanoic acid	C17:0	1.10	$CH_3(CH_2)_{15}COOH$
	Stearic acid	n-octadecanoic acid	C18:0	14.11	$CH_3(CH_2)_{16}COOH$
ω-7	Palmitoleic acid	cis-9 – Hexadecenoic acid	C16:1Δ^9	1.99	$CH_3(CH_2)_5CH=CH(CH_2)_7COOH$
ω-9	Oleic acid	cis-9 – Octadecenoic acid	C18:1Δ^9	34.24	$CH_3(CH_2)_7CH=CH(CH_2)_7COOH$
	7z-Palmitoleic acid	cis-7 – Hexadecenoic acid	C17:1Δ^7	0.39	$CH_3(CH_2)_8CH=CH(CH_2)_5COOH$
	Lauroleic acid	cis-9 – Dodecenoic acid	C12: Δ^9	0.39	$CH_3CH_2CH=CH(CH_2)_7COOH$
	(E)-Octadec-8-enoic acid methyl ester	8 – Octadecenoic acid	C18: 1Δ^8	32.65	$CH_3(CH_2)_8CH=CH(CH_2)_6COOH$
ω-7	Vaccenic acid	trans-11 – Octadecenoic acid	C18:1Δ^{11}	28.26	$CH_3(CH_2)_5CH=CH(CH_2)_9COOH$
	(E)-Octadec-*10*-enoic acid	10 – Octadecenoic acid	C18:1Δ^{10}	1.66	$CH_3(CH_2)_6CH=CH(CH_2)_8COOH$
	(8E,11E)-Octadeca-8, 11-dienoic acid methyl ester	8, 11-Octadecedienoic acid	C18:2$\Delta^{8,11}$	39.43	$CH_3(CH_2)_5CH=CHCH_2CH=CH(CH_2)_6COOH$
ω-6	Linoleic acid	cis-9, 12 – Octadecadienoic acid	C18:2$\Delta^{9,12}$	50.00	$CH_3(CH_2)_4CH=CHCH_2CH=CH(CH_2)_7COOH$
	(10E,13E)-octadeca-10,13-dienoic acid methyl ester	10, 13 –Octadecadienoic acid	C18:2$\Delta^{10,13}$	10.57	$CH_3(CH_2)_3CH=CHCH_2CH=CH(CH_2)_8COOH$

Table 2: Percentage composition of free fatty acid methyl esters in milk of Yankasa sheep

ω-n	Common/other Name	Systemic Name	Δ^n	Area (%)	Structural Formula
	Capric acid	n-Decanoic acid	C10:0	1.59	$CH_3(CH_2)_8COOH$
	Lauric acid	n-Dodecanoic acid	C12:0	2.25	$CH_3(CH_2)_{10}COOH$
	Pentadecylic acid	n-Pentadecanoic acid	C15:0	2.00	$CH_3(CH_3)_{13}COOH$
	Palmitic acid	n-Hexadecanoic acid	C16:0	55.80	$CH_3(CH_2)_{14}COOH$
	Margaric acid	n-Heptadecanoic acid	C17:0	45.33	$CH_3(CH_2)_{15}COOH$
	Stearic acid	n-Octadecanoic acid	C18:0	2.03	$CH_3(CH_2)_{16}COOH$
ω-7	Palmitoleic acid	cis-9 – Hexadecenoic acid	C16:1Δ^9	1.44	$CH_3(CH_2)_5CH=CH(CH_2)_7COOH$
ω-9	Oleic acid	cis-9 – Octadecenoic acid	C18:1Δ^9	53.96	$CH_3(CH_2)_7CH=CH(CH_2)_7COOH$
	(E)-Octadec-8-enoic acid methyl ester	8 – Octadecenoic acid	C18: 1Δ^8	37.91	$CH_3(CH2)_8CH=CH(CH_2)_6COOH$
ω-7	Vaccenic acid	trans-11 – Octadecenoic acid	C18:1Δ^{11}	6.05	$CH_3(CH_2)_5CH=CH(CH_2)_9COOH$
	Sebacic acid	Decanedioic acid	C10:0	0.65	$HOOC(CH_2)_8COOH$
	(7E,10E)-octadeca-7,10-dienoic acid methyl ester	7, 10 – Octadecadienoic acid	C18:2$\Delta^{7,10}$	2.76	$CH_3(CH_2)_6CH=CHCH_2CH=CH(CH_2)_5COOH$
	Linoleic acid	cis-9, 12 – Octadecadienoic acid	C18:2$\Delta^{9,12}$	31.8	$CH_3(CH_2)_4CH=CHCH_2CH=CH(CH_2)_7COOH$
	Octadeca-11,14-dienoic acid methyl ester	11, 14 – Octadecadienoic acid	C18:2$\Delta^{11,14}$	31.81	$CH_3(CH_2)_2CH=CHCH_2CH=CH(CH_2)_8COOH$
	(10E, 13E)-Octadeca-10,13-dienoic methyl ester	10, 13 – Octadecadienoic acid	C18:2$\Delta^{10,13}$	29.04	$CH_3(CH_2)_3CH=CHCH_2CH=CH(CH_2)_8COOH$
		9,12,15-Octadecatrienoic acid (Z,Z,Z)	C18:3$\Delta^{9,12,15}$	2.29	$CH_3CH_2CH=CHCH_2CH=CHCH_2CH=CH(CH_2)_7COOH$
ω-6	Arachidonic acid	cis-5, 8, 11, 14 – Eicosatetraenoic acid	C20:4$\Delta^{5,8,11,14}$	2.29	$CH_3(CH_2)_4CH=CHCH_2CH=CHCH_2CH=CHCH_2CH=CH(CH_2)_3COOH$

Table 3: Percentage composition of free fatty acid methyl esters in milk of Fulani red cow

ω-n	Common/other Name	Systemic Name	Δ^n	Area (%)	Structural Formula
	Lauric acid	n-Dodecanoic acid	C12:0	1.77	$CH_3(CH_2)_{10}COOH$
	Tridecylic acid	n-Tridecanoic acid	C13:0	1.77	$CH_3(CH_2)_{11}COOH$
	Pentadecylic acid	n-Pentadecanoic acid	C15:0	28.16	$CH_3(CH_3)_{13}COOH$
	Palmitic acid	n-Hexadecanoic acid	C16:0	64.48	$CH_3(CH_2)_{14}COOH$
		n-Octadecanoic acid	C18:0	22.35	$CH_3(CH_2)_{16}COOH$
ω-9	Nervonic acid	(Z)-Tetracos-15-enoic acid	C24:1Δ^{15}	1.90	$CH_3(CH_2)_8CH=CH(CH_2)_{13}COOH$
ω-12	Petroselinic acid	6- Octadecenoic acid	C18:1Δ^6	9.33	$CH_3(CH_2)_{10}CH=CH(CH_2)_4COOH$
ω-9	Oleic acid	9-Octadecenoic acid	C18:1Δ^9	64.78	$CH_3(CH_2)_7CH=CH(CH_2)_7COOH$
ω-7	Vaccenic acid	trans-11-Octadecenoic acid	C18:1Δ^{11}	10.72	$CH_3(CH_2)_5CH=CH(CH_2)_9COOH$
ω-6	Linoleic acid	cis-9, 12-Octadecadienoic acid	C18:2$\Delta^{9,12}$	3.83	$CH_3(CH_2)_4CH=CHCH_2CH=CH(CH_2)_7COOH$
		Cyclopropaneoctanoic acid, 2 – hexyl - trans -Oxiraneudecanoic acid, 3 – pentyl -			

Other important long-chain fatty acids associated with dairy fat in ruminant as shown in Tables 1, 2 and 3 include tridecylic acid (C13:0), myristic acid (C14:0), pentacyclic acid (C15:0), palmitic acid (C16:0), margaric acid (C17:0), and stearic acid (C18:0) have also been reported to have beneficial health effects. For instance, a diet rich in saturated fatty acids lauric, myristic, and palmitic acid has the potential to increase low-density lipoprotein (LDL) and high-density lipoprotein- (HDL), i.e., cholesterol-increasing properties (Mensink *et al*., 2003).

Moreover, several epidemiological cohort studies conducted on milk fat suggests there are no reasonable evidence that link milk fat consumption and increase serum lipids (Stähelin, 1992; Willett *et al*., 1993; Fehily *et al*., 1993; Ness *et al*., 2000; Elwood *et al*., 2004). Furthermore, it was suggested that intake of dairy fat and some other dairy products containing C15:0 FA has the potential to protect from myocardial infarction (Biong *et al*., 2006).

Similarly, omega-6, -7, and -9 (n-6, n-7, and n-9) fatty acids have been suggested to provide essential health benefits for humans and are important dietary nutrients. A high proportion of these fatty acids were detected in all milk samples analyzed in this study. For example, the omega-7 fatty acid found in goats and sheep milk samples are; palmitoleic acid (C16:1), with percent abundance of 1.99% and 1.44% respectively (Tables 1 and 2). Vaccenic acid (*trans*-11-octadecenoic) found in all samples however was highest in goat milk constituting 28.26% of the total unsaturated fatty acid then followed by the cow and sheep milk with 10.72% and 6.05%, respectively. Oleic acid, a single unsaturated, and omega-9 fatty acid were found in high concentrations in all the milk samples representing 34.24%, 53.96%, and 64.78% of the total unsaturated fatty acid while nervonic acid was detected only in cow milk. The other omega-6 polyunsaturated fatty acids (PUFAs) detected were linoleic acid (C18:2), with a percent abundance of 50.00%, 31.81% in goat and sheep milk, and a low amount of 3.83% in cow's milk, the Arachidonic acid was found in sheep milk 2.29% (Tables 1, 2 & 3). Other PUFAs detected include (8E, 11E)-octadeca-8, 11-dienoic acid, (10E, 13E)-octadeca-10, 13-dienoic acid in goat milk, (7E, 10E)-octadeca-7, 10-dienoic, and (10E, 13E)-octadeca-10, 13-dienoic acid in sheep milk, respectively. Other major sources of these polyunsaturated fatty acids (PUFAs) include vegetable oils, egg yolk and meat (Whelan *et al*., 2004). The mono-unsaturated fatty (MUFA), e.g., palmitoleic acid (PA), occur naturally and formed a component of healthy skin and a strong antioxidant (Spahis *et al*., 2008). Health benefits and structural functions of these MUFAs have been reported, for example, moderate consumption of n-9 MUFA such as oleic acid lowers cholesterol levels and reduced atherosclerosis (Nicolosi *et al*., 2004) while palmitoleic acid enhances whole-body glucose disposal in rodents (Coa *et al*., 2008) and attenuate hepatic steatosis in high-fat-fed and diabetic mice, protect pancreatic beta-cells from death induced by palmitic acid (Coa *et al*., 2008; Yang *et al*., 2016).

Proteins constitute about 95% of total nitrogen present in milk. In the current study, the percent crude protein content of the milk analysed showed significant variation between goat, sheep, and cow milk. The result indicates that the percent crude protein in goat milk was 24.8% and ash contents of 1.75%, which is significantly higher ($P<0.05$) when compared to sheep and cow milk (Figure 2). Higher protein and ash content are indicators of milk nutritional and mineral values (Rafiq *et al*., 2016). These results are similar to those found by other investigators (Han *et al*., 2007; Ozrenk *et al*., 2008; Strzalkowska *et al*., 2009; Shamsia, 2009). Furthermore, protein content is an important factor affecting the quality of dairy products, as the reduction in proteins such as casein (α- and β-casein) contents results in poor cheese-making (Bernabucci *et al*., 2002). Borkova and Snasolva (2005) demonstrated that cow and goat milk contain 0.47% and 0.53% of whey protein which form the pool of crude protein content.

Milk is an important source of micronutrients (minerals, and vitamins), especially in child and adolescent nutrition (Whitney *et al*., 1990) and deficiencies in the Recommended Dietary Allowances (RDA) could impact negatively on the development of the new-born Studies have shown that zinc, magnesium and potassium form core components in many tissues and as enzyme as co-factors (Underwood, 1981). In this current study, the mineral content of milk from the lactating Sokoto Red Goats, Yankasa sheep, and cows reveal milk from Sokoto Red Goat had highest zinc, magnesium, and potassium contents while levels of magnesium in Yankasa sheep was statistically different ($p < 0.05$) when compared with levels in cow milk (Figure 3).

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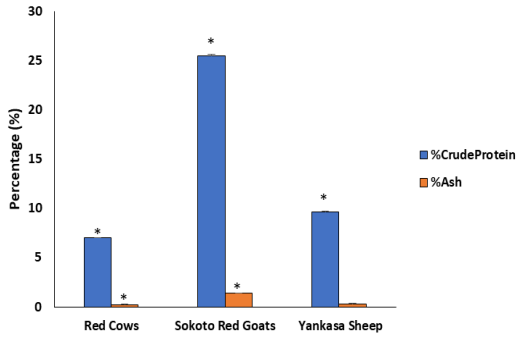

Figure 2: Percent protein and ash contents in milk samples of locally reared ruminants. Values are the mean ± SD of three biological replicates.

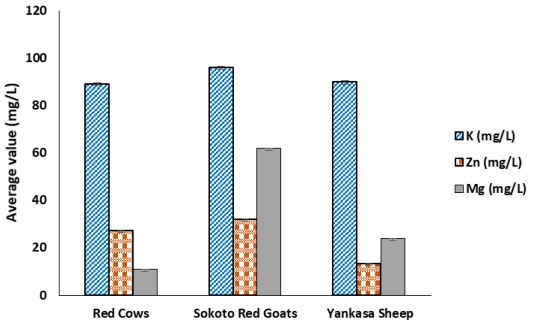

Figure 3: Mineral content of Milk of Locally Reared Ruminants in Sokoto Metropolis
Values are the mean ± SD triplicate determinations

There are many factors reported to influence the concentration of minerals in milk. For instance, Coni *et al*. (1999); Dell'Orto *et al*. (2000) reported that the concentration of certain health-related minerals in milk was dependent upon animal species (genetic) and feeding regime (nature and content of the animal feed), lactation period, and environmental conditions (rainy or dry season). Our results are similar to previously reported work by Al-Wabel, (2008) and Rafiq *et al* (2016) where both show high content of these minerals in goat, sheep, cow as well as camel milk using a modified regime of feeding.

CONCLUSION

In conclusion, the result of this study indicates that Sokoto Red Goat milk is rich in protein and minerals contents as compared to milk from Yankasa sheep and red Fulani cow. Yankasa sheep milk shows the presence of nutritionally important arachidonic acid while cow milk had highest amount of oleic acid. Consumption of milk obtained from locally reared ruminants is recommended which could serve to reduce the over-dependence on imported milk and other dairy products.

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