Biochemical and Physio-Chemical Variation in the Milk Content of Some Selected Nigerian Indigenous Cattle in Nigeria

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Abstract
The study aimed to investigate variation in milk physiochemical and biochemical properties of some indigenous breeds of cattle in Mubi. The breeds comprised the Red Bororo, Sokoto Gudali, White Fulani and Adamawa Gudali. Samples were collected from lactating animals within first and second parity from the pastoralist. Eighty (80) (20 each) milk samples were examined. Data collected were subjected to Analysis of Variance using Statistical Analysis for Science (SAS) and means were separated using Duncan Multiple Range. There were significant (P<0.05) differences among all the milk biochemical properties of some selected indigenous breeds of cattle except for creatinine (P>0.05). White Fulani recorded the highest in Total Protein (3.89). Adamawa Gudali recorded the highest in Triglycerides (0.27). Sokoto Gudali recorded the highest in Albumin, cholesterol and lactose while Red Bororo recorded the least in all parameters. There was also a significant (P<0.05) effect of breed on physio-chemical parameters; Titrated acid (TTA), total solid (TS), total solid nonfat (TSNF) and Iron (Fe^{2+}). White Fulani recorded the highest in TSNF (4.06), White Fulani and Red Bororo Cattle recorded the highest in TS and Iron. Sokoto Gudali recorded the highest in TTA (0.56). It was concluded therefore, the milk of white Fulani was higher in total protein while Sokoto Gudali had higher lactose and cholesterol contents. Red bororo was rich in mineral contents. Also, correlated responses among the milk biochemical and physiological contents can be used to access the quality of milk supplied by milk sellers.

Key words: *Biochemical; Physio-chemical; Milk; Indigenous; Cattle.*
Target audience*: Breeders, milk consumers, nutritionists, health workers*

INTRODUCTION

Milk-producing mammals have been an important part of world's agriculture and cattle are still the major producers of milk providing more than 90% of the total animal domestic milk output (Walshe *et al.*, 1991; Kubkomawa, 2017; Nayak *et al.*, 2018). The current interest in the composition of milk is probably due to its nutritional importance in human diet and owing to the fact that, the composition is not absolute as many factors influence the end products (Roxstrom *et al.*, 2001; Massanyi *et al.*, 2009; Smith *et al.*, 2013). Milk is known by its most diversified natural supplies in terms of composition which contains more than twenty different trace elements including copper, zinc, manganese and iron (Dobrzański *et al.*, 2005; Imran *et al.*, 2008; Malbe *et al.*, 2010; Ali *et al.*, 2011). In many research articles, milk and milk products are an important source of all basic nutrients for mammals as it is reported to be an important part of the human diet and furnishes approximately all the daily requirements

from fat, calcium, phosphorus, riboflavin, one half of the protein, one third of vitamin A, ascorbic acid, thiamine and one fourth of calories needed daily by an average individual (Bilal and Ahmad, 2004; Filipejova and Kovacik, 2009). For instance, calcium (Ca), magnesium (Mg), and phosphorus (P) are needed for growth, reproduction and lactation, which often affect specific requirements, and serve as catalytic components of enzymes that regulate several mechanisms involved in pregnancy and lactation (Tanritanir *et al.*, 2009; Lohrenz *et al.*, 2010).

Milk, the result of various biochemical activities in mammary secretary cell is made up of fat, protein, carbohydrates, enzymes, vitamins and various minerals (Brinez *et al.*, 2003). Biochemical tests are used to evaluate the body's internal condition, the function of organs (kidneys and liver), health and metabolic process in the body of the lactating animals (Scamell, 2006; Filipejova and Kovacik, 2009; Rodhkowska and Herbut, 2014; Qayyum *et al.*, 2016). During lactation, secretory cells of mammary gland utilize 80% of the blood circulating metabolites for milk synthesis, depending on the speed of infiltration in the precursors of milk compounds (i.e. free amino acids, glucose and fatty acids).

Physicochemical analysis is an important tool used to monitor the quality of milk and other dairy products. Fresh milk is considered complete diet because it supplies the essential nutrients in a balanced form than other foods (Hossain and Dev, 2013*)*. Milk from various mammals are used for producing different dairy products including milk cream, butter, yogurt, ghee, sour milk, etc. Consumers always demands nutritionally enriched milk and dairy products (Kamao *et al.*, 2007).

The composition of milk is influenced by various factors; these factors include stage of lactation, lactation number, breed, feeding pattern, environmental and diseased condition of the udder (Qin *et al.*, 2007; Alade *et al.*, 2013).Cow milk consumption is popular in the northern Nigeria because of its medicinal and dietary properties (Ali *et al.*, 2011). There is therefore need to evaluate the biochemical and the physiochemical quality of fresh cow milk supplied to the markets particularly in Mubi which is one of the international cattle business region with different breeds of cattle supplying milk to the populace. This study aims to assess the effect of breed on biochemical and physio-chemical properties on fresh milk from four traditionally managed Nigerian indigenous cattle raised among Fulani rearers in Mubi and its environs in Adamawa State Nigeria.

MATERIALS AND METHODS

Experimental Site

The study was conducted in Mubi and its environs. Mubi is located in the Sub-Sudan savannah vegetation belt with coordinates of $10^0$16"N, 13^0 16"E and an altitude of 1906 feet. The major occupation of the people is farming. However, because of the presence of Yedseram River, the people also engage in fishing activities but at a subsistence level. The climate is tropical with average temperature of about 32.90^0 C in dry season with relative rainfall. The major tribes of the town are: Gude, Nzanyi and Fali with Fulani, Marghi, Higgi and Mundang as minority (Adebayo, 2004; Ovimaps, 2018).

Experimental Animals and management

Four breed of indigenous cattle were used for the experiment. These breeds comprised the Red Bororo, Sokoto Gudali, White Fulani and Adamawa Gudali. Twenty samples of milk from each breed were collected from lactating animals within their first and second parity into a sterile container from the pastoralist. The samples were then transported immediately to the Nutritional laboratory of the Department of Animal Production, Adamawa State University for analysis of biochemical and physiochemical parameters.

Sample Collection

The off springs were separated from their dams overnight. In the morning, they were allowed to suckle for about 1-2 minutes to stimulate milk let down. Milk was collected in labelled plastic vials, and stored at 4^0C in the refrigerator for the analysis.

Parameters Measured/Methods

Cholesterol was determined using a modified form of Liebermanns-Burchard's Method (Kingsley and Schaffert, 1949). Total protein by burrette method as described by Michael and Lubran, (1978), Creatinine and albumin were determined spectrophotometrically using commercial kits (Spencer, 1986), triglycerides by Wako method. The activity of lipase was measured by kinetic method using commercial kits (Alpha Diagnostics). All spectrophotometrical measurement was done using jenway spectrophotometer (AOAC, 2000).

Minerals

Minerals analysis was determined by AOAC (2000). The milk solid content was taken and digested using two volume of concentrated nitric acid. After adding one volume of perchloric acid, the content was heated gently on a hot plate followed by a vigorous heating till dryness (proximately 1-2ml)). This digestion technique made no attempt to dissolve any silicate-base materials that may be present in the sample. After cooling, the digested sample were quantitatively transferred to a flask and diluted to 100ml with de-ionized double distilled water and then filtered. Minerals (Fe, K, Ca, P, and Mg) were determined using an Atomic Absorption Spectrophotometer (210, Buck Scientist USA). Phosphorus (P) was measured by converting phosphorus into phosphorus molybdenum blue pigment and measured at 700nm.

pH and TTA Analysis

The pH measurement was carried out using a digital PH-meter (jenway 3505, UK) calibrated with PH 4 and 7 buffers. Titrateable acidity was measured by titrimetric method, and expressed as percent of lactic acid as described by Jennings *et al.*, 2010)

Total solid

The total content was determined using a forced air oven method described by Boci *et al.*, (2015) by placing the samples in dry aluminium dishes containing dry sea sand as a dispersing agent (fisher scientific), and drying at 105°C until constant weight.

The total solid are determined by formula

Total solid%= $\frac{Weight * 100}{Weight\ of\ milk\ sample}$

Total solid non fats

- **i.** Determine the fat (F) percentage of milk sample by Gerbers method.
- **ii.** Take out the Lactometer reading and temperature of milk and calculate. Corrected lactometer (CLR).
- **iii.** Place the figures of fat and CLR in the following fomula for calculating total solid and solid nonfat. TSNF:

Formula

TSFN%= $\frac{CLR + 0.21F + 0.14}{4}$

Where CLR= corrected lactometer reading.

F= Fat content in milk.

Statistical Analysis

The data obtained from the experiment was subjected to Analysis of Variance (ANOVA) using SAS, 9.4 (SAS, 2004). Means with significant differences were separated using Duncan Multiple Range Test (Duncam, 1955). Correlation analyses were also computed using the correlation procedure (CORR PROC) of the same software.

RESULTS AND DISCUSSION

Table1 shows breed variation in milk biochemical parameters of some selected indigenous breeds of cattle. There were significant ($P < 0.05$) differences among the means of total protein, albumin, Triglycerides, cholesterol and lactose. White Fulani recorded the highest in Total Protein (3.89%) while Sokoto Gudali recorded highest in albumin (3.87 mg/L), cholesterol (10.87 mg/L) and lactose (3.67%).The least of all traits were recorded in Red Bororo, except for triglyceride which was in Sokoto Gudali. White Fulani recorded the highest in TSNF (4.06%) while White Fulani and Red Bororo Cattle recorded the highest in TS (13.42%) and Iron (1.04). Sokoto Gudali recorded the highest in TTA (0.56%) while White Fulani recorded the lowest (0.45%).

The results of the present study show that breed had different effects on biochemical parameters of the dairy animals (Table 1). White Fulani recorded the highest in Total Protein (3.89%). Adamawa Gudali recorded the highest in Triglycerides (0.27 mg/L). Sokoto Gudali recorded the highest in Albumin, cholesterol and lactose. Red Bororo recorded the least of all parameters.

Cholesterol is one of the contending biochemical parameters because of the health threat it pauses. Even though it is an important component for the manufacture of bile acids, steroid hormones, and fat soluble vitamins including vitamin A, D, E and K (Park, 2000; Chilliard and Ferlay, 2004; Shingfield *et al.*, 2008; Ali *et al.*, 2011) its presence in high level in milk is an indicator for diseases such as heart diseases (Ali *et al.*, 2011).Variations in the cholesterol contents of the milk of the indigenous breeds in this study concurred with the report of Raymond, (2017) who reported variation in serum plasma Cholesterol concentration of different breeds of exotic cattle and reported that Brown Swiss had higher plasma glucose than Holstein Friesian and Simmental breeds of exotic cows in Nigeria. Asides breed variation, location and stage of lactation has been reported to cause variations in the cholesterol content of milk (Pysera and Opalka, 2000; Filipejova and Kovacik, 2009; Ali *et al.*, 2011). Also, the cholesterol content of bovine milk is determined by both genetic (breed and milk yield) and environmental factors (Tomaszeski, 2005).

The Total Protein investigated in this study (3.09- 3.89 %) was within the recommended values 2 % to 4 % for the total protein content of milk according as reported by Webb *et al.* (1974), Hassan, (2005) and Kra *et al.*, 2013.Total Protein, Urea and Albumin are the indicators of protein metabolism (Radkowaska and Herbut, 2014). While creatinine is the basic parameter reflecting the kidney function (Stojecvic *et al.*, 2005; Radkowaska and Herbut, 2014), Albumin has been reported to be responsible for the transport of amino acids and bilirubin in the blood (Radkowaska and Herbut, 2014). It was reported that reduced albumin concentration was evident in animals with hepatic lesions, or in animals with inflammatory processes and such animals are considered to have negative acute phase protein (Bertoni *et al.*, 2015; Trevisi *et al.*, 2015; Ren *et al.*, 2018). Breed differences observed for these parameter in this study contradict the reports of other authors (Brzoska, 2005; Radkowaska and Herbut, 2014) who reported non-significant variation of these parameters in cows under different management systems. Sunaric *et al.*, (2015) opined that human milk composition is dynamic and varies within a diet, over a periods of lactation, and between mothers and different populations. Differences between this results with other authors could be due to differences in the factors considered. The results about total protein, albumin, triglycerides, cholesterol, creatinine and lactose among the selected indigenous cattle breed

(White Fulani, Red Bororo, Adamawa Gudali and Sokoto Gudali) confirmed the fact that the composition of milk is considerately affected by factors such as breed, species, lactation period and season (Brinez *et al.*, 2003; Qin *et al.*, 2007; Alade *et al.*, 2013; Molefe and Mwanza, 2019). The lactation stage is one of the important causes of variation in concentration of blood metabolites in dairy cows (Vazques-Anon *et al.*, 1994 and Yaylak *et al.*, 2009).

The lactose in the milk (3.21% to 3.66%) was within the standard range (2% to 5%) as reported in the literatures (Webb *et al.*, 1974; Hassan, 2005; Kra *et al.*, 2013). Lactose is another milk component with high health concern. Even though it does not produce disease condition, there are people who cannot metabolize lactose (Basnet *et al.*, 2010). Lactose is said to be a major milk sugar (Basnet *et al.*, 2010; Ali *et al.*, 2011) is the most important nutrient in milk for children because of the quantity of energy it supplies (Kra *et al.*, 2013). In this study, Sokoto Gudali recorded the highest lactose. Therefore, people within born error lactose metabolism (Basnet *et al.*, 2010; Ali *et al.*, 2011) should be cautious when taking the milk. It was reported that lactose and solid non -fat decreased significantly in cows that were sub-clinically infected with mastitis (Qayyum *et al.*, 2016).

Table 2 shows the breed variation in the physical and elemental parameters of some selected indigenous breeds of cattle. There were significant ($P< 0.05$) differences among the means of Titrated Acid (TTA), Total Solid (TS), Total Solid Non-Fat (TSNF), Calcium (Ca^{2+}), and Iron (Fe^{2+}) whereas, the means of pH, Phosphorus (P), Potassium (K) and Magnesium (Mg) were not significant ($P> 0.05$).

The source of good amount of calcium in many part of the world is diary product. The superiority of Red Bororo and Sokoto Gudali in calcium (Table 2) suggests that milk from these breeds would be good for pregnant and infants (Lohrenz *et al.*, 2010). It also implied that these breed contained more proteins in the bones than the other breeds studied because calcium had been reported to be associated with Osteoporosis (Hang *et al.*, 2007). It was reported that calcium concentration in bovine milk is about 1g/L (Hang *et al.*, 2007). Calcium is the most abundant mineral in the body and essentially all body processes require calcium (Dandare *et al.*, 2014). Getting adequate calcium in the diet gives healthy bones and teeth, and it may also help prevent hypertension, decrease odds of getting colon or breast cancer, improves weight control and reduce the risk of developing kidney stone (Adesina, 2012; Dandare *et al.*, 2014).

The means of Total Solid of White Fulani, Red Bororo, Adamawa Gudali and Sokoto Gudali was similar to the reports of Ren *et al.* (2015) in Murrah and Nili-Ravi cattle breeds in China. It was also similar to that reported by (Legesse *et al.*, 2017). The value of Total Solid of milk collected from Adamawa Gudali and Sokoto Gudali was higher than the values reported by Legesse *et al.*, (2017).

The pH of the milk sample collected from the four indigenous cattle breeds was not significant ($p>0.05$) as shown in table 1 but value of pH of White Fulani and Red Bororo was lower than the normal pH value of fresh cow milk. The normal pH of fresh cow milk ranges from pH 6.6 – 6.8 (FAO, 1999) which is higher than that of Adamawa Gudali and Sokoto Gudali. The low value of pH could be due to genetic differences and other environmental factors.

The mean total solid non -fat (TSNF) of the milk samples in this study was 4.06% (WFC), 3.80 (RBC), 3.65 (AGC) and 3.77 (SGC) respectively. These values are lower than the value reported by (Abbaya, 2012) which was reported to be 9.146 in indigenous cattle in Maiduguri. The differences observed in the quality characteristics of milk had been associated with stage of lactation (Ozrenk and Selculk, 2008), lactation length and lactation yield (Neitz and Robertson, 1991).

White Fulani and Red Bororo recorded the highest in iron. Iron has been reported to be essential for maintaining proper cell functions and is normally tightly controlled by transporter and storage proteins (Lieu *et al.*, 2001). In addition, Cupper, Zink, Manganese and Iron are found as key components in a multitude of enzymes and play an important role in many physiological functions of humans and animals (Wang *et al.*, 2014). Red Bororo was highest in Phosphorus (P^{+}), Sodium (Na^{2+}) and Iron (Fe^{2+}). Even though, low Fe^{2+} concentration in milk cannot meet the needs of the young, it limits bacterial growth in milk; is essential for the growth of many bacteria (Lieu *et al.*, 2011; Wang *et al.*, 2014). Iron is a part of both the oxygen-carrying system and iron–sulfur proteins, which play an important role in oxygen and carbon dioxide transport in vertebrates and in the electron transport system of mitochondria, respectively (Wang *et al.*, 2014).

Generally, variations observed in milk physio-chemical properties of the sampled breeds of cattle and the ones reported by other authors could be due to genetic and non- genetic factors such as breed, location, parity and season (Brinez *et al.*, 2003; Qin *et al.*, 2007; Alade *et al.*, 2013). The milk composition within the same animal breed not only depends on the state of lactation, but also on genetic factors, nutritional status of the animals as well as the composition of feed and the environment (Kondyli *et al.*, 2007).

Significant negative correlation exist between triglycerides versus albumin and lactose (Table 3). This implies that a significant increase in Triglycerides would result to significant decrease in the values of albumin and lactose vice-versa (Abbaya *et al.*, 2017; Abbaya *et al.*, 2020). The fertility of farm animals has also been found to be significantly inversely related to levels of serum biochemical parameters such as serum inorganic phosphorus, serum potassium, serum total protein and serum urea - nitrogen (Hewett, 1974; Ate *et al.*, 2009). Also, the low productivity of indigenous cattle is related to poor genetic base of the livestock, poor management practices, harsh environmental conditions, nutritional inadequacies, and diseases (Agyemang *et al.*, 1991; Ate *et al.*, 2009). Serum calcium has been reported to show a tendency to decrease shortly after calving (Belyea *et al.*, 1975; Wilson *et al.*, 1977) while plasma potassium levels increase in late pre-partum and decrease in early postpartum (Belyea *et al.*, 1975)

Table 4 presents the pooled correlation coefficients of the milk physio-chemical parameters of some selected breeds of cattle. There were significant ($p<0.05$-0.01; $r = -0.75$ to 0.59) relationships between some milk physio-chemical parameters evaluated except ($p>0.05$; $r = -0.23$ to 0.24). pH was not significantly correlated with the parameters measured ($P>0.05$; $r = -0.10$ to 0.18) except with potassium ($P<0.05$; $r = -0.45$). Calcium was only significantly correlated ($p<0.05$; $r = 0.28$) with TTA.

Phosphorus was only significantly correlated ($p<0.05$; $r = -0.30$) with calcium (Table 4). Calcium and phosphorus are reported to one of the important minerals in milk. Calcium is the most abundant mineral in the body and essentially all body processes require calcium (Hang *et al.*, 2007). Getting adequate calcium in the diet gives healthy bones and teeth, and it may also help prevent hypertension, decrease odds of getting colon or breast cancer, improves weight control and reduce the risk of developing kidney stone (Hang *et al.*, 2007). The positive correlation between calcium and phosphorus suggests that the two increase/decrease together in milk. The main components of milk from cow not only reflect the hereditary character, milk secretion character and nutritional status of cow, but also reflect the seasonal changes (Pulina *et al.*, 2006; Qi *et al.*, 2011). However, the knowledge of relationship amongst these traits can help in the formulation of programmes for selection and improvement of milk quality of dairy cattle (Alade *et al.*, 1999; Alphonsus and Essien, 2012).

CONCLUSION

From the study, it is reasonable therefore, to suggest that people within old age and born error lactose metabolism should take Sokoto Gudali milk with caution. Going by the findings that the milk of white Fulani was higher in Total Protein while Sokoto Gudali had higher Lactose and Cholesterol contents. Red bororo was rich in mineral contents and hence can be a good source of mineral supplement. Also, correlated responses among the milk biochemical and physiological contents can be used to access the quality of milk supplied by milk sellers.

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Table 1: Breed variation in Milk Biochemical Parameters of some selected indigenous breeds of cattle

Traits	White Fulani	Red Bororo	Adamawa Gudali	Sokoto Gudali
Total Protein (%)	3.89±0.05^{a}	3.42±0.13^{b}	3.53±0.12±^{b}	3.65±0.09^{ab}
Albumin (%)	3.09±0.11^{b}	2.98±0.01^{b}	2.94±0.23^{b}	3.87±0.06^{a}
Triglycerides (mg/L)	0.22±0.00^{b}	0.23±0.02^{b}	0.27±0.00^{a}	0.13±0.00^{c}
Cholesterol (mg/L)	7.90±0.06^{d}	8.54±0.11^{c}	10.56±0.03^{b}	10.87±0.02^{a}
Creatinine(mg/L)	0.15±0.01	0.16±0.00	0.16±0.00	0.16±0.01
Lactose (%)	3.21±0.05^{b}	3.26±0.07^{b}	3.24±0.06^{b}	3.66±0.18^{a}

abc= means with different superscript within the same row are statistically different ($p< 0.05$)

Table 2: Effect of breed on milk physiochemical properties of indigenous cattle breeds

Trait	White Fulani	Red Bororo	Adamawa Gudali	SokotoGudali
PH	5.61 ± 0.60	5.63 ± 0.59	6.12 ± 0.00	6.09 ± 0.00
TTA	0.45 ± 0.00^{d}	0.50 ± 0.00^{c}	0.53 ± 0.00^{b}	0.56 ± 0.00^{a}
TS	13.42 ± 0.09^{a}	13.49 ± 0.08^{a}	12.46 ± 0.07^{b}	12.54 ± 0.03^{b}
TSNF	4.06 ± 0.03^{a}	3.80 ± 0.04^{b}	3.65 ± 0.10^{c}	3.77 ± 0.02^{b}
Ca	553.38 ± 11.44^{b}	592.58±6.90^{a}	549.56 ± 14.78^{b}	595.74 ± 3.32^{a}
P	303.65 ± 11.73	326.17± 5.13	311.49 ± 8.23	302.79 ±9.07
K	1450.16 ± 187.43	1301.19±25.68	1180.64 ± 119.02	1441.97 ± 188.23
Mg	115.70 ± 2.09	115.70 ± 2.09	105.19 ± 5.61	114.33 ± 4.66
Fe	1.04 ± 0.03^{a}	1.04 ± 0.03^{a}	0.91 ± 0.02^{b}	0.96 ± 0.02^{b}

TTA= Titrated Acid, TS= Total Solid, TSNF= Total Solid Non Fat, Ca= Calcium, P= Phosphorus, K= Potassium, Mg=Magnesium, Fe= Iron; abc= means with different superscript within the same column are statistically different ($p< 0.05$)

Table 3: Pooled correlation coefficients of the milk biochemical parameters of some selected indigenous breeds of cattle

	TP	ALB	TRYG	CHOL	CREA	LACT
TP		0.07	-0.13	-0.23	-0.15	-0.11
ALB			-0.72**	0.49*	-0.05	0.53*
TRY				0.22	0.03	-0.57**
CHO					0.12	0.29*
CRE						-0.19

TP = Total Protein; ALB = Albumin; TRYG = Triglycerides; CHOL = Cholesterol; CRE = Creatinine; LAC = Lactose; * = ($p<0.05$); ** = ($p<0.01$)

Table 4: Pooled correlation coefficients of the milk physio-chemical parameters of some selected indigenous breeds of cattle

	TTA	TS	TSNF	Ca	P	K	Mg	Fe
PH	0.12	0.10	-0.1	-0.12	0.12	-0.45*	-0.03	-0.18
TTA		-0.75**	-0.73**	0.28*	-0.01	-0.16	-0.09	-0.32*
TS			0.59**	0.02	0.23	0.07	0.25*	0.43*
TSNF				-0.13	-0.04	0.21	0.24	0.06
Ca					-0.30*	0.14	0.41*	0.05
P						-0.11	-0.04	0.26*
K							0.07	0.20
Mg								-0.15

TTA= Titrated Acid, TS= Total Solid, TSNF= Total Solid Non Fat, Ca= Calcium, P= Phosphorus, K= Potassium, Mg=Magnesium, Fe= Iron; * = ($p<0.05$); ** = ($p<0.01$)