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Milk yield, composition and their correlated relationships in some selected indigenous breeds of cattle in late wet season of Adamawa state, Nigeria

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Abstract

There is need for characterization of performances of cattle breeds in relation to milk yield and composition particularly in Adamawa State where seasonal fluctuations in climatic elements can affect livestock resilience. This study was carried out to evaluate the breed variation in milk yield and composition of some selected breeds of Nigerian indigenous cattle in Adamawa State in the late wet season (August-October). The milk of 20 cows each from four breeds (Bunaji, Rahaji, Adamawa Gudali and Bokoloji) was sampled for milk yield and composition analysis three times within the season. Milk was analysed for its composition. Breed significantly ($p<0.05$) influenced the milk component evaluated. Bunaji was superior in milk yield (1.92), fat yield (5.73) and total solid non-fat (4.59). Rahaji was superior in phosphorus (410), sodium (61.01) and iron (3.16) while Bokoloji was superior in protein (4.98) and calcium (721). For the correlated relationships between the milk components evaluated in different breeds, there was a significant ($p<0.05$-0.01; $r = -0.89$ to 1.00) correlation between milk components except ($p>0.05$; $r = -0.21$ to 0.24) within various breeds. Zero relationship existed between milk yield and Fe in Adamawa Gudali ($p>0.05$; $r = 0.00$) while a perfect relation exists between milk yield and protein yield ($p>0.01$; $r = 1.00$) in Rahaji, Adamawa Gudali and Bokoloji and between protein yield and fat yield ($p>0.01$; $r = 1.00$) in Bunaji and Bokoloji. For the pooled correlated responses, there was significant ($p<0.05$-0.01; $r = -0.95$ to 0.99) relationships between most milk components. It was therefore concluded that Bunaji had the highest milk yield, Bokoloji was best in milk protein and fat contents while Rahaji was best in mineral contents. Also, correlated relationship between milk components should be maximized in formulating a selection programme for improvement of milk in Nigerian indigenous cattle.

Keywords: Indigenous, cattle, milk, yield, composition

Introduction

The livestock sector is an important sector because of its contribution in the Global food security. They are said to provide 17% of global kilocalories and 33% of global protein consumption (Rosegrant *et al*., 2001; Nayak *et al*., 2018) and the demand for products from this sector is increasing rapidly particularly in the developing countries (Thornton, 2010; Wright *et al*., 2012). Tropical countries have been reported to have over 50% of the world bovine population (Nayak *et al*., 2018) and Nigeria has been reported to be one of the leading countries in cattle production in Sub-Saharan Africa (Kubkomawa, 2017). Over 90% of these populations are traditionally managed in the Northern part of Nigeria (Ken, 1982; Kubkomawa, 2017). Also, over 80% of this is also managed by traditional pastoralists (Kubkomawa, 2017). Milk production from indigenous breeds of cattle in Nigeria represents an important component of the agribusiness sector of the smallholder economy with great economic, nutritional, and social implications (Oladapo and Ogunekunn, 2015). Local breeds of cattle are the primary source of milk, providing more than 90% of the total animal domestic milk output (Walshe *et al.,* 1991; **Oladapo and Ogunekun, 2015**) with the Bunaji or 'Bunaji' breed recognized as the principal producer (Adeneye, 1989; Alphosus *et al*., 2012; Adesina, 2012).

Nutritionally, milk has been regarded as "the most nearly perfect food" because it provides more essential nutrients in significant amounts than any other single food. As a food, milk is important for growth, reproduction, supply of energy, maintenance, repairs and appetite satisfaction (Alade *et al*., 2013; Dandare *et al*., 2014). It is an outstanding source of calcium and phosphorus (for bones and teeth) and contains riboflavin, vitamins B6 and A in a significant amount (Alade *et al*., 2013; Dandare *et al*., 2014; Oladapo and Ogunekun, 2015).

Milk is composed of water, carbohydrate, fat, protein, minerals and vitamins (Heinrichs *et al*., 2005; Matei *et al*., 2010) and is secreted as a complex mixture of these components. Composition of milk varies from cow to cow and differs from the various breeds (Aboagye, 2002; Dandare *et al*., 2014; Oladapo and Ogunekunn, 2015). Even though, several researchers have reported on the yield and composition of milk of different species and localities, there is a dearth of information on the yield and composition of milk of the common indigenous breeds of cattle in Adamawa State particularly, those managed by the traditional pastoralists. Therefore, the aim of this study was to evaluate breed variations in milk yield and composition as well as their correlated responses in some selected indigenous breeds of cattle in Adamawa State to serve as a base line data for improving the common indigenous breeds of cattle in Adamawa State for better milk production.

Materials and methods

Study location

The study was conducted in some selected herds in Adamawa State. Adamawa State is at an altitude of 200 to 300 meters, between latitude 9^0 $20^'$ and 9^0 $33^'$N and longitude 12^0 $30^'$ and 12^0 $50^'$ E. It has average daily minimum and maximum temperatures of 23.2 and 35.2 ^{0}C respectively. The average annual rainfall is 718.1 millimeters and relative humidity, 44.2 %. It occupies an area of 39,742.12 square kilometers. The rest of the year is cold-dry characterized by a lack of heat stress conditions with a relatively cool, dry with continental air mass that originates from the Sahara Desert associated with dry, cold and dusty North-East trades (harmattan) and hot-dry (March-May) characterized by high ambient temperature, relative humidity and heat stress conditions (National Bureau of Statistics, 2010; Ovimaps, 2018).

Sources of experimental animals and management

Eighty (80) clinically healthy lactating cows made up of twenty (20) each of Bunaji, Rahaji, Adamawa Gudali and Bokoloji of similar ages within their first parity in selected settled farms in Adamawa State was used for the experiment. The experiment spanned months (August-October) in the late wet season. The animals used were in their early lactation stage (1-60) days.

Milk collection

Milk sample of the experimental animals was collected three times (third week of each month) in the season in 50mL falcon tubes from the experimental animals and taken to the Nutrition Biochemistry

Laboratory of the Department of Animal Production, Adamawa State University (ADSU), Mubi for milk composition analysis. The milk was analyzed for milk protein content and milk fat content and mineral contents while protein and fat yields were determined by multiplying the respective contents with the milk yield as described by Bradely *et al*., (1992).

Milk yield and composition traits determined

For milk yield (MY), The cows were hand milked early in the morning; three times during the experimental season (late wet season: August-October) and its equivalent measured using a measuring cylinder calibrated in liters on the farm. Milk Protein content (PC) was obtained by determining the total nitrogen using Kjeldahl method and the nitrogen content was converted into equivalent protein content using N×6.38 as conversion factor (Karman and Van Boekel, 1986). Milk Fat content (FC)was determined using Gerber method (Bradely *et al*., 1992). Fat yield (FY) was obtained by multiplying the milk fat content with the milk yield while Protein yield (PY)was determined by multiplying the milk protein content with the milk yield (Bradely *et al*., 1992). For minerals analysis, the milk solid content was taken and digested using two volumes 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 makes no attempt to dissolve any silicate-base materials that may be present in the sample. After cooling, the digested samples were quantitatively transferred to a flask and diluted to 100ml with de-ionised double distilled water and then filtered. Minerals (Ca, P, K and Fe,) were estimated 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.

Statistical model

The statistical model for the experiment is as given below;

$Y_{ij} = \mu + B_i + e_{ij}$

Where; μ = general mean,

B_i = i^{th} fixed effect of breed (B = 4) and

e_{ij} = experimental error.

Statistical analysis

The data obtained on milk yield and composition were subjected to analysis of variance (ANOVA) using General Linear Model of (SAS) (2002) while means with significant differences were separated using Duncan's Multiple Range Test (Duncan, 1955). The degrees of relationship between all pairs of variables were computed for all the animals within each breed groups and as a pool using CORR procedure of the SAS (2002) statistical package.

Results and discussion

Breed variation in milk yield and composition are shown in Table 1. The effect of breed on milk yield and composition of the sampled animals indicated that breed had significantly influenced ($p<0.05$) all the traits evaluated. The Bunaji was superior in milk yield, fat yield and Total Solid Non-fat (TSNF) while the least of those traits were in Adamawa Gudali. Rahaji was highest in Phosphurus (P), Sodium (Na) and Iron (Fe). Bokoloji was superior in milk protein and calcium. Bokoloji and Adamawa Gudali had recorded the highest in milk fat while Bunaji and Bokoloji recorded in protein yield. It is worth knowing that Adamawa Gudali was not superior in any trait evaluated. The superiority of Bunaji in milk yield in this study suggests that the breed produces more milk than its indigenous counterparts. Other researchers (Alphonsus *et al*., 2012; Adesina, 2012) also reported that among the indigenous cattle breeds in Nigeria, Bunaji was identified as the principal producer. Milk yield is largely determined by genetic factors that depict low genotypic potential of the indigenous animals (Millogo, 2010). According to Johnson (1991), milk yields are product of animal genetic and environmental interactions (Dandare *et al*., 2014; Oladapo and Ogunekun, 2015). Pagot (1992) contended that cattle breeds which originate from the tropics generally have limited genetic potential for milk production and remain mediocre producers (500-1500 kg per lactation) even when the best possible husbandry condition have been provided for them. The superiority of Bokoloji in milk protein and calcium over other indigenous breeds suggest that the breed has the best milk composition because proteins are required for body building and repair (Oladapo and Ogunekun, 2015) and calcium is required in large quantity for rapid growth of neonate for bone growth and development of soft tissues (Adesina, 2012). Calcium also plays a major role in bone formation and metabolism, muscle contradiction, nerve transmission and blood clothing (Adesina, 2012). 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 (Hauge *et al*., 2007). On the other hand, Oladapo and Ogunekun (2015) reported that Bokoloji breed had higher percentage of crude protein (4.10 and1.30) and calcium (3.43 and 1.25) than Bunaji. Contrary to the findings of this study, breed differences was reported for milk protein with Bunaji and Rahaji recording the highest in milk protein than their indigenous counterparts (Alemede and Sadiq, 2008; Adesina, 2012; Dandare *et al*., 2014; Oladapo and Ogunekun, 2015). Murrah was reported to have higher milk protein value (4.92) than Nili-Ravi (4.54) breed of Buffalo in China (Han *et al*., 2007; Ren *et al*., 2015; Zhou *et al.,* 2018). Bokoloji and Adamawa Gudali were highest in milk fat. It's not surprising that milk protein and fat were highest in the same animal (Bokoloji). This is because generally, milk protein percentage and milk fat percentage are said to be positively correlated (Ahmed and El-Zubairu, 2007; Dandare *et al*., 2014). Contrary to the findings of this study, Oladapo and Ogunekun, (2015) reported higher percentage of fat (4.70) in Bunaji than (4.60) in Bokoloji. The superiority of Rahaji in Phosphurus (P), Sodium (Na) and Iron (Fe) in this study suggests that the milk of Rahaji is richer in mineral contents than other selected indigenous breeds studied. Phosphorus have been reported to be involved in maintaining body pH in storage and energy transfer while Iron is said to be a component of blood and many enzymes because it is involved in blood metabolism and oxygen transport (Adesina, 2012). Milk and its products were reported to constitute vital sources of mineral components that satisfy human and animals demand for calcium, phosphorus, Sodium and iron (Smigielska *et al*., 2003; Dandare *et al*., 2014). Contrary to the breed differences reported in the present study, several authors have reported that mineral contents of milk are one of the least variables in breed differences in cow (Hurley, 1997; Adesina, 2012). However, breed differences were reported for calcium and phosphorus in Rahaji, Bunaji, Holstein Friesian and the crosses of Bunaji with Holstein Friesian (Dandare *et al*., 2014). Similarly, breed differences was reported in Iron, Sodium, phosphorus contents of the milk of Nigerian indigenous breeds of cattle with Rahaji having higher values of mineral contents than other breeds except for iron where Bunaji recorded the highest (0.67) than the Rahaji (0.38) (Adesina, 2012). Generally, the fat contents of the milk of sampled animals were lower than the reported values of 4.77 -5.25 in White Fulani and other indigenous breeds of cattle (Ibeawuchi and Daylop, 1995; Ndubueze *et al*., 2006; Adesina, 2012; Dandare *et al*., 2014) and 3.78-5.71% reported in white Fulani cows fed poultry waste-cassava based diets (Ndubueze *et al*., 2006). The variations could be attributed to differences in stage of lactation, season of sample collection and herd management by pastoralists (Nickerson, 1999; Zeleke, 2007; Dandare *et al*., 2014; Oladapo and Ogunekun, 2015).

Table 1: Breed variation (Mean ±SE) in milk yield and composition of some selected indigenous breeds of cattle in Adamawa State

Parameters	Bunaji	Red Sokoto	Adamawa Gudali	Bokoloji
Milk yield (Kg)	1.92 ± 055^{a}	1.35 ± 0.55^{bc}	1.13 ± 0.46^{c}	1.66 ±0.43^{ab}
Milk fat (%)	2.98 ± 0.13^{c}	2.93 ± 0.08^{b}	3.27 ± 0.24^{a}	3.18 ± 0.14^{a}
Milk protein (%)	4.27 ± 0.14^{c}	3.87 ± 0.18^{d}	4.83 ± 0.18^{b}	4.98 ± 0.09^{a}
Fat yield (Kg)	5.74 ± 1.65^{a}	3.95 ±1.55^{bc}	3.65 ± 1.39^{c}	5.26 ± 1.30^{ab}
Protein yield (Kg)	8.27 ± 2.30^{a}	5.21 ± 2.13^{b}	5.44 ± 2.20^{b}	8.29 ± 2.22^{a}
Total solid non-fat(%)	4.59 ±0.05^{a}	4.35 ± 0.11^{b}	3.85 ± 0.03^{c}	4.41 ± 0.13^{b}
Calcium (mg/L)	669.09 ± 19.04^{b}	578.29 ± 59.83^{c}	587.49 ± 52.08^{c}	721.47 ± 37.47^{a}
Phosphorus (mg/L)	332.34 ± 19.40^{c}	410 ± 0.13^{a}	366.16 ± 14.35^{b}	337.93 ± 17.42^{c}
Sodium (mg/L)	38.45 ± 2.56^{c}	61.01 ± 0.68^{a}	40.34 ± 0.39^{c}	44.78 ± 8.26^{a}
Iron (mg/L)	2.63 ± 0.08^{b}	3.16 ± 0.04^{a}	1.39 ± 0.04^{c}	1.02 ± 0.04^{d}

abcd= means with different superscripts within the rows are significantly different at 5%

The correlated relationships among the yield and composition according to the breeds of indigenous cattle are shown in Table 2. The correlated relationships among the milk yield and composition according to the breeds of indigenous cattle studied indicated that the traits evaluated were significantly ($p<0.05$-0.01; r = -0.89 to 1.00) correlated with each other except ($p>0.05$; r= -0.21 to 0.24) for relationship between milk yield with Ca in white Fualni and Rahaji; fat with P and Na in Bunaji and Bokoloji; protein with fat yield and protein yield in Rahaji and Adamawa Guadali; protein yield with Ca in Bunaji and Rahaji; total solid non fat with Ca in Rahaji, Adamawa Gudali and Bokoloji; phosphorus with Na in Bunaji, Rahaji and Bokoloji and with Fe in Rahaji and Bokoloji. Zero relationship exists between milk yield and Fe in Adamawa Gudali ($p>0.05$; r =0.00) while a perfect relation exists between milk yield and protein yield ($p>0.01$; r = 1.00) in Rahaji, adamawa gudali and Bokoloji and between protein yield and fat yield ($p>0.01$; r = 1.00) in Bunaji and Bokoloji. The negative relationship between milk yield and fat content in Rahaji, Adamawa Gudali and Bokoloji in this study suggest that it's difficult to select indigenous cows for both milk yield and fat content in the milk (Alphonsus and Essien, 2012). This by implication means that whenever there is a significant increase in milk yield, there will be a corresponding decrease in milk fat (Alphonsus and Essien, 2012; Abbaya *et al*., 2017). Similar negative correlation between milk yield and fat content were also reported by Alphonsus and Essien, (2012) in Bunaji and Bunaji X Friesian cows in Nigeria. Belewu (2006) also reported that breeds with higher fat content produce less milk quantity than those with low fat content. Contrary to this, the relationship between milk yield and fat in white Fulani in this study was positive ($p<0.05$: r =0.42). Variations in the

Table 2: Correlation between milk yield and compositionof some selected indigenous breeds of cattle

		F	P	FY	PY	TSNF	Ca	P	Na	Fe
B	MY	0.42*	0.36*	0.99**	0.99**	0.24	-0.12	-0.36*	-0.44*	-0.37*
	F		0.87**	0.54*	0.50*	-0.38*	-0.61**	-0.09	-0.75**	-0.22
	P			0.47*	0.46*	-0.47*	-0.82**	-0.47*	-.61**	-0.32*
	FY				1.00**	0.16	-0.21	-0.36*	-0.51*	-0.38*
	PY					0.17	-0.21	-0.39*	-0.48*	-0.38*
	TSN						0.79**	-0.39*	-0.15	-0.57**
	Ca							0.31*	0.08	-0.19
	Pho								0.15	0.56**
	Na									0.74**
R	MY	-0.54*	-0.13	1.00**	1.00**	-0.43*	0.17	0.40*	0.35*	-0.35*
	F		0.59**	-0.48*	-0.47*	0.62**	-0.64**	-0.02	-0.85**	0.62**
	P			-0.09	-0.01	0.06	-0.28*	-0.33*	-0.74**	-0.04
	FY				0.99**	-0.40*	0.12	0.41*	0.29*	-0.32*
	PY					-0.42*	0.13	0.37*	0.25*	-0.36*
	TSN						-0.06	-0.08	-0.41*	0.93**
	Ca							-0.59**	0.35*	-0.31*
	Pho								0.23	0.24
	Na									-0.30*
AG	MY	-0.53*	-0.25*	0.99**	1.00**	0.49*	0.40*	-0.57**	-0.16	0.00
	F		0.59**	-0.41*	-0.50*	-0.02	-0.08	0.39*	0.20	-0.07
	P			-0.18	-0.17	-0.40*	0.35*	0.32*	-0.14	-0.57**
	FY				0.99**	0.51*	0.41*	-0.55**	-0.13	-0.00
	PY					0.45*	0.43*	-0.55**	-0.17	-0.04
	TSN						0.20	-0.63**	0.14	0.36*
	Ca							0.14	-0.83**	-0.81**
	Pho								-0.55**	-0.63**
	Na									0.89**
BK	MY	-0.35*	0.48*	0.99**	1.00**	-0.55**	-0.39*	0.07	0.45*	0.52*
	F		-0.11	-0.21	-0.34*	0.26*	0.87**	-0.80**	0.15	-0.53*
	P			0.48*	0.54*	-0.57**	0.05	-0.32	0.69**	0.28*
	FY				1.00**	-0.53*	-0.28*	-0.03	0.48*	0.48*
	PY					-0.57**	-0.37*	0.05	0.48*	0.53*
	TSN						0.05	-0.28*	-0.89**	-0.43*
	Ca							-0.61**	0.32*	-0.74**
	Pho								-0.16	0.24
	Na									0.24

B= Bunaji; R= Rahaji; AG= Adamawa Gudali; BK= Bokoloji; MY=Milk yield; F = fat; P =Protein; FY= Fat yield; PY= protein yield; TSN= Total solid not fat; Ca = Calcium; Pho= Phosphorus; Na = Sodium; Fe = Iron; *=significant at 5%; **=significant at 1%

relationships between milk yield and fat in White Fulani with other reports (Belewu, 2006; Alphonsus and Essien, 2012) could be due to several factors such as breed and health of animal, nutrition and genetics which can cause variations in the yield and relative milk constituents (Rafiq *et al.*, 2018).

The negative correlation between milk yield and other milk composition in these breeds at different levels is in agreement with the reports of other authors (Ezekwe and Machebe, 2005; Alphonsus and Essien, 2012) that genetic relationship between milk yield and milk composition are highly negative. Hence if milk quality is ignored in a programme that include selection for high milk, some milk composition may tend to decline (Alphonsus and Essien, 2012). Strong and t positive correlations ($p<0.01$; r = 0.99-1.00) existed between milk yield and fat yield and protein yield. This implies that an increase in the quantity of milk will automatically bring about an increase in fat yield and protein yield since fat yield and protein yields are products of milk yield and the corresponding percentages of fat and protein contents (Bradely *et al*., 1992).

The pooled correlation between milk yield and composition of the four selected indigenous breeds are shown in Table 3. There were significant (p<0.05-0.01; r = -0.95 to 0.99) relationships between milk components evaluated except ($p>0.05$; r = -0.21 to 0.23) for fat yield with fat and protein; protein yield with fat and protein; calcium with fat; phosphorus with fat; sodium with milk yield, fat yield and total solid nonfat and calcium; Fe with milk yield, fat yield and protein yield. The pooled correlated relationships among the milk yield and composition of the studied indigenous breeds shows that milk yield are negatively correlated with milk fat, protein and potassium ($p<0.05$; r = -0.32-0.40). The implication is that high milk yield in these breeds would result in low milk fat, protein and potassium (Akpa *et al*., 2017). This concurred with the report of Belewu (2006) that breeds with higher fat content produce less milk quantity than those with low fat content. This is also in agreement with the report of Ahmed and El-Zubairu (2007) and Dandare *et al.* (2014) that milk protein and fat are positively correlated. The implication of the correlated relationships between milk yield with fat and protein which are the important components (Hossain and Dev, 2013) that determine the quality of milk is that these traits could be difficult to be improved the same time. However, the knowledge of relationship amongst these traits can help in the formulation of programmes for selection and improvement of milk quality and quantity of dairy cattle (Alade *et al.,* 1999; Alphonsus and Essien, 2012). The strong negative correlated relationship between iron (Fe) with fat and protein ($p<0.01$; r = -0.62-0.95) with fat and protein in this study implied that a significant increase in the milk composition in the indigenous cattle will result to a significant decrease in the iron content. While fat is required as source of energy and protein is needed for body building and repair, iron (Fe) is a component of blood and may enzymes that aids buffering capacity of milk (Adesina, 2012; Oladapo and Ogunekun, 2015). Therefore, no milk component should be ignored in building a selection index for milk improvement (Alphonsus and Essien, 2012). In the pooled correlation, significant negative ($p<0.05$; r = -0.30-64) between

Table 3: Pooled correlation coefficients of the milk yield and composition of some selected indigenous breeds of cattle in the late rainy season

	F	P	FY	PY	TSNF	Ca	P	Na	Fe
MY	-0.32*	-0.33*	0.99**	0.96**	0.41*	0.38*	-0.40*	-0.12	0.07
F		0.69**	-0.19	-0.15	-0.56**	0.04	-0.21	-0.33*	-0.62**
P			0.08	0.23	-0.38*	0.39*	-0.55**	-0.55**	-0.95**
FY				0.98**	0.37*	0.41*	-0.46*	-0.17	-0.03
PY					0.32*	0.48*	-0.54*	-0.23	-0.18
TSN						0.46*	-0.30*	0.01	0.41*
Ca							-0.64**	-0.30*	-0.41*
P								0.71**	0.50*
Na									0.51*

MY=Milk yield; F = fat; P =Protein; FY= Fat yield; PY= protein yield; TSN= Total solid not fat; Ca = Calcium; Pho= Phosphorus; Na = Sodium; Fe = Iron; *=significant at 5%; **=significant at 1%

calcium content of the milk with other mineral contents of the milk (P, Na and Fe). Calcium has been reported to be the most abundant mineral in the body and essentially all body processes require calcium. 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 (Hauge *et al*., 2007).

Conclusion

The study showed that Bunaji had the highest milk yield; Bokoloji was best in Protein and fat contents while Rahaji was the richest milk in terms of mineral contents. Also, correlated relationships amongst milk yield and composition should be maximized in formulating selection programmes for improvement of milk yield and composition of the Nigerian indigenous breeds of cattle.

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