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Species and breed-dependent differences in saturated and unsaturated fatty acids of ruminant milk

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Abstract

This study investigated the effect of species and breed on the composition of saturated and unsaturated fatty acids in milk. The species examined were goats and cattle, with two breeds selected from each: Sokoto Red and Kano Brown for goats, and Bunaji and Rahaji for cattle. A 2 × 2 factorial experiment was conducted using a completely randomized design (CRD) with five replications. Ten fatty acids were analyzed—five saturated (lauric, myristic, palmitic, stearic, and arachidic acids) and five unsaturated (palmitoleic, oleic, linoleic, linolenic, and arachidonic acids). Data collected were subjected to analysis of variance (ANOVA) and Pearson's product-moment correlation (PPMC). The results revealed that species had a significant ($p < 0.05$) effect on the concentrations of palmitic and stearic acids (saturated) and palmitoleic, oleic, and linoleic acids (unsaturated). Cow milk contained higher levels of saturated fatty acids, while goat milk had higher levels of unsaturated fatty acids. Breed also significantly ($p < 0.05$) affected palmitic and linoleic acid concentrations, with milk from Sokoto Red goats showing the highest values, and the Rahaji breed the lowest. Correlation analysis indicated that most coefficients were negative and non-significant, ranging from −0.590 to −0.995 for goats and −0.436 to −0.994 for cattle. In conclusion, goat milk is recommended over cow milk due to its higher average content of unsaturated fatty acids, which are considered beneficial to human health.

Keywords: Milk; Saturated fatty acids; Unsaturated fatty acids; Specie and Breed

1. Introduction

Milk is a vital source of essential nutrients, including proteins, minerals, vitamins, and lipids. Among its constituents, milk fat plays a crucial role in human nutrition, not only as a dense energy source but also for its content of bioactive fatty acids that influence health outcomes (Górska-Warsewicz et al., 2019). Fatty acids in milk can be broadly categorized into saturated fatty acids (SFAs) and unsaturated fatty acids (UFAs), with the latter being particularly valued for their positive health implications, such as reducing cardiovascular risk and improving lipid metabolism (Hassanpour Ardekanizadeh et al., 2026).

The composition of milk fatty acids varies significantly across animal species, breeds, feeding systems, and lactation stages (Chilliard et al., 2007). Species differences between goats and cattle, for example, are known to influence the lipid profile of milk, with goat milk generally containing higher proportions of short-chain and unsaturated fatty acids compared to cow milk (Park et al., 2007; Stergiadis et al., 2019). These differences may be attributed to physiological variations in lipid metabolism between ruminant species.

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Furthermore, within species, breed variation can significantly impact milk composition. Genetic differences among breeds influence the biosynthesis and secretion of milk components, including fatty acids (Stoop et al., 2008). Understanding these breed-specific differences is essential for optimizing milk quality and selecting breeds for targeted nutritional or industrial purposes.

Despite the growing interest in the nutritional benefits of ruminant milk, limited comparative studies have focused on the interactive effects of species and breed on both saturated and unsaturated fatty acid profiles. Therefore, this study aims to evaluate the effects of species (goats vs. cattle) and breed on the composition of saturated and unsaturated fatty acids in milk. The findings could guide dietary recommendations and breed selection strategies for enhanced milk quality and public health.

2. Materials and methods

2.1. Study area

The study was conducted at Danbatta Local Government, Kano State positioned on latitude 12˚20.260'N and longitude 8˚31.567'E (Ovimaps, 2018). The area possesses a tropical climate with mean annual rainfall of 600 mm which lasts for four months (May to September). The mean annual temperature is 38˚C with the highest occurring in April (41˚C) and lowest in January (30˚C). The relative humidity ranges from 22 to 52% (Ahmad, 2015).

2.2. Experimental Design and Animal Selection

The study employed a 2 × 2 factorial arrangement in a CRD, with five replications per treatment group. Two ruminant species, goats and cattle, were selected, with two breeds chosen from each species. The goat breeds included Sokoto Red and Kano Brown, while the cattle breeds were Bunaji and Rahaji. All animals used in the study were healthy lactating females, maintained under similar management conditions to minimize environmental variation.

2.3. Feeding and Management

Animals were housed in well-ventilated pens and fed a standard diet consisting of a basal roughage component (grass hay) and a concentrate supplement formulated to meet maintenance and lactation requirements. Clean water was also provided. Feeding was done twice daily, and all animals were allowed a two-week acclimatization period prior to sample collection.

2.4. Milk Sampling

Milk samples were collected manually from each animal in the morning over five consecutive days to account for individual variation. Approximately 200 mL of milk was collected from each animal per sampling session. The samples were immediately cooled and transported to the laboratory under refrigerated conditions (4°C) for fatty acid analysis.

2.5. Fatty Acid Analysis

Fat extraction was performed using the Folch method, with minor modifications (Washburn 1989; Ajit et al., 2025). The extracted lipids were methylated to fatty acid methyl esters (FAMEs) using methanolic potassium hydroxide (KOH), and analyzed using Gas Chromatography (GC) equipped with a flame ionization detector (FID). Ten fatty acids were quantified, comprising five saturated fatty acids (lauric, myristic, palmitic, stearic, and arachidic acids) and five unsaturated fatty acids (palmitoleic, oleic, linoleic, linolenic, and arachidonic acids). Identification was based on retention times compared with known standards.

2.6. Statistical Analysis

The data obtained were subjected to two-way Analysis of Variance (ANOVA) using statistical software (SAS, version 9). The main effects of species, breed, and their interaction were tested. Means were separated using the least significant difference (LSD) test at a significance level of $p < 0.05$. In addition, Pearson's Product-Moment Correlation (PPMC) was employed to determine the relationships between the concentrations of different fatty acids.

3. Results and Discussions

Effect of species on saturated and unsaturated fatty acid composition of milk is presented in Table 1. Significant effect ($p<0.05$) of species was observed on two saturated (palmitic and stearic) and tree unsaturated (palmitoleic, oleic and linoleic) fatty acids. Milk from cows had higher saturated fatty acids than goats' milk, while for the unsaturated, the latter had higher values than the former. However, non-significant effect of species was noticed on lauric, myristic, arachidic, linolenic and arachidonic acids. Effect of breeds of goats and cattle on saturated and unsaturated fatty acid composition of milk is presented in Table 2. Significant effect ($p<0.05$) of breed was observed on palmitic and and linoleic acids. Milk from Sokoto Red goats had the highest for these fatty acids, while the least values were recorded in milk obtained from Rahaji breed. However, non-significant effect of breeds of goats and cattle was noticed on lauric, myristic, stearic, arachidic, palmitoleic, oleic, linolenic and arachidonic acids. Fatty acids play an important role in human health. It has been reported that polyunsaturated fatty acid (PUFA) protects against heart attack risk, improve brain function, and reduce risk of dementia (Calder, 2015), and conjugated linoleic acids (CLA) inhibit the carcinogenesis and reduce the risk of atherosclerosis and diabetes (Walter *et al.*, 2008). The significant effect of livestock species observed on palmitic and stearic acid with the cattle having the highest values showed that milk from these animals (cattle) had higher saturated fatty acid which is detrimental to human health. This was similar reported by Boyazoglu and Morand-Fehr (2001) who estimated the percentages of about eight saturated fatty acid in lactating cows and goat and noticed that the values of these fatty acid reported in the former (cows) were significantly higher than the estimates recorded in the latter (goats). The authors attributed these variations to species differences. Among the species, variations were observed on myristics, palmitic and arachidic, they concluded that these differences could be as a results of management system since the milk samples were randomly selected from different farms. The work by Lordan *et al.* (2018) in the same species of livestock proved that milk from dairy cow had higher values on all the saturated fatty acids recorded and recommended the consumption goat milk heath wisely. Jirillo *et al.* (2010) conducted a research on reconstituted yoghurts made from cow and goat milk powder and observed that yoghurt from cows had higher stearic acid (a saturated fatty acid) than that of goats. The author concluded that this could be reason why goat milk is cherished and priced high in most part of the world since it had more health benefit and now a days, people are very much conscious about health issues. Faye and Konuspayeva (2012) recommended butter fat from goats to individuals with high blood pressure due to low saturated fatty observed in their milk. The authors explained that saturated fatty acid triggers blood pressure and such compounds are very high in cow milk thereby unhealthy for hyperthetic individuals. On the other hand, the work by Park (1994) on different breeds of dairy cows and goats showed that goat had higher value on most saturated fatty acid estimated. Similarly, Manuelian *et al.* (2017) review on milk fatty acid and composition of ruminants (cows, sheep and goats) observed that goats' milk had the highest mean on all saturated fatty acids recorded. Furthermore, Calder (2015) observed that yoghurt from goats' milk had higher saturated fatty acid than that of cows and buffaloes. The non-significant effect of species observed on lauric, myristic and arachidic acids is in line with the report by Walther *et al.* (2008) who noticed that cows' milk had higher for these acids but it is not statistically significant.

Table 1 Effect of species on saturated and unsaturated fatty acid composition of milk

Fatty acid type	Parameters	Goat	Cattle
Saturated	Lauric acid	2.14±0.16	2.47±0.18
	Myristic acid	1.79±0.37	2.02±0.29
	Palmitic acid	2.22±0.36	30.74±10.94
	Stearic acid	2.73±0.26	8.72±2.50
	Arachidic acid	0.67±0.11	0.52±0.05
Unsaturated	Palmitoleic acid	1.75±0.11	0.66±0.22
	Oleic acid	38.33±7.57	12.99±1.93
	Linoleic acid	30.70±7.00	7.90±2.49
	Linolenic acid	2.24±0.18	1.53±0.41
	Arachidonic acid	2.67±0.46	2.14±0.20

Also, Poppitt *et al.* (2002) in some selected breeds of dairy goats and cows indicated the absence of significant variation on estimated fatty acids. The fact that goats' milk had higher unsaturated fatty (palmitoleic, oleic and linoleic acids) as reported in the present study is well documented (Schonfeld and Wojtczak, 2016). Similar observation was made by Van Schalkwijk *et al.* (2014) who reported that the unsaturated fatty acid found in goats' milk were higher than that of cows and noticed that they are antagonists to saturated fatty acid (even though not clearly understood). The fact that breeds of goat and cattle had effect on palmitic acid as reported in the current study agrees with the finding by Chilliard *et al.* (2000) who worked in different breed of both species and recorded higher myristic and arachidic values (both saturated fatty acid) in goats than cows. The work of Palmquist (2009) among different cattle breed showed that there was significant variation on palmitic acid. Benedet *et al*. (2019) reported that goats had higher percentage than cows on overall fatty acid profile recorded. Working on Saneen and other specialized dairy goat, Griinari *et al*. (1998) reported higher values of milk components and fatty acid profile in this breed (Saneen) and attributed the results obtained to specialization of this breed in milk production. Other factor that affected fatty acid composition includes feed and stage of lactation. For example, Strzalkowska *et al*. (2009) reported differences of FA profile in early, mid, and late lactation of Polish White Improved goats. Yurchenko *et al*. (2018) demonstrated that milk from Saanen and Landrance goat breeds fed the same ration differed from C4:0 to C14:0, C16:0, C16:1, and C18:1. Diets richer in concentrate than forage cause the reduction of the ruminal pH and the activity of cellulolytic bacteria; this leads to the increase of trans-10, cis-12 CLA synthesis in milk which could induce milk fat depression syndrome (Griinari *et al*., 1998). However, the existing literature about fatty acid profile characterization is limited to a restricted number of breeds and to our knowledge few studies have investigated the milk FA composition of older and endangered goat breeds.

Table 2 Effect of Breed on saturated and unsaturated fatty acid composition of milk

Fatty acid type	Parameters	Sokoto Red	Kano Brown	Bunaji	Rahaji
Saturated	Lauric acid	2.38±0.13	1.90±0.13	2.64±0.24	2.30±0.27
	Myristic acid	1.30±0.30	2.28±0.51	1.71±0.31	2.33±0.46
	Palmitic acid	45.93±9.87^{a}	15.54±12.62^{b}	2.05±0.66^{c}	2.40±0.53^{c}
	Stearic acid	8.07±6.04	9.38±0.22	3.17±0.14	2.29±0.04
	Arachidic acid	0.55±0.10	0.49±0.05	0.48±0.08	0.85±0.08
Unsaturated	Palmitoleic acid	1.72±0.28	1.79±0.01	0.43±0.13	0.88±0.43
	Oleic acid	47.10±12.86	29.56±4.92	11.56±0.64	14.41±4.24
	Linoleic acid	40.90±9.10^{a}	20.50±1.85^{b}	11.07±0.17^{c}	4.72±4.13^{d}
	Linolenic acid	1.20±0.81	1.86±0.39	2.34±0.24	2.14±0.36
	Arachidonic acid	1.98±0.32	3.36±0.48	2.08±0.48	2.21±0.00

3.1. Phenotypic Correlation Coefficients of Fatty Acid Composition

The phenotypic correlation coefficients of fatty acid composition of both goats' and cows' milks are presented in Table 3 and 4, respectively. The results indicated that most of the coefficients recorded in both livestock species were negative and non-significant, with few having values ranging from – 0.590 to – 0.995 for goats and -0.436 and -0.994 for cattle. However, high, positive and significant values were observed between lauric and linoleic (0.878), myristic and linolenic (0.830), palmitic and oleic (0.917) and stearic and palmitoleic (0.929) acids in goats and between lauric and linolenic (0.959), myristic and oleic (0.787), palmitic and oleic (0.758), stearic and linoleic (0.749), arachidic and palmtoleic (0.808) and linoleic and linolenic (0.782) acids. The negative and mostly non-significant coefficients observed in both livestock species agrees with the finding of Gama *et al*. (2008) in the same livestock species. The work of Lordan *et al.* (2018) in milk obtained from dairy sheep and goats showed negative and non-significant correlation coefficients among both saturated and unsaturated fatty acid which indicates that these compounds did not share the same genes (no pieotropic effect). However, some investigators (Popitto *et al*., 2002) showed that significant relationship existed among the fat acid components of dairy cattle milk.

Table 3 Correlation matrix of milk fatty acid in goats

Parameter	1	2	3	4	5	6	7	8	9	10
Lauric acid (1)	1	- 0.590**	0.425*	0.203	-0.104^{ns}	0.161^{ns}	0.272^{ns}	0.878**	-0.540**	-0.995**
Myristic acid (2)		1	-0.755**	-0.186^{ns}	-0.232^{ns}	-0.195^{ns}	-0.434*	-0.875**	0.830**	0.516**
Palmitic acid (3)			1	-0.501**	0.789**	-0.496*	0.917**	0.530**	-0.261^{ns}	-0.392^{ns}
Stearic acid (4)				1	-0.894**	0.998**	-0.796**	0.393^{ns}	-0.703**	-0.160^{ns}
Arachidic acid (5)					1	-0.878**	0.929**	-0.100^{ns}	0.340^{ns}	0.102^{ns}

Palmitoleic acid (6)						1	-0.797**	0.375^{ns}	-0.708**	-0.114^{ns}
Oleic acid (7)							1	0.223^{ns}	0.139^{ns}	-0.273^{ns}
Linoleic acid (8)								1	-0.855**	-0.829**
Linolenic acid (9)									1	0 .462*
Arachidonic acid (10)										1

** = p<0.01, * = p<0.05 and ns = non-significant

Table 4 Correlation matrix of milk fatty acid in cattle

Parameter	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Lauric acid (1)	1	-0.515*	-0.943**	0.457*	-0.184^{ns}	0.302^{ns}	-0.872**	0.847**	0.959**	0.428*
Myristic acid (2)		1	0.240^{ns}	-0.737**	0.526**	-0.043^{ns}	0.787**	-0.887**	-0.482*	0.549**
Palmitic acid (3)			1	-0.150^{ns}	-0.114^{ns}	-0.482*	0.758**	-0.634**	-0.956**	-0.678**
Stearic acid (4)				1	-0.944**	-0.571**	-0.436*	0.749**	0.240^{ns}	-0.400*
Arachidic acid (5)					1	0.808**	0.114^{ns}	-0.488*	0.071^{ns}	0.461*
Palmitoleic acid (6)						1	-0.485*	0.110^{ns}	0.560**	0.345^{ns}
Oleic acid (7)							1	-0.922**	-0.913**	-0.049^{ns}
Linoleic acid (8)								1	0.782**	-0.118^{ns}
Linolenic acid (9)									1	0.451*
Arachidonic acid (10)										1

** = p<0.01, * = p<0.05 and ns = non-significant

4. Conclusions

Milk from cows had higher saturated fatty (palmitic and stearic) acids than goats' milk, while for the unsaturated ones (palmitoleic, oleic and linoleic), the latter had higher values than the former. Significant effect (p<0.05) of breed was observed on palmitic and linoleic acids. Milk from Sokoto Red goats had the highest for these fatty acids, while the least values were recorded in milk obtained from Rahaji breed. The phenotypic correlation of fatty acid composition of both goats' and cows' milks indicated that most of the coefficients recorded in both livestock species were negative and non-significant.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare no conflict of interest.

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