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VARIATIONS AND CORRELATIONS IN THE COMPOSITION OF BOVINE, OVINE AND CAPRINE MILK

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Summary
Variations in the milk composition of cattle, sheep and goats as well as residual phenotypic correlations between the milk constituents were investigated. The study utilised Bunaji, Yankasa and Red Sokoto breeds of cattle, sheep and goats, respectively. Results indicated that sheep and goats differed significantly ($P<0.05$) from cattle in all constituents except protein percentage that averaged 5.43, 5.43 and 5.49%. Goat milk contained the highest percentages of fat (5.4%), total solids (15.3%) and ash (0.77%), while cattle milk contained the least percentage of fat (0.68%). Overall, milk compositions of sheep and goats were very similar since they were not statistically different from each other ($P>0.05$). Residual phenotypic correlations between the milk constituents revealed highly significant ($P<0.01$) and positive relationships between total solids and solids-not-fat (0.97 and 0.98 in cattle and sheep respectively). All other correlations were positive (ranging from 0.12 to 0.77), except between protein and total solids (-0.44) and protein and solids-not-fat (-0.64) in cattle. Multiple linear regression equations were fitted to predict the percentages of protein and fat. It was demonstrated that protein percentage could be predicted from total solids and solids-not-fat with the highest accuracy of 94, 86 and 82 % in cattle, sheep and goats, respectively. On the other hand, the accuracy of prediction of fat percentage was very low in all the species (R^2=0.01, 0.03 and 0.37 in cattle, sheep and goats, respectively).

Introduction
Milk composition and quality are important attributes that determine the nutritive value and consumer acceptability of fresh milk and milk products. The majority of milk consumed throughout the world is bovine milk, although in some countries, sheep and goats are commonly used. In Nigeria, the most common breeds of cattle, sheep and goats are Bunaji (White Fulani), Yankasa and Red Sokoto respectively. This study was conducted to determine variations in the milk composition of cattle, sheep and goats and to compute the phenotypic correlations between the milk constituents.

Materials and methods
The study utilised milk from 15 Bunaji cattle, Yankasa sheep and Red Sokoto goats that were in their first lactation at the Dairy and Small Ruminant Research Programmes of the National Animal Production Research Institute (NAPRI) Shika, Zaria. Ehoche and Buvanendran (1983) and Malau-Aduli et al (1996a, 1996b) have described animal management practices in NAPRI. In the laboratory, standard procedures adopted by the Association of Official Analytical Chemists (AOAC, 1993) were followed in the determination of total solids (TS), solids-not-fat (SNF), fat and protein percentages. One way analysis of variance was utilised in which species was fitted as a fixed effect in the model using the general linear model procedures (PROC GLM) of SAS (1986) to compute least squares means. Correlation coefficients between milk components were calculated using PROC CORR (SAS, 1986) and Bonferroni probabilities for tests of significance computed. PROC REG (SAS, 1986) was used in running simple linear regressions to predict protein and fat percentages.

Results and discussion
Goat milk contained the highest fat (5.8%), total solids (15.37%) and ash (0.77%) while cattle milk had the least percentages (Table 1). Overall, the milk compositions of sheep and goats were very similar because they were not statistically different from each other ($P>0.05$).

Table 1: Variations in the composition of bovine, ovine and caprine milk (% ± s.e.).

Species	Breed	Protein	Fat	Total solids	Solids-not-fat	Ash
Cattle	Bunaji	5.43 ± 0.09^a	4.82 ± 0.11^a	12.77 ± 0.58^a	7.95 ± 0.58^a	0.68 ± 0.02^a
Goat	Red Sokoto	5.49 ± 0.14^a	5.80 ± 0.14^b	15.37 ± 8.44^b	9.57 ± 0.42^b	0.77 ± 0.03^b
Sheep	Yankasa	5.43 ± 0.17^a	5.30 ± 0.18^b	15.19 ± 0.69^b	9.89 ± 0.64^b	0.73 ± 0.04^b

Column means with different superscripts differ significantly ($P<0.05$)

The fat content of the milk in this study compare favourably with the average percentage of 5.6% for the Zebu reported by O'Connor (1995), but the protein percentage was higher than the value reported for *Bos taurus* (3.5%) and *Bos indicus* (3.4%) by Webb et al (1996). However, the protein percentages of 5.43, 5.49 and 5.43 for cattle, goat and sheep respectively, in this study agree with the values of 5.4, 5.6 and 5.9% in Finn, Lincoln and Rambouillet breeds of sheep respectively (Sakul and Boylan, 1992). The observation in Table 1 in which the milk compositions of sheep and goats were not statistically different from each other agrees with the findings of Boujenane and Lairini (1992) and Peters et al (1992) which demonstrated that milk composition was not significantly influenced by the breed group of ewes, goats and their crosses. Residual phenotypic correlations between the milk constituents were all positive, except those between protein and total solids (-0.44) and protein and solids-not-fat (-0.64) in cattle (Table 2). This implies that as the percentage of protein increases in bovine milk, there is a corresponding decrease in total solids (TS) and solids-not-fat (SNF). However, this relationship was not statistically significant (Table 2).

Table 2: Residual phenotypic correlation coefficients between milk constituents in cattle, sheep and goats

Variables	Bunaji cattle	Yankasa sheep	Red Sokoto goats
Protein and Fat	0	0.17	0.25
Total solids and Protein	-0.44	0.62	0.77
Solids-not-fat and Protein	-0.64	0.73	0.77
Fat and Total solids	0	0.14	0.51
Solids-not-fat and Fat	0	0.12	0.20
Total solids and solids-not-fat	0.97**	0.98**	0.77

** P(<0.01)

This finding supports an earlier observation by Mba et al (1975) in which the correlation between protein and SNF were not statistically significant. On the other hand, highly significant (P<0.01) and positive correlations were observed between TS and SNF (0.97 and o.98 in cattle and sheep respectively). This indicates a very strong relationship in which there is a corresponding increase in SNF as TS increases.

Multiple linear regressions of protein and fat percentages on TS and SNF were carried out and the results portrayed in Table 3. It was evident that protein percentage could be predicted from TS and SNF with the highest accuracy of 94, 86 and 82% in cattle, sheep and goats respectively, whereas fat percentage could not be accurately predicted. The implication is that we cannot have confidence in the predicted values of fat percentage since the R^2 values were 0, 0.03 and 0.37 in cattle, sheep and goats (Table 3). This in turn infers that simple linear regression equations would be inadequate for predicting fat from TS and SNF. Perhaps other forms of complex regression procedures (e.g. stepwise regression) might be able to improve the accuracy of prediction.

Table 3: Multiple linear regressions of protein and fat on TS and SNF in cattle, sheep and goats

Species	Dependent variable (Y)	Intercept	b_1	b_2	R^2
Cattle	Protein	3.74	0.96	-1.33	0.94
	Fat	5.00	0	0	0.01
Sheep	Protein	5.00	-0.83	1.33	0.86
	Fat	4.50	0.17	-0.17	0.30
Goat	Protein	0.92	0.46	-0.30	0.82
	Fat	2.94	0.31	-0.20	0.37

Conclusion

Species variation exists in the milk compositions of cattle, sheep and goats. Goat milk appears to be more ideal for farmers interested in butter production since it contained the highest fat percentage. The fact that goat, sheep and cow milk contained the same or similar percentages of protein implies that any of them can adequately serve as a nutritional source of protein for human consumption. Total solids and solids-not-fat are highly positively correlated in cattle and sheep, whereas protein and total solids and protein and solids-not-fat are negatively correlated. Therefore, incorporating these traits in a selection index should take into consideration these relationships for genetic progress.

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