

Comparison of the Mineral Content and Apparent Biological Value of Milk from Human, Cow and Goat.

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Abstract

The mineral content and apparent biological value (ABV) of milk from Human (T1), White Fulani (Bunaji) cow (T2) and West African dwarf goats (T3) (n=10) were assessed following a completely randomised design model and covariance analysis respectively. Concentration per million (ppm) were 210, 150 and 52 Na, (goat, human and cow milk) while potassium content was similar ($P>0.05$) in human (1.60) and goat (1.55) milk compared to that of cow milk. Quantity of Ca, Mg, P, Fe, Cu and Mn were higher in goat and human milk. They were lowest in cow milk: 4.03, 0.92, 1.07, 0.25 and 1.59ppm respectively. In these three treatments, the respective ratios Ca:P¹ were 4.2:1 (T1), 4.4:1 (T2) and 4.6:1 (T3) while Ca:Mg⁻¹ and P:Mg⁻¹ were decreased from 3.9 (cow milk) to 1.9 (human milk) and 0.89 (cow milk) to 0.45 (human milk). In conclusion, the milk of goat (West African dwarf) which contained more of these mineral contents similar to that of human milk, is a pointer to the nutritional contribution of goat milk in a country like Nigeria where prevailing undernourishment and malnutrition are accompanied by low intake of some minerals and vitamins among the populace and most especially the vulnerable (pregnant, lactating mothers, infants and weanlings and the sick) groups.

Key words: West African dwarf goat, White Fulani (Bunaji) cow, Mineral composition, Apparent Biological Value.

Introduction

Goats in Nigeria are kept mainly for meat production while the production and consumption of the milk are regarded as taboo. Milk which is an excellent source of most essential minerals for human contains mostly calcium, phosphorus but low in copper, iron and manganese (ICAR, 1981).

The main components of goat milk are similar to those of cow milk but differs as to particular physical and chemical properties (small size of fat globules, higher content of short and medium chain fatty acids (Haenlein *et al.* 1992) higher content of selenium and glutathione peroxidase (Debski *et al.*, 1987). The mineral content of goat milk (potassium and chlorides) is higher than that of cow milk but similar to that of human milk. However, goat milk was found to contain more of calcium and phosphorus than cow and human milk (Jeness, 1978). The superiority of goat milk over that of the cow lies in its higher content of digestible calcium.

It is noteworthy that milk of each

species has a particular individual pattern of minerals, which may be a pointer of the relative nutritional importance of the element. Hence, the thrust of this work was to investigate the biological value and mineral composition in milk of West African dwarf goat bred in Nigeria. This investigation was extended to the comparison of goat milk with that of cow (Bunaji) and human milk. The multivariate approach was used to find out those minerals, which also could be useful indicator in future research.

Materials and Methods

Milk samples were obtained from human beings (T1), White Fulani (Bunaji) cows (T2) and West African dwarf goats (T3) (10 animals each for goat and cow and 10 human beings), in first six month of lactation. The animals were grazed extensively on pasture at the Teaching and Research Farm, University of Ilorin and the lactation period was from September, 1999 to February, 2000 while human milk was obtained from lactating women (10, in

the morning) at the Maternity Wing of the University of Ilorin Teaching Hospital, Ilorin Kwara State.

Milk samples were collected from the morning milking of all the healthy animals and stored on ice until reaching the laboratory, then frozen at 20°C before being analysed. A wet oxidation method (Piper, 1942) was used, thus: the milk (1g each) was digested with mixture of concentrated nitric acid and perchloric acid (4:1), the solution obtained was washed with de-ionized water into 250ml flask and lanthanum in 5% hydrochloric acid was added to mark the effect of interfering elements; analysis for various minerals were done thus: Calcium was burnt off in an atomic absorptiometer and the intensity of the flame was measured at the appropriate wave-length, slit, current and pressure and then percentage of calcium content of the milk was calculated. Phosphorus, iron and manganese were determined by the atomic absorption spectrometry method using the model SP800 spectrometer (Pyne Unicam Cambridge

CBI 2BX, UK). Sodium and potassium were determined by the flame emission spectrometry method using a flame photometer (Daves, 1965) while magnesium was determined by the EDTA titrimetric method after precipitation (Walter, 1965).

Apparent biological value (ABV) was determined with twenty four albino rats (initial BW $AV.28.5g^{\pm}$) fed different oven dried ($60^{\circ}C$) milk sample for a 21 day period: (a 14 day adjustment and preliminary period and a 7 day collection period (Kiers, 1982). Enough human milk could not be obtained for the biological value determination due to non-cooperation by lactating mothers. The animals which were kept in separate metabolic cages were fed and watered ad-libitum.

The apparent biological value (ABV) was calculated as follows:

$$ABV = \frac{\text{Nitrogen intake} - \text{faecal nitrogen} - \text{Urinary nitrogen}}{\text{Nitrogen intake} - \text{faecal nitrogen}}$$

All data collected were subjected to a completely randomised design model and covariance analysis (Steel and Torrie, 1969).

Results and Discussion

Table 1 shows the content of major and minor elements. Out of the 12 different mineral salts found in milk, 5 occur in human, 6 in cow milk and 9 in goat milk (ICAR, 1981). ICAR (1981) reported that goat milk has 7-10 times as much minerals as human and cow milk. This assertion was confirmed in this study as goat milk has highest mineral contents compared to that of cow or human milk. Due to their different characteristics, the elements are discussed in separate paragraphs.

(a) Sodium (Na): The sodium content of goat milk as was found in the study were superior ($P < 0.05$) to that of cow or human milk but satisfied requirement of human infant adequately (Jenness, 1978). The low content of sodium in human milk also agreed with the report of Desjeux (1993). The variation is due probably to the breed (Rook, 1961), period of lactation and dietary content (Daves, 1965). Also, NRC (1978) reported that goat may consume excess

of their sodium requirement if provided as free choice. However, the sodium content reported here was lower than 0.63g/kg milk reported by ARC (1965). The low content of sodium in cow milk has been recognised more recently (Gorban, 1997) while the high content of sodium in goat milk confirmed the report of ICAR (1981) that goats secrete a good amount of sodium ion in milk. The salt often helps to tone up the system and may even have some effect in removing worms from the body.

(b) Calcium and Phosphorus: One of the most vital concentration of milk to human nutrition is the calcium and phosphorus it supplies (Jenness, 1980). Both elements are needed for tissue and bone development while deficiency results in slow growth, depraved appetite, unthrifty appearance and rickets (NRC, 1978). Jenness (1980) indicated that goat milk provides a great amount of calcium and phosphorus as reported in this study. The high calcium and phosphorus contents reported here also supported the earlier report of Desjeux (1993). The Calcium: Phosphorus ratio did not show any substantial difference among milk types (**Table 1**)

(c) Potassium and Copper: The Potassium content of goat milk was higher than cow milk but similar to that

of human milk. Again, the level of potassium can be affected by seasonal heat and water intake (Yagil *et al.*, 1980). Goat milk has higher content of copper compared to that of human beings and cow milk but similar to those reported elsewhere (Sawaiya *et al.*, 1984 and Elarain and Wilcox, 1992). The naturally occurring copper is associated predominantly with the fat phase of the milk (Berestova *et al.*, 1967).

(d) Iron: There was no significant difference in the iron content of goat and human milk. Both minerals are vital in the component of blood haemoglobin required for oxygen transportation and enzymes system (NRC, 1978). The high concentration of iron in goat milk suggests that the extent of iron binding may be a profitable study.

(e) Zinc and Manganese: Zinc and manganese contents of goat milk were found to be lower but adequate for human infant (Jenness, 1980). In most species, including human being (Vaughan *et al.*, 1979; Cassey *et al.*, 1989) zinc concentration falls as lactation advances. This could probably be due to depletion of maternal zinc stored (Krebs *et al.*, 1985).

Table 2. presents intake, weight gain and biological values as expressed in grams and percentages, showing that goat milk

Table 1. Mean mineral composition of Human, Cow and Goat milk.

Mineral content (ppm)	Human milk (T1)	Cow milk (T2)	Goat Milk (T3)	±SEM
Sodium	150.00 ^a	51.92 ^b	210.41 ^c	±5.80
Potassium	1.60 ^a	1.30 ^b	1.55 ^a	±1.06
Calcium	6.26 ^a	4.03 ^b	5.56 ^c	±2.15
Magnesium	3.33 ^a	1.03 ^b	2.30 ^c	±1.25
Phosphorus	1.50 ^a	0.92 ^b	1.20 ^c	±1.03
Iron	1.40 ^a	1.07 ^b	1.30 ^{ab}	±1.02
Zinc	2.95 ^a	0.11 ^b	0.80 ^c	±1.42
Copper	0.34 ^a	0.25 ^b	0.56 ^c	±0.53
Manganese	5.19 ^a	1.59 ^b	3.29 ^c	±2.78
Ca : P	4.2	4.4	4.63	2.10 NS

a,b,c= Means on the same line followed by the different superscripts are significant at $P < 0.05$

NS = Not significant at $P < 0.05$

Table 2. Covariance analysis of mean intake, apparent biological value (BV) and weight gain of experimental rats.

	Intake (g)	BV (%)	Weight gain (g/d)	Growth rate (%)	Unadjusted Mean	Adjusted mean
Cow Milk (T2)	18.60	90.4	2.2	79.7	$P < 0.05$	$P > 0.05$
Goat Milk (T3)	19.20	90.9	1.80	84.3	$P < 0.05$	$P > 0.05$

was greatly consumed by the experimental rats. The consumption and apparent biological value (ABV) of both cow and goat milk types were determined by covariance analysis. The consumption and apparent biological value curves for the different groups receiving milk types showed slopes of 1.17 (intake) and 0.58 (biological value). The higher biological value recorded for goat milk is vital since some essential minerals elements are used as constituent of protein and lipids that make up the muscle, connective tissue, skin, hair and blood cells (NRC, 1978). The mineral elements are also needed for various enzyme system as well as acid-base equilibrium.

The regression equation of adjusted means for milk types are shown below:

$$Y = 1.17x + 9.2 (r^2 = 0.67) (\text{intake})$$

$$Y = 0.58 - 1001.93 (r^2 = 0.02) (\text{ABV})$$

However, the coefficient of variation is >1 . This is probably explained by the palatability of goat milk obvious from **table 2** of the rate of change in consumption due to the milk, that of goat milk is maximum. There was no significant difference when the treatment mean for Y was adjusted for the regression of Y on X. This revealed that no real difference exists between the treatment means for Y adjusted for X. However, the unadjusted treatment means show significant differences. This indicates that differences among the unadjusted means merely reflected differences in appetite, growth rate or feed capacity and not in the intake nor the biological value. This contention agreed with the report of NRC (1978)

that variation among animals in ability to digest feed is relatively small. However, larger differences exist in feed capacity, appetite, growth rate and level of milk production.

Conclusion

Cow milk is distinguished by a lower concentration of sodium, phosphorus, zinc, copper and manganese with respect to other milk types (goat and human milk). From the viewpoint of human nutrition, therefore the milk of goat is to be preferred to that from cow (Bunaji) due to higher content of most of the minerals. Hence goat milk, like cow milk cannot replace human milk in young children but could complement it. A greater diffusion of knowledge on nutritional value of goat milk could promote its complementary effect in human diet, mostly if used in association with other foods for children after the age of 1 year as well as adults.

References

- Agricultural Research Council (1965).** The nutrient requirement of Farm Livestock No.2. Ruminant, London.
- Barestova, V.I., Panova, M.K. (1967).** Cobalt and copper content of food products of animal origin in Kotelins autonomous SSR. Yehen Petrozavodsk. Gos Univ. 13: 107 Dairy Science abstract 29 pg 2077.
- Dawes, S.N. (1965).** Sodium and Potassium in cow's milk NZ J Sci. 3:161-172.
- Debski, B., Picciano, M.F., Milner, J.A. (1987).** Selenium content and distribution of human, cow and goat milk, J. Nutr. 117:1091-1097.
- Desjeux, J.F. (1993).** Valeur nutritionnelle du lait de chevre. Lait 73: 573-580.
- Elamin, F.M., Wilcox, C.J. (1992).** Milk composition of Majahora camela. J. Dairy Sci. 75 : 3156-3157.
- Gorban, A.M.S., Izzeldin, O.M. (1997).** Mineral content of camel milk and colostrum, J. Dairy Sci. 64: 471-474.
- Haenlein, G.F.W. (1992).** Role of goat meat and milk in human nutrition. Proc. V. International Conference on goats. Vol.II part I, New Delhi, India, pp 575-580.
- Indian Council for Agricultural Research (ICAR).** A Handbook of Animal Husbandry. Edited by SHRI. P.J. Joseph for the Indian Council of Agricultural Research, New Delhi. Pg. 99.
- Jenness, P.E. (1978).** The nutritive value of dairy products. Dairy Industries International. 43(6):7-16.
- Jenness, P.E. (1980).** Composition and characteristics of goat milk. A review 1968-1979. J. Dairy Sci. 63:1605-1630.
- Kiers, C. (1982).** Nutritional Bioavailability of Fe. Am. Chem. Society, Washington, D.C.
- Krebs, N.F., Hambique, K.M. (1985).** The effects of dietary Zn supplement during lactation. Am. J. Clin. Nutrition 41: 560-570.
- National Research Council; Nutrient Requirement of dairy cow. (NRC, 1978).** National Academic of Science 2nd ed.
- Piper, C.S. (1942).** Soil and plant analysis, pp 272.
- Rook J.A. F. (1961).** Variation in the chemical composition of cow milk J Dairy Sci. 23:252-258.
- Steel, R.G.D., Torrie, J.H. (1969).** Principles and procedures of statistics McGraw-Hill Co. New York.
- Vaughan, I.A., Weber, C. W. (1979).** Longitudinal changes in the mineral content of human milk. Am. J. Clin. Nutrition 32: 2301-2306.
- Walter R.H. (1965).** Calcium and magnesium. EDTA Titration method. In methods of soil analysis (chemical and microbiological properties) Ed. by Black, C.A., Evans D. D., White J.L.; Ensminger, L.E., Clark F.E. pp 999-1003. Published by American Society of Agronomy, U.S.A.
- Yagil, R., Etazion, Z. (1980).** Effect of drought condition on the quality of camel milk J Dairy Res. 47:159-166.