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# Calcium and phosphorus in milk of Yankansa ewes as influenced by stages of lactation

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## ABSTRACT
A study was conducted to*Objectives*: To examine the composition of calcium and phosphorus in sheep milk as influenced by the stages of lactation in Yankansa ewes.

*Methodology and objectives*: Four Yankansa ewes aged two years and weighing between 39.5 and 41.0 kgs were used for the experiment, which was conducted at the Institute of Agriculture Research and Training, Ibadan and the Department of Animal Science, University of Ibadan. The ewes were fed the same diet consisting of 0.5 kg of concentrate supplement and grass (*Cynodon nlemfuensis)* ad libitum. The ewes were brought to heat by synchronization then herd ram served. Milk samples were collected from each ewe once daily on days 2, 4, 6 and once a week from week 2 to 10 after parturition. The milk samples were analyzed for minerals using an atomic spectrophotometer. The trend in the contents of calcium in colostrum and milk varied significantly with stage of lactation while the phosphorus content was low in the colostrum.

*Conclusion and application of findings*: Milk minerals are important in human nutrition and are also important in stability of milk lipids and milk proteins especially in processing of milk products like cheese and yoghurt. The relative concentrations of the various minerals vary significantly with stage of lactation, breed of animal, feed, infection of udder and season of year.

**Key words:** Sheep milk, calcium, phosphorus, stages of lactation.

## INTRODUCTION
Sheep milk is presently preferred in Europe and America for cheese making while in Africa and Asia it is a major food and a good source of minerals that are vital in human nutrition because they are components of body tissues and fluids.

Sheep milk is used in high amounts in Sudan, Somalia and Ethiopia. The Turkana people of Kenya, Fulani and Hausa of West Africa consume a lot of sheep milk. In Syria sheep milk is the second highest in amount produced mainly from the Awassi breed (FAO, 1990).

Inspite of the importance of sheep milk, more emphasis worldwide has been on sheep wool and meat production. Dairy sheep breeds are recognized mainly in the Mediterranean area and are distinguished by higher milk fat and protein levels than in goat and cow (Haenlein, 2001).

In Nigeria, sheep and goat milk is consumed domestically, alone or mixed with cow milk. In the North and Northwestern Nigeria, sheep milk is used in the preparation of soft cheese and in the south and southeastern it is converted into 'ghee', which can be stored for a longer time without spoilage (Olaniyi, 2004).

Ewe's milk has a very high solid content and the fat content is approximately twice that of European cows, which is similar to that of buffalo cow (Gatenby, 1986). The protein content is greater than that of all species but the lactose content is similar to that of cow's milk. Ewe's milk contains almost all the minerals required by lambs and humans i.e. calcium, phosphorus, potassium, sodium, chloride and trace minerals. Only about a third of the minerals are in the true solution, the rest are associated with the milk solids.

Thus when ewe's milk is made into cheese or other products it retains its value as a mineral source. The contents of several minerals in ewe's milk have been reported to be lower than in goat's milk (Abou-Dawood & Taha, 1980). Due to its good quality, ewe's milk can contribute greatly to human nutrition especially in the dry tropical countries where cows' milk may be scarce and sheep will produce better in these dry areas. Sheep are also easy to rear and require less space thus farmers in peri-urban and urban areas prefer them.

**Milk Minerals:** Minerals contribute to the buffering capacity of milk, eminence of milk pH, ionic strength of milk and milks osmotic pressure. (Hurley, 2002). A study done to compare the mineral composition of human milk, Fulani cow milk and West African Dwarf goat milk concluded that the milk of goats contained more of minerals and that the minerals present were similar to those present in human milk, pointing to the value of goat milk in nutrition (Belewu and Aiyegbusi 2002).

The ionized calcium obtained from milk is essential for physiological functions as nerve conduction and maintenance of muscle contraction and relaxation. Calcium also acts as an inhibitor or activator of some enzymes and it must be present for normal blood clotting i.e. prothrombin to form thrombin (Underwood 1981; Mc Dowell 1985). Calcium is a water-soluble element so it is solubilized in the stomach or rumen.

According to Neville and Morton (2001) the substantial volume increase in milk occurring 36 to 96 hrs postpartum is perceived as the incoming of milk and it reflects a massive increase in the rates of synthesis and secretion of lactose, casein, lipid, calcium, sodium and potassium. From an experiment conducted in women 8 days postpartum it was discovered that the daily secretion rate of calcium increased as the days post partum increased (Neville & Morton, 2001).

Calcium is important for lactating animals. Deficiency of calcium will lead to rickets in young children and animals, osteomalacia in adults, dental maldevelopment, reduced milk flow in dairy cows, parturient paresis in dairy ewes and cows, tendency of bones to fracture and presence of titanic seizures (Blood *et al*., 1994; O'Connor 1995).

Phosphorus is the second most abundant mineral in the body of the animal where 80% is found in bones and teeth (Underwood, 1981). Phosphorus has several functions independent of calcium, e.g. as part of the phospholipids molecules it binds and alters the solubility of dietary fat thus making it easier for the fat to enter the aqueous environment of the cell. In addition, phosphorus is a constituent of the nucleic acids RNA and DNA in which genetic information is contained and translated. Phosphate is also a key constituent of many enzymes. Phosphorylation of numerous compounds is essential for metabolism as in the glycolytic pathway in which living cells utilize phosphate to transport cellular energy via adenosine triphosphate (ATP). Phospholipids are also the main structural component of all cellular membranes (Underwood, 1981). There are three chemical forms of phosphate in milk, free inorganic phosphate in solution, colloidal phosphate and casein phosphate.

Phosphorus and calcium levels in milk are usually high in colostrum and then decrease constantly until near the end of lactation when they rise again (Haenlein, 1992). Phosphorus concentration in human milk declines with progressing lactation especially between 4 and 25 weeks of lactation. Changes in concentration of minerals during lactation are common in mammals.

The lactation of the ewe usually lasts from 12 to 20 weeks although individuals show considerable variations. The stage of lactation has a pronounced effect on milk yield, which is at a maximum at the second and third week before it falls steadily. It has been calculated that about 38% of total yield is obtained in the first 4 weeks, 30% in the next 4 weeks and 21% in the next 4 weeks and 11% in the final 4 weeks (Mc Donald, 1995). The stage of lactation also affects the composition of ewe's milk. The butterfat content is usually higher towards the end of the lactation period than soon after freshening (Ensimiger, 1983). Fat, protein and ash contents increase towards the end of lactation while lactose contents decrease with time (Haenlein, 2001).

The composition of milk varies through out the lactation cycle. The colostrum secreted during the first days after parturition has an increased content of protein and ash and contains 20-30% dry matter. At 3 – 5 days after parturition, the milk will have reached its normal stable composition as shown in the Table 1 below.

**Table 1:** Composition (%) of ewe milk at 1 and 5 days after parturition.

| Component | At birth | After 5 days |
|---|---|---|
| Minerals | 1.5 | 1 |
| Sugar | 2 | 4.7 |
| Protein | 22 | 4.2 |
| Fat | 6.5 | 4.1 |
| Water | 68 | 86 |

Source: FAO (1994)

Potassium and calcium salts are the most abundant in normal milk although the amounts of salts present are not constant. Calcium is higher in colostrum whereas potassium is low. Rowland *et al.* (1975) reported that calcium concentration rose in the first months of lactation but there was no change in phosphorus and magnesium.

Only 25 % of the calcium and 44% of the phosphorus are in a soluble form whereas the total amounts of the other major mineral constituents are in insoluble form. The calcium and magnesium in the insoluble form is in chemical or physical combination with caseinate, phosphate and citrate.

This provides a mechanism by which milk can contain a high concentration of calcium and at the same time maintain normal osmotic equilibrium with the blood (Schmidt, 1971). According to Akinsoyinu (1980), in Friesian cows, concentration of major minerals was higher in the colostrum than in the mature milk. According to Adeneye (1970) the stage of lactation had a significant ($P<0.05$) influence on sodium and magnesium and highly significant effect on calcium, potassium and phosphorus ($P<0.01$).

## MATERIALS AND METHODS

Four Yankansa ewes two years old and weighing 39.5 kg to 41.0 kgs were used for the experiment conducted at IAR&T, Moore Plantation, Ibadan in collaboration with the Department of Animal Science, University of Ibadan, Nigeria. The ewes were treated with antihelminthics and acaricides to rid them off internal and external parasites, respectively. The ewes were then synchronized and brought to "heat" at the same time. The Herd ram then served them. One concentrate diet was formulated (Table 2). The four ewes were fed on the same diet, which was 0.5 kg per head of the concentrate supplement and the grass (*Cynodon nlemfuensis*) *ad libitum*. The ewes were fed in individual pens and had access to fresh water daily.

**Table 2**: Composition of concentrate supplement fed to ewes.

| Ingredients | Composition % |
|---|---|
| Groundnut cake | 15.0 |
| Ground maize | 28.7 |
| DUSA | 20.0 |
| Palm Kernel Cake | 15.0 |
| Dried Brewers Grain | 20.0 |
| Common Salt | 00.5 |
| Mineral/Vitamin premix | 00.3 |
| Oyster Shell | 00.5 |
| TOTAL | 100 |

DUSA – This is a residue from fermented guinea corn used in production of local gin (alcohol) called Burukutu.

**Table 3:** Composition (g/100g DM) of concentrate supplement in diet.

| | |
|---|---|
| Crude Protein | 18.5 |
| Crude Fiber | 16.3 |
| Ether Extract | 8.9 |
| Ash | 9.8 |
| NFE | 46.5 |

**Table 4:** Composition (g/100g DM) of grass *Cynodon nlemfuensis* in diet.

| | |
|---|---|
| Crude Protein | 12.8 |
| Cruder Fiber | 25.2 |
| Ether Extract | 5.6 |
| Ash | 6.2 |
| NFE | 50.2 |

**Milk collection:** The milk samples were collected once a day on days 2, 4, and 6 after parturition, and then once a week from weeks 2 to 10. The ewes were hand milked and the milk was collected in plastic specimen bottles. Milk samples were taken to the laboratory for analysis on the same day of collection.

**Milk analysis***:* An amount of 1ml of each milk sample was digested in duplicate with 20 ml Nitric acid and 5ml Perchloric Acid in a Kjedahl flask in a fume cupboard. The digest of each sample was allowed to cool and washed with distilled water into standard 100ml volumetric flasks, distilled water was added to the digest to make up to the 100ml mark. A 40 ml volume of this digest was then dispensed into specimen bottles.

An Atomic Absorption Spectrophotometer was used to determine the concentration of the sodium, potassium, calcium, phosphorus and magnesium using the appropriate lamp for each mineral (A.O.A.C, 1990). Data recorded were subjected to analysis of variance using Statgraphics Software (Mannungistics Inc.) Version 3.1. The means were the separated using Fishers Least Significant Difference Procedure.

## RESULTS AND DISCUSSIONS

Calcium concentration was high in colostrum averaging 0.066g/kg then it decreased slightly in week 2. It increased again from the 6th week to 1.1833g/kg by week10 (a concentration higher than that in colostrum). Phosphorus concentration was low in colostrum averaging 0.328g/kg and it gradually increased from the 4th week (0.677 g/kg) and doubled in concentration by the 10th week (1.175g/kg) .

Starting at a level of 0.845 g/kg, calcium concentration in colostrum decreased significantly through days 4 to 6 (Table 1). The reduction in calcium continued until the 3rd week post parturition (average 0.57 g/kg) after which there was a significant increase to an average of 1.78g/kg by week 10 (Table 2; Figure 2). Similar results were obtained by Olaniyi (2004) who reported that the values of calcium in colostrum of West African dwarf ewes were higher than in mature milk but there was a significant increase after the 3rd week.

Mackenzie *et al*. (1998) reported that a negative calcium and phosphorus balance occurs during the first part of the lactation period when milk flow is greatest and that replenishing of the stores occurs during the latter part of the lactation period and during the dry period. According to Haenlein (1992) calcium and phosphorus levels in milk are high in colostrum then they decrease constantly until near the end when they rise again.

The phosphorus levels in the Yankansa ewe's milk were low in the colostrum but increased with days of lactation. The concentration increased almost fourfold from 0.365g/kg at day 2 to 1.18g/kg by the 10th week post parturition (Tables 1and 2; Figure 3).

**Table 5:** Variation of calcium and phosphorus content in colostrum of Yankansa ewes.

| Days after parturition | Calcium g/kg | Phosphorus g/kg |
|---|---|---|
| Day 2 | $0.845^{a}$ | $0.365^{a}$ |
| Day 4 | $0.65^{b}$ | $0.3175^{b}$ |
| Day 6 | $0.5^{c}$ | $0.3025^{b}$ |
| *Mean* | 0.665 | *0.3283* |
| P-Value | 0.0000 | 0.0004 |
| LSD | 0.036 | 0.023 |

Means followed by different superscripts are significantly different (P<0.05).

**Table 6:** Variation of calcium and phosphorus in milk of Yankansa Ewes between the second and tenth week after parturition.

| Weeks | Calcium g/kg | Phosphorus g/kg |
|---|---|---|
| Week 2 | $0.5125^{a}$ | $0.625^{a}$ |
| Week 3 | $0.5725^{b}$ | $0.6425^{ab}$ |
| Week 4 | $0.8275^{c}$ | 0.6775b |
| Week 5 | $0.91^{d}$ | $0.77^{c}$ |
| Week 6 | $1.29^{e}$ | $0.885^{d}$ |
| Week 7 | $1.45^{f}$ | $0.8875^{d}$ |
| Week 8 | $1.6075^{g}$ | $0.95^{e}$ |
| Week 9 | $1.7^{h}$ | $1.1375^{f}$ |
| Week 10 | $1.78^{i}$ | $1.175^{f}$ |
| P-Value | 0.0000 | 0.0000 |
| LSD | 0.0552 | 0.0496 |

Means followed by different superscripts in the same column are significantly different (P<0.05).

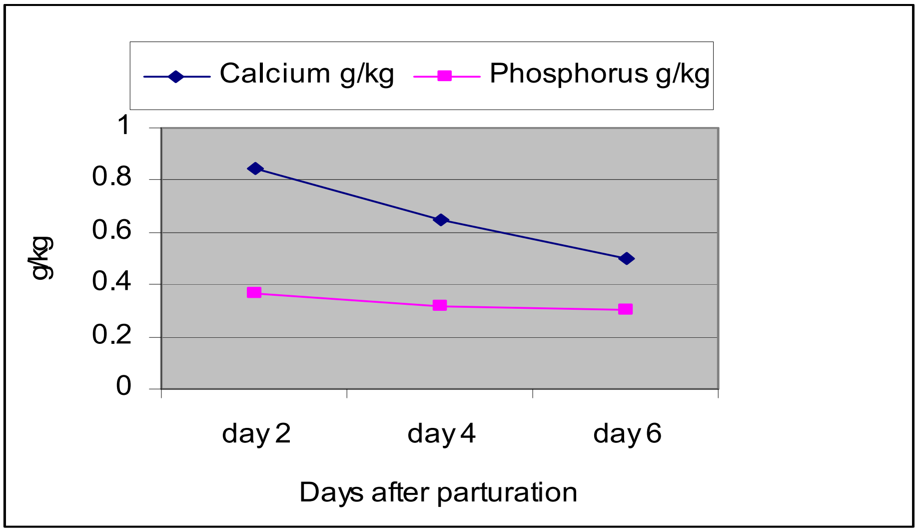


**Figure 1:** Variation of Calcium and Phosphorus content in colostrum of Yankansa Ewes

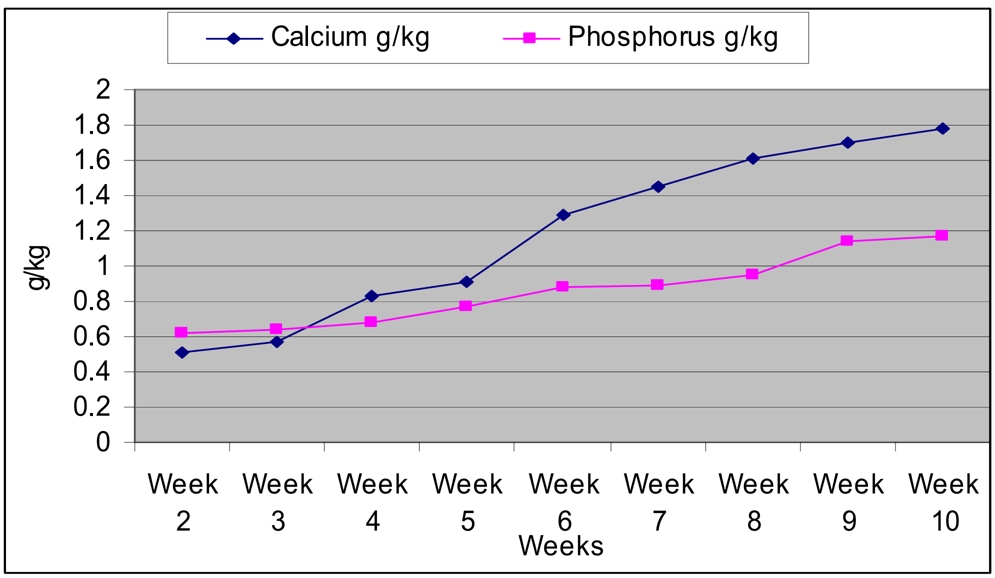


**Figure 2:** Variation of calcium and phosphorus in milk of Yankansa Ewes between the second and tenth week after parturition

The result of this study was contrary to results obtained by Akinsoyinu (1980; Bath *et al*. (1981); Haenlein (1992; Olaniyi (2004) who observed that phosphorus was higher in colostrum than in mature milk. A possible explanation for this discrepancy could be differences in phosphorus content in the grass and concentrate supplement or due to breed differences. However in an experiment conducted to study phosphorus partitioning during early lactation phosphorus secretion was unaffected by dietary P concentration, but milk P as a proportion of P intake decreased with increasing dietary P content. Milk P output should decline linearly both in quantity and as a proportion of P intake due to decreasing milk yield but this was not observed in this study (Knowlton & Herbun, 2002).

## CONCLUSION

This work has added to the existing knowledge on calcium and phosphorus in ewe's milk and has observed some differences from previously reported studies. The trend of calcium in milk was similar to what has been reported for ewes and other animals. The phosphorus content was low in the colostrum and this could have been the effect of diet or genetics.

Further research is required on the minerals in sheep milk to add onto the little available information. In addition, more research is required on sheep in the tropics since most of the available information is on sheep in the temperate regions.

## REFERENCES


Abou-Dawood AE. and Taha SM, 1980. Major and minor components and trace elements of the Egyptian ewes and goat milk. Egyptian Journal of Dairy Science 8:109-115.

Adeneye JA, Oyenuga VA, Olaloku EA, 1970.Preliminary Findings on the composition of milk of White Fulani cattle. Nigerian Journal of Science 4: 181-186.

Akinsoyinu AO 1980. The composition of milk of Friesian cattle imported into Nigeria. Journal of Science Food and Agriculture 32: 861-867.

A.O.A.C., 1990. Official Methods of Analysis. 15th Edition. Association of official Analytical Chemists, Inc, Arlington.VA.

Babcock, 1995. Milk composition and Nutritional value. Babcock Institute for International Dairy Research and Development. http://babcock.cals.wisc.edu

Bath Donald, Dickson Frank H, Tucker Allen, Appleman Robert D, 1981. Dairy Cattle: Principles, Practices, Problems and Profits. 3rd Edition.

Belewu MA. and Aiyegbusi OF, 2002. Comparison of the mineral content and apparent biological value of milk from human, cow and goat. Journal of Food Technology in Africa Vol 7.

Blood CD, Radostatis OM, Gay CC, 1994. Veterinary Medicine. A textbook of diseases for cattle, sheep, pigs, goats and horses. ELBS. Bailliere Tindall. 8th edition.

Ensiminger ME, 1983. Animal Science (Animal agricultural series) 8th edition. Interstate publishers Inc. Illinois.

FAO, 1990. The technology of traditional milk products in developing countries. Paper 85

Haenlein GFW, 1992. Milk Secretion. Goat Extension Handbook. US Department of agriculture, Washington DC.

Haenlein GFW, 2001. The Nutritional Value of Sheep Milk. Department of Animal and Food Science. University of Delaware, Newark .USA

Hurley WL, 2002. Lactation Biology. University of Illinois http://animsciagrenvimcgill.ca/courses/460/topics/2/text.pdf

Knowlton KF. and Heben JH, 2002. Phosphorus partitioning during early lactation in dairy cows fed diets varying in phosphorus content. Journal of Dairy science 85; 1227-1236

Looper M, Stokes S, Jordan E, 2001. Managing milk composition: Normal sources of Variation. New Mexico State University.

Mc Donald P, Edwards RA, Greenhalgh JFP, Morgan CA, 1995. Animal Nutrition, 5th Edition, Longman, UK.

Mackenzie SR, Back PJ, Davis SR, Hams PM, 1998. The effect of insulin nutrient supply interaction on ewe lactation. Proceeding of the New Zealand society of animal production 58: 205-208.

Mc Dowell Lee Russell, 1985. Nutrition of Grazing Ruminants In Warm Climates. Harcourt Brace, Academic Press Inc.

Neville CM. and Morton J, 2001. Physiology and Endocrine changes underlying Human Lactogenesis. Journal of Nutrition 131: 3005-3008.

O'Connor CB, 1995. Rural Dairy Technology. ILRI Addis Ababa. Training Manual I.

Olaniyi BA, 2004. Calcium, Phosphorus and Iodine in milk of WAD ewes as influenced by stages of lactation. M.Sc Thesis.

Prentice Ann, 2003. Micronutrients and Bone mineral Content of the mother, Fetus and Newborn. Journal of Nutrition 133: 1693- 1699.

Rowlands GT, Manton RR, Poccock M, Dew S, 1975. Relationship between stage of lactation and Pregnancy and blood composition in a herd of dairy cows and the influences of seasonal changes in management of these relationships 42:349-362

Schimdt GH, 1971. Biology of Lactation. W H Freeman and Co. San Francisco.

Shennan D. and Peaker M, 2000. Transport of Milk constituents by the mammary gland. Physiological Reviews 80:925-951.

Underwood JE, 1981. The Mineral Nutrition of livestock. 2nd Edition Commonwealth Agricultural Bureaux, England.