

International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
 ISSN Online: 2617-4707
 NAAS Rating (2026): 5.29
 IJABR 2026; 10(6): 830-832
www.biochemjournal.com
 Received: 11-04-2026
 Accepted: 13-05-2026

SP Maharathi
 Department of Veterinary
 Physiology, College of
 Veterinary Science & A.H,
 OUAT, Bhubaneswar, Odisha,
 India

N Dalai
 Department of Veterinary
 Physiology, College of
 Veterinary Science & A.H,
 OUAT, Bhubaneswar, Odisha,
 India

APK Mahapatra
 Department of Veterinary
 Physiology, College of
 Veterinary Science & A.H,
 OUAT, Bhubaneswar, Odisha,
 India

K Shweta
 Department of Vety & A.H
 Extension Education, College
 of Veterinary Science & A.H,
 OUAT, Bhubaneswar, Odisha,
 India

J Pamia
 Department of Veterinary
 Pathology, College of
 Veterinary Science & A.H,
 OUAT, Bhubaneswar, Odisha,
 India

J Bagh
 Department of Livestock
 Production & Management,
 College of Veterinary Science &
 A.H, OUAT, Bhubaneswar,
 Odisha, India

Corresponding Author:
N Dalai
 Department of Veterinary
 Physiology, College of
 Veterinary Science & A.H,
 OUAT, Bhubaneswar, Odisha,
 India

Assessment of macro-minerals levels in follicular fluid and their correlation with serum concentrations in Ganjam goat

SP Maharathi, N Dalai, APK Mahapatra, K Shweta, J Pamia and J Bagh

DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i6j.8772>

Abstract

The present study was planned to study the levels of macro-minerals in follicular fluid and evaluate the relationship between the concentration of minerals in follicular fluid and serum. Ovaries were collected from slaughter houses and follicular fluid has been aspirated from small, medium, and large follicles. For conducting the biochemical assay of serum, 5 ml of blood was withdrawn from the jugular vein immediately before the time of slaughtering in clot activator vials. Various macro-minerals such as calcium, phosphorus, magnesium, sodium, and potassium have been analyzed in follicular fluid. It has been observed that the concentration of calcium, phosphorus, and sodium was significantly high while magnesium and potassium were significantly low in large follicles.

Keywords: Follicle, goat, macro-minerals, oocytes, serum

Introduction

In ovine, caprine, bovine the major part of ovulatory follicles is follicular fluid. The ovarian follicles size classification in goat as reported by Ahmed-Ali and Dubos (1995) ^[1] is considered the small follicles (<3 mm), medium follicles (3-5 mm) and large follicle (>5 mm). Folliculogenesis refers to the orderly process of development and differentiation, involving somatic as well as germ cells within the follicle, and represents the synthesis of oocytes' components that lead to fertilization and embryogenesis (Ana and Adrain, 2012; Tripathi *et al.*, 2015) ^[4, 11]. In the process of folliculogenesis, growth takes place through proliferation of the cells and secretion of follicular fluid, while development involves cytodifferentiation of all the cells of the follicle. During follicular growth, equilibrium of ionic and metabolic concentration is established between serum and follicular fluid (Erickson, 2008) ^[6]. Follicular fluid components depend significantly on the developmental stage of the follicle, causing differential influence on the process of oocyte maturation (Wise, 1987) ^[12]. Follicular fluid serves as an index of the secretory function and metabolic processes of follicular cells, and hence is associated with the follicular quality. Therefore, the profiling of follicular fluid at various stages of follicular maturation would allow the selection of follicular fluid at a particular developmental stage that creates favorable conditions for the oocyte maturation. The biochemical environment of oocytes before ovulation is formed by follicular fluid as the follicular fluid contains essential substances involve in oocyte maturation and fertilization. As the oocyte and the granulosa cell undergo development in a biochemical environment where they transform from smaller to larger follicles, there is a strong correlation between the metabolites, ions and enzymatic composition of follicular fluid and the development of follicles/oocytes (Iwata *et al.*, 2006) ^[7]. Hence, biochemical assessment of follicular fluid and the categorization of follicles on the basis of their size plays an important role in this area of research.

Before focusing on possible effects of metabolic changes of follicular fluid on oocyte quality, it is necessary to establish physiological levels of the most common metabolites in follicular fluid of different size follicles and to investigate the degree of correlation between blood and follicular fluid levels of such metabolites. Hence, the current study was designed to establish the concentrations of macro-minerals in follicular fluid and assess the correlation of their concentrations in follicular fluid and serum.

Materials and Methods

Experimental Materials

The materials used for this experiment were obtained from the local slaughter house. The animals used in this study belong to the native breed called 'Ganjam' goat. The laboratory analysis was carried out at the Department of Biochemistry, C.V.Sc & A.H., OUAT, Bhubaneswar, Odisha.

Collection of Blood Samples

Collection of 5ml blood samples in clot activator tubes from the jugular vein right before slaughtering was done for serum biochemical parameters determination. The samples were then put into a centrifuge tube, centrifuged for half an hour at 3000 revolutions per minute, and serum samples were stored in the deep freezer at minus twenty degrees centigrade.

Collection of follicular Fluid

Ovary samples were obtained from slaughter houses. No pre-slaughter information regarding the reproductive status of these goats was available. Ovaries (n = 100) were collected from the slaughterhouses in chilled (4 °C) normal saline containing gentamycin solution (50 mg/ml) within two hours of slaughter. Fluid was aspirated from the small follicle (<3 mm), medium follicle (3-5 mm), and large follicle (>5 mm) using a tuberculin syringe separately. The fluid was centrifuged at 2000 rpm for 5 minutes, and the supernatant was kept frozen at -20 °C.

Biochemical Analysis of the Follicular Fluid

The concentrations of macro elements were determined by Clinical analyzer (Systronic 635). Standard commercial kits were used for analysis and procedures were adopted as recommended by the manufacturer of kits.

Statistical analysis

All the parameters for each test sample were compared (Analyze-Compare Means) for obtaining the mean value along with standard error (S.E). Then they were analyzed by Duncan method (One-way-ANOVA) and the significance (P-value) was recorded at 5% ($p < 0.05$) level. The complete statistical analyses were done with the help of Statistical Package for Social Scientist (SPSS) Version 22, Windows 10.0.

Results

The mean ($\pm$ SE) values for macro-minerals in serum and follicular fluid were presented in Table. 1.

The concentration of calcium was found to be higher in serum (9.02 ± 0.54 mg/dl) as compared to small (5.33 ± 0.43 mg/dl), medium (6.14 ± 0.40 mg/dl) and large follicles (7.56 ± 0.46 mg/dl). The result of present study showed that there were no significant differences among serum and follicles. The concentration of Calcium gradually increased from small to large follicle and significantly ($p < 0.05$) higher than small follicle. The mean Phosphorous concentration in serum of goat included in this study was 4.32 ± 0.52 mg/dl and the values of Phosphorous in small, medium and large sized follicular group of animals were 5.13 ± 0.52 and

6.03 ± 0.51 and 7.45 ± 0.41 mg/dL, respectively. There was a significant difference ($p < 0.05$) between serum and fluid from large follicle. The concentration of Phosphorous gradually increased from small to large follicle.

The results demonstrated that the mean serum magnesium concentration was 2.0 ± 0.23 mg/dL, while magnesium levels in the follicular fluid were 2.25 ± 0.23 , 1.27 ± 0.16 , and 1.98 ± 0.27 mg/dL for small, medium, and large follicles, respectively. No significant differences were observed between serum and follicular fluid magnesium concentrations across all follicle sizes. The mean serum sodium concentration was 144.17 ± 2.65 mEq/L. Sodium concentrations in the follicular fluid of small, medium, and large follicles were 115.2 ± 4.30 , 121.14 ± 7.0 , and 128.06 ± 5.43 mEq/L, respectively. Although sodium concentration increased progressively from small to large follicles, no significant differences were found among the follicle size groups. However, sodium levels in small and medium follicles were significantly lower compared to serum values. The results revealed a significant difference ($p < 0.05$) in the concentration of potassium in the follicular fluid (SF), which measured 10.41 ± 0.96 mEq/L, compared to the medium follicle (5.04 ± 0.68 mEq/L). Additionally, potassium levels in the serum (4.02 ± 0.60 mEq/L) were significantly different ($p < 0.05$) from both the SF and large follicle (LF), indicating distinct potassium distributions across these biological compartments.

Discussion

The observed increase in follicular fluid calcium concentration with follicular development in the present study is consistent with previous reports by Al-Hamedawi *et al.* (2017) [2] and Al-Rubaei *et al.* (2023) [3]. Calcium ions play a critical role in estradiol synthesis within follicles and are key regulators of gonadotropic hormones, which govern steroid hormone secretion and ovulation. The elevation of calcium levels in larger follicles likely reflects its involvement in enhanced estrogen production, as estrogen secretion escalates with follicular growth (Nandi *et al.*, 2007) [9]. Similarly, phosphorus levels demonstrated a linear increase with follicle size, aligning with findings in sheep (Nandi *et al.*, 2007) [9]. Phosphorus is an essential component of cAMP, the second messenger mediating steroid hormone effects (Hafez, 1993), and its rise corresponds with increased cAMP levels during follicular development (Chang *et al.*, 1976) [5]. Magnesium concentrations remained stable across follicle sizes, corroborating prior observations (Nandi *et al.*, 2012) [10]. Notably, sodium ion concentration was significantly higher in large follicles, supporting follicle vitality and estradiol-associated sodium retention (Wise, 1987) [12]. In contrast, potassium levels were elevated in small follicles, consistent with earlier studies (Al-Rubaei *et al.*, 2023; Al-Hamedawi *et al.*, 2017) [3, 2], likely due to potassium's intracellular-extracellular ion exchange linked to calcium influx during glucose metabolism, which reduces potassium in follicular fluid while increasing it within follicular cells (Leroy *et al.*, 2004) [8]. Collectively, these ion concentration dynamics underscore their integral roles in follicular maturation and hormonal regulation throughout the reproductive cycle.

Table 1: Mean ($\pm$ SE) Values of different Macro-minerals in serum and of ovarian follicles

Macro-minerals	Serum	Small Follicle	Medium Follicles	Large Follicle
Calcium (mg/dl)	5.83 $\pm$ 0.51 ^{ab}	5.33 $\pm$ 0.40 ^a	6.14 $\pm$ 0.37 ^{ab}	7.56 $\pm$ 0.43 ^b
Phosphorous (mg/dl)	4.69 $\pm$ 0.52 ^a	5.13 $\pm$ 0.49 ^a	6.03 $\pm$ 0.47 ^{ab}	7.45 $\pm$ 0.38 ^b
Magnesium (mg/dl)	2.0 $\pm$ 0.21	2.25 $\pm$ 0.21	1.41 $\pm$ 0.17	1.98 $\pm$ 0.22
Sodium (mEq/L)	144.18 $\pm$ 2.48 ^b	115.2 $\pm$ 4.20 ^a	121.15 $\pm$ 6.55 ^a	128.06 $\pm$ 5.08 ^{ab}
Potassium (mEq/L)	4.02 $\pm$ 0.56 ^a	10.41 $\pm$ 0.93 ^c	5.04 $\pm$ 0.64 ^{ab}	7.71 $\pm$ 0.79 ^{bc}

Superscript bearing different letters in the same row differ significantly ($p < 0.05$)

Conclusion

In conclusion, the study highlights the significant variations in follicular fluid ion concentrations associated with follicular development. The observed increase in calcium and phosphorus concentrations aligns with their established roles in steroidogenesis and follicular maturation, reflecting enhanced estrogen synthesis and cAMP-mediated hormonal signaling. The stability of magnesium levels and the distinct patterns of sodium and potassium concentrations further emphasize the complex ionic regulation underlying follicle vitality and metabolic activity. These findings collectively reinforce the integral involvement of specific ions in orchestrating the hormonal and physiological processes essential for successful follicular growth and ovulation.

Acknowledgement

We thank the Dean, CVSc and A.H., OUAT for providing the facilities to conduct the present study.

Conflict of Interest

The authors declare that they have no conflict of interest.

References

- Ahmed-Ali MN, Dubos MP. Development competence of goat oocytes from follicles of different size categories following maturation, fertilization and culture *in vitro*. J Reprod Fertil. 1995;103:293-298.
- Al-Hamedawi TM, Zalzal SJ, Al-Shammary SM. Biochemical composition of caprine follicular fluid in relation with different follicle sizes in Iraqi local goats. Adv Anim Vet Sci. 2017;5(3):145-147.
- Al-Rubaei HM, Radhi MM. Study of the relationship between follicle size and some hormonal and ionic components of ovarian follicular fluid with oocyte development in local goats (*Capra hircus*). AIP Conf Proc. 2023;2776:020032.
- Ana M, Rosales-Torres A, Garcia AG. Follicular development in domestic ruminants. Trop Subtrop Agroecosyst. 2012;15:147-160.
- Chang SCS, Jones JD, Ellefson RD. The porcine ovarian follicle: I. Selected chemical analysis of follicular fluid at different developmental stages. Biol Reprod. 1976;15:321-328.
- Erickson GF. Follicle growth and development. Glob Libr Womens Med. 2008. doi:10.3843/GLOWM.10289.
- Iwata H, Inoue J, Kimura K, Kuge T, Kuwayama T, Monji Y. Comparison between the characteristics of follicular fluid and the developmental competence of bovine oocytes. Anim Reprod Sci. 2006;91:215-223.
- Leroy JLMR, Vanholder T, Delanghe JR. Metabolite and ionic composition of follicular fluid from different-sized follicles and their relationship to serum in dairy cows. Anim Reprod Sci. 2004;80:201-211.
- Nandi S, Kumar VG, Manjunatha BM, Gupta PSP. Biochemical composition of ovine follicular fluid in relation to follicle size. Dev Growth Differ. 2007;49:61-66.
- Nandi PR, Mehta BK, Sengupta D. Changes in concentration of minerals in follicular fluid of growing follicles. Explor Anim Med Res. 2012.
- Tripathi S, Farman M, Nandi S, Girish Kumar V, Gupta PSP. Biochemical constituents of ovarian follicular fluid in ruminants and their significance in follicle and oocyte development. Vet Sci Med Diagn. 2015;4:3-8.
- Wise T. Biochemical analysis of bovine follicular fluid: albumin, total protein, lysosomal enzymes, ions, steroids and ascorbic acid content in relation to follicular size, rank, atresia classification and day of estrous cycle. J Anim Sci. 1987;64:1153-1169.