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Blood biochemical profiles during ovarian cycle in purebred Saanen does: comparative analysis of total protein and cholesterol levels

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Abstract

Blood biochemical profiles during the ovarian cycle provide valuable information for enhancing animal reproductive performance. This research specifically compared total protein and cholesterol profiles of purebred Saanen does maintained in tropics during follicular and luteal phases. Twelve clinically healthy second-lactation does (average body weight of 60 kg) without hormonal synchronization treatment were used in this study. The does were classified into two ovarian cycle groups, follicular (n=6) and luteal (n=6) phase, determined based on estrus stages using vaginal smear method. Blood samples were collected three times prior to morning feeding across two consecutive estrus cycles. The blood samples were further analyzed for biochemical profiles including total protein (TP) and cholesterol (CHOL) based on spectrophotometry method. The concentrations of TP and CHOL between the follicular and luteal phases were compared statistically using an independent sample T-test. Results indicated that the mean TP and CHOL levels in the follicular phase were 7.36±0.29 g/dL and 109.20±17.38 mg/dL respectively, while in the luteal group these values were 6.99±1.67 g/dL and 62.02±11.76 mg/dL respectively. Both total protein and cholesterol concentrations in this study remained within normal physiological ranges. Although no significant differences were observed in total protein levels between follicular and luteal phases, cholesterol concentrations were significantly higher during the follicular phase ($p<0.05$).

Keywords: Cholesterol; Follicular Phase; Luteal Phase; Saanen Does; Total Protein; Vaginal Smear

1. Introduction

Goats demonstrate diverse response and varying capacities for adaptation to different climatic condition [1]. The Saanen dairy goat *(Capra hircus)*, originally bred in temperate regions, has been developed and introduced in Indonesia to enhance its adaptability and productivity under tropical environments. However, extrinsic factors particularly such as feed availability [1,2], nutritional status [3,4], and environmental stressors [1,5,6] profoundly influence reproductive performance, which remains a critical determinant of efficiency, productivity, and economic viability in dairy goat systems [7]. In female goats, feed availability and its quality directly affect reproductive traits, including litter size, age at first kidding, kidding interval, and lactation length [8]. Moreover, nutritional deficiencies and imbalances can disrupt endocrine function, reduce estrus rates, impair ovarian activity, and consequently lower reproductive success [3,9,10]. Under tropical condition, high ambient temperatures further exacerbate these reproductive challenges by inhibiting ovarian follicle growth, oocyte maturation, embryo development, and conception rates [6]. Therefore, understanding the adaptive response of purebred Saanen does to such extrinsic factors in tropical environments is essential to improve their reproductive efficiency and ensure sustainable dairy goat production in Indonesia.

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The ovarian cycle is consisted of two principal phases [11]: 1). the follicular phase, characterized by follicular waves development leading to ovulation, and 2). the luteal phase, extending from corpus luteum formation to regression [12,13]. Vaginal smear has been widely applied as a non-invasive diagnostic technique to identify these cyclic phases [14,15] , by evaluating vaginal epithelial cell morphology of parabasal, intermediate, and superficial cells, which vary in estrus cycle under the influence of sex hormones [16,17]. During estrus, keratinized superficial cells dominate the smear, whereas intermediate cells predominate during metestrus or diestrus, and parabasal cells are more abundant during proestrus [18–20]. The follicular phase encompasses proestrus and estrus stages, while the luteal phase includes metestrus and diestrus [21]. These cytological patterns reflect underlying endocrine dynamics and provide valuable physiological indicators of reproductive status in does.

Blood biochemical profiling complements vaginal cytology by providing insights into the physiological and metabolic processes associated with reproduction. Blood biochemical profiles reveal essential information about the health status, nutritional condition, and fertility of dairy animals [2,22]. Profiling specific serum metabolites linked to protein, lipid, and carbohydrate metabolism helps assess nutritional status and reproductive potential [23]. Serum total protein reflects dietary protein intake and helps detect physiological abnormalities [24]. It is associated with gonadotropin-releasing hormone (GnRH) regulation, which influences ovarian activity [3,25]. Cholesterol functions as a precursor for steroid hormone synthesis [26], and varies across the estrus cycle, gestation, and lactation, while also serving as an energy source during lactation [27,28]. Variations in blood biochemical parameters are influenced by several factors, including breed, age, sex, genetics, stress, reproductive status, physiological status, nutrition, and environmental factors [29,30]. Despite extensive research on the effects of nutrition and environment on reproductive physiology, the influence of different ovarian cycle phases on blood biochemical parameters in Saanen does under tropical conditions remains poorly understood. Therefore, this study aimed to compare the blood biochemical profiles (total protein and cholesterol) of purebred Saanen does during the follicular and luteal phases of the ovarian cycle, in order to provide a better understanding of their development in tropical region.

2. Materials and Methods

2.1. Experimental subjects and design

Twelve clinically healthy purebred Saanen does in their second lactation were used in this study, with an average body weight of 60 Kg. All animals were confirmed free of detectable reproductive disorders and exhibited natural estrus without hormonal synchronization. They were maintained under uniform management practices at the Center for Superior Cattle Breeding and Forage Animal Feed Baturraden (BBPTU-HPT Baturraden) Indonesia (7°18′08.5″S, 109°15′13.4″E), characterized by average temperatures of 22.8°C and 84.4% relative humidity. Animals received a standardized local diet consisting of *Calliandra calothyrsus, Penissetum purpureum cv. Mott*, and concentrate with ad-libitum water access. Animals were classified into two groups based on their ovarian cycle status, follicular (n=6) and luteal (n=6). Blood samples were collected from both groups, with status of follicular and luteal phases reconfirmed simultaneously using vaginal smear.

2.2. Vaginal smear sampling and observation

Vaginal smears were collected by gently rolling wet sterile cotton swabs against each animal's vaginal mucosa, then immediately transferred on glass microscope slides. Slides with smear materials were air-dried, fixed in 70% alcohol for 7 minutes, and stained with 3% Giemsa solution for 45 minutes [20]. Percentages of parabasal, intermediate, and superficial cells on slides were quantified at 100× microscope magnification, with follicular and luteal phases classified according to Grunet's criteria [11,31] at the Laboratory of Animal Physiology and Reproduction, Faculty of Animal Science, Universitas Gadjah Mada.

2.3. Blood sampling and biochemical measurement

Blood samples (3 mL each) were aseptically collected from the jugular vein of each doe prior to morning feeding. Sampling was conducted three times at 18-day intervals over two consecutive estrus cycles (totaling 36 days). Samples were transferred to EDTA-anticoagulant tubes, centrifuged at 3000 rpm for 15 min to obtain serum. Serum total protein and cholesterol were analyzed using Biuret and CHOD-PAP method [28,32]. All analyses were conducted using DiaSys clinical chemistry reagents with spectrophotometric detection at the Integrated Research and Testing Laboratory, Universitas Gadjah Mada.

2.4. Ethical statement

All experimental procedures including animal handling, vaginal smear, and blood sampling, complied with the institutional standard operating procedures and ethical regulations of BBPTU-HPT Baturraden.

2.5. Statistical analysis

Data of total protein and cholesterol profiles between the follicular and luteal groups were compared statistically using an independent sample T-test model of Statistical Package for the Social Sciences (SPSS Version 27). Statistical significance was accepted at $p<0.05$.

3. Results and Discussion

3.1. Evaluation of vaginal smear during ovarian cycles

Vaginal smear analysis in this study identified three primary epithelial cell types: parabasal, intermediate, and superficial, as illustrated in Figure 1. Each cell type exhibited characteristic morphologies that corresponded to distinct phases of the estrus cycle, as detailed in Table 1.

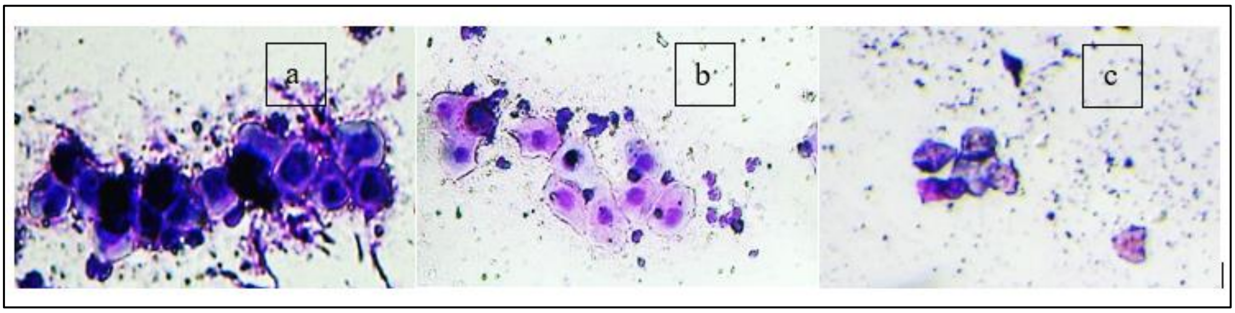

Figure 1 Vaginal epithelial's cell during estrus cycle; (a) parabasal, (b) intermediate, (c) superficial.

Table 1 Predominance of vaginal epithelial cells due to ovarian cycles

	Group 1. Follicular phase				Group 2. Luteal phase			
Saanen does (n=6)	PC (%)	IC (%)	SC (%)	Estrus cycle phase	Saanen does (n=6)	PC (%)	IC (%)	SC (%)	Estrus cycle phase
1	-	7.79±7.23	92.21±7.23	Estrus	1	90.38±5.00	9.62±5.00	-	Diestrus
2	-	12.75±3.79	87.25±3.79	Estrus	2	89.93±1.01	10.07±1.01	-	Diestrus
3	25.93±6.42	68.52±3.21	5.56±5.56	Proestrus	3	91.16±0.44	8.84±0.44	-	Diestrus
4	23.33±8.82	71.67±4.41	5.00±4.41	Proestrus	4	92.48±3.12	7.52±3.12	-	Diestrus
5	22.69±2.52	68.63±1.75	8.68±1.19	Proestrus	5	90.56±0.96	9.44±0.96	-	Diestrus
6	-	11.61±3.55	88.39±3.55	Estrus	6	87.41±6.79	12.59±6.79	-	Diestrus

Abbreviation: PC=parabasal cells, IC=intermediate cells, and SC=superficial cells.

Parabasal cells were observed as small, round to ovoid forms with large nuclei (Fig. 1a). Intermediate cells displayed round to elliptical shapes, occasionally polygonal or irregular, accompanied by relatively smaller nuclei (Fig. 1b). Superficial cells were markedly flattened irregular contours, including anucleated or keratinized variants (Fig. 1c). Quantitative cytological composition delineated phase-specific patterns (Table 1). According to Table 1, proestrus was characterized by a high proportion of intermediate cells, recorded at 68.52%, 68.63%, and 71.67%, alongside a moderate presence of parabasal cells at 25.93%, 22.69%, and 23.33%. This combination highlighted the transitional build-up of epithelial layers during this early follicular stage. During estrus, superficial cells clearly dominated at

87.25%, 88.39%, and 92.21%, accompanied by small numbers of residual intermediate cells (12.75%, 11.61%, and 7.79%) and a complete absence of parabasal cells. The transition from parabasal to superficial cells occurs due to elevated blood estrogen levels [20,31]. The rise in superficial cell numbers during estrus results from estrogen's influence, which boosts glycogen secretion and accumulation within the vaginal lumen [33]. In diestrus, the composition shifted markedly to predominantly parabasal cells (87.41%–92.48%), with only minor contributions from intermediate cells (7.52%–12.59%) and no superficial cells presented. These changes aligned well with the progesterone effects during luteal phase [31,33]. During metestrus and diestrus, corpus luteum formation elevates progesterone concentrations while simultaneously reducing estrogen levels [20]. These observation results were consistent with earlier findings reported in exfoliative cytology studies [19,20,34], which documented dynamic shifts across the estrus cycle: Intermediate cell percentages reached their highest levels during proestrus before decreasing in estrus. Parabasal cells increased during metestrus and diestrus, while their numbers decreased in proestrus and were completely absent in estrus. Superficial (or cornified) cell percentages rose during late proestrus and peaked in estrus, then declined in metestrus and disappeared entirely by diestrus [19,20,35,36].

3.2. Evaluation of blood biochemical during ovarian cycles

Table 2 presents the comparative profiles of serum total protein (TP) and cholesterol (CHOL) concentrations between the follicular and luteal phases of the ovarian cycle in purebred Saanen does.

Table 2 Blood biochemical profiles during ovarian cycles

Saanen does (n=6)	**Group 1. Follicular phase**		**Saanen does (n=6)**	**Group 2. Luteal phase**	
	TP (g/dL)	CHOL (mg/dL)		TP (g/dL)	CHOL (mg/dL)
1	7.77±1.10	139.10±38.79	1	7.66±2.39	49.60±6.57
2	7.26±1.90	100.60±10.60	2	7.91±0.46	69.30±14.50
3	7.60±1.41	94.90±2.42	3	6.91±0.46	61.70±5.21
4	7.40±1.46	101.00±3.73	4	7.53±0.24	76.50±25.26
5	7.00±0.46	98.20±14.50	5	3.70±3.73	68.30±16.89
6	7.10±0.24	121.40±25.26	6	8.20±2.06	46.70±8.27
Average	7.36±0.29	109.20±17.38*	Average	6.99±1.67	62.02±11.76*

Abbreviation: TP=total protein, and CHOL=cholesterol; *Different superscripts indicated significant difference (P<0.05).

The mean TP concentration during the follicular phase was recorded at 7.36±0.29 g/dL, while the luteal phase exhibited a mean value of 6.99±1.67 g/dL. Independent T-test analysis showed no statistically significant difference in TP levels between these phases ($p>0.05$). These findings aligned with previous research on Saanen-Ettawah crossbred does, which also reported no significant differences in TP between follicular and luteal phases [22]. Importantly, both TP values obtained in this study remained within the established normal reference range of 6.11 to 7.01 g/dL for Saanen goats [37]. The slightly elevated TP level observed in the follicular phase (7.36 g/dL) remained below previously reported values of 7.56 g/dL for mature Saanen does (>8 months of age) [38]. It was suspected that local diets provided in BBPTU-HPT Baturraden suitable in term of nutrient quantity and quality, since normal concentrations of total protein are attributed to high quality diet and health status [39]. Further investigations into protein intake and nitrogen utilization [3] are needed to accurately assess this animals' nutritional, reproductive, and overall health status.

Profiles of CHOL in the follicular and luteal phases were 109.20±17.38 mg/dL and 62.02±11.76 mg/dL, respectively, and performing in normal reference ranges, which are 80 to 130 mg/dL [37]. The CHOL concentration was differed ($p<0.05$) in each ovarian cycle group. These findings in line with the previous research about Saanen-Ettawah crossbred does [22], which was found higher cholesterol in the follicular phase. Similarly, in Bligon goats research was found tendency for an increase of cholesterol profiles in the follicular phase rather than luteal phase [40]. The higher cholesterol levels observed in the follicular phase might be associated to sampling does at the end of estrus, showing blood cholesterol peaks at the late follicular phase before declining into the luteal phase [22]. Since cholesterol is the precursor of ovarian steroids, lower cholesterol levels during luteal phase may be a result of enhanced utilization by steroidogenesis [41]. Blood cholesterol levels are regulated through four key processes: dietary absorption, endogenous synthesis in the liver, excretion as neutral steroids and bile acids, and uptake/release by peripheral tissues [42].

4. Conclusion

In conclusion, concentrations of total protein and cholesterol recorded during both follicular and luteal phases in this study remained within established normal physiological ranges. This study highlights that cholesterol levels were significantly elevated during the follicular phase, whereas total protein showed no significant differences between phases. These findings warrant further validation through comprehensive analyses of blood biochemistry, hormonal profiles, and nutritional balance to better elucidate the underlying physiological mechanisms.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflicts of interest were declared in relation to this article. All authors have reviewed and approved the final version of the manuscript.

References

[1] Mugoti A, Nyamukanza C, Munengwa A, Moyo S, Chikumba N. Effects of climate change on goat production and mitigatory measures in semiarid savanna ecosystems. Journal of Integrative Environmental Sciences. 2025; 22(1): 1-26.

[2] Sitaresmi PI, Widyobroto BP, Bintara S, Widayati DT. Effects of body condition score and estrus phase on blood metabolites and steroid hormones in Saanen goats in the tropics. Veterinary World. 2020; 13(5): 833–9.

[3] Sitaresmi PI, Hudaya MF, Kumala S, Herdis H, Sofyan A, Bintara S, Widyobroto BP, Widayati DT. Effect of short time precise dietary energy–protein in reproductive parameters of local crossbred dairy goats. Journal of Advanced Veterinary and Animal Research. 2023; 10(2): 257–68.

[4] Teixeira IAMA, Härter CJ, Vargas JAC, Souza AP, Fernandes MHMR. Review: Update of nutritional requirements of goats for growth and pregnancy in hot environments. Animal. 2024; 18:1-14.

[5] Danso F, Iddrisu L, Lungu SE, Zhou G, Ju X. Effects of heat stress on goat production and mitigating strategies: A Review. Animals. 2024; 14: 1-22.

[6] Adjassin JS, Assani AS, Bani AA, Worogo HSS, Alabi CDA, Assogba BGC, Azando EBV, Alkoiret IT. Impact of heat stress on reproductive performances in dairy goats under tropical sub-humid environment. Heliyon. 2022; 8: 1-6.

[7] Mamutse J, Susanto A, Purwantini D, Sumaryadi MY, Subagyo Y, Sodiq A. Exploring the non-genetic factors that affect reproductive traits of Saanen goats in Indonesia. Journal of Agriculture and Rural Development in the Tropics and Subtropics. 2023; 124(2): 129–35.

[8] Mawussi EB, Assah AK, Kulo EA. Reproduction and milk production performance of Saanen dairy goat in Southern Togo (West Africa). Advances in Animal and Veterinary Sciences. 2024; 12(6): 1028–33.

[9] Chaves AS, Silva F, Valentim R, Quintas H. Body condition in small ruminants—effects of nutrition on the hypothalamic–pituitary–gonad axis and ovarian activity that controls reproduction. Physiologia. 2024; 4: 213–25.

[10] Susilowati S, Mustofa I, Khairullah AR, Oktanella Y, Agus A, Bramantya C, Hermadi HA, Akintunde AO, Tophianong TC. Effect of minerals and concentrate supplementation on the fertility of Pote goat during the dry season. German Journal of Veterinary Research. 2024; 4(3): 185–96.

[11] Kumala S, Sitaresmi PI, Suranindyah Y, Widayati DT. Profiles of steroid hormones on follicular and luteal phase in Saanen Etawah Crossbred (SAPERA) does. Advances in Biological Sciences Research. 2022; 21: 205-29.

[12] Bhoi DB, Raval JK, Dangar NS. Technological advances in goat reproduction. Bulletin of Environment, Pharmacology and Life Sciences. 2020; 9(12): 189-94.

[13] Kim SJ. Patterns of ovarian changes associated with surge mode secretion of gonadotropin in dairy cows with cyclic estrous cycle. Journal of Animal Reproduction and Biotechnology. 2018; 33(4): 297–304.

[14] Perez-Guerra UH, Quispe YM, Gonzáles HI, Luque N, Ruelas DA, Carretero MI, Gutiérrez-Reinoso MA, Pérez-Durand MG, García-Herreros M. Ovarian follicular dynamics and its functional significance in relation with follicle deviation, vaginal cytology, and hormone profiles in Llamas (Lama glama). Animals. 2022; 12: 1-15.

[15] Yahia A, Kaidi R, Hamrat K. The post-partum exfoliative vaginal cytology of local goats in Northern Algeria. Bulletin UASVM Veterinary Medicine. 2016; 73(1): 57-60.

[16] Bello UM, Ojo SA, Ghaji A, Voh AA, Bappah MN, Igbokwe CO. Cyto-morphological changes in exfoliated vaginal cells and thermal rhythms of Red Sokoto does during the oestrous cycle. Advances in Animal and Veterinary Sciences. 2023; 11(1): 94–103.

[17] Sharma M, Sharma N. Vaginal cytology: An historical perspective on its diagnostic use. Advances in Animal and Veterinary Sciences.2016; 4(6): 283–8.

[18] Nurcholis, Sumaryanti L. Estrus detection of PE goats using the ASM application and confirmed by vagina cytology. IOP Conference Series: Earth and Environmental Science. 2024; vol 1341 (Institute of Physics)

[19] Sitaresmi PI, Widyobroto BP, Bintara S, Widayati DT. Exfoliative vaginal cytology of Saanen goat (Capra hircus) during estrus cycle. IOP Conference Series: Earth and Environmental Science. 2019; vol 387 (Institute of Physics)

[20] Magistrama ME, Diatmono DFF, Masruroh MT, Padmawati FG, Sitaresmi PI, Suranindyah YY, Widayati DT. Optimizing estrus detection techniques in tropical Saanen does (Capra aegagrus hircus): A comparative study. Pakistan Journal of Agricultural Research. 2024; 37(4): 355–62.

[21] Kasimanickam R, Harting Q, Hanson R, Boler R. Estrus and ovulation synchronization strategies in beef cattle. Clinical Theriogenology. 2025; 17: 9–23.

[22] Diatmono DFF, Kumala S, Sitaresmi PI, Paramita SW, Andi M, Suranindyah YY, Widayati DT. Response of blood metabolite levels of Saanen-Etawah crossbred does to ovarian cycle. Advances in Animal and Veterinary Sciences. 2024; 12(6): 1034–40.

[23] Hussein HA, Thurmann JP, Staufenbiel R. 24-h variations of blood serum metabolites in high yielding dairy cows and calves. BMC Veterinary Research. 2020; 16(327): 1-11.

[24] Asrar SIN, Rimayanti R, Ismudiono I, Mafruchati M, Yuliani MGA, Riady G. Total protein, albumin, and globulin levels of blood serum in repeat breeder Holstein Friesian cows. Ovozoa: Journal of Animal Reproduction. 2023; 12(2): 90–8.

[25] Setiawati EN, Sumaryadi MY, Saleh DM. Hematological and blood metabolite response in relation to the conception rate of Pasundan cows with synchronized estrous and ovulation. Journal of the Indonesian Tropical Animal Agriculture. 2020;.45(4): 287–97.

[26] Islamiyati R, Azis IU, Amal I, Bahar MR, Sabil S, Santoso S, Khan FA, Nurlatifah A, Diansyah AM, Irawan F, Damayanti E. Integrative metabolomics and hormonal profiling reveal biomarkers of milk yield efficiency in Sapera dairy goats under tropical conditions. Veterinary World. 2025; 18(11): 3594–606.

[27] Barraso C, Sánchez P, García A. Haematological and biochemical parameters in Verata goat breeds reared in a Mediterranean semi-extensive system. Archivos de Zootechnia. 2025; 74(287): 210–6.

[28] Widayati DT, Suranindyah YY, Kumala S, Sitaresmi PI. The comparison of creatinine, iron, and blood metabolites in primiparous and multiparous Saanen Etawah crossbred goats in tropical country, Indonesia. Acta Veterinaria Brno. 2024; 93: 377–83.

[29] Siza M, Tyasi LT, Rust J, Ikusika S, Zuko M, Tokozwayo S, Luxolo Q, Rumosa-Gwaze F, Yawa M, Washaya S. Effect of season, age and physiological status on body weight and blood metabolites of communal sheep. Veterinary and Animal Science. 2025; 30: 1-8.

[30] Hien NTT. Physiological and biochemical blood indicators of Boer X Saanen crossbred goats raised in Binh Duong Province, Vietnam. International Journal of Multidisciplinary Research and Analysis. 2024; 7(9): 4150–6.

[31] Sitaresmi P I, Wulandari A, Hudaya MF, Santoso S, Herdis H, Anwar R I, Nurlatifa A, Maulana H, Yulianto MDE, Widayati DT. Estrus detection on different Thoroughbred crossbreed horses with vaginal smear and vaginal acidity method. IOP Conference Series: Earth and Environmental Science. 2024; vol 1360 (Institute of Physics).

[32] Megerssa YC. Stability of some biochemical parameters in sheep and goat serum stored at −20°C. Veterinary Medicine: Research and Reports. 2022; 13: 323–8.

[33] Setiadi D, Agil M, Arifiantini I, Sajuthi D, Manansang J, Hastuti Y, Liwa S. Vaginal cytology characteristics during estrous cycle and clinical sign during estrus in Banteng (Bos javanicus d'Alton 1823). Acta Veterinaria Indonesiana. 2020; 8(3): 40–7.

[34] Indhumathi B, Joseph C, Kulasekar K, Sivaselvam SN, Sarath T, Monica G. Vaginal exfoliative cytology during normal and induced estrum in non-descript goats (Capra hircus)-A Comparative study. Haryana Vet. 2020; 59(SI): 20-2.

[35] Sitaresmi PI, Astuti PK, Widyobroto BP, Bintara S, Widayati DT. Exfoliative vaginal cytology and vaginal acidity profile in Ettawa-Saanen grade does. International Journal of Pure and Applied Mathematics. 2018; 118(24): 1-16.

[36] Rahayu J, Salmah S, Yusuf M, Ramadhan B, Sari DK. The profile and percentage of vaginal epithelial cell numbers during the estrous cycle in Bali cattle. IOP Conference Series: Earth and Environmental Science. 2019; vol 247 (Institute of Physics).

[37] Meza-Herrera CA, Pacheco-Alvarez P, Castro OE, MacIas-Cruz U, Avendaño-Reyes L, Mellado M, Veliz-Deras FG, Contreras-Villarreal V, Abad-Zavaleta J, Rodriguez-Martinez R, Arellano-Rodriguez G. Beta-carotene supplementation positively affects selected blood metabolites across time around the onset of puberty in goats Czech Journal of Animal Science. 2017; 62(1): 22–31.

[38] Elitok B. Reference values for hematological and biochemical parameters in Saanen goats breeding in Afyonkarahisar Province. Kocatepe Veterinary Journal. 2012; 5(1): 7–11.

[39] Dauda A, Saingbe P, Jibrin D. Haematological and biochemical parameters of West Africa Dwarf goats fed pleurotus tuber regium biodegraded groundnut shells included diets. International Journal of Molecular Biology. 6(I): 19–23.

[40] Kartikasari N, Ummami R. Cholesterol levels In Bligon goats during estrous cycle. Sain Veteriner. 2014; 32(2): 162–7.

[41] Aydilek N, Varişli Ö, Selek Ş, Korkmaz Ö, Atli MO, Taşkin A. The effect of estrous cycle on oxidant and antioxidant parameters in dairy cows. Kafkas Universitesi Veteriner Fakultesi Dergisi. 2014; 20(5): 703–9.

[42] Vasilenko T. Multidirectional changes in the blood cholesterol in mammals of different species during pregnancy and lactation. International Journal of Sciences: Basic and Applied Research. 2016; 30(2): 59–70.