Turkish Journal of Agriculture - Food Science and Technology, 11(8): 1331-1336, 2023
DOI: https://doi.org/10.24925/turjaf.v11i8.1331-1336.5946

Turkish Journal of Agriculture - Food Science and Technology

Available online, ISSN: 2148-127X | www.agrifoodscience.com | Turkish Science and Technology Publishing (TURSTEP)

The Effect of Selenium, Vitamin E, Vitamin A and Vitamin D3 Applications on Fertility in Awassi Sheep with Estrus Synchronization During the Breeding Season

Mehmet Efe[1,a], Mustafa Kemal Sarıbay[1,b,*], Ece Koldaş Ürer[1,c], Ayşe Merve Köse[1,d]

[1]Department of Obstetrics and Gynecology, Faculty of Veterinary Medicine, Hatay Mustafa Kemal University, 31060, Hatay, Türkiye
[*]Corresponding author

A R T I C L E I N F O

Research Article

Received : 16-01-2023
Accepted : 25-06-2023

Keywords:
Sheep
Synchronization
Selenium
Vitamin E
Vitamin A

A B S T R A C T

The purpose of this study was to determine the effects of selenium, vitamin E, vitamin A, and vitamin D3 treatments on reproductive parameters in Awassi sheep fed solely dry grass and grain stubble during the breeding season with estrus synchronization. Seventy-five sheep were implanted with intravaginal sponges containing 20 mg of flugestone acetate for 9 days for estrus synchronization. On the day the sponges were inserted, the first group received an intramuscular injection of a supplement containing 200,000 IU of vitamin A, 30,000 IU of vitamin D3, and 20 mg of vitamin E, as well as a supplement containing 1 mg of sodium selenite and 60 mg of vitamin E. The second group was the control group, with no supplementary vitamin injected. On the day of sponge removal, the sheep received intramuscular injections of 500 IU PMSG and 250 mcg cloprostenol sodium in both groups. The sheep in the first group were given a second injection of the supplement on the same day that contained 20 mg of vitamin E, 30,000 IU of vitamin D3, and 200,000 IU of vitamin A. The sheep that showed signs of estrus were mated naturally after the estrus synchronization. Estrus rates were 86.11% and 85.29%, conception rates were 74.19% and 58.62%, pregnancy rates were 63.88% and 50%, lambing rates were 100% and 100%, and litter size was found to be 126.08% and 123.52% in Group I and II, respectively (P=0.858). Although there was no significant difference in the reproductive characteristics between the groups (P>0.05), Group I had a greater pregnancy rate and litter size. During the breeding season, it is believed that the regular application of vitamin and mineral supplements on a program basis in sheep fed only dry pasture and grain stubble contributed to fertility.

[a] me111701003@gmail.com https://orcid.org/0000-0002-7636-7007
[b] saribaymk@yahoo.com https://orcid.org/0000-0002-9903-4942
[c] ecekoldas@gmail.com https://orcid.org/0000-0002-9631-8501
[d] aysemervekose@gmail.com https://orcid.org/0000-0003-1863-5955

Introduction

In sheep herds, estrus synchronization during the breeding season provides estrus, ovulation, and lambing simultaneously (Alaçam, 1993). Hormones (progestins, prostaglandins, pregnant mare serum gonadotropin, gonadotropin-releasing hormone) are frequently used for estrus synchronization in the breeding season (Alaçam, 1993; Alaçam, 1999; Wildeus, 2000). Vitamin and mineral supplementation is also used to increase fertility during synchronization. According to research, sheep bred in areas where dry grass and grain stubble are fed may benefit from the addition of vitamins A, E, D3, and selenium, especially during breeding season (Chew, 1993; Boland et al., 2005; Koyuncu and Yerlikaya, 2007; Köse et al., 2013; Yeşil and Sarıözkan, 2017).

The synthesis of ovarian steroid hormones and the process of folliculogenesis are both require vitamin A (Bagavandoss and Midgley, 1988; Bozkurt et al., 1998; Haliloğlu et al., 2002; Pu et al., 2014). Animal products and oils contain vitamin A, while most grains other than corn do not. Consequently, ruminants may suffer from vitamin A deficiency. A lack of vitamin A can result in the formation of follicular and luteal cysts, inadequate CL development, and embryonic and fetal mortality from insufficient progesterone secretion. Furthermore, it is believed that conditions, such as anestrus, sub-estrus, and delayed ovulation can be occurred (Eberhardt et al., 1999; Bindari et al., 2013). It has been reported that the use of vitamin A supplements improves fertility parameters and reduces the prevalence of reproductive diseases (Bindari et al., 2013; Yeşil and Sarıözkan, 2017).

Although the primary function of vitamin D is to regulate calcium and phosphorus absorption and balance, bone mineralization, and neuromuscular functions (Horst et al., 2003), but it is also linked to fertility. The fact that the vitamin D receptor is expressed in granulosa cells suggests that vitamin D is essential for steroidogenesis. Furthermore, because it affects the gene expression of anti-mullerian hormone and follicle-stimulating hormone, it appears to be a crucial factor in follicle development (Muscogiuri et al., 2017). Its deficiency can result in sub-estrus and structural abnormalities in the fetus (Yeşil and Sarıözkan, 2017; Turan, 2018). The active form of vitamin D, calcitriol (1,25(OH)2D3), is reported to increase the synthesis of progesterone by 13%, estradiol by 9%, and estrone by 21% (Muscogiuri et al., 2017).

Vitamin E prevents the formation of free radicals that have detrimental effects on the structure of intracellular membranes by saturating peroxides and hydroperoxides (Infante, 1999). Disruption of ovarian function, vascular degeneration in the embryo, early embryonic death, fetal resorption, stillbirths, and fetal muscular dystrophy can all result from vitamin E deficiency in sheep (Braun et al., 1991; Kott et al., 1998; Kaçar et al., 2008).

The most important function of selenium is to participate in the structure of Glutathione peroxidase (GSH-Px), which protects the cell membrane from free radicals during lipid peroxidation (Hostetler et al., 2003; Mehdi and Dufrasne, 2016; Yeşil and Sarıözkan, 2017). Selenium has been linked to the synthesis of estrogen and prostaglandins, as well as the proliferation of granulosa cells (Nebbia, 1982). Furthermore, it protects follicles from the damage caused by increased oxidative stress during folliculogenesis (Ceko et al., 2014). Selenium deficiency can cause low fertility, sub-estrus, increased stillbirth rate, low birth weight, growth retardation, and immune system deficiency (Humann-Ziehank, 2016).

It is stated that oxidative stress, which develops due to the increase in the level of free radicals in the organism, can lead to infertility (Arechiga et al., 1998; Agarwal and Allamaneni, 2004). Free radicals such as peroxides and hydroperoxides that form during oxidative stress cause damage to the structural integrity of the cell by oxidizing unsaturated fatty acids of mitochondrial, microsomal, and cell membrane phospholipids (Infante, 1999). It is suggested that estrus synchronization techniques can also raise the concentration of free radicals (Arechiga et al., 1998). It is stated that free radicals increasing in the preovulatory follicle fluid adversely affect the quality of the oocyte, fertilization rate, and embryo quality (Jowzik et al., 1999). On the other hand,According to reports, vitamin E can improve oocyte quality and maturation, decrease the concentration of free radicals in the follicular fluid, and have positive effect on fertilization and early embryonic development (Agarwal and Allamaneni, 2004; Agarwal et al., 2005; Ceko et al., 2014). Selenium assists vitamin E binding plasma lipoproteins. Given the similarities of their effects and the similar symptoms associated with their deficiencies, simultaneous use is recommended, it is recommended that they be applied together (Hostetler et al., 2003; Mehdi and Dufrasne, 2016). Se and Vit E administrations in sheep are reported to improve fertility by preventing oxidative damage caused by progesterone used in estrus synchronization (Hostetler et al., 2003; Mehdi and Dufrasne, 2016; Kuru et al., 2017).

According to reports, the Mediterranean region's pastures and grain stubbles are deficient in Se, vitamin E, and vitamin A in the summer and fall, which are thought to have a positive impact on reproductive processes. The study's objective was to establish the effects of Se, vitamin E, vitamin A, and vitamin D3 treatments on reproductive parameters in Awassi sheep with estrus synchronization that were solely fed natural grass and grain stubble during the breeding season.

Material and Methods

The study was conducted at a private commercial sheep farm in the Hatay province during the breeding season (36° 26° North latitude, 36° 56° East longitude) at the beginning of July 2021. Animal material was 75 Awassi sheep aged 2–6 years who had given birth at least once and weighed 45–60 kg. The average ambient temperature was 31.6 °C during the day and 25.13 °C at night, and the average length of the day and night was 14 hours, 15 minutes, and 9 hours, 45 minutes, respectively. Feeding and management schdule of farm was followed during the study. Sheep were not in lactation, spent the day eating on pasture and grain stubble.

Sponges that contain 20 mg of flugestone acetate (Chronogest CR®, Intervet, Türkiye) were inserted into the vagina of all the sheep by speculum. After that, sheep were randomly divided into two groups: treatment (Group I, n=38) and control group (Group II, n=37). On the day of inserting the sponges to the sheep in the first group, 1 ml of selenium and Vit E mixture (1 mg/1 ml of sodium selenite and 60 mg/ml of Vit E, Yelvit®, Teknovet, Türkiye) and 1 ml/50 kg of Vit A, Vit D3 and Vit E (200,000 IU/ml Vit A, 30,000 IU/ml Vit. D3 and 20 mg/ml Vitamin E containing Adevil®, Vilsan, Türkiye) mixture injected intramuscularly. The sheep in the second group didn't received any treatment. Sponges were left in the vagina for 9 days in both groups, and during the removal of the sponges, 500 IU PMSG (Chronogest/PMSG, 6000 IU, Intervet, Istanbul, Türkiye) and 250 µg cloprostenol sodium (Minoprost®, Vilsan, Türkiye) were administered intramuscularly. The sheep in the treatment group received a second injection of vitamin A, vitamin D3, and vitamin E on the day of sponge removal (Figure 1).

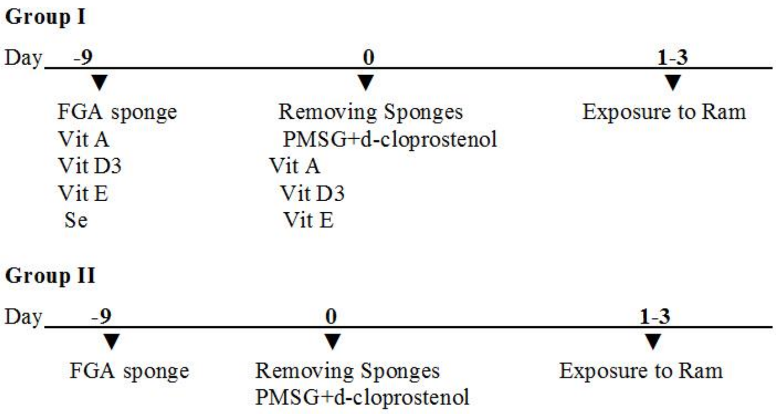

Figure 1. Applications in Group I and Group II

Table 1. Fertility parameters of Group I and Group II

	Estrus rate (%, x/n)	Conception rate (%,x/n)	Pregnancy rate (%,x/n)	Kidding rate (%,x/n)	Litter size (%,x/n)
Group I	86.11(31/36)	74.19 (23/31)	63.88 (23/36)	100 (23/23)	126.08 (29/23)
Group II	85.29 (29/34)	58.62 (17/29)	50 (17/34)	100 (17/17)	123.52 (21/17)
P	0.922	0.275	0.334	---	0.858

24 hours a day after the sponge removal, the rams joined the flock and spent an hour with the sheep twice daily (morning and evening). The ewes that stood estrus mated and were taken out of the herd and put in a separate area. The sheep were examined for pregnancy 50 days after mating using a 6-8 MHz probe real-time ultrasound device (Falco, Pie Medical, Netherlands). The sheep were considered as pregnant when the part of placenta, fetus, and heartbeat of fetus were viewed during the ultrasound examination.

The Stata 12/MP4 statistical package program was used to conduct all statistical analyses for the study. All variables that were received had their descriptive statistics calculated and reported as "Percent-Frequency." Chi-square analysis was applied to look into any differences in estrus frequency, pregnancy frequency, and conception frequency between the study's groups. The number of offspring in each group was assessed using a Student's t-test. Litter size was also represented as a "Percentage" for the number of offspring in each group. The threshold for statistical significance was set at $P<0.05$.

The following formulas were used to determine the reproductive parameters evaluated in the study:

Estrus ratio: (Number of sheep stand estrus / number of sheep in group) x 100

Pregnancy rate: (Number of pregnant sheep / Number of sheep in the group) x 100

Conception rate: (Number of pregnant sheep / Number of vaccinated sheep) x 100

Kidding rate: (Number of sheep lambing / Number of pregnant sheep) x 100

Litter size: (Number of lambs born / Number of sheep that lambing) x 100

Results

Three sheep were removed from the study and not counted in the evaluation: two sheep in Group I with fallen sponges, one sheep in Group II with fallen sponge, and one sheep with laminitis.

Estrus rates were 86.11% and 85.29%, conception rates were 74.19% and 58.62%, pregnancy rates were 63.88% and 50%, kidding rates and litter size were 100% and 100%, and 126.08% and 123.52%, in Groups I and II, respectively (Table 1).

Discussion

The fact that free-grazing is the predominant method of sheep breeding in our country suggests that the mineral content of pastures and fields may have an impact on fertility. The current study's objective was to determine the effect of Se, vitamin E, vitamin A, and vitamin D3 supplements on reproductive parameters in Awassi ewes that synchronized in the breeding season under field breeding condition.

The number of free radicals in the preovulatory follicular fluid rises as a result of estrus synchronization. It is suggested that these conditions have a negative effect on oocyte quality, fertilization rate, and embryo quality (Arechiga et al., 1998; Jowzik et al., 1999; Miyamoto et al., 2010). It is also reported that it can damage granulosa cells and luteinizing hormone (LH) receptors and reduce progesterone synthesis (Albertini and Barrett, 2002;Taniguchi et al., 2009). It has been sated that vitamin E can lower the number of free radicals in follicular fluid (Jowzik et al., 1999; Agarwal et al., 2005; Ceko et al., 2014), and selenium helps preserve follicles and aids activity of vitamin E (Hostetler et al., 2003; Ceko et al., 2014; Mehdi and Dufrasne, 2016). Hemingway (2003) reported that the combination of vitamin E and selenium increased the conception rates and reduced the early embryonic death in sheep. According to Munoz et al. (2008), the addition of Se has beneficial effects on implantation and fetal development. Sen et al. (2011) state that Se and vitamin E supplementation increase the concentration of estrogen in preovulatory follicles, which has a positive effect on ovulation and pregnancy rates. As a result of the low levels of vitamin E in the dry pastures and stubbles, Koyuncu and Yerlikaya (2007) note that the risk of deficiency is considerable in sheep grazing in this area. From June through December, sheep's main feed sources are dry pastures and grain stubble. Given that vitamin E and α-tocopherol levels are insufficient in dry pastures in the Mediterranean region, particularly in summer and autumn, animals fed this type can suffer from severe vitamin E deficiency (Liu et al., 2014).

Conception rates in progesterone-based estrus synchronization in sheep are reported to be in the 70-80% range (Gordon, 1997). In the current study, conception rates in Groups I and II were 74.19% and 58.62%, respectively (Table 1). The pregnancy rate of the control group was found to be lower than the rate stated by Gordon (1997). Although there was no statistical difference between the groups, it was thought that giving stubble to sheep might have adversely affected fertility in the sheep in this study, given that it causes vitamin E deficiency (Koyuncu and Yerlikaya, 2007; White and Rewell, 2007; Liu et al., 2014). Awawdeh et al. (2019) reported that conception rates in the Awassi sheep during the transition period were 63.9% in the control group and 86.8% in the group that received vitamin E and Se injections after sponge insertion, removal, and on the 19th day after sponge removal. They are also reported that vitamin E and selenium supplements applied at the beginning of the breeding season when sheep start to graze on dry pastures and stubbles have beneficial effects on increasing fertilization rates. Koyuncu and Yerlikaya (2007) found that the pregnancy rates were not different between the Se, Se+VitE and control groups in Merino sheep, but the Se group had the highest oestrus rate. According to Farahavar et al. (2020) pregnancy rate of ewes after administartion of 0.5 mg/ml sodium selenite and 50 IU DI-α-tocopherol for 3 times during synchronization protocol (2 weeks before CIDR insertion, at the CIDR insertion, at the CIDR removal) was 61.11%, while it was 55.56% in the control group. Pregnancy rates in our study were 50% in the control group and 63.88% in the group that received vitamin E and selenium supplements. Despite a 13.88% rise in pregnancy rates, there was no statistically significant change (P=0.334) (Table 1). It has been reported that Mediterranean dry grass pastures are deficient in vitamin E during the summer and fall (Liu et al., 2014). On the other hand, Koyuncu and Yerlikaya (2007) stated that sheep grazing on dry pastures and grain stubble are at a significant risk of vitamin E deficiency. The number of animals used in the study, the application time (before and/or after breeding), the route of administration, the frequency, dose, or amount of administration, the environment and management style of the farms, ewe breed, the phase of cyclic activity, feeding, and most importantly, whether there was a deficiency in vitamin E and Se in sheep prior to the applications were factors reported by researchers (Köse et al., 2013; Awawdeh et al., 2019) as to why the pregnancy rates varied between studies. It is thought that the result obtained in our study may depend on many factors, especially the small sample size (or numbers). Ruminant fertility is directly impacted by vitamin A, which the organism naturally produced as retinol, retinal, and retinoic acid (Chew, 1993). Because of its antioxidant properties (Nayyar and Jindal, 2010) and support for the growth of embryos and fetuses as well as progesterone production, vitamin A has beneficial effects on fertility (Chew, 1993; Kolb and Seehawer, 1998). Furthermore, it has an impact on ovulation and folliculogenesis process (Bozkurt et al., 1998; Haliloğlu et al., 2002; Brown et al., 2003; Hashem et al., 2016). Depending on the severity of the vitamin A deficiency, gametogenesis abnormalities and embryonic fatalities are known to occur. In addition, diseases like impairment of ovum's structure, a lack of progesterone synthesis, reduced fertilization ability of ovum, infertility are also possible during vitamin A deficiency (Chew, 1993; Bozkurt et al., 1998; Eberhardt et al., 1999). In Jordan, where mostly natural pastures and stubble are used for sheep breeding, Harb (1994) states that the low nutritional content of these pastures from June to the end of September may have detrimental effects on fertility. Given that vitamin A is only available in green grass, it is reported that sheep fed on grain stubble and dry pastures of dry months for three to four months have reduced fertility because of vitamin A deficiency (Abdelrahman and Al-Karablieh, 2002). The present study suggests that the nutritional quality of dry pasture and grain stubble in the breeding season may be low, as suggested by Harb (1994), because pregnancy rates were lower in the control group than in the treatment group after feeding sheep just pasture and grain stubble.

Vitamin D is crucial for absorption of calcium and phosphorus, mineralization of bones, and neuromuscular activity, but also for fertility. Vitamin D stimulates steroidogenesis in granulosa cells, and influences the gene expression FSH and increases the synthesis of progesterone and estrogen. Its deficiency has been linked to sub-estrus, according to reports (Muscogiuri et al., 2017; Yeşil and Sarıözkan, 2017).

Although the roles played by vitamins and minerals in the body and the disorders caused by their deficiency are known separately, it is advised to be used simultaneously due to their interactions. Study of Birdane and Avdatek (2020) estrus rate, pregnancy rate, and litter size in the study group of sheep that were synchronized with FGA during the breeding season and administered a combination of vitamin A (300,000 IU), vitamin D3 (100,000 IU), and vitamin E (50 mg) intramuscularly were 92.5%, 87.5%, and 154%, respectively, compared to 90%, 75%, and 137% in the control group that received no treatment. In Awassi sheep synchronized with FGA outside of breeding season, Özar et al. (2022) founded pregnancy rates of 54.05% and 58.33%, respectively, in the group given Vitamin E, Se, and β-carotene and the control group. They emphasized that there was no vitamin/mineral deficiency because of the good quality pasture conditions in March, when the study was conducted. It is also reported in the same study that geographical characteristics and climatic conditions of breeding region may have effect on pregnancy rate be related to the. It has been reported that the possible reasons for the different results obtained in studies investigating the effects of vitamins A and E in sheep are variables such as vitamin dose, application frequency, form, timing, pasture and feed quality (Birdane and Avdatek, 2020). Harb (1994) underlines that vitamins A, D3, and E should be supplemented when dry pasture and stubble are used as sheep feed. Abdelrahman and Al-Karablieh (2002) investigated the effects of vitamin A, D3, and E supplementation on fertility in Awassi sheep during the breeding season, with pregnancy rates of 74.1% and 82.1% in the control and treatment groups, respectively, and reported that the sheep had an 8% rise in the pregnancy rate with this application particularly when vitamin A deficiency was a significant issue. The reproductive parameters in the group that received vitamins A, D3, E, and Se in the current study did not differ statistically from the control group (Table 1). It would not be accurate to conclude that the supplements were entirely unsuccessful, as these vitamin and mineral levels in sheep were not evaluated before the study. Pregnancy rate increased by 13.88% even though there was no statistically difference (P>0.05) between the treatment group and the control group. It is believed that this increase would have substantial economic contributions for the breeder.

Since the number of offspring represents a significant economic output in the animal breeding, it has been established that the proportional increase in pregnancy rate and litter size cannot be disregarded. It was found that estrus synchronization in the sheep fed on dry pasture and grain stubble throughout the breeding season, where herd management is crucial, may benefit from the routine administration of vitamin and mineral supplements on a program basis. However, in further studies to be conducted on the same subject, it is recommended to expand the sample size in order to reach concrete data.

Acknowledgements

This study was conducted pursuant to the 16/06/2021 dated and 2021/04-07 numbered approval of the Local Ethics Board for Animal Experiments of Hatay Mustafa Kemal University. The article was summarized from the master's degree thesis of Mehmet EFE.

References

Abdelrahman MM, Al-Karablieh EK. 2002. Effect of Vitamins AD3E Injections on Reproductive Performance and Net Cash Revenue from Awassi Sheep Raised under Semi-intensive System. J King Saud Univer, 14: 15-22.

Agarwal A, Allamaneni SS. 2004. Role of free radicals in female reproductive diseases and assisted reproduction. Reprod Biomed Online, 9(3): 338-347

Agarwal A, Gupta S, Sharma RK. 2005. Role of oxidative stress in female reproduction. Reprod Biol Endocrin, 3(1): 1-21.

Alaçam E. 1993. Koyunlarda siklik düzen ve üremenin denetlenmesi. Hayvancılık Araş Derg, 3: 65-69.

Alaçam E. 1999. Üreme Kontrolü. In: Alaçam E (editör). Evcil Hayvanlarda Doğum ve İnfertilite, Medisan, Ankara, pp. 71-81.

Albertini D, Barrett S. 2002. Oocyte-somatic cell communication. Reprod Suppl, 61: 49-54.

Arechiga CF, Vazquez-Flores S, Ortiz O, Hern J, Porras A, McDowell LR, Hansen PJ. 1998. Efect of injection of β-carotene or Vitamin E and selenium on fertility of lactating dairy cows. Theriogenology, 50: 65-76.

Awawdeh MS, Eljarah AH, Ababneh MM. 2019. Multiple injections of vitamin E and selenium improved the reproductive performance of estrus-synchronized Awassi ewes. Trop Anim Health Prod, 51(6): 1421-1426.

Bagavandoss P, Midgley AR. 1988. Biphasic action of retinoids on gonadotropin receptor induction in rat granulosa cells in vitro. Life Sci, 43(20): 1607-1614.

Bindari YR, Shrestha S, Shrestha N, Gaire TN. 2013. Effects of nutrition on reproduction-A review. Adv Appl Sci Res, 4(1): 421-429

Birdane MK, Avdatek F. 2020. Effect of vitamin A, D3, E treatment on fertility in the Pırlak sheep. Kocatepe Vet J, 13(2): 179-184.

Boland TM, Brophy PO, Callan JJ, Quinn PJ, Nowakowski P, Crosby TF. 2005. The effects of mineral supplementation to ewes in late pregnancy on colostrum yield and immunoglobulin G absorption in their lambs. Livest Prod Sci, 97(2-3): 141-150.

Bozkurt T, Gür S, Sönmez M. 1998. Vitamin AD3E'nin ineklerin döl verimi üzerine etkisi. YYÜ Vet Fak Derg, 9(1): 80-82.

Braun U, Forrer WF, Lutz H. 1991. Selenium and vitamin E in blood sera of cows from farms with increased incidence of disease. Vet Rec, 128: 543-547.

Brown JA, Eberhardt DM, Schrick FN, Roberts MP, Godkin JD. 2003. Expression of retinol-binding protein and cellular retinol binding protein in the bovine ovary. Mol Reprod Dev, 64: 261-269.

Ceko MJ, Hummitzsch K, Hatzirodos N, Bonner WM, Aitken JB, Russell DL, Lane M, Rodgers RJ, Harris HH. 2014. X-Ray fluorescence imaging and other analyses identify selenium and GPX1 as important in female reproductive function. Metallomics, 7(1): 71-82.

Chew BP. 1993. Effects of supplemental β-carotene and vitamin A on reproduction in swine. J Anim Sci, 71(1): 247-252.

Eberhardt DM, Will WA, Godkin JD. 1999. Retinol administration to superovulated ewes improves in vitro embryonic viability. Biol Reprod, 60(6): 1483-1487.

Farahavar A, Rostami Z, Alipour D, Ahmadi A. 2020. The effect of pre-breeding vitamin E and selenium injection on reproductive performance, antioxidant status, and progesterone concentration in estrussynchronized Mehraban ewes. Trop Anim Health Prod, 52(4): 1779-1786.

Gordon I. 1997. Controlled Reproduction in Sheep and Goats, Universty College Dublin, Ireland, pp. 241-259.

Haliloğlu S, Baspjnar N, Serpek B, Erdem H, Bulut Z. 2002. Vitamin A and β -carotene levels in plasma, corpus luteum and follicular fluid of cyclic and pregnant cattle. Reprod Dom Anim, 37: 96-99.

Harb M. 1999. Sheep production under extensive systems in the Near East: Jordan pastoral system, a case study. FAO/RNE Near East Regional Office, Food and Agriculture Organization of the United Nations: Rome, Italy.

Hashem NM, Abd-Elrazek D, Abo-Elezz ZR, Latif MGA. 2016. Effect of vitamin A or C on physiological and reproductive response of Rahmani ewes during subtropical summer breeding season. Small Rumin Res, 144: 313-319.

Hemingway RG. 2003. The influences of dietary intakes and supplementation with selenium and vitamin E on reproduction diseases and reproductive efficiency in cattle and sheep. Vet Res Commun, 27: 159-174.

Horst RL, Goff JP, Renhardt TA. 2003. Role of vitamin D in calcium homeostasis and its use in prevention of bovine periparturient paresis. Acta Vet Scan Supp, 97: 35-50.

Hostetler CE, Kincaid RL, Mirando MA. 2003. The role of essential trace elements in embryonic and fetal development in livestock. Vet J, 166 (2): 125-139.

Humann-Ziehank E. 2016. Selenium, copper and iron in veterinary medicine-From clinical implications to scientific models. J Trace Elements Med Biol, 37: 96-103.

Infante JP. 1999. A function for the vitamin E metabolite α-tocopherol quinone as an essential enzyme cofactor for the mitochondrial fatty acid desaturases. FEBS Letters, 446: 1-5.

Jozwik M, Wolczynski S, Szamatowicz M. 1999. Oxidative stress markers in preovulatory follicular fluid in humans. Mol Hum Reprod, 5: 409-413.

Kaçar C, Kamiloğlu NN, Uçar Ö, Arı UÇ, Pancarcı ŞM, Güngör Ö. 2008. İneklerde β-karoten+E Vitamini uygulamasıyla kombine edilen ovsynch ve cosynch senkronizasyon programlarının gebelik oranı üzerine etkisi. Kafkas Üniv Vet Fak Derg, 14(1): 45-50.

Kolb E, Seehawer J. 1998. Nutritional biochemical aspects of the use of beta-carotene, vitamin A, D and E as well as ascorbic acid in domestic animals and influence on the secretion and activity of hormones. Tierarztl Umsch, 63: 150-156.

Kott RW, Thomas VM, Hatfield PG, Evans T, Davis KC. 1998. Effects of dietary vitamin E supplementation during late pregnancy on lamb mortality and ewe productivity. J Am Vet Med Assoc, 212 (7): 997-1000.

Koyuncu M, Yerlikaya H. 2007. Effect of selenium-vitamin E injections of ewes on reproduction and growth of their lambs. S Afr J Anim Sci, 37: 233-236.

Köse M, Kırbaş M, Dursun Ş, Bayrıl T. 2013. Anöstrüs döneminde koyunlara β-karoten veya E vitamini+ selenyum enjeksiyonlarının döl verimi üzerine etkisi. YYÜ Vet Fak Derg, 24(2): 83-86.

Kuru M, Sogukpinar O, Makav M, Cetin N. 2017. Effect of barium selenate injections on fertility of Pirlak ewes subjected to estrus synchronization during non-breeding season. Med Weter, 73(8): 479-82.

Liu S, Masters D, Ferguson M, Thompson A. 2014. Vitamin E status and reproduction in sheep: potential implications for Australian sheep production. Anim Prod Sci, 54(6): 694-714.

Mehdi Y, Dufrasne I. 2016. Selenium in cattle: a review. Molecules, 21(4): 545.

Miyamoto K, Sato EF, Kasahara E, Jikumaru M, Hiramoto K, Tabata H, Katsuragia M, Odob S, Utsumic K, Inouea M. 2010. Effect of Oxidative Stress During Repeated Ovulation on the Structure and Functions of the Ovary, Oocytes, and Their Mitochondria. Free Radic Biol Med, 49: 674-681.

Munoz C, Carson AF, McCoy MA, Dawson LER, O'Connell NE, Gordon AW. 2008. Nutritional status of adult ewes during early and mid-pregnancy. 1. Effects of plane of nutrition on ewe reproduction and offspring performance to weaning. Animal, 2(1): 52-63.

Muscogiuri G, Altieri B, Angelis C, Palomba S, Pivonello R, Colao A, Orio F. 2017. Shedding new light on female fertility: The role of vitamin D. Rev Endocr Metab Disord,18(3): 273-283.

Nayyar S, Jindal R. 2010. Essentiality of antioxidant vitamins for ruminants in relation to stress and reproduction. Iranian J Vet Res, 11: 1-9.

Nebbia C. 1982. Selenium in veterinary medicine. Riv Zoot Vet, 10: 246-278.

Özar E, Sarıbay MK, Köse AM, Sertkol R. 2022. Effects of selenium, vitamin E, and β-carotene administration on fertility of Awassi ewes synchronized for estrus in non-breeding season. MAE Vet Fak Derg, 7 (3): 167-174.

Pu Y, Wang Z, Bian Y, Zhang F, Yang P, Li Y, Zhang Y, Liu Y, Fang F, Cao H, Zhang X. 2014. All-trans retinoic acid improves goat oocyte nuclear maturation and reduces apoptotic cumulus cells during in vitro maturation. Anim Sci J, 85: 833-839.

Sen W, Fucai C, Yanyan W, Zhanqin Z. 2011. Effects of selenium supplement on the serum hormone concentration and super ovulation effect of Suffolk sheep. Chinese Agric Sci Bull, 23: 9-23.

Taniguchi K, Taketani T, Lee LM, Kizuka F, Tamura I, Sugino N. 2009. Melatonin protects granulosa cells for progesterone production as an antioxidant in human ovarian follicles. Biol Reprod, 81: 378-378.

Turan ÖD. 2018. Vitamin D Level and Infertility. Meandros Med Dent J, 19(2): 106.

White CL, Rewell L. 2007. Vitamin E and selenium status of sheep during autumn in Western Australia and its relationship to the incidence of apparent white muscle disease. Aust J Exp Agric, 47: 535-543.

Wildeus S. 2000. Current concepts in synchronization of estrus: Sheep and goats. J Anim Sci, 77: 1- 14.

Yeşil M, Sarıözkan S. 2017. Dişi üreme sistemi açısından önemli bazı vitamin ve mineraller. Erciyes Üniv Vet Fak Derg, 14(3): 201-208.