Erciyes Üniversitesi Veteriner Fakültesi Dergisi

Research Article
10.32707/ercivet.1771145

Imprint:
Volume: 22(3)
Year: 2025
Page: 213-222

Mehmet Dede TİKEN[a]
Mustafa Kemal SARIBAY[b]
Gökhan UYANIK[c*]

[a] Master's Student, Hatay Mustafa Kemal University, Institute of Health Science
mehmetdede.tiken@hotmail.com
[b] Prof., Hatay Mustafa Kemal University, mksaribay@mku.edu.tr
[c] Asst. Prof., Hatay Mustafa Kemal University,
gokhan.uyanik@mku.edu.tr

* Corresponding Author

Received: 8/23/2025
Accepted: 12/17/2025

Citation:
Tiken MD, Sarıbay MK, Uyanık G. Effects of vitamin A, D3, E, and selenium supplementation on reproductive performance in lactating kilis goats applied with estrus synchronization during the breeding season. Erciyes Univ Vet Fak Derg 2025; 22(3):213-222. https://doi.org/*10.32707/ercivet.1771145*

Screened by iThenticate for Authors & Researchers

Except where otherwise noted, content in this article is licensed under a Creative Commons 4.0 International license. Icons by Font Awesome.

Effects of Vitamin A, D3, E and Selenium Supplementation on Reproductive Performance in Lactating Kilis Goats Applied with Estrus Synchronization During the Breeding Season

Abstract

This study investigated the effects of supplementation with vitamins A, D3, E, and selenium (Se) on fertility parameters in Kilis goats during the breeding season, in addition to a synchronization protocol. A total of 70 Kilis goats were randomly divided into vit-min (n = 35) and control (n = 35) groups. All goats received a vaginal sponge containing 20 mg of flugestone acetate for 9 days. On the day the sponge was inserted, the vit-min group received intramuscular injections of 200,000 IU of vitamin A, 30,000 IU of vitamin D3, 20 mg of vitamin E, 1 mg of sodium selenate, and an additional 60 mg of vitamin E, while the control group received no supplements. On the day the sponges were removed, both groups received 500 IU of eCG and 250 µg of cloprostenol, and the vit-min group also received a second injection containing vitamins A, D3, and E. Estrus monitoring was performed by introducing bucks to the flock twice daily, 24-72 hours after the removal of sponges. Pregnancy diagnosis was made by transabdominal ultrasonography on the 50th day after mating, and litter size was determined at kidding. Estrus rates were found to be 100% in both groups (P>0.05). Although the pregnancy rate was numerically higher in the vit-min group (68.57%) compared to the control group (48.57%), there was no statistically significant difference (P>0.05). Similarly, although litter size was higher in the vit-min group, it was not statistically significant (P>0.05). In contrast, the fecundity rate was significantly higher in the vit-min group (154.28%) compared to the control group (91.42%) (P<0.05). No difference was found between the groups in terms of multiple pregnancy rates (P>0.05). In conclusion, adding vitamin-mineral supplementation to the synchronization protocol improved reproductive performance in lactating Kilis goats by increasing fecundity. This approach is considered applicable and potentially economically advantageous in pasture-based systems. However, comprehensive studies with larger sample sizes are needed to more clearly demonstrate its effectiveness.

Keywords: Breeding season, fertility parameters, goat, mineral, vitamin

Üreme Sezonunda Östrüs Senkronizasyonu Uygulanan Laktasyondaki Kilis Keçilerinde Vitamin A, D3, E ve Selenyum Takviyesinin Üreme Performansı Üzerine Etkileri

Öz

Bu çalışmada, üreme sezonu boyunca Kilis keçilerinde senkronizasyon protokolüne ek olarak A, D3, E vitaminleri ve selenyum (Se) uygulamasının

fertilite parametreleri üzerindeki etkileri araştırılmıştır. Toplam 70 Kilis keçisi rastgele vit-min (n = 35) ve kontrol (n = 35) gruplarına ayrılmıştır. Tüm keçilere 9 gün süreyle 20 mg flugeston asetat içeren vajinal sünger uygulanmıştır. Sünger yerleştirildiği gün, vit-min grubuna intramüsküler olarak 200.000 IU A vitamini, 30.000 IU D3 vitamini, 20 mg E vitamini, 1 mg sodyum selenit ve ilave 60 mg E vitamini uygulanırken, Kontrol grubuna herhangi bir takviye yapılmamıştır. Süngerlerin çıkarıldığı gün, her iki gruba 500 IU eCG ve 250 µg kloprostenol uygulanmış, vit-min grubuna ayrıca A, D3 ve E vitaminlerini içeren ikinci bir enjeksiyon yapılmıştır. Östrüs takibi, süngerlerin çıkarılmasından 24-72 saat sonra tekelerin günde iki kez sürüye katılmasıyla gerçekleştirilmiştir. Gebelik tanısı, aşımdan sonraki 50. günde transabdominal ultrasonografi ile yapılmış, yavru sayısı doğumda belirlenmiştir. Östrüs oranları her iki grupta da %100 olarak tespit edilmiştir (P>0.05). Gebelik oranı vit-min grubunda (%68.57), kontrol grubuna (%48.57) kıyasla sayısal olarak daha yüksek olsa da istatistiksel fark bulunmamıştır (P>0.05). Benzer şekilde, yavru verimi vit-min grubunda daha yüksek olmasına rağmen anlamlı bulunmamıştır (P>0.05). Buna karşın fekondite oranı vit-min grubunda (%154.28), kontrol grubuna (%91.42) göre anlamlı derecede yüksek bulunmuştur (P<0.05). Çoğul gebelik oranları açısından gruplar arasında fark saptanmamıştır (P>0.05). Sonuç olarak, senkronizasyon protokolüne vitamin-mineral takviyesinin eklenmesi, laktasyondaki Kilis keçilerinde fekonditeyi artırarak üreme performansını iyileştirmiştir. Bu yaklaşımın mera bazlı sistemlerde uygulanabilir ve ekonomik açıdan avantajlı olabileceği düşünülmektedir. Ancak, etkisini daha net bir şekilde ortaya koymak için daha büyük örneklem büyüklüklerine sahip kapsamlı çalışmalara ihtiyaç vardır.

Anahtar kelimeler: Üreme mevsimi, fertilite parametreleri, keçi, mineral, vitamin

❋ ❋ ❋

Introduction

The growing global population and changing dietary habits are steadily increasing the demand for animal protein sources. In particular, the sustainable production of essential protein sources such as meat and milk is of strategic importance not only for food supply security but also for rural development and socio-economic stability (Ronda-Borzone et al., 2022). In this context, small ruminant farming stands out due to its low input costs, adaptability to extensive pasturelands, and high resilience to climate change. Goats, in particular, have become an important component of the global livestock sector thanks to their ability to maintain productive performance even in arid and rugged terrains (Lohani and Bhandari, 2021).

Türkiye, with its rich genetic diversity, diverse climate zones, and extensive pasture areas, is among the advantageous countries for goat breeding (Semerci and Çelik, 2016). As of 2024, the goat population in Türkiye reached approximately 10.8 million head (TÜİK, 2024). Within this population, the Kilis goat, a breed native to the Southeastern Anatolia Region, stands out with its milk yield reaching 300-500 liters per lactation and its high adaptability to adverse environmental conditions. Today, the Kilis goat, a significant source of income for small and medium-sized family businesses, makes significant contributions to the rural economy (Keskin et al., 2019). In recent years, environmental stress factors such as increasing temperatures, decreasing rainfall, and drought due to global warming have negatively affected goat breeding. In particular, deterioration of pasture quality and reduction of forage resources negatively affect the nutritional status of animals, leading to decreases in milk and fertility (Ronda-Borzone et al., 2022). Therefore, protecting and increasing the populations of native breeds with high milk yield, such as the Kilis goat, which has a high adaptability to adverse environmental conditions, is becoming increasingly important, especially in order to ensure the sustainable production of goat milk (Darcan and Silanikove, 2018; Keskin et al., 2019).

Goats are seasonally polyestrous species; sexual activity generally begins in August-September, when the days begin to shorten, and continues until the end of the year (Habeeb and Kutzler, 2021). The breeding season lasts an average of 3-4 months, varying depending on geography, climate, and breed. Distributed matings throughout the breeding season result in kidding spread out over a longer period of time, making flock management challenging. Therefore, estrous synchronization protocols are implemented to consolidate kidding into a short period during the breeding season. Combinations

of progestogens, gonadotropins, and prostaglandin analogs are generally preferred in estrous synchronization protocols to control estrus and ovulation (Hashemi and Safdarian, 2018; Habeeb and Kutzler, 2021). In addition, it is recommended to include vitamin and mineral supplements in protocols in order to increase protocol effectiveness and improve reproductive performance (Özar et al., 2022; Efe et al., 2023; Syaiful et al., 2024).

The positive effects of vitamins A, D_3, E, and Se on processes such as ovarian function, folliculogenesis, oocyte quality, embryo development, and steroid hormone synthesis are well known (Pasquariello et al., 2022; Swelum et al., 2022). Vitamin A deficiency can cause the formation of follicular and luteal cysts (Ahmed et al., 2024), inadequate corpus luteum development, and embryonic losses (Pasquariello et al., 2022), while vitamin D deficiency is associated with subestrus and fetal developmental disorders (Stenhouse et al., 2022). Vitamin E and Se have been reported to positively affect oocyte quality, fertilization rate, and embryo development by reducing oxidative stress. It has also been reported that vitamin E and selenium have a synergistic effect, limiting cellular damage that may occur during synchronization and improving reproductive performance (Swelum et al., 2022).

Because goats are primarily grazed on pastures and stubble and their rations contain limited amounts of concentrated feed, they are highly susceptible to vitamin and mineral deficiencies. Indeed, pastures and grain stubbles in the Mediterranean and Southeastern Anatolia regions have been reported to be deficient in vitamins A, E, and Se during the summer and autumn months, coinciding with the breeding season for goats (Efe et al., 2023). The reduced trace element content of natural forage sources during this period fails to meet the physiological needs of goats and can negatively impact reproductive performance. In this context, it is anticipated that adding vitamins A, D_3, and E, as well as Se supplementation to the estrus synchronization protocol implemented in Kilis goats, which are fed exclusively pasture-based diets during the breeding season, may improve reproductive performance by reducing the negative effects of environmental stress conditions.

The aim of this study, carried out in the light of available literature data, was to determine the effects of estrus synchronization protocol plus vitamin A, D_3, E and Se administration on reproductive parameters in lactating Kilis goats fed only natural grass and cereal stubble during the breeding season.

Materials and Methods

Location of the Study

The experiment was carried out in Akkerpiç neighborhood of Kumlu district of Hatay province, located in the Southeastern Anatolia Region (36° 21′ 47″ N, 36° 27′ 14″ E and altitude: 97 m) during the breeding season (August 2024-January 2025).

Animals and Management

A total of 70 Kilis goats, clinically healthy, 2-6 years old, with an average live weight of 45-60 kg and fed entirely on pasture, were used in the study. All goats included in the study were allowed to graze on natural pastures near the village for a total of 10 hours, from 06:00 to 10:00 in the morning and from 14:00 to 20:00 in the afternoon. Between grazing periods, all goats (n=70) were brought to semi-open pens with soil floors and were hand-milked once a day. No additional concentrates or roughage were provided outside of the pasture, but they were given access to water ad *libitum* for 24 hours. No flushing was applied to goats or bucks before mating.

Experimental Design

The goats in the study (n=70) were randomly divided into two groups: vit-min group (n = 35) and control group (n = 35). Commercial sponges (Chronogest CR®, Intervet, Türkiye) containing 20 mg flugesterone acetate (FGA) were administered intravaginally to all goats for 9 days. On the day of

intravaginal sponge insertion, the vit-min group received 1 mL/goat Se and vitamin E (1 mg/mL sodium selenite and 60 mg/ml vitamin E, Yelvit®, Teknovet, Türkiye) and 1 mL/50 kg vitamin AD_3E (200.000 IU/mL vitamin A, 30.000 IU/mL vitamin D_3, and 20 mg/mL vitamin E, Adevil®, Vilsan, Türkiye) intramuscularly. The control group did not receive any vitamin or mineral administration. On the day the sponges were removed, all goats received an intramuscular injection of 500 IU eCG (Chronogest/PMSG®, Intervet, Türkiye) and 250 µg cloprostenol sodium (Minoprost®, Vilsan, Türkiye). Additionally, the vit-min group received a second injection of vitamin AD_3E at a dose of 1 mL/50 kg on the same day (Figure 1).

Estrus/mating monitoring was performed by introducing fertile Kilis bucks into the flock at a 7:1 ratio twice daily (08:00-09:00 and 20:00-21:00) from 24 hours until 72 hours after sponge removal. Goats detected to be mounding were marked and moved to a different pen.

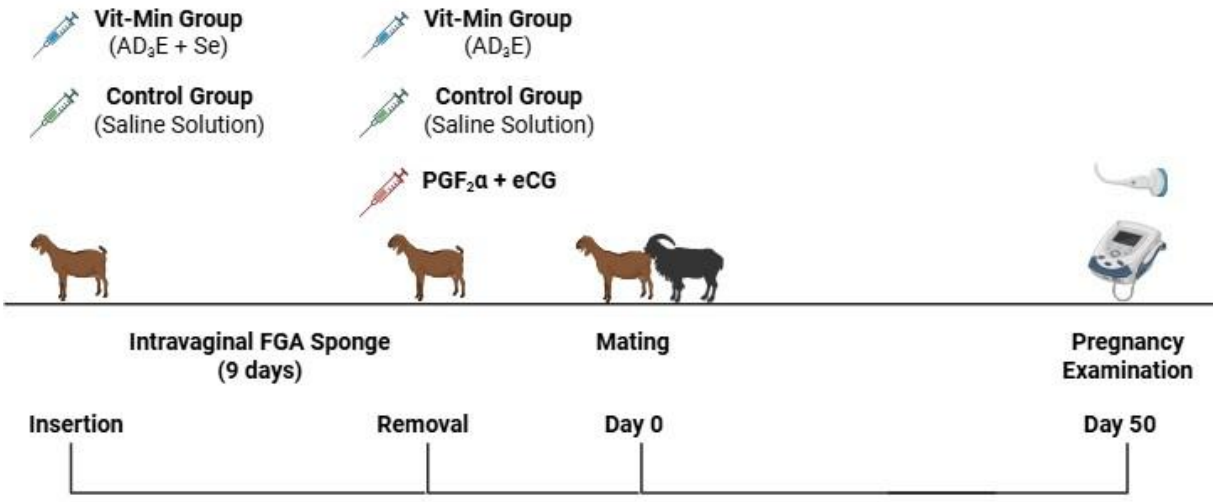


Figure 1. *Schematic view of the synchronization protocol and experimental procedures applied to goats in the Vit-Min and control groups. For oestrus synchronization, a 20 mg fluorogestone acetate (FGA) intravaginal sponge was inserted for 9 days, followed at sponge removal by intramuscular administration of 500 IU eCG and 250 µg cloprostenol ($PGF_2\alpha$). In the vit-min group, selenium+vitamin AD_3E were administered intramuscularly on sponge insertion day, with a second vitamin AD_3E dose given on sponge removal day. The control group received no vitamin-mineral injection. Pregnancy diagnosis was performed by ultrasonography on Day 50.*

Pregnancy Diagnoses

Pregnancies were determined by ultrasonographic examination on day 50 after mating (Figure 1). Pregnancy examinations were performed transabdominally using a real-time B-Mode ultrasonography (Hasvet® 838, Türkiye) device with a linear rectal probe (L50/7.5 MHz). After the gestational sac was identified during the uterine examination, pregnancy was determined based on the visualization of the embryo/fetus, foetal membranes, fluids, heartbeat, and placentomes. After parturition, offspring productivity and multiple pregnancy rates were determined.

Determination of Fertility Parameters

The fertility parameters of goats were calculated using the formulas provided below.

Estrus rate (%) = Number of goats in estrus / Total number of goats x 100

Pregnancy rate (%) = Number of pregnant goats / Total number of goats x 100

Single rate (%) = Number of goats kidding single / Number of goats kidding x 100

Twinning rate (%) = Number of goats kidding twins / Number of goats kidding x 100

Triplet birth rate (%) = Number of goats kidding triplets / Number of goats kidding x 100

Litter size = Number of kids born / Number of goats kidding

Fecundity rate (%) = Number of kids born / Total number of goats x 100

Statistical Analysis

Categorical fertility variables were summarised as "Percentage-Frequency", and between-group differences (except litter size) were assessed with Pearson's chi-square test. Litter size (quantitative variable) was compared between the two groups using the independent-samples t-test. The assumptions of normality and homogeneity of variances were tested using the Kolmogorov-Smirnov and Levene's tests, respectively. Statistical significance was set at $P<0.05$. All analyses were performed using Stata/MP 12 (4-core) for Windows (StataCorp LLC, College Station, TX, USA).

Results

Fertility parameters of the control and treatment groups are summarized in Table 1. Estrus rates were 100% in both groups ($P>0.05$). Although the pregnancy rate in the vit-min group (68.57%) was numerically higher than in the control group (48.57%), the difference was not statistically significant ($P=0.145$). Similarly, although the litter size in the vit-min group (2.25) was higher than in the control group (1.88), this difference was also not statistically significant ($P=0.116$). No significant difference was found between the multiple pregnancy rates ($P>0.05$). However, the fecundity rate was significantly higher in the vit-min group (154.28%) than in the control group (91.42%) ($P=0.029$).

Table 1. Comparison of fertility parameters between goat supplemented with vitamin AD_3E and Se (vit-min) and the control group.

Fertility parameters	**Groups**		***P* - value**
	Control (n=35)	**Vit-Min (n=35)**	
Estrus (%)	100.0 (35/35)	100.0 (35/35)	**-**
Pregnancy (%)	48.57 (17/35)	68.57 (24/35)	0.145
Single (%)	35.29 (6/17)	12.50 (3/24)	0.128
Twinning (%)	41.17 (7/17)	50.00 (12/24)	0.752
Triplet (%)	23.52 (4/17)	37.50 (9/24)	0.499
Litter size	1.88 (32/17)	2.25 (54/24)	0.116
Fecundity (%)	**91.42 (32/35)**	**154.28 (54/35)**	**0.029***

Discussion and Conclusion

The present study investigated the effects of adding vitamin A, D_3, E, and Se supplements to the intravaginal progesterone-based estrus synchronization protocol on reproductive performance in lactating Kilis goats during the breeding season.

The data obtained showed that all goats in both groups exhibited estrus after the synchronization protocol (Table 1). This finding indicates that Kilis goats responded quite well to the synchronization protocol despite adverse environmental conditions such as lactation and feeding on cereal stubble and suggests that estrus rates are not the main determining factor in fertility losses observed after synchronization. When compared with previous reports, the present data were

generally consistent with the literature. Indeed, estrus rates obtained after progestogen-containing intravaginal sponge-based synchronization applications during the breeding season have been reported to range from 73.7% to 100% (Amarantidis et al., 2004; Holtz et al., 2008; Kılboz and Karaca, 2010; Acar et al., 2013). However, the higher rates achieved in our study than those reported in some studies were thought to be due to the genetic and physiological structure of the animal material and the variables in the synchronization protocol.

When pregnancy rates were examined, although proportionally higher values were obtained in goats supplemented with vitamin-mineral supplements (Group vit-min) compared to the control, no statistically significant difference was found ($P>0.05$; Table 1). It is stated that pregnancy rates reported in goats in the literature vary between 50% and 80%, and that this rate is affected by the synchronization protocol applied, animal material used, feeding and management conditions, and environmental factors (Holtz et al., 2008; Sen and Onder, 2016; Hashemi and Safdarian, 2018). The fact that the pregnancy rates in our study are compatible with this range indicates the effectiveness of the applied protocol. When compared with the results reported in similar reports, the data obtained in our study are largely parallel. Similar to our findings, Sönmez et al. (2009) reported that vitamin E injection administered during the pre-ovulation period in goats did not statistically change pregnancy rates but increased multiple kidding and litter size by reducing oxidative stress levels. Conversely, El-Moghazy et al. (2025) reported that vitamin and mineral supplementation increased pregnancy and multiple birth rates in goats, with this effect becoming more pronounced, particularly with higher doses and nano-selenium applications.

It has been reported that during estrus induced by synchronization methods, free radical levels such as peroxides and hydroperoxides in the preovulatory follicle fluid increase, which can have negative effects on oocyte quality, ovulation, fertilization rate, corpus luteum progesterone production, and embryo quality (Miyamoto et al., 2010). Eşki et al. (2021) conducted studies in goats using intravaginal sponges with different protocols, demonstrating that estrus synchronization increases oxidative stress, which negatively affects fertility parameters. Similarly, other researchers (Sönmez et al., 2009; Kuru et al., 2016; Martinez-Ros et al., 2018; Farahavar et al., 2020) reported that the application of devices such as intravaginal sponges and CIDRs increases oxidative stress, and high levels of free radicals during estrus can negatively affect ovulation, oocyte quality, and progesterone production.

Giorgio et al. (2020) stated that maintaining the redox balance by clearing the increased oxidant load after synchronization practices is only possible with sufficient antioxidant presence in the body. Therefore, it has been stated that supplementing animals with antioxidants during estrus synchronization practices may be beneficial (Farahavar et al., 2020; Soto-Heras and Paramio, 2020; Fernando et al., 2024). In this context, although our findings are biologically consistent with studies reporting that vitamin E and Se supplements can increase pregnancy rates (Musa et al., 2018; Kaya et al., 2023; El-Moghazy et al., 2025), the lack of statistical significance may be due to variables in field conditions and limited sample size.

In terms of multiple pregnancy rates, vitamin-mineral supplemented ewes (87.5%) were numerically superior to controls (64.7%) (Table 1). Although this difference was not statistically significant, it is biologically significant. It has been reported in the literature that vitamins A and D_3 may increase multiple pregnancy rates by supporting folliculogenesis, steroidogenesis, and embryo implantation (Shahrokhi et al., 2016; Kaya and Koçak, 2022). Vitamin A has been reported to enhance the development of dominant follicles and progesterone synthesis, making embryo development and the uterine environment conducive to multiple pregnancy, while vitamin D facilitates follicle maturation and embryo implantation by regulating steroid hormone production in the ovary and

placenta (Pu et al., 2014; Shahrokhi et al., 2016). The increase observed in our findings is consistent with these mechanisms. It has also been reported that vitamin E and Se may facilitate embryo implantation and minimize embryonic losses by reducing oxidative stress (Sönmez et al., 2009; Awawdeh et al., 2019). Abdelrahman and Al-Karablieh (2002) found that multiple pregnancy rates increased in ewes treated with vitamin A, D_3 and E. Similarly, Birdane and Avdatek (2020) reported that a similar treatment increased litter size.

The most striking and statistically significant finding of our study is the increase in fecundity rates. While fecundity was 154.28% in the vitamin-mineral supplemented group, it was determined as 91.42% in the control group, and this difference was found to be statistically significant (P=0.029). Fecundity rates in ewes and goats are reported to range between 95% and 165% in the literature (Sen and Onder, 2016; Hashemi and Safdarian, 2018). These values are consistent with previous studies showing that powerful antioxidants such as vitamin E and Se maintain redox balance by reducing free radical levels, supporting luteal function and embryo viability (Soto-Heras and Paramio, 2020; Fernando et al., 2024). Indeed, Sönmez et al. (2009) reported that intravaginal sponge application in goats increased MDA levels, while vitamin E injections suppressed free radical production, increasing fecundity and the number of offspring per litter. Similarly, Kaya et al. (2023) reported a significant increase in fecundity in ewes treated with a vitamin E-mineral combination, while Musa et al. (2018) reported that vitamin E and Se injections maximized fecundity.

The numerical increase in multiple pregnancy rates achieved in the treatment group in our study is thought to have played a significant role in this effect. This increase in multiple pregnancy rates was directly reflected in fecundity values and is consistent with studies in the literature reporting that vitamin-mineral supplements can increase multiple kidding rates (Shahrokhi et al., 2016; Kaya and Koçak, 2022). Therefore, vitamin-mineral supplementation is thought to increase fecundity by both preserving embryo viability and increasing the rate of multiple pregnancies.

In lactating Kilis goats during the breeding season, intravaginal vitamin E and Se administered at the beginning of a progesterone-based synchronization protocol, along with double doses of vitamin A, D_3, and E administered at the beginning of the synchronization protocol and on the day of sponge removal, have been shown to have positive effects on reproductive performance. This approach demonstrates its potential to support reproductive performance and increase fecundity. Furthermore, supplementation with vitamins A, D_3, and E, as well as Se, administered in addition to the synchronization protocol, resulted in higher fecundity rates compared to the control group, offsetting the implementation costs and making their practical use economically justifiable.

In conclusion, adding vitamin-mineral supplements to the synchronization protocol is considered a feasible and beneficial method for improving reproductive efficiency in lactating Kilis goats fed entirely on pasture. However, further studies in different production systems and with larger sample sizes are needed to further validate the findings.



Peer-review: External, Independent.

Acknowledgements:

-

Declarations:

1. Statement of Originality:

This study was derived from the MSc thesis entitled "Effects of Selenium, Vitamin E, Vitamin A, and Vitamin D_3 Supplementation on Fertility Parameters in Kilis Goats with Synchronized Estrus during the Breeding Season."

2. Author Contributions:

Concept: MDT,MKS; ***Conceptualization:*** MDT,MKS; ***Literature Search:*** MDT,MKS,GU; ***Data Collection:*** MDT,MKS,GU; ***Data Processing:*** MDT,MKS,GU; ***Analysis:*** GU; ***Writing – original draft:*** MDT,MKS,GU; ***Writing – review & editing:*** MDT,MKS,GU.

3. Ethics approval:

This study was conducted with the approval of the Hatay Mustafa Kemal University Animal Experiments Local Ethics Committee, Hatay, Türkiye (2024/04-06).

4. Funding/Support:

This work has not received any funding or support.

5. Competing Interests:

The authors declare no competing interests.

6. GenAI Usage Statement:

No GenAI tools were used at any stage of the study.

7. Sustainable Development Goals:



REFERENCES

Abdelrahman MM, Al-Karablieh EK. Effect of vitamins AD3E injections on reproductive performance and net cash revenue from Awassi sheep raised under semi-intensive system. J King Saud Univer 2002; 14 (1): 15-22.

Acar BD, Birdan MK, Özenç E, Yeni D, Doğan İ. Effectiveness of different progesterone analogues and GnRH on reproductive parameters in nulliparous Saanen goats at the end of the transition period. Kafkas Üniv Vet Fak Derg 2013; 19(7): 181-6.

Ahmed OMM, Hassen A, Lehloenya K. The effect of β-carotene supplementation above requirement on the production and reproduction performance of female sheep and goats-a mini review. Aceh J Anim Sci 2024; 9(2): 60-6.

Amarantidis I, Karagiannidis A, Saratsis PH, Brikas P. Efficiency of methods used for estrous synchronization in indigenous Greek goats. Small Rumin Res 2004; 52(3): 247-52.

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

Birdane MK, Avdatek F. Effect of vitamin A, D3, E treatment on fertility in the Pırlak sheep. Kocatepe Vet J 2020; 13(2): 179-84.

Darcan NK, Silanikove N. The advantages of goats for future adaptation to Climate Change: A conceptual overview. Small Rumin Res 2018; 163: 34-8.

Efe M, Sarıbay MK, Ürer EK, Köse AM. The effect of selenium, vitamin E, vitamin A and vitamin D3

applications on fertility in Awassi sheep with estrus synchronization during the breeding season. Turkish J Agric-Food Sci Tech 2023; 11(8): 1331-6.

El-Moghazy M, Ashmawy T, Akl F. Effect of supplementation different forms of selenium on reproductive performance of Zaraibi goats. Damietta J Agric Sci 2025; 4(1): 165-74.

Eşki F, Kurt S, Demir PA. Effect of different estrus synchronization protocols on estrus and pregnancy rates, oxidative stress and some biochemical parameters in Hair goats. Small Rumin Res 2021; 198: 106348.

Farahavar A, Rostami Z, Alipour D, Ahmadi A. The effect of pre-breeding vitamin E and selenium injection on reproductive performance, antioxidant status, and progesterone concentration in estrus-synchronized Mehraban ewes. Trop Anim Health Prod 2020; 52(4): 1779-86.

Fernando PDSM, Ko DO, Piao MJ, Kang KA, Herath HMUL, Hyun JW. Protective effect of luteolin against oxidative stress-mediated cell injury via enhancing antioxidant systems. Mol Med Rep 2024; 30(1): 1-10.

Giorgio D, Di Trana A, Di Gregorio P, Rando A, Avondo M, Bonanno A, Di Grigoli, A. Oxidative status of goats with different CSN1S1 genotypes fed ad libitum with fresh and dry forages. Antioxidants 2020; 9(3): 224.

Habeeb HMH, Kutzler MA. Estrus synchronization in the sheep and goat. Veterinary Clinics: Food Anim Prac 2021; 37(1): 125-37.

Hashemi M, Safdarian M. Efficiency of different methods of estrus synchronization followed by fixed time artificial insemination in Persian downy does. Anim Reprod 2018; 14(2): 413-7.

Holtz W, Sohnrey B, Gerland M, Driancourt MA. Ovsynch synchronization and fixed-time insemination in goats. Theriogenology 2008; 69(7): 785-92.

Kaya S, Koçak G. Üreme mevsimindeki Romanov koyunlarında senkronizasyon protokolleriyle birlikte D vitamini enjeksiyonunun bazı üreme parametreleri üzerine etkisi. Van Vet J 2022; 33(3): 76-9.

Kaya S, Koçak G, Demir MC, Kaçar C. The effect of vitamin e-trace mineral treatments on reproductive performance in Morkaraman sheep during the breeding season. Kafkas Üniv Vet Fak Derg 2023; 29(2): 161-9.

Keskin M, Gül S, Biçer O, Mutlukoca G. Importance of Kilis Goat Breeding in Turkey. 11. International Animal Science Conference. October, 431-6, 2019; Nevşehir-Turkey.

Kılboz Eİ, Karaca F. Üreme mevsimi dışında genç keçilerde flugeston asetat vaginal sünger ve norgestomet kulak implantı uygulamalarıyla östrüslerin uyarılması. Van Vet J 2010; 21(1): 1-6.

Kuru M, Ögün M, Oral H, Kükürt A, Makav M, Kulaksız R. The use of controlled internal drug release for synchronization augmented oxidative and nitrosative stress and leptin levels in Georgian goats. J Cell Neurosci Oxid Stress 2016; 8(1): 541-2.

Lohani M, Bhandari D. The importance of goats in the world. Prof Agric Workers J 2021; 6(2): 9-21.

Martinez-Ros P, Lozano M, Hernandez F, Tirado A, Rios-Abellan A, López-Mendoza MC, Gonzalez-Bulnes A. Intravaginal device-type and treatment-length for ovine estrus synchronization modify vaginal mucus and microbiota and affect fertility. Animals 2018; 8(12): 226.

Miyamoto K, Sato EF, Kasahara E, Jikumaru M, Hiramoto K, Tabata H, Inoue M. Effect of oxidative stress during repeated ovulation on the structure and functions of the ovary, oocytes, and their mitochondria. Free Radic Biol Med 2010; 49(4): 674-81.

Musa SI, Bitto II, Ayoade JA, Oyedipe OE. Effects of vitamin E and selenium on fertility and lamb

performance of Yankasa sheep. Open J Vet Med 2018; 8(09): 167.

Özar E, Sarıbay MK, Köse AM, Sertkol R. 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 2022; 7(3): 167-74.

Pasquariello R, Anipchenko P, Pennarossa G, Crociati M, Zerani M, Brevini TA, Maranesi M. Carotenoids in female and male reproduction. Phytochemistry 2022; 204: 113459.

Pu Y, Wang Z, Bian Y, Zhang F, Yang P, Li Y, Zhang X. All-trans retinoic acid improves goat oocyte nuclear maturation and reduces apoptotic cumulus cells during in vitro maturation. Anim Sci J 2014; 85(9): 833-9.

Ronda-Borzone P, Donoso G, Riveros FJL. Food security and livelihood challenges of extensive goat production systems in desertification areas. CABI Reviews 2022; 17(44): 1-3.

Semerci A, Çelik AD. Türkiye'de küçükbaş hayvan yetiştiriciliğinin genel durumu. MKÜ Ziraat Fak Derg 2016; 21(2): 182-96.

Sen U, Onder H. The effect of estrus synchronization programmes on parturition time and some reproductive characteristics of Saanen goats. J Appl Anim Res 2016; 44(1): 376-9.

Shahrokhi SZ, Ghaffari F, Kazerouni F. Role of vitamin D in female reproduction. Clin Chim Acta 2016; 455: 33-8.

Sönmez M, Bozkurt T, Türk G, Gür S, Kızıl M, Yüce A. The effect of vitamin E treatment during preovulatory period on reproductive performance of goats following estrous synchronization using intravaginal sponges. Anim Reprod Sci 2009; 114(1-3): 183-92.

Soto-Heras S, Paramio MT Impact of oxidative stress on oocyte competence for in vitro embryo production programs. Res Vet Sci 2020; 132: 342-50.

Stenhouse C, Suva LJ, Gaddy D, Wu G, Bazer FW. Phosphate, calcium, and vitamin D: key regulators of fetal and placental development in mammals. Adv Exp Med Biol 2022; 1354: 77-107.

Swelum AA, Abdelnour SA, Sheiha AM, Hashem NM, Taha AE, Khafaga AF, Abd El-Hack ME. Enhancing in vitro oocyte maturation competence and embryo development in farm animals: roles of vitamin-based antioxidants–a review. Ann Anim Sci 2022; 22(1): 3-19.

Syaiful FL, Jaswandi J, Mundana M, Yendraliza Y, Udin Z. Estrus response and pregnancy rate of swamp buffalo: The use of multivitamins in different estrus synchronization hormone protocols. J Adv Vet Anim Res 2024; 11(3): 729.

TÜİK. (2024). Hayvansal Üretim İstatistikleri. https://data.tuik.gov.tr/Bulten/Index?p=Hayvansal-Uretim-Istatistikleri-2024-53935; Accessed Date: 23.08.2025.

