

Effect of selenium-enriched yeast supplementation on ewe and lamb performance during late pregnancy and early lactation

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ABSTRACT

The current study aimed to evaluate the impact of selenium (Se)-enriched yeast supplementation on the performance and some biochemical parameters in local Awassi ewes and their lambs during late pregnancy and early lactation under local conditions in the Kurdistan Region. Twenty-seven pregnant ewes (56.0 ± 4.77 kg BW; 2 years old) were assigned to three treatments: control (T1, 0 mg Se/kg DM), low supplementation (T2, 1 mg Se/kg DM), and high supplementation (T3, 2 mg Se/kg DM). The trial extended from six weeks prepartum to eight weeks postpartum. Measurements included ewe body weight (BW), body condition score (BCS), lamb growth, milk yield and composition, Serum (Se; $\mu\text{g/L}$), cortisol (COR; ng/ml), Triiodothyronine hormone (T3; ng/ml), Thyroxin hormone (T4; ng/ml). The results show that Selenium supplementation dramatically enhanced serum Se levels in T2 and T3 compared with the control ($P < 0.001$), confirming efficient absorption of organic Se. Although BW and BCS decreased across all groups due to the high demands of late gestation and lactation, ewes in T2, despite the non-significant effect, exhibited less BW loss during postpartum, suggesting a potential protective effect of moderate Se supplementation. Lamb birth weights were unaffected by treatment, though control lambs were transiently heavier than supplemented groups during weeks 1–3 postpartum ($P < 0.05$). Cortisol levels peaked at late gestation but declined progressively after lambing, likely reflecting reduced physiological stress following parturition and adaptation to lactation.

Key words: selenium-yeast, cortisol, oxidative stress, late pregnancy, early lactation.

1. Introduction

The efficiency of sheep production depends on the output of lambs [31,12]. Throughout the preceding four decades, the lamb death rate has been generally stable at around 15% across many different countries [16,44]. Factors that influence lamb mortality include breed [35], environmental conditions [14], hypothermia [17, 44], and the type of birth. Lambs with low birth weights tend to exhibit weakness and an increased mortality rate [14,38]. Furthermore, insufficient intake of colostrum, milk, or suckling practices can result in increased lamb mortality [11]. A significant percentage of lamb death (up to 50%) typically occurs

between the first 24 hours to three days of life [21,16]. The transition of lambs from uterine to external oxygen levels induces cellular damage and the liberation of free radicals [36,26]. Numerous vitamins and minerals can act as non-enzymatic antioxidants [28,29,55]. Non-enzymatic antioxidants include Minerals such as selenium (Se), iron, copper, zinc, and manganese, as well as vitamins (E, C, and β -carotene), which are metabolized by enzymes [45]. Selenium is a vital trace element recognized for its antioxidant characteristics [29]. Selenium serves as a vital constituent of various selenoprotein-based antioxidant

enzymes, such as glutathione peroxidases (GPxs) and thioredoxin reductases (TrXR1) [27,29]. A selenium deficiency may lead to disruptions in thyroid metabolism, leading to decreased growth rates, reproductive efficiency, and impaired resistance to diseases [30]. Thyroid metabolic processes are particularly impaired in the context of selenium shortage, as selenium is necessary for the synthesis of thyroid hormones, particularly triiodothyronine (T3) and tetraiodothyronine (T4). A selenium-deficient diet has been shown to reduce T3 levels while simultaneously increasing T4 concentrations, resulting in a diminished blood T3/T4 ratio [10,51]. Selenium's continuous effectiveness in maintaining metabolic homeostasis in livestock is largely due to its function as a cofactor in selenoproteins, protecting cell membranes from oxidative stress [43]. Supplementation with selenium in forms such as yeast or methionine has been shown to bolster antioxidant recycling and synergistic processes [7]. Furthermore, [40] demonstrated that dietary inclusion of selenium (both organic and inorganic forms) at a concentration of 0.3mg/kg DM in lambs and their dams effectively enhanced their metabolic and immunological functions without eliciting adverse effects. Selenium has been identified as one of the trace elements that exhibits a toxicity property when it is supplemented at high levels. The maximum tolerated dietary concentration for animals was updated between 2.0 mg/kg DM [41] and 5.0 mg/kg DM [42], with chronic poisoning observed at prolonged intakes of 5-40 mg/kg DM [41,39]. Numerous studies have investigated the positive impact of selenium (Se) supplementation on ewe and lamb productivity. [4] concluded that the addition of selenium (0.4 mg/kg DM) and vitamin E (100 mg/kg DM) to lamb diets enhanced productivity and growth rates, including live body weight and daily gain. Furthermore, supplementation of organic Selenium at 0.3 mg/day. Enhanced antioxidant function and bolstered immune health in both ewes and lambs, facilitated by effective transfer via the

placenta and milk [40]. It is not clear whether supplementation of yeast-enriched Se above 1 mg/kg DM has an effect on pregnant and lactating ewes with their lambs. Furthermore, to our current knowledge, dedicated research on this topic within Kurdistan Region is scarce. Should such investigations exist, their adherence to established guidelines, such as those provided by the [39], is often undocumented. This identifies a critical need for further investigation, particularly concerning the late pregnancy and early lactating periods. Therefore, the current experiment aimed to study the effect of supplementing the diet with yeast-enriched selenium in different amounts on local ewes and lambs, both pregnant and nursing.

2. Materials and Methods

The present experiment was conducted in the animal farm of the Department of Animal Production, College of Agricultural Engineering Sciences, University of Duhok, from October 5, 2024, to January 11, 2025. The Animal Production Research Ethics Committee provided ethical approval.

3. Experimental Animal

In the current trial, At the Department of Animal Production's farm, twenty-seven local Awassi pregnant ewes, around two years old, the live body weight was 56.0 kg \pm SD 4.77. The trial lasted from day 105 of gestation (week -6 prepartum) to week +8 postpartum plus a two-week adaptation period. During the adaptation period, all ewes were drenched with Levazide Forte to eliminate internal parasites, and this process was repeated 21 days later. At the beginning of the trial, the ewes were dipped in Cypervet 100 EC to attack external parasites. Before the trial, the ewes received a C&D antitoxin vaccination to prevent enterotoxemia. Then the ewes were separately placed in cages (1.50 x 1.30 m) on sawdust and offered straw ad libitum, which were equipped with plastic

containers for water and feed. Concentrates were fed to meet the metabolizable energy (ME) and metabolizable protein (MP) requirements of ewes during late pregnancy

and producing milk during early lactation according to [18]. All animals were fed the same concentrate twice daily at about 09:00 a.m. and 04:00 p.m. (Table 1).

Table 1: Raw material and predicted chemical composition of the experimental concentrate diets (kg/100 kg)

	T1	T2	T3
Raw material composition			
Barley	49.8	49.78	49.76
Wheat bran	25	25	25
Soybean	15	15	15
Yellow corn	10	10	10
Mineral mixture without Se	0.2	0.2	0.2
Selenium yeast ¹	0	0.02	0.04
Total	100	100	100
Predicted² chemical composition%			
Dry matter	89.91	90.11	89.95
Crude protein	16	16	16
Crude fiber	6.99	6.19	6.21
Ether extract	2.1	2.1	2.1
Ash	2.57	4.47	4.07
Starch	41.47	38.36	38.87
Selenium yeast (mg/kg DM)	0	1	2
ME (MJ/kg DM)	11.3	11.3	11.3

¹Selenium yeast supplement (ALKOSEL) \approx 5000ppm/kg, the premium source of bioavailable selenium (Lallemand Animal Nutrition, 31702 Blangac Cedex- France).

²Diet chemical composition predicted according to [18].

4. Experimental design

The selenium-enriched yeast was introduced into the diet in three various amounts: T1 (0 mg/kg DM), T2 (1 mg/kg DM), and T3 (2 mg/kg DM). Throughout the research period, information was gathered from T1, T2, and T3 ewes. Every week, ewes and lambs were weighed and their condition was scored. Every week, blood samples were taken (5 ml) of the drawn blood were poured into test tube that free from anticoagulants, refrigerated for a whole day, subsequently centrifuged for fifteen minutes at 3000 rpm, and the obtained serum was stored at -20 C° in a plastic Eppendorf tube for later analysis serum selenium concentration

(Se μ g/L), cortisol (COR ng/mL), triiodothyronine (T3; ng/ml) and thyroxin (T4; ng/ml) Every one of the previously listed parameters has been determined by using Cobas device. Additionally, milk samples were gathered at 28 days after birth utilizing a methodology adapted from [15], then stored in a freezer at -20 °C until further laboratory examination. Furthermore, weekly samples of the concentrate diet and straw were collected and stored in a dry environment for subsequent analysis of selenium content .

5. Statistical analysis

The data were analyzed using a one-way ANOVA with the GenStat statistical program (GenStat V 12th edition, VSN International Ltd, UK). The data were evaluated to determine the differences among the experiment groups for the blood serum Se levels ($\mu\text{g/L}$), ewe body weight, ewes body condition score, lamb weight, milk yield and composition, cortisol (ng/ml), triiodothyronine (T_3 ; ng/ml), thyroxin (T_4 ; ng/ml). Repeated measurement to compare treated groups at various intervals (weeks) and the treatment-time interaction, an ANOVA was employed. The experimental groups were compared across all parameters using Tukey's test. $P < 0.05$ was considered significant for differences, while $P < 0.1$ to > 0.05 was considered for trends.

6. Result and Discussion

6.1 Selenium Serum Concentration

There was a noticeable impact of time ($p = 0.001$) and selenium yeast supplementation ($p < 0.001$) on the concentration of Se in the blood

serum. Selenium yeast supplementation had increased blood serum concentration of selenium as the experiment progressed in both supplemented treatments (T2 and T3 treatments) compared to the control group (Table 2). In addition, blood serum Se concentration was increased in the supplemental group in comparison with the control group. It is improved that selenium has been absorbed in the small intestine's lower portions and then transferred to the liver, finally to the bloodstream [37]. This means that supplementation of Se in feedstuff increases blood Se concentration. The present experiment's findings agree with the work published by [19], who noticed that serum selenium concentration increased significantly in lambs given 0.30 and 0.45 mg/kg DM of organic selenium compared to the control group. [40] Further confirmed the current experiment's findings, which showed that giving sheep 0.3 mg/kg of both organic and inorganic selenium had increased blood Se concentration, and the organic source supplementation had a higher increase in blood Se concentration.

Table 2: The effect of selenium-enriched yeast supplementation on ewes' blood serum selenium concentration ($\mu\text{g/L}$) during late gestation and early lactation.

Weeks	T1	T2	T3	SED	P-value
-6	112.75	132.93	110.78	34.598	0.781
-2	70.64	375.80	323.31	85.521	0.006
+2	96.11	350.52	314.63	50.066	<0.001

T1 (no selenium, 0 mg/day), T2 (1 mg/day), and T3 (2 mg/day). Different superscript letters show significant differences ($P < 0.05$). SED: standard error of deviation, Analysis of repeated measurements: SED values: Treatment= 36.7, Time= 34.1, Treatment \times Time= 60.6. P-values: Treatment= <.001, Time= 0.001, Treatment \times Time=0.020

6.2 Ewes' and Lambs' Performance

6.2.1 Ewes' Body Weight

Time had an impact ($P < 0.001$) on ewes' body weight (figure 1). Ewes' body weight increased during late pregnancy in all treatments, while

the weight of ewes decreased during the lactation period. Supplementing diet with selenium-enriched yeast had no impact on the weight gain of the ewes during late pregnancy and the lactation period. The current results reflect the expected physiological changes

during gestation and lactation, in which ewes have increased metabolic activity to boost milk output, which leads to considerable weight loss [24]. The results of the current study agree with the previous research carried out by [25], who reported that Se supplementation, both adequate or high (3.05 or 70.4 $\mu\text{g}/\text{kg}$ of BW), didn't affect maternal weight throughout both mid- and late gestation. [49] support our result when they reported that there were no

significant differences in the ewes' weight between control ewes and those were either with Se or Se+ vitamin E supplemented. In contrast, [3] reported that ewes' body weight was enhanced when they were injected with selenium and vitamin E. This may be related to the combination of vitamin E and Se dietary supplements minimizes oxidative stress and thus lowers the metabolic energy cost of tissue repair during early lactation, allowing the ewe to retain more energy [1].

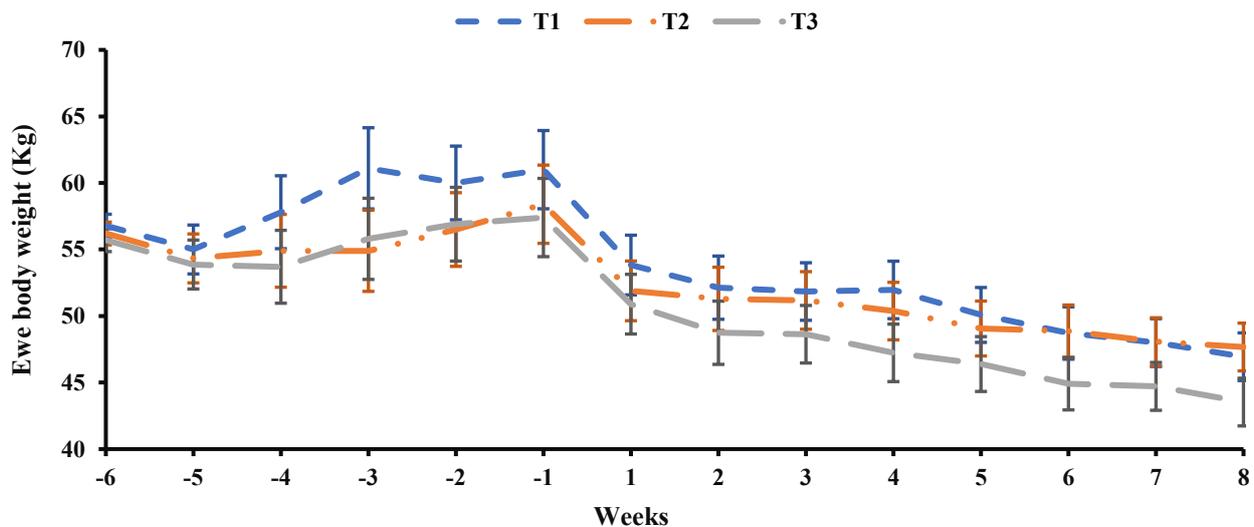


Figure 1: The effect of selenium-enriched yeast supplementation on ewes' body weight (kg) during late gestation and early lactation

6.2.2 Ewes' Body Condition Score (BCS)

Time had a significant influence on BCS ($P < 0.001$). Ewes' BCS declined with experiment progress from week -6 prepartum until week +8 postpartum. Selenium supplementation had no effect on BCS (Figure 2). Indicating a negative energy balance due to increased demands during late gestation and early lactation. In agreement with the current study, [8] reported that multiple doses of selenium and vitamin E had no substantial effect on body weight, so it had no effect on BCS during lambing. [34] also concluded that

no significant differences were observed in body condition score (BCS) between pregnant cows supplemented with 0.3 mg/kg DM either organic or inorganic Se and those in the control group without supplementation at late gestation, nor after calving. However, the present findings disagree with [50], who found that ewes receiving high doses of organic selenium (24.5 mg Se each week) over 62.5 weeks exhibited a higher BCS (2.95) compared to those receiving lower doses (2.66). The reason that the current experiment results disagree with those found by [50] could be due to the long period of Se supplementation compared to the current experiment results (14 weeks).

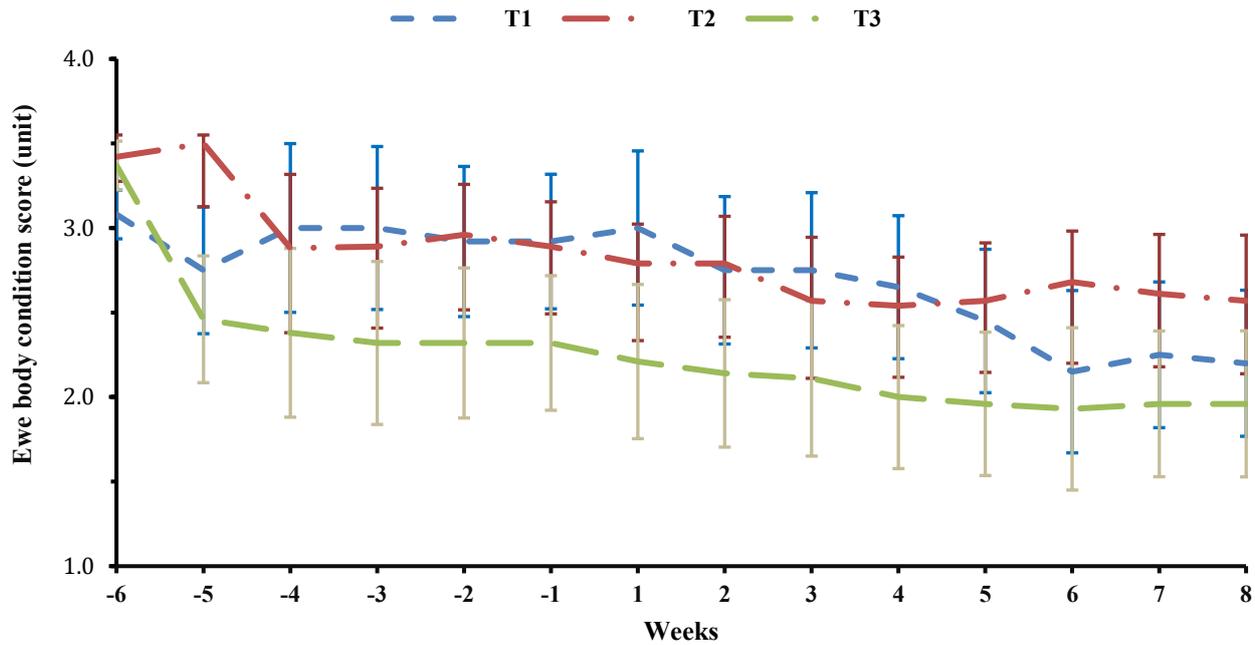


Figure 2: The effect of selenium-enriched yeast supplementation on ewes' body condition score (BCS) during late gestation and early lactation.

6.2.3 Milk Yield, Composition, and Component Yield

Selenium-enriched yeast supplementation had no substantial influence on total milk composition or milk component production ($P > 0.05$) (Table 3). However, ewes receiving 1 mg Se/day (T2) tended to show lower values of lactose, protein, salt, and SNF compared to T1 and T2 treatments. These results support the idea that dietary selenium supplementation is unlikely to change milk composition [46]. In agreement with the current experiment results [20], supplementation of dairy cow diets with selenium, whether in organic form (0.3 mg/kg DM) or inorganic form (0.3 mg/kg DM), showed no noticeable Variation in milk yield

among treatment groups or the amounts of lactose, fat, and protein in milk. In contrast, [32] documented that ewes' supplementation with 0.3 mg Se-NP/kg DM, 30 mg Zn-NP/kg DM, or a combined treatment containing 0.3 mg Se-NP and 30 mg Zn-NP per kilogram of dry matter increased milk production, fat-corrected milk, and milk component yields ($p < 0.05$) compared to the control. The different type of Se or zinc that was supplemented in the previously mentioned experiment could be the reason for the results of [32] disagreeing with the current experiment results regarding milk yield and composition.

Table 3: The effect of selenium-enriched yeast supplementation in late pregnancy on milk yield, composition, and component yield.

	T1	T2	T3	SED	P-value
Secretion rate (ml/h)	50.1	50.2	48.4	7.380	0.962
Milk composition (g/kg)					
Fat	63.9	61.0	56.2	8.650	0.676
Lactose	38.9	35.9	38.9	1.454	0.087
Protein	41.0	37.8	40.9	1.536	0.087
Salt	6.34	5.83	6.33	0.243	0.085
Solid Non-Fat (SNF)	86.8	80.0	86.5	3.230	0.086
Component yield (g/h)					
Fat	3.20	2.90	2.70	0.590	0.750
Lactose	1.94	1.84	1.87	0.285	0.936
Protein	2.04	1.94	1.97	0.299	0.938
Salt	0.32	0.30	0.30	0.046	0.931
Solid Non-Fat (SNF)	4.33	4.11	4.16	0.633	0.935

T1 (no selenium, 0 mg/day), T2 (1 mg/day), and T3 (2 mg/day). Different superscript letters show significant differences ($P < 0.05$). SED: standard error of deviation

6.2.4 Lambs Weight

Time had a significant influence on lamb weight ($P < 0.001$) (Figure 3). Lamb weight increased with progress. Selenium supplementation did not affect the weight of lambs. In agreement with the current results, [52] stated that ewes treated with Vitamin E-Se had no significant influence on lamb weight at birth compared to the control groups. The current result disagrees with [6], who reported that Slow-release ruminal pills containing selenium and cobalt during late gestation enhanced lamb birth and weaning weights. Furthermore, [56] found that lambs delivered to ewes that received selenium at 0.3 mg per day had a greater average daily weight and weaning weight compared to those that received no selenium ($P < 0.05$). This variability may be attributed to the influence of the method of

selenium supplementation or supplementation of Se in combination with other minerals. In addition, [2] reported that lamb supplementation with selenium yeast (1 and 3 mg/day) had lower levels of minerals (Mn, Fe, I and Zn) in both rumen fluid and meat than lambs in the control group (0mg/day). This means that the concentration of minerals reaches to the animal tissues (uterus or udder) may decrease when the animal is supplemented with Se. In the current experiment, Se supplementation may reduce the mineral content of milk or the placenta, leading to an insufficient amount of these minerals that reach the lambs during both pregnancy and lactation. This could be the reason that Se supplementation did not affect lamb weight.

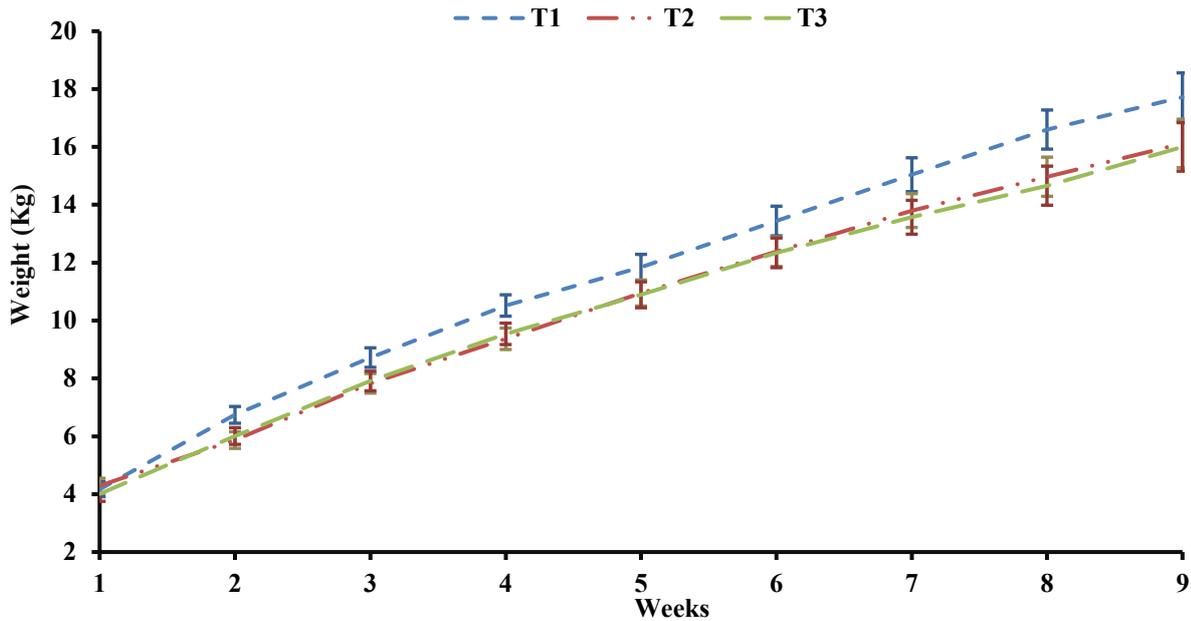


Figure 3: The effect of selenium-enriched yeast supplementation on ewes' lamb weight (kg).

6.3 Biochemical Parameters

6.3.1 Serum Cortisol Concentration

Time influenced the amount of cortisol in the blood ($P < 0.001$), with levels rising at late gestation (week -2) and declining markedly by +2 weeks postpartum (Table 4). Selenium supplementation showed no significant effect on cortisol ($P = 0.063$), however, ewes in T1 treatment (1 mg Se/day) tended to have lower levels during late gestation that is mean selenium supplementation seems to have a lower cortisol level largely by its antioxidant activity, which its functions through selenoproteins like glutathione peroxidase to minimize the oxidative stress that may both induce and stimulate the production of cortisol, so minimizing the stress response [13]. [47]

discovered a decrease in plasma cortisol levels in dystocia-affected buffaloes administered intramuscularly with Vitamin E with selenium (50 mg tocopherol acetate and 1.5 mg/ml sodium selenite) [48] also supports the current experiment results by reporting that the cortisol level was significantly (<0.01) low in treated sheep with 0.3 mg Se/day + 50 gm vit E compared to the control group. In the last few days of gestation, the fetal Hypalamic-Pituitary-Adrenal Axis (HPA axis) develops and activates, resulting in a significant, rapid rise in fetal plasma cortisol concentration [22].

Table 4: The effect of selenium-enriched yeast supplementation on ewe's blood serum cortisol (COR) (ng/ml) during late gestation and early lactation

Weeks	T1	T2	T3	SED	P-value
-6	13.8	10.5	9.00	3.710	0.441
-2	19.9	8.60	15.2	4.590	0.075
+2	2.31	2.33	2.64	0.283	0.449

T1 (no selenium, 0 mg/day), T2 (1 mg/day), and T3 (2 mg/day). Different superscript letters show significant differences ($P < 0.05$). SED: standard error of deviation. Analysis of repeated measures of COR: SED values: Treatment=1.905, Time=2.001, Treatment \times Time=3.411, P-values: Treatment=0.063, Time= <0.001 , Treatment \times Time= 0.199

6.3.2 Thyroid Hormones (Triiodothyronine T₃ and Thyroxine T₄)

Table 5 illustrates data of hormones (triiodothyronine T₃ and thyroxine T₄) during weeks -6, -2, and +2 of both prepartum and postpartum, respectively, and shows T₃ and T₄ concentrations altered over time, with T₃ appearing to have a significant time impact ($P < 0.001$) and T₄ demonstrating a significant time \times treatment interaction ($P = 0.035$). However, differences across selenium treatments were not typically significant. The findings of the current study are in agreement with those stated by [54], who showed that there was no significant impact of selenium supplementation on FT₃ and FT₃:FT₄ ratio. [23] reported that Se supplementation, despite of its source, did not affect thyroid hormones in cows during the dry period. [9] observed no distinct changes in thyroid hormone levels were seen ($p > 0.01$) when comparing the supplemented horse with diets containing sodium selenite (30 μ g/kg WT), when selenium

content was about 13.5 μ g to the control group. The findings of the present experiment conflict with the earlier study conducted by [48], who observed that T₃ and T₄ concentrations in treated sheep were substantially higher than those in control ($P < 0.01$) when supplemented with selenium (0.3 mg/kg feed + 50 mg vitamin E). [5] showed that Plasma T₃ and T₄ levels were significantly higher ($P < 0.05$) in treated sheep, which were injected intramuscularly with 1.0 ml/head Vite Selene (150 mg vitamin E acetate and 1.67 mg sodium selenite), compared to control ewes. Where some studies show an increase in thyroid hormones and others show no effect in ewes, is scientifically possible and can be attributed to several critical factors: The environmental variables, like heat, might alter how selenium affects thyroid hormones and general health [53], the breed of ewe [48].

Table 5: The effect of dietary selenium yeast on thyroid hormones profile thyroxine (T₃) and triiodothyronine (T₄) of ewe during late pregnancy and early lactation (ng/ml)

Hormones	T1	T2	T3	SED	P-value
Triiodothyronine(T₃)					
-6	1.60	1.41	1.47	0.130	0.362
-2	2.15	1.61	2.22	0.334	0.167
2	2.31	2.33	2.60	0.283	0.449
Thyroxine (T₄)					
-6	83.0	71.3	79.3	8.270	0.378
-2	78.6	59.3	74.6	9.160	0.116
2	66.5	73.2	76.3	8.210	0.486

T1 control (0 mg Se/day); T2 (1 mg Se/day), T3 (2 mg Se/day). Means in the same row with different superscript letters are significantly different ($P < 0.05$). SED=standard error of deviation. Repeated measurements analysis of T₃: P-values: T= 0.260, Time= <.001, Time × T=0.0.231. SED values: T= 0.1969, Time= 0.1243, T × Time= 0.2640. Repeated measurements analysis of T₄: P-values: T= 0.430, Time=0.078, Time × T=0.035. SED values: T= 7.32, Time= 3.13, T × Time= 8.56

7. Conclusion

Selenium-enriched yeast supplementation (1 to 2 mg/kg DM) improved blood Se status without significantly enhancing productivity, although moderate administration (1 mg/kg DM) reduced postpartum BW loss in sheep. More study is needed to optimize Se levels for balancing health and performance.

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