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Effect of Vitamin E and Selenium on Performance and Productivity of Goats

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Abstract: Although there are many studies dealing with the effect of vitamin E and Selenium on the performance and productivity of ewes and their lambs, there are very a few studies on their effect on goats and their kids. This study was carried out to investigate the effect of Vitamin E, selenium and vitamin E plus selenium on goats and their kids during late gestation on their performance and immune status. Seventy two pregnant goats (n=72) were allotted to four treatment groups (n=18/group). Group one was kept as control. Animals of groups 2nd, 3rd and 4th received four injections (twice before parturition and twice after parturition) of vitamin E, selenium and vitamin E plus selenium respectively. The results revealed that kids from treated groups had significantly higher birth weights, rectal temperature and weaning weights with no effect on dam's body weight. In addition, the immune status of treated goats and their kids was higher than untreated animals.

Keywords: Goat, Performance, Productivity, Immune Status, Vitamin E, Selenium

1. Introduction

Newborns are susceptible to vitamin E deficiency due to the negligible amount of vitamin E crossing placenta to the fetus in uterus. For this reason it is important that colostrum supplies the neonates with sufficient amounts of vitamin E [1]. Both vitamin E and selenium (Se) have been shown to improve immune response [2]. As antioxidants, vitamin E (α-tocopherol) and selenium (Se) have complementary roles in protecting the cells against damaging effects of lipid peroxides and free radicals produced during normal metabolism. The multiple functions of both nutrients, at cellular and molecular levels, extend beyond antioxidant protection, as their inclusion in the diet at concentrations above requirements is associated with variable improvements in sheep performance and immune function [3] [4] [5]. Vitamin E and Se in the diet improved the physiological, hormonal and antioxidant status of supplemented sheep [6] and had the ameliorative potential against toxic effects of arsenic [7]. In livestock, the dietary supplementation with vitamin E and selenium may improve the negative effect of heat stress and restore the redox homeostasis in different breeds of sheep [8]. Selenium in supplementation to the diet of animals could be eliminate certain types of stress such as heat stress or postpartum stress [9] and resulted in increased selenium concentration in the colostrum of goat [10] [11] and ewe [12] [13]. Supplementation of pregnant dairy cow with vitamin E and Se resulted in increased α-tocopherol and Se concentrations in blood plasma and in colostrum on the day of parturition [14].

Dietary Se and vitamin E injections to ewes in late gestation and during lactation improved performance and livability of lambs [15]. Injection of vitamin E plus Se to ewes at 4 weeks late gestation and during suckling period for 12 weeks significantly improved average body weight and daily weight gains of offspring from birth up to weaning [16].

When the nutrient requirements for ewes are not met, supplementation of vitamin E during late gestation and early lactation might be an effective strategy to minimize ewe weight loss as well as to increase lamb growth [17]. Weekly injection of 900 IU of vitamin E to ewes in late gestation did not affect lambs birth weight, but increased the pre-weaning weight and daily weight gain while supplement of Se at 90 ppm to ewes in late gestation and during lactation insignificantly increased birth weight (3.68% only) [15]. Administration of Se alone improved reproductive performance of ewes and average daily gain of offspring [18] and in combination with zinc improved semen characteristics and reproductive performance of rams during breeding season [19]. Selenium is necessary for growth and fertility in animals and for prevention of various disease conditions that show a variable response to vitamin E. Besides, selenium deficiency can interfere with the transport of vitamin E. Diseases caused by deficiencies of Se and/or vitamin E in sheep and goats include nutritional muscular dystrophy (NMD), ill thrift and reproductive inefficiency (the last two are Se responsive) and bone marrow abnormalities [20]. Additionally, Se status in grazing crops is dependent on incorporation from soil, which in turn obtains most of its selenium from surrounding rocks. Selenium levels that occur in the Egyptian soil are considered low because the mean values of selenium in the soil as well as plants were 0.045 and 0.027 mg/kg respectively [21]. On the other hand, crops, cereal grains and dry hays tend to be poor sources of vitamin E and prolonged storage of feedstuffs results in a degradation of Vitamin E content. Consequently, a great attention has recently been focused on the role of vitamin E and Se in protecting leukocytes and macrophages during phagocytosis, It has been found that the performance of phagocytes can be improved by Se/vitamin E injection [22]. The health status and efficiency of growth and production could be increased by supplemental vitamin E in sheep [15]. As indicated by [23] feeding of vitamin E has beneficial effects on the male reproductive system of mammals as well as birds and the deficiency of this vitamin resulted in infertility in male. Although there are many studies dealing with the effect of vitamin E and Se on ewes and their lambs, there are a only few studies in goats and their kids. Therefore, this work was designed to investigate the effect of vitamin E and Selenium on performance, productivity and immune status of goats and their kids.

2. Material and Methods

The current study was carried out at Sakha Animal Production Research Station, Animal Production Research Institute, Ministry of Agriculture, Kafr El-Sheikh Governorate, Egypt, during the period from September 2012 to March 2013.

2.1. Animals and Management

Seventy two pregnant goats, approximately 4.79 years of age (Baladi, Damuscus and Zaraibi breeds) were allotted to one of four experimental groups of 18 animals (6 animals from each breed). Goats in each group were housed in a semi-covered large pen (6m×20m) with a free access to green fodder (Trifolium Alexandrium) during the green season, hay in the dry season and fresh drinking water. Concentrate mixture (corn grains 45.3%, decorticated cotton seed 11%, soya bean meal 12%, wheat bran 29%, limestone 1.8%, 0.22% sod. bicarbonate, 0.4 common salt, 0.28% mineral mixture) containing 15.5% crude protein and 65% TDN was provided during pregnancy to all groups at a rate of 1% of average body weight (500g daily/goat). This amount was increased gradually to reach 2% of average body weight (1000g/goat) at late stage of pregnancy (last 4-6 weeks).

Kidding occurred in large straw-bedded pens (6 × 9 m), in groups of 10 goats / pen. Goats were transported to these pens 2 weeks before expected kidding date. Pregnant goats were accustomed to observer presence as they were regularly checked for signs of parturition from outside of pen. They were subjected to continuous observation during the 10-14 day kidding period to ascertain the exact time of birth of each kid. All parturitions occurred naturally without assistance over a period of two months.

2.2. Animals and Dosing

During gestation period all animals received two injections 15 and 30 days prior to the expected day of birth. After parturition, goats received two injections (at kidding and 15 days after kidding). Goats in the first group (control) were injected with 1.0 ml/head of saline solution (0.9% Na Cl). Animals of the 2nd group were injected with 5ml of vitamin E acetate oily injection which contained 500 mg of vitamin E. Goats of the 3rd group were injected with 5ml of Selenite 45% per injection per animal containing 10 mg of selenite. Animals of the 4th group were injected with 5ml vitamin E acetate and Selenite per injection per animal which contained 500mg vitamin E and 10mg selenite.

2.3. Data Recordings

Maternal body weights were recorded before the starting of the treatments and at parturition. Kids birth weight and rectal temperatures were recorded within two hours after birth. Weaning weights of kids were recorded at 66 days on average. Blood samples were collected from does and kids after parturition. Blood samples were centrifuged at 3000 rpm for 15 min for serum separation. Serum was frozen at -20 °C until subsequent analysis. Total proteins and albumin were estimated for dams and their kids. T3 and T4 were measured for kids.

2.4. Blood Analysis

1. Total protein was estimated by spectrophotometer (Spekol 11, Carl Zeiss Jena, Germany) according to the instructions of the manufacturer (Diagnostic diamond, Egypt; [24]).
2. Serum albumin concentration of all kids were assayed

by spectrophotometer (Spekol 11, Carl Zeiss Jena, Germany) according to the instructions of the manufacturer (Diagnostic Biosystem, Egypt, [25]). The concentration of serum globulin was calculated as the difference between serum total protein and albumin.

3. T3 and T4 concentration of all kids were assayed by spectrophotometer (Spekol 11, Carl Zeiss Jena, Germany) according to the instructions of manufacturer.

2.5. Statistical Analysis

Data are reported as mean ± S.E.M., and were subjected to a one-way analysis of variance (ANOVA). Differences between groups means were tested with the Duncan multiple tests. Means were considered significant ($p < 0.05$ and $p < 0.01$). Statistical analyses were performed using the computer software SPSS 18.0 [26] for Windows.

3. Results and Discussion

Table 1. *Effect of vitamin E and selenium supplementation on dam body weight (kg) (Mean ± SE).*

Items	Treatments				P-value
	Control	Vit. E	Se	Vit E + Se	
Initial BW	37.58 ± 2.59	39.30 ± 2.84	42.22 ± 2.99	39.00 ± 3.18	NS
Final BW	33.08 ± 2.59	33.60 ± 2.83	36.44 ± 2.99	32.50 ± 3.17	NS

NS: Non significant

Table 2. *Effect of vitamin E and selenium supplementation during late stage of gestation on birth weight, rectal temperature at birth and weaning weight of kids (Mean ± SE).*

Items	Treatments				P-value
	Control	Vit. E	Se	Vit. E + Se	
Birth weight (kg)	1.99 ± 0.21^{b}	2.70 ± 0.25^{a}	2.75 ± 0.23^{a}	2.66 ± 0.17^{a}	0.01
Rectal temperature (°c)	38.40 ± 0.1^{b}	38.92 ± 0.09^{a}	38.76 ± 0.11^{a}	38.80 ± 0.10^{a}	0.001
weaning weight (Kg)	8.30 ± 0.59^{b}	10.36 ± 0.56^{a}	9.89 ± 0.62^{ab}	10.12 ± 0.66^{a}	0.01

Means within the same column carry different superscripts are significantly different.

Table 3. *Effect of vitamin E and selenium supplementation on serum total protein (TP), albumin (Alb) and globulin (Glob) of goats at kidding (Mean ± SE).*

Items	Treatments				P-value
	Control	Vit. E	Se	Vit. E + Se	
TP (g/dl)	5.54 ± 0.41^{b}	6.31 ± 0.27^{b}	7.72 ± 0.33^{a}	6.53 ± 0.30^{b}	0.01
Alb (g/dl)	2.92 ± 0.25^{ab}	2.73 ± 0.16^{b}	3.38 ± 0.20a	3.15 ± 0.18^{ab}	0.02
Glob (g/dl)	2.62 ± 0.38^{c}	3.58 ± 0.25^{b}	4.34 ± 0.30^{a}	3.38 ± 0.28^{b}	0.01

Means within the same row carry different superscripts are significantly different.

Table 4. *Effect of vitamin E and selenium supplementation on serum total protein (TP), albumin (Alb) and globulin (Glob) of kids (Mean ± SE).*

Items	Treatments				P-value
	Control	Vit. E	Se	Vit. E & Se	
TP (g/dl)	5.33 ± 0.30^{c}	6.48 ± 0.34^{b}	7.96 ± 0.39^{a}	6.20 ± 0.35^{bc}	0.01
Alb (g/dl)	2.44 ± 0.12^{b}	2.31 ± 0.14^{b}	3.23 ± 0.16^{a}	2.68 ± 0.14^{b}	0.01
Glob (g/dl)	2.88 ± 0.30^{c}	4.17 ± 0.35^{ab}	4.73 ± 0.40^{a}	3.52 ± 0.36^{bc}	0.01

Means within the same row carry different superscripts are significantly different.

Table 5. *Effect of vitamin E and selenium supplementation on serum total protein (TP), albumin (Alb) and globulin (Glob) of kids in relation to birth rank (Mean ± SE).*

Groups	Birth-rank	TP (g/dl)	Alb (g/dl)	Glob (g/dl)
Control	1	6.02 ± 0.43	2.05 ± 0.17	3.97 ± 0.43^{a}
	2	5.48 ± 0.54	2.45 ± 0.21	3.03 ± 0.54^{ab}
	3	4.98 ± 0.63	2.60 ± 0.25	2.37 ± 0.64^{b}
	4	4.82 ± 0.71	2.67 ± 2.28	2.16 ± 0.72^{b}
P-value		NS	NS	0.03
Vitamin E	1	6.14 ± 0.47	2.15 ± 0.19	4.00 ± 0.48
	2	6.61 ± 0.58	2.44 ± 0.23	4.17 ± 0.59
	3	6.92 ± 0.82	2.50 ± 0.33	4.41 ± 0.83
	4	6.26 ± 0.82	2.15 ± 0.33	4.11 ± 0.83
P-value		NS	NS	NS
Selenium	1	8.16 ± 0.54^{ab}	3.02 ± 0.21	5.14 ± 0.54^{a}
	2	9.26 ± 0.71^{a}	3.06 ± 0.28	6.20 ± 0.72^{a}
	3	6.21 ± 1.00^{b}	3.21 ± 0.40	3.00 ± 1.01^{b}
	4	8.21 ± 0.82^{ab}	3.63 ± 0.33	4.58 ± 0.83^{ab}

Groups	Birth-rank	TP (g/dl)	Alb (g/dl)	Glob (g/dl)
P-value		0.02	NS	0.05
Vit. E + Se	1	6.40 ± 0.58	2.41 ± 0.23	3.99 ± 0.59
	2	6.52 ± 0.71	2.58 ± 0.28	3.95 ± 0.72
	3	5.66 ± 0.71	2.93 ± 2.28	2.74 ± 0.72
	4	6.23 ± 0.82	2.81 ± 0.33	3.42 ± 0.83
P-value		NS	NS	NS

Means within the same column carry different superscripts are significantly different. NS: Non significant

Table 6. *Effect of vitamin E and selenium supplementation during late stage of pregnancy on T3 and T4 levels of kids.*

Items	Treatment				P
	Control	Vitamin E	Selenium	Vit. E & Se	
T3	5.28 ± 0.75	4.99 ± 0.75	4.93 ± 0.75	4.95 ± 0.75	NS
T4	9.20 ± 1.60	10.26 ± 1.60	9.48 ± 1.60	10.48 ± 1.60	NS

NS: Non significant

3.1. Goats and Kids Performance

Results of this study showed that injection of vitamin E or selenium or both during the late stage of gestation had no effect ($p>0.05$) on the goats' body weight (Table 1). This is in agreement with the data reported of [27], [28], [16] who reported that supplementation of Selenium-vitamin E to pregnant goats had no effect on their body weights. Also, [29] found that injection of post-partum nursing ewes with vitamin E and Se had no effects on ewe's body weight, milk yield and composition.

Treatment of pregnant goats with vitamin E, selenium or vitamin E plus selenium significantly improved ($p<0.01$) birth weight of their kids compared to kids from untreated pregnant goats (Table 2). This result is in agreement with [17] [30] [31] [32] who reported a significant increased lamb birth weight with increased dietary vitamin E to pregnant ewe. The supplementation of goat with Selenium plus vitamin E was significant for kid's birth weight, with a more positive effect at dose of (0.5 mg/kg Se and 20 mg/kg vit E) which improved their reproductive performance and growth of their kids [33]. Contrary to the result of the present study, no differences in birth weight of lambs were found between vitamin E supplemented ewes and non-supplemented control ewes [28]. Selenium and vitamin E supplementation at the late of pregnancy of ewes had no effect on lamb birth weight [12]. As stated by [33] dietary supplementation of goat with Selenium or vitamin E alone had no effect on their reproductive parameters. In the same trend, [13] noted that, lamb birth weight was not affected by maternal supplementation with different levels of selenium at late gestation period.

Significant effect was demonstrated in kids' rectal temperature within the first 2 hrs of birth in supplemented groups with vitamin E or selenium or both ($p<0.001$) compared to kids' from control groups (Table 2). Vitamin E is an integral component of lipid membranes. Therefore, during neonatal period, brown adipose tissue (BAT) acts as a primary source of non-shivering heat production [34], [35]. Activation of BAT causes large increases in oxygen consumption and consequently causes increases in oxygen radical generation [36]. The activity of BAT in the neonate would suggest a need for ample amounts of antioxidants to reduce the amount of free radical buildup. As stated by [36] with the relatively low activities of antioxidants in BAT and increased free radical generation, BAT activation could lead to a physiological oxidative stress on the body. Newborns are susceptible to vitamin E deficiency and, due to the negligible amount of vitamin E crossing to the fetus in uterus, it is important that colostrum supplies the lamb with sufficient amounts of vitamin E [1], [37]. In fact there are no reports in the literature on whether supplemental vitamin E to does or kids affects the use of BAT or thermogenesis in general in lambs.

Kids born to goats with vitamin E or vitamin E plus Selenium had significantly higher weaning weights ($p < 0.01$) than kids from untreated control goats (Table 2). This result is in agreement with the findings of [1] who showed that injection of pregnant ewes with vitamin E two weeks pre-partum and again at lambing increased the average daily gains than lambs born to untreated ewes. Also, [31] [38] [17] indicated that weaning weights of lambs born to ewes treated with vitamin E were greater than lambs from untreated ewes. Injection of ewes with vitamin E plus Se before mating and lambing seasons [39] or at 4 and 2 weeks before parturition [12] significantly increased lambs' daily weight gain from birth up to 60 days and mean lambs' body weight at 60 days. On the other hand, [29] indicated that postpartum injection of ewes with vitamin E and selenium failed to improve their lambs growth rate and weaning weight.

Weaning weights of kids born from goats supplemented with vitamin E and vitamin E plus selenium were non significantly higher ($p>0.05$) than weaning weight of kids born from selenium only treated goats (Table 2). Contrarily, [40] reported that supplementation of Baladi ewes with 50 mg vitamin E plus 0.3 mg of Se /kg diet starting 2 weeks before mating and extended through pregnancy till lambing had significant improvement of their reproductive performance and growth performance of their lambs from birth up to weaning compared to lambs from ewes supplemented with vitamin E or Se alone. Also, [39] found that, lambs from ewes supplemented with Se-vitamin E had a higher birth weight, daily weight gain and body weight at 60 days of age compared to lambs from ewes received Se only.

Injection of selenium to pregnant goats non-significantly improved weaning weight of their kids ($p>0.05$) compared to control group (Table 2). Similarly, [41] reported that when ewes received selenium alone in organic and inorganic forms during pregnancy and lactation there were no significant effects on either birth weight or growth of their lambs. In the same trend, [10] indicated that selenium supplementation to goats had no effect on their kid's weight at birth and 4th week of age. Practically, Se supplementation enhances the level of selenium and may indirectly improve animal performance [42], possibly by strengthening the immunity of the animals [43].

Parental supplementation of vitamin E is better than dietary supplementation as absorption in first mode is higher and leading to superior action and this may explain our good results. As mentioned by [44] vitamin E administrated orally via gelatin capsules was less bio-available than intramuscular or intravenous injections. This may explain the positive benefits of injected vitamin E alone on improvement of kids weaning weight.

3.2. Goats and Kids Immunity

In this study the level of the serum globulin in goats treated with selenium or vitamin E or both was higher ($p<0.01$) than serum globulin of untreated goats (Table 3). Also, kids born to goats supplemented with selenium or vitamin E had significantly more ($p<0.01$) serum globulin compared to kids born from control un-supplemented goats (Table 4). This result is in agreement with [16] who found that ewes supplemented with vitamin E plus selenium had significantly improved serum globulin compared to untreated ewes. Also, [31] noted increased serum IgG in lambs injected with vitamin E at birth. In the same trend, [45] noticed higher IgG level in colostrum of dams injected with vitamin E plus selenium (viteselen) and in the serum of their calves. Moreover, [13] reported that supplementation of ewe at late pregnancy with organic selenium resulted in increased serum IgG concentration in the supplemented ewe and their lambs compared to control ewes and their lambs. Selenium and vitamin E injection during late pregnancy of ewe at the level of 10 ml improved passive immune system and colostrum production [12]. Contrarily, [46] found no differences in IgG levels between vitamin E-supplemented lambs and non-supplemented lambs. Also, [10] reported that the mean serum IgG level was not different among goats supplemented with organic and inorganic selenium and their kids compared to control goats and kids.

Results from (Tables 3 and 4) indicated the strengthening action of the selenium towards the immunity state which highly reflected on the serum globulin level of both goats and their kids in the selenium only treated group. This result is in agreement with [47], [48] who reported that supplementation of Selenium alone is more beneficial than supplementation of vitamin E and Selenium together on production of immunoglobulins. On the other hand, our results disagree with those of [49], [4] who found that vitamin E and Selenium together have an important beneficial effect on immunity than administration of Selenium alone. It has been suggested that selenium can protect immune cells for long time whereas vitamin E has an immediate effect [49]. Another study on buffalo calves indicated that supplementation of Se improved the humoral immune response, whereas vitamin E showed a tendency towards improvement in cell mediated immune response [2]. L-selenomethionin supplementation to pregnant goat resulted in higher WBC, neutrophil and lymphocyte counts in their kids at birth and 7 days of age compared to kids from the control group [10]. Although the effects of selenium and vitamin E on the immune system are still unclear, they are most probably attributed to their antioxidant properties [4]. Further investigations are needed to fully clarify that issue.

Results from (Table 5) showed no differences ($P>0.05$) in serum globulin level between kids of different birth ranks within the treated groups except selenium treated group. Kids of rank one and two that were born to goats injected with selenium had significantly more globulin concentrations than kids of rank three ($p=0.05$). On the other hand globulin level in kids of birth rank number one is better than three and four in control group ($p=0.03$). Results in the current study indicated that, injection of vitamin E and vitamin E plus Selenium improved globulin concentration in kids of all ranks including third and fourth rank.

The results of current study (Table 6) showed no positive appreciable changes ($p>0.05$) in the plasma metabolites and thyroid hormones (T3 and T4) of kids born from goats injected with vitamin E, selenium and vitamin E plus selenium compared to kids from control goats. This result is not in agreement with that of [16] who indicated that supplementation of ewes with vitamin E plus selenium had appreciable changes in T3 and T4 and revealed that some metabolic activity processes might be enhanced in their study. Also, [13] reported that lambs born to ewes supplemented with selenium (0.300 mg/kg Se and 0.425 mg/kg Se) had significantly higher free triiodothyronine and free thyroxine compared to lambs born to unsupplemented control ewes. T3 and T4 were significantly higher in the treated sheep with Se and vitamin E compared to the control sheep under heat stress [6].

In conclusion, injection of Selenium, vitamin E or vitamin E plus Selenium to goats at late gestation and during suckling period significantly improved kid's birth weight and kid's rectal temperature within the first 2 hrs of birth, with no effect on goat's body weight.

Kids born to supplemented goats with vitamin E or vitamin E plus Selenium but not Selenium alone had significantly higher weaning weight compared to kids born to control goat. Weaning weight of kids born from Se supplemented dam not differed from weights of kids born to control or other treated goats.

Serum globulin level was significantly higher in the supplemented goats and their kids with compared to control goats and their kids.

Vit E or vit E plus Se supplementation to pregnant goats resulted in improved globulin concentration in their kids of

all ranks including third and fourth rank. However, globulin concentration in kids of birth rank number one is better than three and four in control group.

The plasma metabolites and thyroid hormones (T3 and T4) of kids were not affected by maternal supplementation.

Vitamin E has more beneficial effect on kids' performances than Selenium. However, the effect of Selenium on the immunity was more marked than vitamin E in both dams and kids.

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