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The effects of different levels of vitamin E supplementation in the diet on the reproductive performance of crossbred rabbits using artificial insemination technique

Truong Thanh Trung[1*], Pham Thi Cam Nhung[2], Nguyen Thi Kim Dong[3], and Tran Long Hai[1]

[1]*Faculty of Animal Sciences, College of Agriculture, Can Tho University, Viet Nam*

[2]*Department of Physiology, Faculty of Veterinary, Chulalongkorn University, Thailand*

[3]*Tay Do University, Viet Nam*

**Corresponding author (tttrung@ctu.edu.vn)*

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ABSTRACT

This experiment was conducted to evaluate the effects of dietary vitamin E supplementation in female rabbits on reproductive performance and economic efficiency, monitored across three consecutive litters using artificial insemination. The experiment was arranged in a completely randomized design with 32 crossbred doe rabbits (New Zealand White × local), aged 8-8.5 months, with an average body weight of 2.693 ±115 g, and they were divided into 4 treatments, each consisting of 8 replicates. The diet of all rabbits in the experiment was the same, contained 21% crude protein (CP) and 10.5 MJ/KgDM of metabolizable energy (ME). The experimental treatments were as follows: Treatment 1 served as the control, without vitamin E supplementation (E0), while the other treatments included dietary supplementation with vitamin E at levels of 40 mg/kg DM (E40), 80 mg/kg DM (E80), and 120 mg/kg DM (E120). Artificial insemination was used for all experimental rabbits. The experiment results showed that the E80 performed better than the others in terms of conception rate, mean weight at birth, milk yield of doe, mean weight at weaning (P>0.05), and produced the highest economic efficiency.

1. INTRODUCTION

Artificial insemination (AI) has played a significant role in enhancing the economic performance of livestock farms worldwide. In recent years, growing interest has emerged in the Mekong Delta regarding the application of AI in rabbit production, as a promising technique for reducing breeding costs and optimizing the reproductive potential of bucks. Furthermore, dietary supplementation with varying levels of crude protein, vitamin E, and metabolizable energy has shown positive effects on improving semen quality in bucks (Hai & Trung, 2024; Trung et al., 2024a, 2024b) but also enhanced on doe's reproductive performance resulting in the effective evaluation of artificial insemination.

The Mekong Delta's tropical climate, which is hot and humid year-round, provides a diverse natural feed source for rabbits but also presents significant challenges. The high temperature-humidity index (THI) leads to prolonged heat stress in rabbits (Hai, 2024). Prolonged heat stress reduced the secretion of LH and FSH, affecting follicle development and ovulation in does (Chatterjee & Chatterjee, 2009; Arabameri et al., 2017). Additionally, reduced feed intake due to stress contributed to nutritional imbalances, resulting in nutrient deficiencies, lower average birth weight, decreased milk yield, and reduced offspring survival (Hassnaa et al., 2008). Vitamin E provides more benefits to oxidative stress reduction and lowers the risk of pregnancy complications by eliminating the body's primary peroxyl lipid free radicals (Anderson et al., 2019). The vitamin E requirement for rabbits was suggested by Lebas (2000) to be 40 mg/kgDM in the diet. Shaibu (2014) reported that there were no significant differences in conception rates in rabbits supplemented with 40 mg/kgDM of vitamin E, however, there was an improvement in mean weight at birth. At the level of 80 mg, vitamin E/kgDM improved in weaning weight (Abdel-Khalek et al., 2008).

This study aims to evaluate the effects of vitamin E different levels supplementing in the diet on the reproductive performance and economic efficiency of New Zealand White crossbred doe rabbits by using artificial insemination.

2. MATERIALS AND METHOD

2.1. Animals and management

The experiment consisted of 32 crossbred doe rabbits (New Zealand White×local), aged 8-8.5 months, with an average weight of 2.693±115 g. The rabbits were fully vaccinated against parasitic and respiratory diseases. The experiment was carried out from January to September 2023 at the experimental farm in Thoi Hoa ward, O Mon district, Can Tho City, Viet Nam. The chemical analysis of feed and semen quality was conducted in the laboratories of the Faculty of Animal Sciences, College of Agriculture, Can Tho University.

2.2. Experimental design and data collection

The experiment was arranged in a completely randomized design with four treatments and eight replications. The four treatments consisted of different levels of vitamin E supplementation in the diet, (0 mg, 40 mg, 80 mg, and 120 mg/KgDM) across three litters of does (litter first, litter second, and litter third) corresponding to E0, E40, E80, and E120, respectively.

The rabbits were housed individually, equipped with an automatic water supply, and fed a balanced nutritional diet consisting of soya waste (200 g), soybean extraction meal (30 g), local commercial feed (30 g), and *Brachiaria mutica* (300 g). The diet contained 21% crude protein (CP) and 10.5 MJ/KgDM of metabolizable energy (ME). Vitamin E was added to the diet according to the experimental design. The rabbits were fed three times daily (at 8:00, 13:00, and 18:00), and feed intake was determined by weighing the feed offer and feed refusal to calculate dry matter intake. During the pregnancy and lactation periods, the diet was increased by 20%, 30%, and 40% basal diet in the second, third, and fourth pregnancy weeks, respectively. The diet was increased up to 40% basal diet during lactation weeks.

All feeds used in the experiment were fresh, and feed samples were analyzed for Dry Matter (DM), Organic Matter (OM), Crude Protein (CP), Ether Extract (EE), Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF), and ash following the AOAC (1990) procedures. The metabolizable energy (ME) values of the feeds were calculated based on these analyses.

$$\mathrm{ME} = \mathrm{DE} \times \left(0.995 - 0.048\,\frac{\mathrm{DCP}}{\mathrm{DE}}\right) \text{ (MJ/KgDM)}$$

(Maertens et al., 2002) in which:

$\mathrm{DE} = 14.9 - 0.22 \times \mathrm{ADF} + 0.35 \times \mathrm{EE}$ (MJ/KgDM) (De Blas et al., 1992)

$\mathrm{DCP} = (-1.15) + 0.82 \times \mathrm{CP} - 0.06 \times \mathrm{ADF}$ (%/DM) (Fernandez-Carmona et al., 2004)

Where: DCP is digestible crude protein

2.2.1. Artificial insemination method

Fresh semen was collected from three New Zealand White × Local crossbred bucks, each averaging 2.51 ± 0.06 kg in body weight. The semen had an average volume of 0.6 mL, a sperm concentration of 200–300 × 10^6 sperm/mL, and a motility rate of 60–70%. After collection, the semen samples were thoroughly mixed and diluted with TCG extender to ensure uniform quality, providing consistent semen parameters for artificial insemination across all does involved in the experiment.

Semen samples were collected from bucks using an artificial vagina (Ewuola et al., 2014), consisting of a plastic cylinder with a rubber lining around the rim to warm the water. The artificial vagina (AV) was pre-warmed in water at 50 –55°C, ensuring a temperature of 40 –42°C at the time of collection. The inner sleeve was lubricated with Vaseline, and a teaser doe was introduced into the buck's pen. As the buck mounted the teaser doe, the AV was inserted, and the ejaculate was collected.

The semen samples were processed to remove the gel portion (rabbit seminal plasma) and were evaluated for volume, pH, motility, and sperm concentration following the methods described by Hai et al. (2023) before being used for artificial insemination. Semen samples with a volume >0.3 mL, motility >60%, and concentration >200×10^6 sperm/mL were considered meeting the average quality standards for rabbit semen, as per Battaglini et al. (1993). The evaluated samples were pooled and diluted at a ratio of 1:10 with TCG medium (tris-glucose-citric acid) at a pH of 6.9-7.1. Each insemination dose contained at least 0.5 mL of diluted semen. The does were injected with a hormone (containing GnRH) to induce ovulation 6 hours before insemination.

The does were re-mated after weaning the kits (30 days postpartum). The newborn kits were weighed daily before and after milk consumption. Kit weights at birth and weaning, as well as daily milk yields, were recorded. The does were weighed weekly from mating until the weaning of their kits, and their weight gains were calculated.

2.3. Statistical analysis

The data were analyzed using the General Linear Model of the Minitab 13.21 program (Minitab, 2016). To determine the significance of pair-wise comparisons, a Tukey method was performed. Significance was declared at P<0.05.

3. RESULTS AND DISCUSSION

3.1. Chemical composition of feed ingredients used in the experiment

Table 1 shows the chemical composition and energy values of the feeds used in the experiment. Soya waste had a lower DM content and higher CP content and was used as the main feed source for rabbits. Soybean extraction meal had a high CP content and was used as an ideal protein supplement. The commercial feed was included to balance the nutrients, providing appropriate nutritional balance for rabbits during pregnancy and lactation. *Brachiaria mutica* served as a natural fiber source, aiding in the balance of vitamins and minerals due to the rabbits' cecal digestion. The chemical composition of these feed ingredients was consistent with previous studies by Tinh et al. (2023) and Hai and Trung (2024).

Table 1. Chemical composition of feed ingredients used during the experimental period (%DM)

Feed Ingredients	DM	OM	CP	EE	NDF	ADF	Ash	ME, MJ/KgDM
Soya waste	15.2	91.0	18.7	9.23	32.2	27.8	5.00	11.2
Soybean extraction meal	92.1	93.6	42.3	2.68	26.4	16.8	6.40	12.9
Commercial feed	90.3	92.1	16.8	4.52	41.3	25.1	7.90	10.7
Brachiaria mutica	18.5	90.3	11.8	3.65	68.2	39.6	9.70	7.04

DM: Dry Matter, OM: Organic Matter, CP: Crude Protein, EE: Ether Extract or Crude Fat, NDF: Neutral Detergent Fiber, ADF: Acid Detergent Fiber, Ash: Total Minerals, ME: Metabolizable Energy.

3.1. Nutrient intake and reproductive performance in the first litter

Table 2 shows the nutrient intake on average pregnancy and lactation period in the first litter. Generally, there was no difference among all treatments in terms of DM, OM, CP, EE, NDF, ADF, Ash, and ME (P>0.05). This was suitable for the experiment design only differences in levels of vitamin E.

Table 2. Nutrient intake on average pregnancy and lactation period in the first litter

Items	Treatments				SEM	P
	E0	E40	E80	E120		
Feed intake, g/day						
Soya waste	31.7	33.9	33.9	32.4	0.951	0.265
Soybean extraction meal	28.4	28.9	29.0	27.7	0.925	0.734
Commercial feed	35.5	35.5	35.5	35.5	0.020	0.630
Brachiaria mutica	37.3	32.0	35.2	30.6	2.253	0.169
Vitamin E (mg)	0.00	5.00	10.0	15.0	-	-
Total nutrient intake, g/day						
DM	133	130	134	126	3.463	0.433
OM	121	119	123	116	3.158	0.437
CP	28.3	28.3	28.7	27.3	0.720	0.577
EE	6.65	6.68	6.80	6.46	0.163	0.526
NDF	57.8	55.0	57.2	53.3	1.828	0.295
ADF	37.3	35.9	37.1	34.7	1.127	0.343
Ash	11.1	10.8	11.1	10.5	0.306	0.400
ME, MJ	1.36	1.36	1.38	1.32	0.032	0.527

DM: Dry Matter, OM: Organic Matter, CP: Crude Protein, EE: Ether Extract or Crude Fat, NDF: Neutral Detergent Fiber, ADF: Acid Detergent Fiber, Ash: Total Minerals, ME: Metabolizable Energy.

Table 3 shows the reproductive performance of the first litter. The conception rate increased from E0 to E80, however, there did not differ among all treatments (P>0.05). Litter size at birth, litter weight at birth, litter size at weaning, mean weight at weaning, and litter weight at weaning gave better results at the E80 compared to other treatments (P>0.05). The milk yield of the doe rabbit got the highest value at E80 compared to others (P<0.05).

Table 3. Reproductive performance of the first litter

Items	Treatments (Mean±SD)				SEM	P
	E0	E40	E80	E120		
Pregnancy weight gain, g/doe	356±72.3	377±112	374±157	341±57.7	37.82	0.901
Conception rate, %	53.0±0.43	63.0±0.44	75.0±0.38	88.0±0.35	0.143	0.365
Litter size at birth (kits/litter)	5.00±1.31	6.00±0.00	6.63±0.92	6.13±1.96	0.447	0.097
Mean weight at birth, g/kit	53.2±9.14	60.2±10.0	55.4±8.32	51.3±9.30	3.257	0.273
Litter weight at birth, g/litter	325±42.4	325±85.8	342±82.1	288±78.6	26.26	0.527
Litter size at weaning (kits/litter)	5.00±1.31	5.85±0.29	6.46±0.82	5.26±1.83	0.426	0.096
Mean weight at weaning, g/kit	429±61.1	391±53.2	426±69.7	407±97.4	25.56	0.701
Litter weight at weaning, g/litter	2082±451	2197±383	2316±338	1924±314	132.6	0.214
Milk yield of the doe rabbit, g/day	90.6 ± 9.60^{ab}	84.9 ± 13.9^{ab}	94.4 ± 4.78^{a}	73.2 ± 22.8^{b}	5.088	0.035
Liveborn to weaning survival rate, %	100 ± 0.00^{a}	97.5 ± 4.63^{a}	97.7 ± 2.71^{a}	86.0 ± 9.80^{b}	1.975	0.001
Eye-opening weight, g/kit	137±20.6	137±12.8	136±22.9	132±23.1	7.174	0.946
21-day weight, g/kit	263±35.2	252±55.5	260±54.6	260±70.6	19.60	0.979

3.2. Nutrient intake and reproductive performance in the second litter

The experimental rabbits were fed a similar diet in all treatments; there was no significant difference in feed intake among all treatments (P>0.05). However, the nutrient intake tended to increase slightly from treatment E0 to E80 (P>0.05). Most studies did not record any impact of vitamin E supplementation alone in the diet on feed intake of does (Adeyemo et al., 2022). However, research involving the combined supplementation of vitamin E with Selenium or a mix of vitamins AD_3E reported improvements in feed intake of pregnant does under heat stress conditions (Sharaf et al., 2021). A similar trend was observed in the study by Tinh et al. (2023), were the feed intake of pregnant does improve at 80 mg/kg DM of vitamin E compared to the control (P>0.05).

Table 4. Nutrient intake on average pregnancy and lactation period in the second litter

Items	Treatments				SEM	P
	E0	E40	E80	E120		
Feed intake, g/day						
Soya waste	39.2	38.5	39.3	39.0	0.230	0.093
Soybean extraction meal	35.2	35.0	35.6	35.3	0.383	0.763
Commercial mixed feed	36.0	36.2	35.7	35.8	0.229	0.408
Brachiaria mutica	30.4	32.8	36.5	31.6	2.630	0.406
Vitamin E (mg)	0.00	5.50	11.0	16.5	-	-
Total nutrient intake, g/day						
DM	141	143	147	142	2.759	0.402
OM	129	131	135	130	2.495	0.402
CP	31.9	32.0	32.7	32.0	0.375	0.378
EE	7.30	7.33	7.53	7.32	0.105	0.393
NDF	57.6	59.0	61.7	58.2	1.826	0.412
ADF	37.9	38.7	40.3	38.2	1.065	0.408
Ash	11.6	11.7	12.2	11.7	0.264	0.404
ME, MJ	1.49	1.50	1.54	1.50	0.021	0.403

DM: Dry Matter, OM: Organic Matter, CP: Crude Protein, EE: Ether Extract or Crude Fat, NDF: Neutral Detergent Fiber, ADF: Acid Detergent Fiber, Ash: Total Minerals, ME: Metabolizable Energy.

The reproductive results of the second litter (Table 5) did not show any significant differences among the different levels of vitamin E supplementation in the reproductive performances (P>0.05). However, the experiment still provided positive indications that artificial insemination in higher efficient rabbit production. The average conception rate was 75%, with the highest rate being 81.3% at 80 mg/kg DM of vitamin E. This was consistent with our previous study, where the conception rate of does using artificial insemination reached 75% when different semen dilution ratios were applied (Hai & Trung, 2023).

Table 5. Reproductive performance of the second litter

Items	Treatments (Mean±SD)				SEM	P
	E0	E40	E80	E120		
Pregnancy weight gain, g/doe	277±125	295±83.5	338±142	331±128	42.98	0.709
Conception rate, %	72.9±38.8	73.2±31.6	81.3±34.7	71.3±32.3	12.18	0.954
Litter size at birth (kits/litter)	5.00±1.31	4.94±1.15	5.50±1.77	5.50±1.41	0.501	0.770
Mean weight at birth, g/kit	61.0±10.5	55.5±6.27	60.5±10.2	54.2±6.51	3.043	0.297
Litter weight at birth, g/litter	300±69.3	273±64.0	320±71.7	293±62.2	22.67	0.553
Litter size at weaning (kits/litter)	5.00±1.31	4.94±1.08	5.50±1.77	5.38±1.41	0.500	0.817
Mean weight at weaning, g/kit	350±82.9	362±34.1	390±108	358±72.6	27.92	0.770
Litter weight at weaning, g/litter	1718±518	1784±380	2015±390	1866±404	150.8	0.548
Milk yield of the doe rabbit, g/day	81.6±15.9	79.3±10.7	88.6±15.3	88.1±13.4	4.946	0.460
Liveborn to weaning survival rate, %	100±0.00	100±0.00	100±0.00	97.9±5.89	1.042	0.407
Eye-opening weight, g/kit	127±24.4	136±15.3	140±24.5	133±17.5	7.368	0.671
21-day weight, g/kit	225±44.7	229±25.0	243±75.0	227±38.0	17.40	0.872

Litter size at birth ranged from 4.94 to 5.5 kits/litter, with the lowest mean weight at birth recorded at E120 of 54.2 g/kit and the highest at E0 of 61.0 g/kit. This outcome aligned with the feed intake of the experimental rabbits, where the E80 showed higher intake due to the larger litter size and more requirements for nursing more kits. However, the E120 demonstrated poor reproductive performance, with a lower weaning rate of kits. This was attributed to the lower nutrient intake of the does in this group, which, despite nursing more kits, resulted in limited nutrients available in the milk and during pregnancy, leading to lower kit survival and lower weaning weights. Nevertheless, no study has reported adverse effects of vitamin E overdose in animals.

3.2. Nutrient intake and reproductive performance in the third litter

Nutrient intake on average pregnancy and lactation period in the third litter (Table 6) showed no significant differences among all treatments (P>0.05). According to the research by Fortun-Lamothe (1997), the optimal ether extract (EE) level in the diet for reproduction should be >4.5%, which indicated that the EE intake of the experimental does in the third litter was appropriate, with an average EE content of 6.8%. The fat content in the diet plays a major role in animal reproduction, as it is a crucial component in the synthesis of hormones. Furthermore, the absorption of vitamin E is linked to the fat content in the diet, as vitamin E is fat soluble.

The average NDF intake of the experimental rabbits was 61.0 g, accounting for 41.7% of the diet(Table 6). The increase in fiber in the diet is often paired with fat to balance the energy for the animal. Fiber provides 5% of the energy in the diet and contributes 12-40% of the maintenance energy for the animal through the production of volatile fatty acids via hindgut fermentation (Hoover & Heitmann, 1972). This shows that the nutrient intake of the experimental does fully met the requirements for pregnancy and lactation.

Table 6. Nutrient intake on average pregnancy and lactation period in the third litter

Items	Treatments				SEM	P
	E0	E40	E80	E120		
Feed intake, g/day						
Soya waste	39.3	39.2	39.5	39.1	0.465	0.933
Soybean extraction meal	35.4	35.7	35.4	35.7	0.334	0.864
Commercial mixed feed	35.6	35.6	35.6	35.5	0.045	0.488
Brachiaria mutica	34.7	33.2	41.3	33.2	2.141	0.036
Vitamin E (mg)	0.00	5.50	11.0	16.5	-	-
Total nutrient intake, g/day						
DM	145	144	152	144	2.177	0.038
OM	133	132	139	132	1.967	0.038
CP	32.4	32.3	33.2	32.3	0.283	0.095
EE	7.45	7.39	7.71	7.38	0.090	0.052
NDF	60.4	59.4	64.9	59.3	1.461	0.034
ADF	39.6	39.0	42.2	38.9	0.855	0.034
Ash	12.0	11.8	12.6	11.8	0.211	0.036
ME, MJ	1.52	1.51	1.57	1.51	0.016	0.051

DM: Dry Matter, OM: Organic Matter, CP: Crude Protein, EE: Ether Extract or Crude Fat, NDF: Neutral Detergent Fiber, ADF: Acid Detergent Fiber, Ash: Total Minerals, ME: Metabolizable Energy.

Table 7. Reproductive performance of the third litter

Items	Treatments (Mean±SD)				SEM	P
	E0	E40	E80	E120		
Pregnancy weight gain, g/doe	256±111	259±94.5	285±160	360±173	49.02	0.423
Conception rate, %	79.2±29.2	76.6±33.0	93.8±17.7	92.2±22.1	9.262	0.451
Litter size at birth (kits/litter)	5.10±1.25	5.00±1.31	6.10±0.64	5.00±1.77	0.462	0.266
Mean weight at birth, g/kit	58.9±8.91	57.8±13.0	60.0±9.35	57.0±6.81	3.450	0.931
Litter weight at birth, g/litter	296±54.8	291±95.8	368±66.5	277±75.1	26.36	0.091
Litter size at weaning (kits/litter)	4.63±1.19	4.60±1.05	5.90±1.13	4.80±1.58	0.433	0.145
Mean weight at weaning, g/kit	373±85.2	393±72.7	374±109	350±61.4	29.72	0.790
Litter weight at weaning, g/litter	1675±350	1788±452	2157±608	1651±555	177.2	0.180
Milk yield of the doe rabbit, g/day	86.5±15.5	82.8±14.1	94.1±11.5	83.3±14.6	4.939	0.363
Liveborn to weaning survival rate, %	90.8±12.9	97.6±5.38	97.5±11.4	96.4±10.1	3.673	0.518
Eye-opening weight, g/kit	148±25.4	133±23.0	138±24.3	133±19.2	8.161	0.562
21-day weight, g/kit	244±61.7	220±26.2	229±68.1	248±46.9	18.81	0.711

Similar to the reproductive results observed in the second litter, the results in Table 7 did not show any significant differences in the reproductive performances among all treatments (P>0.05). The conception rate ranged from 76.6% to 93.8%. This result was higher than the natural mating conception rate in rabbits reported by Maertens and Luzi (1995), which ranged from 66% to 80%. The average litter size of the third litter was 5.6, larger than the 4.84±0.1 average reproductive rate reported for crossbred does in the Mekong Delta (Chau & Thu, 2014). This was consistent with our previous results using artificial insemination in rabbits, with a range of 4.2-6.8 kits (Hai & Trung, 2023). The survival rate from birth to weaning in the third litter reached over 95% for supplemented treatments, while the lowest rate was 90.8% in the control group. The highest litter size at weaning was 5.9, approximately one kit more than the other treatments. This result was suitable with the weaning numbers in the third litter reported by Trung and Truong (2020), where 4-6 kits were observed when vitamin C was supplemented in the diet of reproductive does.

The results in all three litters showed that supplementing vitamin E at a level of 80 mg/kg DM in the diet of reproductive does contributed positively to improving reproductive performance, with trends of higher conception rates, litter size at birth, litter size at weaning, and survival rates from birth to weaning compared to the control group. However, there was no significant difference in the results between the treatments, which could be attributed to the crossbred rabbits' adaptation to the environment over generations. Therefore, the environmental conditions may not have had a substantial impact on the heat stress of the experimental rabbits, leading to the unclear demonstration of the role of vitamin E. As noted by Niki (2005), the variation in experimental results regarding vitamin E is linked to the limited impact of the oxidative stress process on the experimental subjects.

3.3. Comparison of reproductive performance across two litters and economic efficiency

Overall, the reproductive performances of the does showed no significant differences among the three litters (P>0.05). This had a positive effect on evaluating the effectiveness of artificial insemination in rabbits. The high results in terms of litter size at birth, litter size at weaning, the survival rate from birth to weaning, and other parameters were higher compared to studies on natural mating in does, as reported by Trung and Truong (2020), the rabbit farming survey in the Mekong Delta by Chau and Thu (2014), and our previous study on artificial insemination in rabbits (Hai & Trung, 2023).

Table 8. Comparison of the reproductive performance among three litters

Items	Litter			P		
	Mean 1±SD	Mean 2±SD	Mean 3±SD	Litter 1 vs 2	Litter 2 vs 3	Litter 1 vs 3
Litter size at birth	5.94±1.34	5.27±1.38	5.31±1.33	0.040	0.091	0.060
Birth weight, g/kit	55.0±9.37	57.8±8.73	58.4±9.35	0.239	0.759	0.194
Litter weight at birth, g/litter	320±73.4	299±65.1	308±79.4	0.188	0.579	0.526
Litter size at weaning (kits/litter)	5.64±1.28	5.20±1.37	4.96±1.31	0.187	0.490	0.037
Weaning weight, g/kit	413±70.5	365±76.6	373±81.4	0.012	0.709	0.006
Litter weight at weaning, g/litter	2130±386	1846±421	1818±519	0.009	0.795	0.016
Milk yield of the doe rabbit, g/day	85.8±15.9	84.4±13.9	86.7±14.0	0.718	0.493	0.809
Liveborn to weaning survival rate, %	95.3±7.69	99.5±2.95	95.6±10.3	0.009	0.052	0.901

The highest economic return was E80 compared to other treatments. It was higher than at 86,574 VND (33.9%) compared to E0. This indicated that the level of 80 mg/kgDM of feed was the optimal level of vitamin E supplementation and gave the highest economic efficiency.

Table 9. Estimate the economic efficiency of the experiment over 3 litters (VND)

Items	Treatments			
	E0	E40	E80	E120
Feed cost	77.930	78.224	79.382	77.886
Hormone cost	22.602	20.265	14.949	16.012
Medicine cost	10.000	10.000	10.000	10.000
Total cost	110.532	108.489	104.331	103.898
Income	365.625	383.750	445.938	384.688
Difference	255.093	275.261	341.607	280.789

Notes: *The cost of Brachiaria mutica is 500 VND/Kg, soybean waste is 1,000 VND/Kg, soybean extraction meal is 15,000 VND/Kg, mixed feed is 10,800 VND/Kg, Vitamin E is 500,000 VND/Kg, hormone cost is 36,083 VND/cc, and 75,000 VND/weaned rabbits.*

4. CONCLUSION

Dietary supplementation with vitamin E at 80 mg/kg DM in reproductive rabbits across three consecutive litters resulted in an upward trend in conception rate, increased litter sizes at birth and weaning, and improved economic efficiency.

CONFLICT OF INTEREST

We certify that there is no conflict of interest.

5. ACKNOWLEDGMENT

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