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EFFECT OF VITAMIN E OR PROPOLIS ADDITION ON ALLEVIATION OF HEAT STRESS IMPACT ON GROWING RABBITS

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SUMMARY

This study was conducted to evaluate the effects of propolis (PS) or vitamin E (Vit. E) dietary supplementation on growth performance, nutrients digestibility, carcass characteristics and meat quality of growing New-Zeland White rabbits (NZW). Rabbits were reared in batteries and divided into five experimental groups (3 replicates in each treatment contain 10 NZW growing weaned rabbits in each replicate). The first group was fed a basal diet without any supplementation (control group). The second and third groups were fed basal diet supplemented with 100 and 150mg Vit. E/kg feed, while, the fourth and fifth groups supplemented with 100 and 150mg PS/kg feed, respectively. Rabbits were reared under heat stress condition (summer season in Egypt). Results showed that summer season had negative effects on all tested parameters. Supplementation of Vit. E or PS significantly increased final live body weight, total weight gain as well as improved, feed conversion rate, and performance index compared to the non- supplemented group (control group). There were no significant effects of rabbit diets supplemented with Vit. E or PS on crude fiber (CF) and nitrogen-free extract (NFE) digestibility, while all other nutrient digestibility and nutritive values were significantly increased. Rabbits fed diet supplemented with PS showed better growth performance and nutrient digestibility than those fed diet supplemented with Vit. E. The results clarified that, carcass and dressing percentages were significantly ($P \leq 0.01$) increased, also Heart, stomach and intestine percentages were significantly higher, while liver and lung percentages were not significantly affected in all experimental groups compared to the control group. Furthermore, the inclusion of Vit. E or PS on rabbit diets significantly reduced abdominal and shoulder fat percentages in all experimental groups compared to the control group. There was a significant increase in total protein content in meat with Vit. E or PS supplementation, this improvement is parallel to a significant decrease in total cholesterol, triglycerides and malondialdehyde (MDA). Furthermore, the percentages of drip loss and cook loss were significantly decreased in the supplemented groups compared with the control group. In conclusion, supplementing the NZW growing rabbit diets with Vit. E or PS allivated the harmful effects of heat stress on growth performance, nutrients digestibility, carcass characteristics and meat quality.

Keywords: *propolis, vitamin E, rabbit, performance, nutrients digestibility, carcass and meat quality.*

INTRODUCTION

The summer in Egypt is characterized by high ambient temperature and high relative humidity. Therefore, rabbits could be exposed to heat stress for about 6 months of the year. The temperature in summe33c r in Egypt reaches 40° C, while the suitable temperature for rabbits is around 18-21° C (Habeeb *et al*., 1998 and Maya-Soriano *et al*., 2015).

In Egypt, Climate changes have led to a significant increase in temperatures, so heat stress has become a great challenge. Heat stress impair both productive and reproductive performance (Marai*et al*., 2001, 2004). During heat stress, the free radicals especially reactive oxygen species (ROS) increased (Sivakumar *et al*., 2010; Chauhan *et al*., 2014). The increase in ROS causes oxidative stress in cells (Lord-fontaine and Averill-Bates, 2002). This causes imbalance between oxidative and antioxidant defense systems causing an oxidative damage to proteins and DNA (Droge, 2002). The few antioxidants in the body exhausted and led to oxidative stress (Abou-Ashour *et al*., 2004).

Heat stress in rabbits modifies their digestive behavior as the metabolic rate increased by about 20% in rabbits to keep a constant internal body temperature (Rakes *et al*., 1988). Ondruska *et al*., (2011) reported that feed intake; feed conversion ratio and body weight gain in white growing New-zeland rabbits were badly affected by heat stress. When Mady *et al.,* (2018) reared white new-zeland rabbit in summer in Egypt, they found that rabbit decreased frequency of feeding. Tuzcu *et al.*, (2008) found that the negative effects of heat stress in animals could be overcomed by addition of natural antioxidants.

Vitamin E is a highly effective natural antioxidant that protects cellular membranes against oxidative damage (Morrissey *et al*., 1994). Also, Ebeid *et al*., (2013) reported that vitamin E is essential for some body functions as growth, reproduction, improved biological systems and prevent some diseases. Inclusion of 20 mg vitamin E /kg in rabbit bucks diet increased average daily gain and growth performance (Asebe *et al*., 2020). Supplementing rabbit does with 100 mg /kg diet vitamin E during heat stress have a positive effect on reproductive performance (El-Ratel and Gabr ,2019).

Propolis shows an ntioxidant, antibacterial, immunomodulatory and or anti-inflammatory activity (Bankova *et al*., 2014). Also, (Orsi *et al*., 2005) reported anti-biotic and anti-fungal properties of propolis. Also, Da Silva, *et al*., (2006) reported that the antioxidant activity of propolis is due to its flavonoids content. While, Choi *et al*., (2006) suggested that there are other compounds that could be involved in the antioxidant activity of propolis. propolis is one of powerful antioxidants which are capable to get rid of free radicals (Basnet *et al*., 1997 and Banskota *et al*., 2000). Flavonoids and phenolic contents in propolis are capable of scavenging free radicals (Tatli Seven *et al*., 2009). The high content of total flavonoids leads to the anti-free radical activity in propolis extracted (Ahn *et al*., 2007). Furthermore, supplementing growing NEZ rabbits with 200mg/kg propolis improved productive performance and meat quality (Waly, *et al*., 2021).

The aim of this work was to study the effect of supplement dietary with vitamin E (Vit. E) or propolis (PS) as a natural antioxidant on growth performance, nutrient digestibility, carcass characteristics and meat quality of growing New-Zeland White ribbits to overcome the heat stress negative effects.

MATERIALS AND METHODS

Animals and experimental design:

This work was carried out at Sakha Station, Animal Production Research Institute, Agriculture Research Center, Egypt. One hundred and fifty New Zealand White (NZW) weaned rabbits at 4 weeks were randomly divided into five groups with three replicates (10 rabbits for each replicate). The first group fed basal diet (without supplementation) which formulated according to NRC (1977) to cover growing rabbit requirements. The basal diet composition and chemical analyses are presented in Table 1. The other four experimental groups were fed diets supplemented with 100 and 150 mg Vit. E /kg feed and 100 and 150mg PS/ Kg feed. This work lasted for 10 weeks in summer season (June to August), and the environmental temperature ranged between 35 to 42°C and, relative humidity was between 45 to 65%. Rabbits were weaned at 4 weeks of age and individually housed in wire cages provided with feeders and automatic nipple drinkers. Basal diet and water were offered *ad libitum*. Rabbits were reared under the same managerial and hygienic conditions.

Table (1): Experimental basal diet ingredients and chemical composition:

Ingredients	%	**Chemical composition:**	On DM bases%
Corn, ground	31.95	Dry matter	87.80
Soybean meal 44%	11.50	Crude protein	16.00
Wheat bran	11.50	Crude fibre	13.04
Alfalfa hay	39.00	Ether extract	7.80
Molasses	5.00	Nitrogen free-extract	54.57
NaCl	0.50	Calcium	0.59
DL- Methionine	0.25	Total phosphorus	0.35
*Premix	0.30		
Total	100		

**Each 3 kg contain: vitamin A, 12.000.000 IU; vitamin D, 2.500.000 IU; vitamin E, 10.000mg; vitamin K3, 1000 mg; vitamin B1, 1000 mg; vitamin B2, 5000 mg; vitamin B6, 1500 mg; niacin, 30.000 mg; biotin, 50 mg; folic acid, 1000 mg; pantothenic acid, 10.000 mg; Mn, 60.000 mg; Zn, 50.000mg; Fe, 30.000 mg; Cu, 5.000 mg; Se, 100 mg; Co, 100 mg; Mn, 250.000 mg; and $CaCO_3$, up to 3kg.*

Growth performance:

Every week live body weight and feed intake of the experimental groups were recorded, whereas total weight gain, and feed conversion ratio were calculated during the experimental period. Also, the performance index (%) was calculated according to Amber *et al*., (2004) as:

Performance index (%) = Final live body weight (Kg)/ Feed conversion ratio x 100.

Nutrient digestibility:

At the last week of the experiment, digestibility trials were conducted according to Cheeke (1987). Three males from each group were used in digestibility trial. Rabbits were housed individually in metabolism cages and diets and faeces were collected every day for 5 days' collection period. Samples of diets and dried feces were chemically analysed to determine DM, OM, CP, CF and EE according to A.O.A.C. (2000) and NFE was calculated by difference. The nutritive values of the experimental diets (DCP and TDN) were calculated according to Cheeke (1987).

Carcass characteristics:

At the end of the experiment, three males from each group were slaughtered and hot carcass, liver, kidneys, heart, spleen, emptysmall intestine, abdominal fat and shoulder fat were weighed and calculated as percentages of live weight, besides the dressing, giblets and total edible parts percentages were calculated as a percentages of live weight.

Meat quality:

The pH values of fresh meat were measured by pH meter (Blasco *et al.,* 1993). Meat mixtures of each carcass from the lumbar vertebra muscles were stored on -20°C for 4 days before chemical analysis. Colorimetric methods were used to measure the contents of total protein, triglycerides, total cholesterol, and malondialdehyde (MDA) by kits produced by Egyptian Company "Biodiagnostic". Drip loss percentages were determined by Lundström and Malmfors, (1985) and the cooking loss were calculated by Omojola and Adesehinwa (2006).

Statistical analysis:

The data were statistically analyzed using the general linear model (GLM) procedure of SAS User's guide (SAS, 2001). Differences among means were separated by using Duncan's Multiple Range test (Duncan's, 1955). The following model used=

$$Yij = \mu + Ti + eij.$$

Where: μ= Overall mean of Yij, Ti = Effect of treatment, I= (1,2,3) eij =Random error.

RESULTS AND DISSCUTION

Growth performance:

The effects of supplemented diet with Vit. E or PS on growth performance during heat stress are showed in Table 2. All treatment groups showed significantly ($P \leq 0.05$) improve in growth performance compared with control group. Rabbits received PS had significantly ($P \leq 0.01$) higher final body weight. Either Vit. E or PS significantly ($P \leq 0.01$) improved body weight gain and the best group was 1866.5g which received 150mg PS /kg feed. Total feed intake was significantly decreased in treatment group received 100 mg Vit. E /kg feed also 100 and 150mg PS /kg feed by 9.5, 9.2 and 15.9 %, respectively, compared to the control group. However, addition of Vit E or PS significantly improved FCR by 15.1, 7.0 for rabbit received 100 and 150mg Vit. E /kg feed and 13.8 and 28.6 % for rabbit received 100 and 150mg PS /kg feed, respectively, compared to the control group. Regarding performance index% of the growing NZW rabbits, there were significant improvement ($P \leq 0.01$) in the treatment groups compared with control. This improvement estimated by 26.17, 15.93% for rabbit received 100 and 150mg Vit.E /kg feed, and 24.35 and 60.71% for rabbit received 100 and 150mg PS /kg feed, respectively, compared to the control group. The group received 150mg PS /kg feed recorded the best final live weight, total weight gain, feed conversion rate, and performance index compared to the other groups.

Ondruska *et al*. (2011) results are in agreement with our results. They found that feed intake, feed conversion ratio, and body weight gain of growing NZW rabbits were negatively affected during heat stress. Arafa *et al*. (2012) reported that supplementing growing rabbit diets with 120mg Vit. E improved growth performance during moderate heat stress. This improvement in growth performance may be related to that Vit.E inhibit production of both prostaglandins and the enzymes involved in gluco-corticoids production, corticosterone which has a negative effect on growth performance (Dalólio *et al*., 2015; Hajati *et al*., 2015).

Gabr (2013) which reported that the oral administration of propolis at a level of 0.5 g /d for rabbit bucks improved body weight at 6 weeks of age. Also, 200 mg/kg body weight bee pollen and propolis increased body weight gain significantly of rabbit does 1 wk. after mating (Attia *et al*., 2015). Furthermore, many authors found a significantly increase in body weight gain with the supplementation of propolis (Shalmany and Shivazad, 2006). In contrast, Coloni (2007) and Piza *et al*. (2021) found that the weight gain did not affected with inclusion of crude propolis in growing rabbit diet. The improvement in growth performance may be due to that Propolis may help rabbits to overcome the negative effects of oxidative stress during heat stress (Mahmoud *et al*., 2015). Also, propolis contains flavone and flavonoid which has an antiviral activity (Serkedjieva *et al*., 1997).

Table (2): Growth performance of NEZ growing rabbits supplemented with Vit E and PS.

Items	Experimental groups					Pooled SE	Sig
	Control (non-supplemente)	100mgVit E /kg feed	150mg Vit E /kg feed	100mgPS/kg feed	150mg PS/kg feed		
Initial live body weight (g)	623	615	620.5	621.5	627	20.94	Ns
Final live body weight (g)	2204[c]	2306.5[bc]	2344.5[b]	2292.5[bc]	2494.5[a]	38.41	**
Body weight gain (g)	1581[c]	1691.5[b]	1724[b]	1671[b]	1866.5[a]	7.65	**
Total feed intake (g)	6081.5[a]	5505[b]	6143[a]	5525[b]	5116.5[b]	36.73	**
FCR	3.85[a]	3.27[b]	3.58[ab]	3.32[b]	2.75[c]	0.18	**
Performance index (%)	57.32[c]	72.28[b]	66.45[bc]	71.28[b]	92.13[a]	13. 8	**

a, b and c: Means in the same row having different superscripts differ significantly ($P \leq 0.01$)

Nutrient digestibility:

The nutrient digestibility of growing NZW rabbit diets supplemented with PS and Vit. E are presented in Table 3. Data clearly show that DM improved by 5.48, 5.91 for rabbit received 100 and 150mg Vit.E /kg feed and 6.91 and 5.5 % for rabbit received 100 and 150mg PS /kg feed, respectively, compared to the control group. In the same trend, OM digestibility values were improved by 2.96, 3.26 for rabbit received 100 and 150mg Vit. E /kg feed and 3.59 and 3.63 % for rabbit received 100 and 150mg PS /kg feed, respectively, compared to the control group. Adding both Vit. E or PS significantly ($P \leq 0.01$) improved CP digestibility coefficient by 0.88 for rabbit received 100mg Vit.E /kg feed and 3.65 and 4.78 % for rabbit received 100 and 150mg PS /kg feed, respectively, compared to the control group. There was no significant effect on CF and NFE digestibility by supplementing rabbit diets with Vit. E or PS. While, EE digestibility values were significantly improved by 2.17, 7.22 for rabbit received 100 and 150mg Vit. E /kg feed and 4.48 and 8.76 % for rabbit received 100 and 150mg PS /kg feed, respectively, compared to the without group. Also, DCP and TDN were significantly improved by supplementing rabbit diets with Vit. E or PS, and the best groups were those which received d 150mg PS /kg feed.

The negative effect of heat stress on nutrient found that digestibility and nutritive values possibly because of that heat stress may affect cecal flora structure which lead to increase the harmful bacteria (Liu *et al*., (2022). Earlier, Thaxton *et al*. (1968) pointed out that rise in temperature will significantly inhibit the immune function. Our results are in agreement with Abd El-Moniem*et al*. (2016) who found that supplementing growing rabbits during heat stress with Vit.E improve of the digestibility of DM, OM, CP and nutritive values compared to the control group. Regarding to PS, the improvement in nutrients digestibility and nutritive values of rabbit received diets supplemented with PS during heat stress may be due to that propolis have an anti-bacterial, anti-fungal, anti-inflammatory, anti-oxidant, immune-modulatory, antiviral and anti-carcinogenic properties (Ramos and Miranda, 2007 and Sabuncuoglu *et al*., 2007), which help rabbit to relief of the negative effects of heat stress.

Table (3): Nutrient digestibility coefficients and nutritive values of NEZ growing rabbits supplemented with Vit E and PS.

Items	Experimental groups					Sig	Pooled SE
	Control (non-supplemente)	100mg Vt.E /kg feed	150mg Vit.E /kg feed	100mg PS /kg feed	150mg PS /kg feed		
DM	63.1^{b}	66.56^{a}	66.83^{a}	67.46^{a}	66.57^{a}	2.25	*
OM	75.24^{b}	77.47^{a}	77.69^{a}	77.94^{a}	77.97^{a}	0.23	**
CP	72.33^{c}	72.97^{bc}	72.25^{c}	74.97^{ab}	75.79^{a}	1.42	**
CF	53.79	54.91	52.69	54.91	55.63	1.27	Ns
EE	58.45^{c}	60.06^{b}	62.67^{a}	61.07^{b}	63.57^{a}	0.5	**
NFE	81	81.51	81.63	82.05	81.9	0.61	Ns
Nutritive value (%DM)							
DCP	11.69^{c}	11.79^{bc}	11.68^{c}	12.11^{ab}	12.25^{a}	0.04	**
TDN	69.39^{c}	70.01^{bc}	69.89^{bc}	70.77^{ab}	71.09^{a}	0.26	**

a, b and c: Means in the same row having different superscripts differ significantly (P ≤ 0.01).

Carcass characteristics:

The effects of supplementing the rabbit diets with Vit.E or PS during summer season on carcass characteristics are shown in Table 4. Both percentages of carcass and dressing were significantly higher (P≤0.01) in all experimental groups compared to the control group. Carcass percentages were significantly increased by 27.39 and 32.51% for rabbit received 100 and 150mg Vit.E /kg feed and 31.94 and 36.38% for rabbit received 100 and 150mg PS /kg feed, respectively, while dressing percentages were significantly increased by 29.93, 31.67 for rabbit received 100 and 150mg Vit.E /kg feed and 31.6 and 33.79% for rabbit received 100 and 150mg PS /kg feed, respectively, compared to the control group. Rabbits received diets supplemented with Vit.E or PS showed the highest giblets percentages compared to the control group. There were no significant effects on liver and lung percentages due to supplementing rabbit diets with Vit.E or PS. Heart, kidney, stomach, and intestine percentages were significantly increased, while abdominal fat and shoulder fat percentages were significantly decreased in experimental groups compared to the control group.

Tabl (4): Carcass characteristics of NEZ growing rabbits supplemented with Vit E and PS.

Items	Experimental groups					Sig	Pooled SE
	Control (non-supplemente)	100mg Vit.E /kg feed	150mg Vit.E /kg feed	100mg PS /kg feed	150mg PS /kg feed		
Carcass%	47.5^{b}	60.73^{a}	62.94^{a}	62.67^{a}	64.78^{a}	16.78	**
Dressing %	54.43^{b}	70.72^{a}	71.67^{a}	71.63^{a}	72.82^{a}	14.99	**
Giblets %	2.21^{b}	3.66^{a}	3.46^{a}	3.33^{a}	3.17^{a}	0.22	*
Liver %	1.58	2.73	2.5	2.4	2.37	0.17	Ns
Lung%	0.52	0.47	0.44	0.47	0.47	0.01	Ns
Heart %	0.18^{c}	0.33^{a}	0.31^{ab}	0.29^{ab}	0.25^{bc}	0.02	**
Kidney %	0.45^{b}	0.6^{a}	0.64^{a}	0.64^{a}	0.56^{a}	0.05	*
Stomach %	2.79^{b}	4.46^{b}	4.55^{b}	4.92^{a}	4.87^{a}	0.42	**
Intestine%	1.55^{b}	2.39^{a}	2.81^{a}	2.48^{a}	2.13^{ab}	0.15	*
Abdominal fat %	0.75^{a}	0.53^{b}	0.52^{b}	0.54^{b}	0.47^{b}	0.003	**
Shoulder fat %	0.4^{a}	0.29^{ab}	0.25^{b}	0.23^{b}	0.19^{b}	0.04	*

a, b and c: Means in the same row having different superscripts differ significantly (P ≤ 0.01)

These results are agreeing with the results by Liu *et al*. (2011) who cleared that the rise in environmental temperature decreases intestine percentage, which may be due to the excessive reactive oxygen species that oxidize and destroy cellular biological molecules, which inhibit some ATP ase activities and impaired intestinal tissues. However, heat stress in rabbits cause heat balance change (Chiericato *et al*., 1994), and this may affect the carcass traits (Zeferino *et al*., 2011). Although supplementing rabbitsdiet with vitamin E had no significant effect on the body temperature (Li and Wang, 2004), vitamin E supplementation improved the total antioxidant capacity in rabbits during acute heat stress (Zhang *et al*., 2007), which improved carcass.

Meat quality:

The effects of supplemented diets with Vit. E or PS as feed additives in NZW growing rabbit diets under the heat stress condition on meat quality are shown in Table (5). The addition of Vit. E or PS significantly ($P \leq 0.01$) alleviated the harmful effect of heat stress on meat content of total protein, triglycerides, total cholesterol, and malondialdehyde (MDA). There was not significant effect in meat content of total protein between the control group and the groups received 100mgVit E/kg feed or 100mg PS/kg feed, while 150mgVit. E/kg feed or 150mg PS /kg feed significantly ($P \leq 0.01$) increased meat content of protein by 10.5 and 11.67% respectively, compared to the control group. Rabbits received Vit. E or PS had significantly ($P \leq 0.01$) lower total cholesterol and triglycerides content in meat. Rabbits received 150mg Vit. E /kg feed or 100 and 150mg PS /kg feed had significantly ($P \leq 0.05$) lower MDA content in meat by 9.51, 14.57 and 16.8% respectively, whereas rabbits received 100mg Vit. E /kg feed had insignificant effect compared to the control group. Both drip loss and cook loos percentages were significantly decreased with diet supplemented with Vit. E or PS.

IN this connection, Liu *et al*. (2022) reported that heat stress has a harmful effect on production performance of rabbit meat through decreased feed utilization. Also, Marai *et al*. (2002) distinct that heat stress decrease rabbit's meat quality. This is may be because heat stress lead to increase the alkaline phosphatase, total protein and serum glucose contents in rabbit meat (Liu *et al*., 2016). From the other hand, Zeferino *et al*. (2013) reported that heat stress lead to increase in cooking loss and decrease in meat juiciness.

Many author reported that the essential fatty acids in propolis have an inhibitor effect on some coenzyme which regulate cholesterol synthesis (Babińska *et al*., 2013), which may decrease in triglycerides and cholesterol in meat. Also, propolis have an antioxidant activity that reduced the oxidative stress (Fokt *et al*., 2010).

Table (5): Effect of supplementing diet with vitamin E and propolis on meat quality of NZW rabbits

Items	Experimental groups					Sig	Pooled SE
	Control (non-supplemente)	**100mg Vit E /kg feed**	**150mg Vit E /kg feed**	**100mg PS/kg feed**	**150mg PS/kg feed**		
Total protein (mg/100g)	6^{b}	6.3^{b}	6.63^{a}	6.17^{b}	6.7^{a}	0.03	**
Total cholesterol (mg/100g)	207.4^{a}	187.4^{b}	187.03^{b}	179.63^{b}	166.3^{c}	14.99	**
Triglycerides (mg/dl)	131.63^{a}	121.37^{b}	115.73^{b}	115.33^{b}	113.53^{b}	22.43	**
Malondialdehyde (MDA) (nmol/mg)	4.94^{a}	4.78^{a}	4.47^{ab}	4.22^{b}	4.11^{b}	0.07	*
pHu of meat	0.49	0.47	0.45	0.47	0.43	0.01	Ns
Drip loss %	25.24^{a}	19.82^{b}	18.8^{c}	18.61^{c}	18.48^{c}	0.26	**
Cook loss %	35.75^{a}	34^{b}	33.71^{b}	33.16^{b}	32.89^{b}	0.4	**

a, b and c: Means in the same row having different superscripts differ significantly ($P \leq 0.01$)

CONCLUSION

Results show that supplementing growing NZW rabbit with 150 mg/kg diet vitamin E (Vit E) or propolis (PS) may alleviate the harmful effects of heat stress during summer season.

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تأثير إضافة فيتامين هـ أو بروبوليس على التخفيف من آثار الإجهاد الحراري على الأرانب النامية

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أجريت هذه الدراسة لتقييم تأثير اضافة البروبوليس أو فيتامين هـ على الأداء الانتاجي، ومعاملات هضم العناصر الغذائية، وخصائص الذبيحة وجودة اللحم في الأرانب نيوزيلندا البيضاء النامية تحت ظروف الإجهاد الحراري. تم تربية الأرانب في البطاريات وقسمت إلى خمس مجموعات تجريبية (٣٠ أرانب نامية مفطومة في كل مجموعة). تم تغذية المجموعة الأولى على عليقة بدون إضافات (مجموعة المقارنة). تم تغذية المجموعتين الثانية والثالثة على عليقة مضاف اليها ١٠٠ و ١٥٠ مجم فيتامين هـ / كجم علف، بينما تم تغذية المجموعتين الرابعة والخامسة على عليقة مضاف اليها١٠٠ و١٥٠ مجم بروبوليس / كجم علف على التوالي. ربيت هذه الأرانب تحت ظروف الإجهاد الحراري (موسم الصيف في مصر). أظهرت النتائج أن موسم الصيف كان له آثار سلبية على جميع القياسات. أدت إضافة فيتامين هـ أو البروبوليس إلى زيادة معنوية في الوزن النهائي للجسم والوزن المكتسب ومعامل التحويل الغذائي، ومؤشر الأداء الانتاجي مقارنة بالمجموعة بدون اضافات. لم تكن هناك آثار معنوية لإضافة فيتامين هـ أو البروبوليس للأرانب النيوزلاندي على معاملات هضم الالياف الخام والمستخلص الخالي من النيتروجين، بينما زادت جميع معاملات هضم باقي العناصر الغذائية والقيم الغذائية بشكل كبير. أدت إضافة البروبليس إلي على الأداء الانتاجي ومعاملات هضم العناصر الغذائية أفضل من فيتامين هـ. أوضحت النتائج زيادة نسب الذبيحة والتصافي زيادة معنوية، كما زادت نسب القلب والمعدة والأمعاء زيادة معنوية، بينما لم تتأثر نسب الكبد والرئة معنوياً في جميع المجموعات التجريبية مقارنة بالمجموعة بدون اضافات. بالاضافة إلي ذلك أدت إضافة فيتامين هـ أو البروبوليس إلى انخفاض كبير في نسب دهون البطن والكتف في جميع المجموعات التجريبية مقارنة بالمجموعة بدون اضافات. زاد محتوى البروتين الكلي في اللحوم زيادة معنوية مع إضافة فيتامين هـ أو البروبوليس، وهذا التحسن يوازي انخفاض كبير في الكوليسترول الكلي والدهون الثلاثية والمالونالدهيد. علاوة على ذلك، انخفض معدل فقد الماء ومعدل الفقد في الطهي بشكل كبير في المجموعات التجريبية مقارنة بالمجموعة غير المكملة. من هذه النتائج نستنتج أن إضافة فيتامين هـ أو البروبوليس للأرانب النيوزلاندي النامية يخفف التأثير الضار للإجهاد الحراري على الأداء الانتاجي ومعاملات هضم العناصر الغذائية وخصائص الذبيحة وجودة اللحم.