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RESPONSE OF GROWING RABBITS TO STOKING DENSITY AND DIETARY SUPPLEMENTATION WITH ASCORBIC ACID, AND VITAMIN E UNDER SUMMER CONDITIONS

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ABSTRACT: In factorial arrangement of treatments (2×4), an experiment was conducted to evaluate the effects of stocking density and vitamin C, vitamin E and their combination on growth performance of Californian rabbits during summer season (high ambient temperature of 36.4 °C and maximum relative humidity of 97%). Sixty unsexed 7-week-old rabbits were distributed into 8 groups of three replications each. The rabbits were kept in battery cages at two stocking densities; 10 or 15 rabbits/m^2 and were fed on four experimental diets; first group was fed the control diet. The other three experimental diets were formulated to contain vitamin C (0.5 g/kg diet), vitamin E (0.25 g/kg diet) or both at the same suggested levels. Growth trial lasted for 7 weeks. The tested criteria included live body weight, live weight gain, feed intake, feed conversion ratio, some blood metabolites and carcass characteristics. Low stocking density increased significantly final live weight, daily weight gain and feed intake. The concurrent administration of vitamin C and vitamin E significantly improved the final body weight, daily gain and feed conversion ratio of rabbits. However, stocking density did not significantly affect feed conversion, carcass traits or plasma blood parameters. The single or combined addition of vitamins C and E significantly increased the percentages of carcass yield and total edible parts. A significant reduction was observed in plasma albumin level due to added dietary vitamin E. The effect of interaction between added dietary vitamins and cage density did not significantly affect most of variables examined in the present study. It can be concluded that stocking density of 10 rabbits/m^2 or combined addition of dietary vitamins C (0.5g/kg diet) and E (250 mg/kg diet) may improve rabbit performance during summer season.

Key words: Heat stress – Rabbits - Stocking density -Vitamins C and E.

INTRODUCTION

Rabbits are hoped to play an important role in solving meat production deficiency particularly in the developing countries. These developing countries are mostly localized in tropical and subtropical regions so; rabbits are suffered from many problems related to heat stress. Rabbits tend to have a constant internal body temperature. Heat production must neutralize the losses to maintain normal body temperature. They do this by modifying their behavioral and physiological aspects (Balabel, 2004). Heat stress is known to modify rabbit's performance. Heat stress reduces growth, carcass quality and feed efficiency in rabbits (Baumgard and Rhoads, 2013). In Egypt, high ambient temperatures negatively affect rabbit productivity in terms of feed intake, feed conversion, nutrient utilization and metabolic processes (Okab et al., 2008).

Bahga et al. (2010) found that rabbits reared at temperatures lower than 30°C had better growth performance as measured by feed consumption and body weight gain. AL-Zafry and Medan (2012) reported that heat-stressed rabbits at (33.5°C) obviously decreased their feed consumption. They also observed a significant increase of the rectal temperatures of heat-stressed rabbits in comparison to rabbits kept under thermo neutral conditions. It has been reported that heat stress reduced feed intake and performance of growing rabbits (Renaudeau et al., 2012; Zeferino et al., 2012; Baumgard and Rhoads, 2013).The thermo neutral zone of temperature in rabbits is around 18–21 °C . Thus, when rabbits are exposed to elevated ambient temperatures, imbalances are induced in their body temperature, which adversely affect their growth. Furthermore, disturbances in feed intake, feed utilization, water metabolism, blood parameters, in heat-stressed rabbits Okab et al. (2008). In addition, Zeferino et al. (2012) found that rabbits kept at 30°C had lighter body weights at slaughter and lower carcass yields than rabbits reared at lower temperatures. Marco-Jiménez et al. (2017) reported that heat stress decreased live weight of rabbits at slaughter.

To gain competitiveness in the animal production area, the rabbit sub-sector of the livestock industry must focus on increasing kit survivability and growth maximization. One of the most crucial ways of achieving this is to create an optimal rearing environment (Aboegla et al., 2013). High stocking densities have an adverse effect on the performance of rabbits. Cage density and housing system can also affect welfare and production of rabbits (Szendro and Luzi, 2006 & Sherif 2018). Growth performance of rabbits depends on group size and cage dimensions. Xiccato et al. (2012) reported that growth performance of rabbits was not affected by stocking density up to 18 animals/m^2. Verga et al. (2004), Princz et al. (2009) and Dalle Zotte et al. (2009) found that rabbits caged in small groups (two to six rabbits per cage) showed similar growth rates. It is generally accepted that provision of adequate space and a suitable environment are needed for physical activity and comfortable movement of rabbits. Housing density is one of the most important factors with respect to production aspects.

Under normal conditions, free radicals are produced as a result of normal and abnormal metabolic processes. When free radical generation exceeds the capacity of the antioxidant system of the organism oxidative stress occurs. The free radicals produced can be alleviated by natural antioxidants. Supplemental natural antioxidants such as vitamins C and E have been proved to be an effective means for inhibiting the oxidation reactions (Botsoglou et al., 2004). Vitamins C and E (α-tocopheryel) can reduce the generation of free radicals. Based on their antioxidant actions, both vitamins have been used under stressful conditions to improve the performance in vivo. Corino et al. (2007) found that supplemental vitamin E had a growth-promoting effect on rabbits. Morsy et al. (2012) reported that vitamin C improved growth performance of rabbits when under heat stress. Okachi and Ani (2016) reported that addition of vitamin C (200mg/kg diet) and/or vitamin E (200mg/kg diet) successfully used in growing rabbits diets under hot humid tropical environment, without any negative effect on carcass yield, and blood parameters of rabbits.

This study was conducted to evaluate the effects of stocking density and diets containing supplemental C and E vitamins on growth performance of growing Californian rabbits during summer season.

MATERIALS AND PROCEDURES

The present study was carried out at Poultry Research Unit, Mansoura University, Egypt during August and September, 2016. The highest ambient temperature and relative humidity, recorded during the experimental period, were 36.4°C and 97%, respectively (Table 2). Sixty unsexed Californian 7-week-old rabbits were distributed into 8 groups of three replications each. The rabbits were kept in battery cages at two stocking densities; 10 rabbits/m^2 (2 rabbits/cage) or 15 rabbits/m^2 (3 rabbits/cage). Rabbits were fed on four experimental diets. The first group was fed the control diet without any supplemental vitamins (control). The other experimental diets were formulated to contain vitamin C (0.5 g/kg diet), vitamin E (250 mg/kg diet) or their combination (0.5 g vitamin C plus 250 mg vitamin E/kg diet). All groups of rabbits had similar initial body weights (average body weight 1133±18 g). Ingredients and chemical composition of the basal diet is presented in Table 1(according to NRC 1977). The rabbits were kept in cages under the same managerial and hygienic conditions. Each cage (for each replicate) has dimensions of 45 cm length, 45 cm width and 35 cm height, and supplied by a feeder and a stainless steel nipple drinker. Rabbits had free access to fresh water and pelleted diets during the whole experimental period. During growth trial of seven weeks, live weight, feed intake and feed conversion ratio (g feed/g gain) were recorded.

During slaughtering, four blood samples per treatment (4 rabbits, each) were taken in heparinized test tubes at the end of growth experiment. The blood plasma was separated by centrifugation at 3000 rpm for 15 minutes. The plasma levels of glucose (Trinder, 1969), total protein (Henry, 1964), albumin (Doumas et al., 1971), triglycerides (Tietz, 1995), cholesterol (Allain et al., 1974), high density lipoprotein (Sawle et al., 2002), total antioxidant capacity (Koracevic et al., 2001) and malondialdehyde (Mihara & Uohiyama., 1978) were determined. Blood plasma globulin was calculated by subtracting plasma albumin from that of total protein. Activities of transaminases in blood plasma (ALT and AST) were also determined according to Reitman & Frankel (1957).

Statistical analysis

All data were arranged using a two-way analysis of variance in factorial design (2×4) of, two stocking density and four feeding form. The statistical analysis of data was made by means of Statgraphics, Version 5.0 STSC (Rockville, 1991). Differences were considered significant at $P \leq 0.05$.

RESULTS AND DISCUSSION

1 Rabbit performance

Effects of stocking density, supplemental vitamins on growing rabbit performance from 7 to 14 weeks of age are presented in Table 3. Regarding the effect of stocking density, analysis of variance indicated that low stocking density (10 rabbits/m^2) significantly improved final body weight, weight gain, and feed intake during 7-14 weeks of age than those of high density group (15 rabbits/m^2). However, stocking density did not significantly affect feed conversion ratio of rabbits. Supplemental vitamins C + E, especially the simultaneous addition, significantly improved final live weight, daily weight gain and feed conversion ratio of rabbits compared with those fed the control diet, however feed intake of rabbits was not significantly affected. Diet containing mix of vitamin E and C significantly improved the marketing weight of rabbits as compared to the control group or those fed the diet supplemented with vitamin C alone. However, there were no significant differences in final body weight of rabbits fed the control diet or diets supplemented with vitamins C or E alone. Addition of vitamins C, E or both significantly increased daily weight gain and significantly improved feed conversion ratio of rabbits compared with the control group during the experimental period. The best feed conversion ratio was recorded by rabbits fed diet supplemented with the mix of vitamins C and E. The effect of interactions between stocking density and dietary vitamins supplementation was not significant on final body weight of rabbits (14-week-old); however it was significant for other growth variables as shown in Table 3.

Our results agree with those reported by Iyeghe et al. (2005), who found that rabbits kept at high stocking density (16.7, 20 rabbits/m^2) had poorer feed conversion ratio than those kept at lower stocking density (6.7, 10, 13.3 rabbits/m^2). Aboegla et al. (2013) found that increasing stocking density up to 26.67 kg/m^2 adversely affected rabbit performance. Xiccato et al. (2013) observed weak effects of stocking density (12 vs. 16 rabbits/m^2) have been reported on rabbit performance housed in large pen groups. Trocino et al. (2015) found that growth performance of pen-housed rabbits was less affected by stocking density (12, 16 rabbits/m^2). Bhattacharjya et al. (2017), who indicated that low stocking density (0.38 m^2/rabbit) led to better performance in growing rabbits than those kept in high stocking density (0.19 or 0.12 m^2/rabbit). Several authors studied reported that high stocking densities (above 12rabbits/m^2) have adversely affected on the performance of rabbits (Verga et al., 2006; Jordan et al., 2006).

On the other hand, Princz et al. (2008) reported that productive performance of rabbits was not affected by stocking density. Trocino et al. (2008) found that stocking density did not negatively affect on body weight and feed intake of rabbits; but feed efficiency was better in 16 rabbits/m^2. Gisella Paci et al. (2013) found that the stocking densities less than 16 rabbits/m2 had no positive effect on growth performance, and carcass traits. Szendrő et al. (2009) demonstrated that stocking densities lower than 16 rabbits/m^2 did not affect the rabbit performance. Verspecht et al. (2011) found that reducing stocking density improved feed conversion and increased feed intake.

Sallam et al. (2005) found that vitamin C (40 mg/kg body weight) caused significant increase in feed intake, while the increase in body weight gain was insignificant of rabbits. Yassein et al. (2008) demonstrated that utilization of ascorbic acid (1 g/L fresh water) was effective in minimizing the heat load of rabbit does and subsequently improving productive performance of rabbits. Zeweil et al. (2009) found that feed intake and body weight were significantly increased by ascorbic acid supplementation (300 mg/L) in drinking water under different ambient temperatures (17, 25 and 33 °C). The improvement in growth performance of rabbits due to supplementation with vitamin C (200, 400 ppm) and E (40, 80 ppm) was reported by Selim et al. (2008). As an antioxidant, vitamin E can scavenge the free radicals which are toxic byproducts of many metabolic processes Takanami et al. (2000). Ebeid et al. (2013) and Szendrő et al. (2012) found that vitamin E (250 or 260 mg/kg) supplementation in rabbit diet had a positive effect on rabbit's growth performance under ambient temperatures of 16-19°C (Szendrő et al., 2012). Adu and Gbore (2015) found that vitamin E (100 mg/kg diet) improved feed intake, weight gain and final weight of growing rabbits. Badr (2015) found that fortification of ascorbic acid at 600 mg/L water intake increased feed intake at 21 days post-weaning of rabbits during summer in Egypt (20.0 and 27.5 °C). Cardinali et al. (2015) found that additional 50 ppm vitamin E in rabbit diet improved final live weight of rabbits. Okachi and Ani (2016) found that rabbits fed diet containing vitamins C (0, 200 and 400 mg/kg diet) and E (0, 200 and 400 mg/kg diet) higher the final body weight than that of the control group under high temperatures of 36.7°C to 41°C. Agbor et al. (2017) obtained that body weight and feed intake were significantly higher for rabbits fed diet containing vitamin C (100, 200, 300 and 400 mg/kg), however daily weight gain and feed conversion ratio were not affected under ambient temperatures of 26-30°C. On the other hand, Amao et al. (2012) found no positive effect of vitamin E (0.03 g/kg diet) supplementation on the growth performance of rabbits reared under an ambient temperature of 26.2°C.

2 Blood Parameters

Data in Table 4 show the effects of stocking density and addition of vitamin C and E singly or in combination on blood parameters of Californian rabbits at 14 weeks of age. Plasma levels of total protein, albumin, globulin, triglycerides, cholesterol, glucose, high-density lipoprotein (HDL), total antioxidant capacity (TAC) and malondialdehyde (MDA) or activity of aspartate aminotransferase (AST) and alanine aminotransferase (ALT) were not affected by stocking density of rabbits. Vitamin supplementation (C, E or their mix) did not significantly affect blood plasma parameters except albumin and cholesterol values which were significantly affected. Vitamin C slightly decreased plasma albumin value compared with the other experimental treatments. Rabbits fed diet supplemented with the mix of vitamin C and E had the lowest level of plasma cholesterol. However the other treatments were not statistically different. The effect of the interaction between stocking density and vitamin supplementation on blood plasma parameters was not significant.

In harmony with the present results, Al-Shanti (2005) found that supplemental ascorbic acid (1.0 g/l drinking water) did not change blood plasma total protein, albumin, globulin, cholesterol, triglycerides, creatinine, or activity of ALT and AST in heat-stressed rabbits.

The current results agree also with those of Onbasilar, E. & I. Onbasilar (2007), who observed no effect of stocking density (1, 3 and 5 rabbits/cage) on serum cholesterol, and triglyceride levels in rabbits. Aboegla et al. (2013) reported that concentrations of blood total protein and globulin were higher in rabbits stocked at 6.6 and 13.33 kg/m^2 than those kept at high densities up to 26.67kg/m^2, but plasma albumin and activity of ALT were not affected by stocking density.

Hazim et al. (2001) found that added dietary ascorbic acid (0, 150, 300, 450 mg/kg diet) during summer months (ambient temperatures of 33-34°C) led to an increase in plasma protein, while levels of glucose, cholesterol and GOT and GPT activities were significantly reduced in broiler chicks. Achuba (2005) found that supplementation of diet with vitamins E (500 mg/kg diet) and C (500 mg/kg diet) had no effect on cholesterol, HDL and triglyceride in growing rabbit's in temperature of 28°C. Okab et al. (2008) found that rabbit plasma total protein (TP), globulins (G), total lipids (TL) and cholesterol were increased but activity of ALT was decreased during the summer season (ambient temperatures of 27.1, 32.2°C) compared with spring. AL-Zafry and Medan (2012) showed that weekly administration of vitamin E and selenium injected subcutaneously with 0.2 ml (5.05 mg) or 0.4 ml (10.10 mg) per animal under a temperature of 35°C resulted in higher levels of plasma glucose and cholesterol than those of control group; however the treated groups were not significantly different in total protein, albumin and globulin. Adu and Gbore (2015) found that supplemental vitamin E (100 mg/kg diet) increased serum albumin, globulin, and activity of transaminases (AST and ALT) as compared to the control rabbits. Badr (2015) found that serum total protein, albumin and globulin did not change with supplementation of vitamin C at 600 mg/L water intake during summer temperature (20.0 and 27.5 °C).

3 Carcass Traits

The effects of stocking density and vitamin C and E supplementation or their mix on carcass traits of Californian14-week-old rabbits are given in Table 5. Stocking density of rabbits did not affect carcass traits and total edible parts of rabbits. Vitamin supplementation (C, E or the mix of them) failed to produce significant effects on the estimated carcass traits, except percentages of carcass yield and total edible parts which were positively affected. Vitamin supplementation (C, E or the mix of them) improved the relative weight of carcass yield% and total edible parts compared with the control group. Source of added vitamin had no significant effect on carcass % and total edible parts. The effect of the interaction between stocking density and vitamin supplementation on carcass traits was not significant, except carcass % in which it was significant.

Trocino et al. (2008) and Villalobos et al. (2008) found that cage density had no or minor influence on carcass of rabbit traits but were significantly affected growth traits. Aboegla et al. (2013), reported that no significant difference was observed in means of carcass weight under different rabbit densities (6.6, 13.33, 20 and 26.67 kg/m^2). However, significantly higher weights of liver and kidney were observed in rabbits stocked individually than other groups. Also, Xiccato et al. (2013) found weak effects of stocking density (12 vs. 16 rabbits/m^2) on carcass traits in rabbits reared in pens in large groups. On the other hand Trocino et al. (2015) found that low stocking density (12 rabbits/m^2) led to higher carcass weight than that of high density (16 rabbits/m^2). Gisella Paci et al. (2013) found that carcass traits were not affected by stocking density (2.5, 5, 16 rabbits/m^2).

Corino et al. (2007) found significant improvement in dressing percentage by supplementation of vitamin E (240 mg vitamin E/kg). Selim et al. (2008) found that the highest dose (80 mg E+ 400 mg C/kg diet) of vitamin E and C improved dressing-out percentage as compared to lower doses of the vitamins or the control. Cardinali et al. (2015) found that rabbits given an additional 50 ppm vitamin E in their diet had higher carcass weight when compared with their control counterparts. Okachi and Ani (2016) found that rabbits fed diet supplemented with vitamins C and E positively affected carcass weight and dressing percentage in rabbits reared in a hot humid tropical environment.

CONCLUSION

It can be concluded that stocking density of 10 rabbits/m^2 and combined dietary supplementation with vitamins C (0.5 g/kg diet) and E (0.25 g/kg diet) may improve rabbit performance.

Table (1): Ingredients and calculated chemical analysis of the basal diet.

Ingredients	**%**
Yellow corn	17.0
Soybean meal (44 % CP)	17.0
Wheat bran	14.5
Alfalfa hay meal (15.3 % CP)	37.0
Barley	10.0
Dicalcium phosphate	0.7
Limestone	1.0
Molasses	2.0
Sodium chloride	0.5
Vit. & min. Premix*	0.3
Total	100
Calculated analysis (air-dry basis; NRC 1977)	
DE kcal/kg	2502
CP %	18.06
EE %	2.54
CF %	13.73
Ca %	1.14
P %	0.59
Lysine %	0.89
Methionine %	0.24
Methionine + Cystine	0.58

* Each 3 kg premix contains: Vitamin A, 12,000,000 IU; Vitamin D_3, 2,700,000 IU; Vitamin E, 20 g; Vitamin K, 1.5 g; Vitamin B1, 1.5 g; Vitamin B_2, 5.5 g; Vitamin B_6, 2.5 g; Vitamin B_{12}, 10 mg; Biotin, 200 mg; Folic acid, 5 g; Nicotinic acid, 30 g; Pantothenic acid, 10 g; phytase, 100 g; Choline chloride, 400 g; Manganese oxide, 60 g; Copper sulfate, 4 g; Zinc oxide, 70 g; Iron sulfate, 70 g; Calcium iodine, 1.1 g; Sodium selenite, 150 mg; Cobalt sulfate, 100 mg; Magnesium, 400g; Organic selenium, 50 g.; and Calcium carbonate up to 3 kg.

Table (2): Average of ambient temperature and relative humidity during the experimental period

Experimental weeks	Ambient temperature °C		Relative humidity %	
	Minimum	Maximum	Minimum	Maximum
1	23.2	35.2	40	95
2	23.0	34.1	50	95
3	22.1	33.7	34	96
4	22.6	33.5	48	96
5	22.1	32.8	49	93
6	20.2	36.4	37	97
7	21.0	33.0	41	95

Table (3): Effects of stocking density and vitamins C and E supplementation on growing Californian rabbit performance from 7 to 14 weeks of age

Treatments	Initial weight, g	Final weight, g	Daily weight gain, g	Daily feed intake, g	Feed conversion ratio
Main factors					
Stocking density (A)					
10/m² (A1)	1141	2228^{a}	25.9^{a}	100.2^{a}	3.88
15/m² (A2)	1126	2043^{b}	21.9^{b}	83.8^{b}	3.93
SEM	26	30	0.6	1.5	0.06
Significance	NS	**	**	**	NS
Feed additives (B)					
control (B1)	1187	2065^{b}	20.9^{c}	91.2	4.40^{c}
Vit. C (B2)	1076	2078^{b}	23.9^{b}	90.6	3.83^{b}
Vit. E (B3)	1147	2141^{ab}	23.7^{b}	92.0	3.90^{b}
Vit. C+E (B4)	1122	2257^{a}	27.0^{a}	94.2	3.50^{a}
SEM	37	42	0.8	2.1	0.09
Significance	NS	*	**	NS	**
Interactions (AB)					
(A1×B1)	1229	2244	24.2	102.8	4.25
(A1×B2)	1047	2178	26.9	97.3	3.61
(A1×B3)	1139	2194	25.1	94.5	3.76
(A1×B4)	1149	2294	27.3	106.2	3.90
(A2×B1)	1145	1887	17.7	79.7	4.55
(A2×B2)	1106	1979	20.8	84.0	4.05
(A2×B3)	1156	2088	22.2	89.5	4.03
(A2×B4)	1096	2219	26.7	82.1	3.10
SEM	52	60	1.1	3.0	0.13
Significance	NS	NS	*	*	**

a-c: For each of the main effects, means within the same column bearing different superscripts differ significantly ($P \leq 0.05$). NS: not significant *: Significant at $P \leq 0.05$ **: Significant at $P \leq 0.01$

Table (4): Effects of stocking density and vitamins C and E supplementation on blood parameters of Californian rabbits at 14 weeks-old.

Treatments	Total protein (g/dl)	Albumin (g/dl)	Globulin (g/dl)	Triglyceride(mg/dl)	Cholesterol (mg/dl)	Glucose (mg/dl)	HDL (mg/dl)	AST (U/l)	ALT (U/l)	TAC (µmol/ml)	MDA (µmol/ml)
Main factors											
Stocking density (A)											
10/m² (A1)	5.91	2.95	2.96	69.34	86.0	116.5	29.57	59.43	13.25	1.16	27.26
15/m² (A2)	6.04	3.06	2.98	70.18	86.1	117.6	28.76	58.57	13.08	1.12	29.87
SEM	0.08	0.05	0.07	0.67	1.8	1.6	0.74	1.0	0.36	0.04	0.96
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Feed additives (B)											
control(B1)	6.22	3.17^{a}	3.05	69.27	87.0^{ab}	117.1	28.78	59.33	13.63	1.18	27.67
Vit. C (B2)	5.97	3.02^{a}	2.95	69.99	91.5^{a}	116.9	29.14	60.21	12.80	1.11	27.56
Vit. E (B3)	5.85	2.81^{b}	3.04	71.57	85.5^{ab}	117.3	29.79	55.60	12.61	1.20	30.69
Vit.C+E(B4)	5.86	3.03^{a}	2.83	68.22	80.4^{b}	116.6	28.96	60.85	13.61	1.06	28.36
SEM	0.11	0.07	0.09	0.95	2.5	2.2	1.04	1.41	0.52	0.05	1.36
Significance	NS	*	NS	NS	*	NS	NS	NS	NS	NS	NS
Interactions (AB)											
(A1×B1)	6.23	3.0	3.23	68.96	87.4	117.9	31.02	58.54	13.80	1.29	23.52
(A1×B2)	6.00	3.0	3.00	70.73	91.0	114.0	29.62	61.79	13.11	1.19	26.57
(A1×B3)	5.67	2.74	2.93	69.37	82.6	117.8	28.60	58.05	13.18	1.12	31.48
(A1×B4)	5.71	3.05	2.66	68.31	83.2	116.1	29.05	59.32	12.92	1.06	27.48
(A2×B1)	6.21	3.33	2.88	69.57	86.7	116.3	26.54	60.12	13.46	1.07	31.82
(A2×B2)	5.93	3.04	2.89	69.25	91.9	119.9	28.65	58.64	12.50	1.07	28.55
(A2×B3)	6.02	2.88	3.14	73.77	88.3	117.0	30.97	53.15	12.05	1.28	29.89
(A2×B4)	5.99	2.99	3.00	68.13	77.6	117.1	28.86	62.39	14.30	1.06	29.23
SEM	0.16	0.1	0.13	1.34	3.6	3.1	1.48d	1.99	0.73	0.07	1.92
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

a-b: For each of the main effects, means within the same column bearing different superscripts differ significantly ($P \leq 0.05$). NS: not significant *: Significant at $P \leq 0.05$

Table (5): Carcass traits of Californian rabbits as affected by stocking density and vitamins C and E supplementation

Treatments	Live weight (g)	Feet +fur (%)	Carcass (%)	Lungs (%)	Kidneys (%)	Heart (%)	Liver (%)	Total edible parts(%)
Main factors								
Stocking density (A)								
10/m^2 (A1)	1970	18.6	59.8	0.71	0.64	0.28	2.91	63.7
15/m^2 (A2)	2019	18.5	59.0	0.68	0.64	0.28	2.81	62.7
SEM	51	0.39	0.32	0.04	0.02	0.02	0.10	0.35
Significance level	NS	NS	NS	NS	NS	NS	NS	NS
Feed additives B								
control (B1)	2000	19.4	57.5^b	0.72	0.68	0.28	3.10	61.5^b
Vit. C (B2)	2033	17.9	60.1^a	0.66	0.64	0.26	2.91	63.9^a
Vit. E (B3)	1983	18	60.1^a	0.70	0.62	0.31	2.71	63.8^a
Vit. C+E (B4)	1961	18.9	60.0^a	0.70	0.62	0.27	2.72	63.6^a
SEM	73	0.55	0.46	0.06	0.03	0.03	0.14	0.50
Significance level	NS	NS	**	NS	NS	NS	NS	*
Interactions (AB)								
(A1×B1)	1950	1808	57.7	0.79	0.68	0.30	3.24	61.9
(A1×B2)	2027	17.9	61.8	0.68	0.61	0.29	2.67	65.3
(A1×B3)	1993	18.6	59.8	0.70	0.67	0.28	2.48	63.6
(A1×B4)	1910	18.9	60.1	0.70	0.61	0.24	2.87	63.8
(A2×B1)	2050	19.9	57.2	0.66	0.68	0.26	2.96	61.1
(A2×B2)	2040	17.8	58.4	0.64	0.67	0.23	3.14	62.5
(A2×B3)	1973	17.3	60.5	0.72	0.58	0.33	2.57	64.0
(A2×B4)	2013	18.9	60.0	0.70	0.62	0.29	2.58	63.4
SEM	103	0.78	0.65	0.08	0.04	0.04	0.20	0.71
Significance level	NS	NS	*	NS	NS	NS	NS	NS

a-b: For each of the main effects, means within the same column bearing different superscripts differ significantly ($P \leq 0.05$). NS: not significant *: Significant at $P \leq 0.05$ **: Significant at $P \leq 0.01$

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الملخص العربى

تأثير كثافة الاسكان واضافة فيتامين ج وفيتامين هـ على الارانب النامية خلال فصل الصيف

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أُجريت تجربة عاملية (2 × 4) لتقييم تأثير كثافة الاسكان مع فيتامين ج وفيتامين هـ وخليطهما على أداء نمو الأرانب الكاليفورنيا خلال موسم الصيف (درجة الحرارة العظمى 36.4 درجة مئوية والرطوبة النسبية العظمى 97%). تم توزيع 60 أرنب غير مجنسة عمر 7 اسابيع إلى ثمانية مجموعات بكل واحدة منها ثلاث مكررات.وتم تربية الأرانب فى بطاريات بمستويين كثافة 10، 15 أرنب/م^2 وغذيت على اربع علائق تجريبية. المجموعة الأولى غذيت على العليقة الكنترول. والثلاث علائق التجريبية الآخرى احتوت على فيتامين ج (0.5جم/كجم عليقة) وفيتامين هـ (0.25جم/ كجم عليقة) أو الاثنين معا بنفس المستويات. استمرت التجربة 7 أسابيع. وتم تقدير وزن الجسم ، والزيادة الوزنية ، والعلف المأكول، ومعامل التحويل الغذائى، وبعض مقاييس الدم وخصائص الذبيحة للارانب. النتائج:- انخفاض الكثافة أدت لزيادة معنوية في وزن الجسم النهائى والزيادة اليومية واستهلاك العلف. الخليط من فيتامين ج وفيتامين هـ أدت لزيادة معنوية فى وزن الجسم النهائي والزيادة اليومية ومعامل التحويل الغذائى. بينما كثافة الاسكان لم تؤثرمعنويا على معامل التحويل الغذائى وصفات الذبيحة ومقاييس بلازما الدم. كان هناك تأثير معنويا بالزيادة لفتامين ج وفيتامين هـ كلا بمفرده او خليطهما على نسبة تصافى الذبيحة والأجزاء الكلية الصالحة للأستهلاك. ولوحظ انخفاضا معنويا فى مستوى البيومين بلازما الدم نتيجة اضافة فيتافين هـ. لم يكن هناك تأثير معنويا نتيجة التداخل بين (المعاملات التجريبية) الاضافات من الفيتامينات وكثافة اسكان الارانب لمعظم القياسات المأخوذة في هذه الدراسة. وفقا لنتائج هذه الدراسة ، يمكن استنتاج أن كثافة الإسكان 10 أرانب/م2 أو تدعيم العليقة بتوليفات من فيتامين ج (0.5جم/كجم عليقة) و فيتامين هـ (250 ملجم/ كجم عليقة) معا يحسن الأداء الانتاجى للأرانب النامية فى فصل الصيف.