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EFFECT OF ASCORBIC ACID SUPPLEMENTATION ON PERFORMANCE OF GROWING RABBITS UNDER EGYPTIAN CONDITIONS

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ABSTRACT: This study was conducted to investigate the influence of the dietary supplementation with different levels of ascorbic acid on growth performance, nutrients digestibility, and carcass traits of growing rabbits under summer and winter conditions in Egypt. Factorial design experiment (2×4) was carried out including two seasons (winter and summer) and four levels of ascorbic acid 0.0, 0.5, 1.0 and 1.5 g /kg diet. Results indicated that growth performance, daily feed intake, nutrients digestibility, nutritive values, hemoglobin, hematocrit, alanine aminotransferase (ALT), Red blood cell counts, dressing (%) and organs (liver, kidney and heart) weight were significantly decreased at summer season compared with winter season. In contrast, ascorbic acid supplementation caused a significant increase in growth performance indices, organic matter (OM) digestibility, some blood parameters *i.e.,* aspirate amino transferase (ALT, AST, urea, total protein and albumin) of growing rabbits. However, ascorbic acid supplementation showed insignificant effects in dressing percentage and relative weights of liver, kidney, heart, lung and spleen. On the other hand, the economical evaluation in this study showed that using of 0.5 or 1g ascorbic acid/kg diet in winter season and 0.5 g ascorbic acid/kg in summer season in the growing rabbit diets was more economical than the other treatment groups. Conclusively, the results revealed that fortification of rabbit diets with ascorbic acid especially level of 0.5 g/kg diet, economically, could enhance the growth performance of growing rabbit during mild and hot climate in Egypt.

Key words: Rabbits, ascorbic acid, growth performance, digestibility, blood biochemistry.

INTRODUCTION

In Egypt, in recent years, there has been rising interest of commercial rabbit production due to their high rate of reproduction, rapid growth rate, small body size and high meat yields (**Youssef *et al.*, 2008**). But, rising temperatures continues to be a barrier in rabbits industry because of its adverse impacts on feed intake, live weight gain, feed efficiency, meat quality, mortality and health of rabbits (**Marai *et al.*, 2008; Hassan *et al.*, 2016**).

Additionally, alterations in rectal, skin and ear temperatures, respiration rate, thyroid and stress hormones, albumin, globulin, total lipids, glucose, sodium, potassium, calcium, magnesium and phosphorus levels are the main physiological responses to heat load in rabbits (**Marai *et al.*, 2008**). Various genetic, managerial, nutritional, buffering, hormonal and physical mitigating strategies have been adopted to palliate heat stress adverse effects (Fa**yez *et al.*, 1994; Marai *et al.*, 1999**).

Ascorbic acid is an essential micronutrient required for normal metabolic functioning of the body (**Carr and Frei, 1999**). In particular, ascorbic acid could guard against oxidative stress damage through its free-radical scavenging activity (**Lee, 2002**), but during stress, ascorbic acid produced is rapidly consumed and amount synthesized fall below animal requirements. Furthermore, **Yousef *et al.* (2003)** reported that ascorbic acid (1.5 g/l) supplementation in drinking water insignificantly affected body weight gain of male rabbits. However, **Al-Shanty (2003)** showed

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that ascorbic acid (1.0 g/l water) significantly improved daily weight gain of growing Flander rabbits as compared to the control group.

Thus, the present study aimed to evaluate the effects of dietary supplementation with different levels of ascorbic acid during winter (mild weather) and summer (hot climate) seasons in the growing rabbits performance.

MATERIALS AND METHODS

The present work was carried out at the Rabbit Research Farm and Laboratories of the Animal Production Department, Faculty of Agriculture, Zagazig University, Egypt.

A total number of eighty New Zealand White male rabbits at five weeks of age with average body weight 696±14.71g were randomly distributed into eight groups (10 rabbits in each). The first four groups were reared during the period from November to January (winter; mild weather). The other four groups were reared during June and July (summer season; hot climate). Within each season, four dietary levels of ascorbic acid (0, 0.5, 1.0 and 1.5 g/kg diet) were used in 2×4 factorial design. The experimental diets were formulated to ensure an adequate supply of all nutrients recommended by **NRC (1977)** for growing rabbits. Ingredients and chemical analysis of the experimental diets were illustrated in Table 1.

Feed and water were offered *ad libitum*. The experimental period was extended for 8 weeks (5-13 weeks of age). The rabbits were housed individually in galvanized wire cages (35×60×35 cm) provided with feeders and automatic drinkers. All groups were kept under the same managerial and hygienic conditions. Live body weight (LBW) of rabbits was recorded weekly in grams; the average daily weight gain (DWG) was individually calculated. Average daily feed intake (DFI) was recorded weekly and feed conversion ratio (g feed/g gain), FCR, was calculated. Mortality rate was recorded weekly.

Throughout the experimental period, ambient temperatures and relative humidity were measured in the rabbitry using automatic thermo-hygrometer (OC 14:140, H 10 – 99%; TFA Dostmann GmbH + Co. KG, Wertheim, Germany) twice a day at 8:30 hr. and 14:30 hr. The temperature humidity index (THI) was calculated using the equation modified by **Marai *et al.* (2000)** as the following equation:

$$THI = db\,°C - [(0.31 - 0.31\,RH)(db\,°C - 14.4)].$$

Where, db °C is dry bulb temperature in Fahrenheit degrees, and RH is the relative humidity as a percentage. The THI values obtained were then categorized as follows: <27.8= absence of heat stress, 27.8–28.9 ° C = moderate heat stress, 28.9–30°C = severe heat stress and above 30°C = very severe heat stress.

At the end of the experimental period, apparent nutrients digestibility were determined for experimental diets. Four animals from each experimental group were housed individually in metabolic cages that allowed feces separation. The feed intake was accurately determined. Feces excreted were collected in labeled polyethylene bags and samples were taken for the chemical analyses. Proximate analyses of the experimental diets and feces samples were carried out. Digestible energy (DE) was calculated according to the equation of **Schieman *et al.* (1972)**. The total digestible nutrients (TDN) was calculated.

At the end of the feeding period, blood samples of four rabbits were collected at slaughter time to estimate blood metabolites. The erythrocyte (RBCs), total leukocyte (WBCs) and hemoglobin (Hb) concentration, hematocrit and lymphocytes were determined according to the method of **Grindem (2011)**. Also, serum total protein, albumin, aspertate amino transferase (AST), alanine amino transferase (ALT), cholesterol, urea creatinine and total glycerides were analyzed using commercial kits purchased from Diamond Diagnostics Company, Egypt. The globulin values were obtained by subtracting the values of albumin from the corresponding values of total proteins. Also, carcass and internal organs (liver, kidneys, heart, lungs, spleen and caecum) were removed from the body, and then weighted. Economic evaluation was calculated according to **Ayyat (1991)** as the following equation: Final margin (Profit) = Income from body gain weight - feed cost.

The data were statistically analyzed on a 2×4 factorial design basis according to **Snedecor and Cochran (1982)** using SPSS software statistical analysis program (**SPSS, 2012**) using the following model.

Table 1. Formulation and chemical analyses of the basal-diets fed to rabbits

Ingredient (%)	(%)
Alfalfa hay	29
Yellow corn	23
Wheat straw	4
Wheat bran	29
Soybean meal	13
Sodium chloride	0.5
Limestone	1.2
Minerals and vitamins mixture*	0.3
Total	100
Chemical analyses (% on DM basis), determined	
Organic matter	90.56
Crude protein	18.53
Crude fiber	12.39
Ether extract	4.87
Nitrogen free extract	54.78

* Each 1.5 kg of minerals and vitamins mixture contains: manganese 80 g, zinc 60 g, iron 30 g, copper 4 g, iodine 0.5 g, selenium 0.1 g and cobalt 0.1 g, vitamin A 12000000 IU, vitamin D_3 3000000 IU, vitamin E 10000 mg, vitamin K_3 2000 mg, vitamin B_1 1000 mg, vitamin B_2 5000 mg, vitamin B_6 1500 mg, vitamin B_{12} 10 mg, Biotin 75 mg, folic acid 1000 mg, nicotinic 30000 mg and pantothenic acid 10000 mg.

$$Y_{ijk} = \mu + S_i + T_j + ST_{ij} + e_{ijk}$$

Where, μ is the overall mean, S is the fixed effect of season (i = 1 …2), T is the fixed effect of ascorbic acid (j = 1 …4), ST is the fixed effect of the interaction between season and treatments and e_{ijk} is random error. Duncan's new Multiple Range procedure was performed to separate means.

RESULTS AND DISCUSSION

Emperature Humidity Index

The averages of ambient temperature, relative humidity and temperature humidity index (THI) inside the rabbitry were 20.26°C, 67.41% and 21.41 in winter and 29.34°C, 45.46% and 31.44 in summer, respectively which indicate absence of heat stress in winter and exposure to severe heat stress in summer. These results were similar to those of **Maria *et al.* (2000) and Abd El-Moneim *et al.* (2016)** under the same Egyptian climate condition.

Growth Performance and Feed Utilization

Growth performance results of growing NZW rabbits as affected by the season, ascorbic acid dietary supplementation and their interaction are presented in Table 2. Results indicated that FBW, DWG and DFI of growing rabbits were declined ($P<0.001$), while mortality rate increased at summer season. However, no significant effect in FCR has been observed in rabbits reared during summer season compared with winter season groups. Similarly, **Ayyat and Marai (1997)** reported that rabbits reared in summer showed a reduction in FBW, DWG, feed intake compared to those reared in winter. Additionally, **Ondruska *et al.* (2011)** reported that feed intake; feed conversion ratio and body

Table 2. Growth performance of New Zealand White rabbits as affected by season, vitamin C level and their interaction

	Initial body weight (g)	Final body weight (g)	Daily weight gain (g/day)	Feed intake (g/day)	Feed conversion ratio	Mortality rate (%)
Season effect						
Winter	695±12.23	2242±26.01	27.63±0.39	123.12±1.38	4.48±0.08	2.5
Summer	712±12.72	2017±19.01	23.31±0.33	105·97±0.90	4.57±0·07	12.5
Sig.	NS	***	***	***	NS	--
Vitamin C level effect						
0.0 g/ Kg diet	696±14.71	2019±41.14 [b]	23.62±0.69 [b]	116.81±3.48	4.95±0.05[a]	20
0.5 g/ Kg diet	713±13.20	2167±45.62 [a]	25.97±0.78 [a]	112.31±2.36	4.34±0.08 [b]	0
1.0 g/ Kg diet	704±13.91	2151±48.15 [a]	25.84±0.91 [a]	112.71±2.50	4.40±0.12 [b]	5
1.5 g/ Kg diet	701±27.00	2182±36.9 [a]	26.44±0.65 [a]	116.34±3.56	4.40±0.07 [b]	5
Sig.	NS	***	***	NS	***	--
The interaction effect						
Winter						
0.0 g/ Kg diet	690±14.60	2129±38.69	25.71±0.49	127.13±2.61[a]	4.95±0.11[a]	10
0.5 g/ Kg diet	708±24.52	2269±67.74	27.88±1.04	118.93±2.22[b]	4.29±0.13[dc]	0
1.0 g/ Kg diet	699±21.74	2303±23.90	28.64±0.55	118.82±2.41[b]	4.16±0.14[d]	0
1.5 g/ Kg diet	685±37.39	2270±47.05	28.31±0.37	127.61±1.73[a]	4.51±0.10[bc]	0
Summer						
0.0 g/ Kg diet	703±26.89	1908±32.65	21.53±0.31	106.49±1.98[c]	4.95±0.03[a]	30
0.5 g/ Kg diet	717±12.56	2065±19.96	24.07±0.43	105.69±1.44 [c]	4.40±0.10[dbc]	0
1.0 g/ Kg diet	709±19.15	2000±21.87	23.05±0.50	106.61±2.59 [c]	4.63±0.14[ab]	10
1.5 g/ Kg diet	717±41.24	2093±25.78	24.57±0.59	105.07±1.38 [c]	4.29±0.08[dc]	10
Sig.	NS	NS	NS	*	*	--

Means in the same column bearing different letters differ significantly (P<0.05).
NS = Not significant and *P<0.05., ***=p<0.001

weight gain of growing NZW rabbits were negatively affected when rabbits were exposed to heat stress.

Ascorbic acid supplementation to rabbit diets were significantly (P<0.001) improved FBW, DWG, FCR and mortality rate while, the DFI was not affected. These results are in harmony with those of **Abd El-Hamid and El-Adawy (1999)** who cleared that supplementing heat stressed-rabbit diets with either 300 or 600 mg ascorbic acid/kg diet significantly improved live body weight. Also, **Al-Shanty (2003)** showed that ascorbic acid (1.0 g/l water) significantly improved BWG of growing Flander rabbits as compared to the control group. The positive effect in rabbit growth performance can be attributed to that ascorbic acid helps to control the increase in body temperature and plasma corticosterone concentration. It also protects the immune system and it has an important role bone formation through the growth rate (**Rama-Rao *et al.,* 2002**).

The obtained results showed no significant effects related to the interaction between season and ascorbic acid dietary supplementation on FBW and DWG. Within each season, the FCR was significantly ($P < 0.05$) improved as a result of ascorbic acid addition compared with unsupplemented one (Table 2). These results are in agreement with **Selim *et al.* (2004)** who found that rabbits had access to extra levels of ascorbic acid beyond recommendation level achieved better FCR compared to control group.

Digestibility Coefficients and Nutritive Values

Nutrients digestibility (organic matter, OM; crude protein, CP; crude fiber, CF and ether extract, EE) and nutritive values as digestible crude protein, total digestible nutrients (TDN) and digestible energy were significantly ($P<0.05$) decreased in summer season compared with winter season (Table 3). Similarly, **Marai *et al.* (2004)** observed a decline in digestibility coefficients of CP and CF by 8.1% and 1.0%, respectively in NZW rabbits during summer compared with winter. The reduction in the nutrients digestibility may be a result of a depression in the production of digestive enzymes due to heat stress **(Habeeb *et al.*, 1992)**.

Results in Table 3 show a significant ($P<0.05$) increase in OM digestibility as a result of ascorbic acid dietary supplementation especially with 1 and 1.5 g/kg diet. **Selim *et al.* (2004)** reported that treatment with ascorbic acid supplementation (300 mg/kg diet) significantly increased OM digestibility. While, **Sallam *et al.* (2005)** indicated that the treatment with ascorbic acid supplementation (40 mg/kg body weight) resulted insignificant increase in digestibility coefficients of DM, CP, CF, EE and nitrogen free extract (NFE) and TDN. On the same trend, **Skrivanova *et al.* (1999)** reported that digestibility of nutrients of Hyla 2000 rabbits supplied with ascorbic acid at 30 mg/kg body weight twice a week had no significant effect. The interaction between season and ascorbic acid dietary supplementation did not show any significant effects on the digestibility of nutrients and nutritive values (Table 3).

Blood Parameters

As shown in Tables 4 and 5, the concentrations of, hemoglobin, hematocrit, ALT and Red blood cells counts were significantly ($P<0.05$) decreased, while cholesterol, creatinine, white blood cells count and lymphocytes increased on summer season compared with winter season. In the same trend, **Deyhim and Teeter (1991), Yahav and Hurwitz (1996)** reported that heat stress resulted in a decrease in hematocrit values. Also, **Fayez *et al.* (1994)** demonstrated that hemoglobin concentration decreased during heat stress due to depression of hematopoiesis and haemodilution.

Dietary ascorbic acid supplementation increased ($P<0.001$) serum ALT, AST, urea, total protein and albumin of growing rabbits (Table 4). While, all estimated hematological parameters were insignificantly affected by all ascorbic acid levels (Table 5). The increase in total protein value with ascorbic acid treatment may be due to the activity of protein synthesis enzymes. **Abd-El-Hamid (1994)** indicated that the addition of ascorbic acid significantly improved red blood cell (RBC´s) and white blood cell (WBC´s) counts of rabbits. In the same respect, some author's noted that addition of ascorbic acid significantly increased the packed cell volume (PCV) and RBCs of heat stressed chickens as compared to the control group **(Sahota *et al.*, 1994). Abd El-Hamid and El-Adawy (1999)** observed that the PCV, WBC and RBC values of NZW rabbits were significantly increased with elevating the level of ascorbic acid supplementation. Moreover ascorbic acid at a level of 40 mg/kg body weight significantly increased the hemoglobin, total erythrocyte count and packed cell volume of male NZW rabbits (**Yousef *et al.*, 2003**).

Table 3. Digestibility and nutritive values of the experimental diets as affected by season, vitamin C level and their interaction

	Digestibility coefficient (%)						Nutritive values (%)		
	DM	OM	CP	CF	NFE	EE	DCP	TDN	DE
Season effect									
Winter	**62.37±1.34**	67.12±1.20	76.75±1.30	50.45±1.40	71.46±1.62	81.04±1.45	14.66±0.25	73.76±**1.17**	3257±51.28
Summer	63.29±0.95	63.94±0.85	72.53±0.90	32.48±2.00	72.44±0.62	63.11±1.93	12.48±0.16	68.76±0.59	3023±**25.97**
Sig.	NS	*	*	***	NS	***	***	**	***
Vitamin C level effect									
0.0 g/ Kg diet	60.35±1.77	62.47±1.02^{b}	74.44±2.39	38.34±4.74	70.45±2.52	70.79±3.05	13.53±0.65	68.89±1.19	3040±54.19
0.5 g/ Kg diet	61.21±1.69	64.20±1.91^{ab}	72.16±1.82	41.84±2.72	70.81±0.88	70.80±6.17	13.12±0.56	70.81±1.87	3117±84.73
1.0 g/ Kg diet	65.21±0.81	67.86±0.92^{a}	77.13±1.09	41.53±4.44	73.61±0.61	73.84±3.32	14.02±0.52	73.49±1.55	3239±70.84
1.5 g/ Kg diet	64.55±1.38	67.60±1.37^{a}	74.85±1.33	44.15±4.80	72.95±2.12	72.87±5.48	13.60±0.49	71.85±1.74	3163±78.37
Sig.	NS	*	NS	NS	NS	NS	NS	NS	NS
The interaction effect									
Winter									
0.0 g/ Kg diet	58.56±3.22	62.59±1.78	76.78±4.43	48.53±2.36	69.39±5.15	75.40±3.43	14.66±0.85	70.11±1.57	3105±68.99
0.5 g/ Kg diet	62.28±2.53	66.54±2.52	74.38±2.60	49.63±3.57	70.27±1.56	83.25±1.17	14.20±0.50	74.10±2.33	3268±103.44
1.0 g/ Kg diet	64.88±1.65	69.82±0.11	79.35±0.94	49.84±1.65	73.83±1.21	80.76±2.33	15.16±0.18	76.90±00.15	3396±4.91
1.5 g/ Kg diet	63.76±2.91	69.54±2.33	76.47±1.84	53.74±3.80	72.36±4.62	84.74±0.89	.14.61±0.35	73.92±3.27	3259±145.23
Summer									
0.0 g/ Kg diet	62.14±1.45	62.35±1.42	72.09±1.88	28.16±1.73	71.50±2.02	66.19±3.68	12.40±0.32	67.67±1.78	2977±76.32
0.5 g/ Kg diet	60.14±2.59	61.85±2.51	69.93±2.20	34.05±6.16	71.34±1.06	58.35±5.69	12.03±0.38	67.52±1.11	2966±49.97
1.0 g/ Kg diet	65.54±0.65	65.90±0.62	74.90±0.32	33.16±5.08	73.39±0.57	60.92±1.31	12.88±0.05	70.07±0.60	3083±24.98
1.5 g/ Kg diet	65.33±0.67	65.66±0.49	73.22±1.69	34.56±2.95	73.55±2.89	60.99±2.93	12.59±0.29	69.77±0.45	3067±20.85
Sig.	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means in the same column bearing different letters differ significantly (P < 0.05).
NS = Not significant, *P<0.05 , **P<0.01 and *** P<0.001.

Table 4. Blood biochemical parameters of New Zealand White rabbits as affected by season, vitamin C level and their interaction

	ALT (u/l)	AST (u/l)	UREA (mg/dl)	CREAT (mg/dl)	CHOL (mg/dl)	TG (mg/dl)	TP (mg/dl)	ALB (mg/dl)	Globulin (g/d)	Albumin/ globulin
Season effect										
Winter	54.66±2.38	55.16±3.48	27.44±1.63	0.67±0.03	112.79±3.64	112.89±4.44	6.54±0.19	3.40±0.13	3.15±0.19	1.17±0.12
Summer	49.18±3.33	51.53±4.89	28.11±1.24	0.85±0.04	91.16±8.11	102.93±4.29	6.29±0.12	3.55±0.15	2.75±0.19	1.46±0.17
Sig.	*	NS	NS	**	**	NS	NS	**	NS	NS
Vitamin C level effect										
0.0 g/ Kg diet	40.01±2.70^{b}	43.66±0.58^{b}	24.16±0.76^{b}	0.66±0.04^{b}	106.91±4.58	110.79±4.74	6.03±0.06^{c}	3.17±0.06^{b}	3.27±0.20	1.01±0.09
0.5 g/ Kg diet	57.72±2.28^{a}	63.20±4.19^{a}	27.16±2.69^{b}	0.81±0.06^{a}	99.27±1.05	102.59±5.92	6.24±0.10^{cb}	3.36±0.20^{ab}	2.72±0.27	1.41±0.24
1.0 g/ Kg diet	56.74±2.34^{a}	57.56±8.12^{ab}	28.29±1.07^{b}	0.85±0.06^{a}	93.27±19.67	100.26±2.10	6.87±0.30^{a}	3.78±0.14^{a}	3.09±0.37	1.40±0.24
1.5 g/ Kg diet	53.22±4.65^{a}	48.96±5.63^{b}	31.50±2.01^{a}	0.71±0.07^{ab}	108.45±1.54	118.01±9.31	6.54±0.22^{ab}	3.58±0.22^{ab}	2.71±0.24	1.45±0.23
Sig.	***	*	*	*	NS	NS	**	*	NS	NS
The interaction effect										
Winter										
0.0 g/ Kg diet	44.04±3.52^{bc}	43.34±0.75^{dc}	24.60±1.44^{b}	0.60±0.05	114.32±6.93^{a}	120.88±3.05	6.04±0.12^{b}	3.12±0.02^{b}	3.41±0.28	0.94±0.08
0.5 g/ Kg diet	59.04±0.98^{a}	69.74±6.65^{a}	22.31±3.34^{b}	0.70±0.07	99.37±1.63^{ab}	107.49±4.99	6.14±0.01^{b}	3.57±0.40^{ab}	2.57±0.41	1.58±0.40
1.0 g/ Kg diet	53.19±2.57^{ab}	47.77±0.41^{dbc}	28.77±1.34^{ab}	0.73±0.04	129.02±1.60^{a}	100.26±4.53	7.47±0.26^{a}	3.82±0.15^{ab}	3.66±0.41	1.10±0.17
1.5 g/ Kg diet	62.38±2.74^{a}	59.81±2.56^{abc}	34.09±1.78^{a}	0.64±0.07	108.45±2.44^{b}	122.94±14.25	6.53±0.27^{b}	3.09±0.05^{b}	2.95±0.18	1.06±0.08
Summer										
0.0 g/ Kg diet	35.98±2.81^{c}	43.99±1.01^{dc}	23.71±0.78^{b}	0.72±0.04	99.49±1.29^{b}	100.70±1.09	6.02±0.06^{b}	3.22±0.13^{b}	3.13±0.33	1.08±0.16
0.5 g/ Kg diet	56.39±4.82^{a}	56.66±0.87^{abcd}	32.02±1.21^{a}	0.92±0.05	99.17±1.69^{ab}	97.69±11.23	6.35±0.20^{b}	3.16±0.37^{b}	2.87±0.43	1.29±0.31
1.0 g/ Kg diet	60.30±2.85^{a}	67.36±15.28^{ab}	27.81±1.92^{ab}	0.97±0.06	98.52±1.56^{ab}	100.26±1.24	6.26±0.17^{b}	3.76±0.28^{ab}	2.53±0.45	1.70±0.41
1.5 g/ Kg diet	44.06±4.08^{cb}	38.12±5.85^{d}	28.91±3.20^{ab}	0.78±0.11	108.45±2.44^{a}	113.09±14.34	6.54±0.41^{b}	4.07±0.04^{a}	2.48±0.45	1.83±0.35
Sig.	**	*	*	NS	**	NS	*	*	NS	NS

Means in the same column bearing different letters differ significantly (P<0.05).
NS=Not significant, **P<0.01 and *** P<0.001.

Table 5. Haematological parameters of New Zealand White rabbits as affected by season, vitamin C level and their interaction.

	RBCs count (10^6/ml)	Hemoglobin (g/dl)	Hematocrit (%)	WBCs (10^3/ml)	Lymphocytes (10^3/ml)
Season effect					
Winter	4.38±0.14	9.68±0.23	0.32±0.01	4.56±0.31	1.97±0.19
Summer	3.95±0.19	9.28±0.24	0.29±0.01	5.54±0.40	3.16±0.32
Sig.	*	NS	*	*	**
Vitamin C level effect					
0.0 g/ Kg diet	4.24±0.24	8.91±0.23	0.32±0.02	4.51±0.55	2.08±0.36
0.5 g/ Kg diet	3.88±0.09	9.60±0.35	0.29±0.01	4.89±0.38	2.84±0.37
1.0 g/ Kg diet	4.17±0.28	9.37±0.27	0.30±0.02	6.03±0.67	3.00±0.63
1.5 g/ Kg diet	4.39±0.33	10.03±0.37	0.32±0.02	4.77±0.38	2.33±0.35
Sig.	NS	NS	NS	NS	NS
The interaction effect					
Winter					
0.0 g/ Kg diet	$4.77±0.05^{a}$	9.38±0.06	$0.36±0.01^{a}$	$3.68±0.44^{b}$	1.44±0.18
0.5 g/ Kg diet	$3.82±0.19^{cb}$	9.17±0.66	$0.29±0.01^{cb}$	$4.51±0.47^{b}$	2.55±0.39
1.0 g/ Kg diet	$4.75±0.06^{a}$	9.70±0.36	$0.34±0.01^{ab}$	$4.79±0.84^{b}$	1.70±0.35
1.5 g/ Kg diet	$4.20±0.27^{abc}$	10.47±0.37	$0.30±0.02^{cb}$	$5.26±0.60^{b}$	2.17±0.30
Summer					
0.0 g/ Kg diet	$3.70±0.09^{cb}$	8.43±0.19	$0.27±0.00^{c}$	$5.34±0.81^{b}$	2.73±0.44
0.5 g/ Kg diet	$3.95±0.04^{cb}$	10.03±0.07	$0.29±0.01^{cb}$	$5.26±0.60^{b}$	3.13±0.67
1.0 g/ Kg diet	$3.58±0.24^{c}$	9.03±0.34	$0.26±0.03^{c}$	$7.27±0.16^{a}$	4.29±0.46
1.5 g/ Kg diet	$4.59±0.66^{ab}$	9.60±0.61	$0.33±0.04^{ab}$	$4.28±0.37^{b}$	2.50±0.71
Sig.	*	NS	**	*	NS

Means in the same column bearing different letters differ significantly (P<0.05).
NS=Not significant, **P<0.01 and *** P<0.001.

The interaction between season and ascorbic acid was significant on blood components. Within each season groups, ascorbic acid supplementation increased the blood concentration of ALT, AST, urea, cholesterol, total protein, albumin, hematocrit and white blood cells count. These results may be due to the beneficial effect of ascorbic acid on reduction oxidative damage initiated by free radicals and improve body organs function as mentioned above. (**Kamar *et al.,* 1984**) found that serum protein was significantly affected by the interaction of ascorbic acid and environmental temperature.

Carcass Traits

In the current study, dressing (%) and organs (liver, kidney and heart) weight as g/kg slaughter weight decreased significantly (P < 0.05) in summer season. Also **Hajati *et al.* (2015)** found non-significant responses of broiler chickens to ascorbic acid supplementation in rising carcass yield. This indicates that although the tested feed additives contributed to enhance growth and digestibility, but it does not act directly on fat and protein deposition.

However, dietary supplementation of ascorbic acid did not have significant effects on dressing (%) and organs weights (g/kg slaughter weight) of growing rabbits in comparison without addition group. The results are in accordance with previous studies by **Al-Shanty (2003), Abd El-Hamid and El-Adawy (1999)** who reported that carcass percentage, dressing hot carcass weight, kidney and spleen were not significantly affected by the treatment by ascorbic acid of heat-stressed rabbits. The interaction between dietary ascorbic acid and season had no significant effect on carcass and non-carcass components.

Economical Evaluation

Table 7 show that the feed cost and income from gain per rabbit were increased with ascorbic acid supplementation within each season groups. The economical evaluation in this study showed that the using of 0.5 or 1g ascorbic acid/kg in winter season and 0.5 g ascorbic acid/kg diet in summer season in the growing rabbit diets was more economical than the other treatment groups. The improvement in final margin may be due to the enhancement of weight gain and feed conversion ratio with ascorbic acid supplementation.

Table 6. Dressing percentage and some internal organs weights of growing New Zealand White rabbits as affected by season, vitamin C level and their interaction

	Dressing (%)	**Liver (g/kg SW)**	**Kidney (g/kg SW)**	**Heart (g/kg SW)**	**Lunges (g/kg SW)**	**Spleen (g/kg SW)**	**Ceacum (g/kg SW)**	**Ceacum Cm**
Season effect								
winter	58.46±0.72	82±2.15.35	6.78±0.31	2.65±0.11	7.16±0.31	0.52±0.05	3.45±0.21	11.85±0.35
summer	55.37±1.11	30.40±1.29	7.55±0.37	3.16±0.14	6.72±0.31	0.53±0.04	3.38±0.20	10.86±0.39
sig	*	*	*	**	NS	NS	NS	NS
Vitamin C levels effect								
0.0 g/ Kg diet	58.28±0.97	82±2.69.33	7.09±0.34	3.30±0.25	7.17±0.24	0.45±0.03	3.67±0.22	11.12±0.47
0.5g/ Kg diet	56.36±2.09	34.52±3.96	6.68±0.19	2.78±0.19	6.94±0.44	0.44±0.06	3.15±0.17	11.57±0.84
0.1 g/ Kg diet	56.72±1.84	79±2.97.32	7.90±0.79	2.79±0.22	7.25±0.52	0.59±0.04	3.36±0.49	11.27±0.53
1. 5 g/ Kg diet	56.30±0.61	31.31±0.81	6.49±0.28	2.74±0.10	6.41±0.53	0.63±0.05	3.47±0.18	11.47±0.41
sig	NS	NS	NS	NS	NS	NS	NS	NS
The interaction effect								
winter								
0.0 g/ Kg diet	60.14±1.06	09±2.30.37	7.28±0.22	2.84±0.26	7.07±0.33	0.47±0.05	3.54±0.30	11.03±0.27
0.5g/ Kg diet	58.91±2.22	41.35±5.47	6.35±0.19	2.63±0.35	6.74±0.51	0.43±0.12	3.26±0.08	13.00±1.00
0.1 g/ Kg diet	57.89±1.13	74±5.74.34	6.45±0.56	2.44±0.12	7.53±1.05	0.51±0.05	3.76±0.88	12.07±0.64
1. 5 g/ Kg diet	56.88±1.05	30.07±0.83	6.05±0.34	2.67±0.16	7.32±0.67	0.67±0.11	3.23±0.15	11.30±0.25
summer								
0.0 g/ Kg diet	56.43±0.37	55±4.49.30	6.91±0.25	3.76±0.16	7.26±0.41	0.43±0.03	3.81±0.37	11.20±1.02
0.5g/ Kg diet	53.81±3.22	27.68±1.35	7.01±0.19	2.92±0.18	7.15±0.82	0.44±0.07	3.04±0.35	10.13±0.67
0.1 g/ Kg diet	55.54±3.79	83±2.70.30	8.34±0.84	3.14±0.31	6.97±0.38	0.66±0.03	2.95±0.49	10.47±0.60
1. 5 g/ Kg diet	55.71±0.64	32.54±1.04	6.93±0.31	2.80±0.15	5.50±0.35	0.59±0.03	3.71±0.28	11.63±0.86
Sig.	NS	NS	NS	NS	NS	NS	NS	NS

Means in the same column bearing different letters differ significantly ($P < 0.05$).
NS = Not significant *P<0.05 and *** P<0.001.

Table 7. Economical visibility of growing New Zealand White rabbits as affected by season, vitamin C level and their interaction

	Total feed intake (kg)	Feed cost LE/Rabbit	Total gain kg	Income from gain LE/Rabbit	Final margin LE/Rabbit
Season effect					
Winter	6.89	23.27	1.55	46.42	23.15
Summer	5.93	20.03	1.31	39.16	19.13
Vitamin C level effect					
0.0 g/ Kg diet	6.54	19.62	1.32	39.68	20.06
0.5 g/ Kg diet	6.29	20.44	1.43	42.79	22.35
1.0 g/ Kg diet	6.31	22.09	1.45	43.41	21.32
1.5 g/ Kg diet	6.52	24.43	1.48	44.42	19.99
The interaction effect					
Winter					
0.0 g/ Kg diet	7.12	21.36	1.44	43.19	21.83
0.5 g/ Kg diet	6.66	21.65	1.56	46.84	25.19
1.0 g/ Kg diet	6.65	23.29	1.60	48.12	24.83
1.5 g/ Kg diet	7.15	26.80	1.59	47.56	20.76
Summer					
0.0 g/ Kg diet	5.96	17.89	1.21	36.17	18.28
0.5 g/ Kg diet	5.92	19.24	1.35	40.44	21.20
1.0 g/ Kg diet	5.97	20.90	1.29	38.72	17.83
1.5 g/ Kg diet	5.88	22.06	1.38	41.28	19.21

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تأثير إضافة حمض الاسكوربك على أداء النمو فى الأرانب النامية تحت الظـــروف المصرية

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أجريت هذه الدراسة لتقييم تاثير إضافة حمض الاسكوربك بمستويات مختلفة لعلائق الأرانب النامية علي أداء النمو، هضم العناصر وخصائص الذبيحة خلال فصل الصيف والشتاء فى مصر، تم إجراء الدراسة خلال فصلي الشتاء والصيف مع استخدام ٤ مستويات من حمض الاسكوربك (صفر، ٠,٥ ، ١,٠ و ١,٥ جم/كجم من العليقة) في تصميم عاملي ٢×٤، أظهرت النتائج حدوث إنخفاض معنوى فى أداء النمو، هضم العناصر (المادة العضوية، البروتين الخام، الألياف الخام، الدهن الخام)، القيم الغذائية (البروتين الخام المهضوم والمركبات المهضومة الكلية والطاقة المهضومة)، الهيموجلبين، الهيماتوكريت، الإنزيم الناقل للألانين، عدد كرات الدم الحمراء، نسبة التصافى ووزن الأعضاء (الكبد والكلى والقلب) خلال فصل الصيف بالمقارنة مع فصل الشتاء، وفى المقابل فقد أدت إضافة حمض الأسكوربك إلى زيادة معنوية فى مؤشرات أداء النمو، هضم المادة العضوية وقياسات الدم (الإنزيمات الناقلة لمجموعة الأمين، اليوريا، البروتين الكلى والألبيومين) فى الأرانب النامية، وعلى الرغم من ذلك فلم تؤدى إضافة حمض الأسكوربك أي تغيير معنوي في أيا من نسبة التصافي أو الأوزان النسبية للكبد والكلي والقلب والرئة والطحال، ومن جهة أخرى فقد أظهر التقييم الإقتصادى أن إضافة ٠,٥ أو ١ جم حمض أسكوربك/كجم خلال فصل الشتاء و٠,٥ جم حمض أسكوربك/كجم خلال فصل الصيف أظهرت كفاءة اقتصادية واضحة بالمقارنة بعلائق الكنترول، ومن الناحية الاقتصادية يستخلص من هذه النتائج ان إضافة حمض الأسكوربك إلى علائق الأرانب، وخاصة بمستوى ٠,٥ جم/ كجم يمكن أن يحسن أداء النمو فى الأرانب النامية خلال الجو المعتدل والحار فى مصر.

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