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GROWTH PERFORMANCE OF FATTENING RABBITS AS AFFECTED BY STOCKING DENSITY AND ADDED DIETARY ORGANIC ACIDS

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ABSTRACT

An experiment of 3×2 factorial arrangement of treatments was undertaken to investigate the influence of stocking density and dietary supplementation with organic acids on growth performance, carcass characteristics, and some blood parameters of fattening rabbits. A total of 54, 7-week-old New Zealand White × California rabbits were randomly divided into 6 experimental groups, of three replicates of 2, 3 or 4 rabbits each. Two experimental pelleted diets (a basal diet and a 0.4% Salkil-supplemented diet; Salkil is a mixture of formic and propionic acids.) were formulated and used from 7 to 13 weeks of age. The rabbits were individually weighed, kept in battery cages at three stocking densities (8.6, 12.9 and 17.2 rabbits/m^2), fed their respective experimental diets and managed similarly up to 13 weeks of age. Criteria of response were the performance of rabbits for growth, feed intake and feed conversion, mortality rate, economic efficiency of feeding, and some carcass traits. Some blood plasma parameters (levels of glucose, total protein, albumin, triglycerides and cholesterol as well as activity of the transaminases: alanine aminotransferase and aspartate aminotransferase) were also determined. The results obtained could be summarized as follows: No deaths of rabbits occurred during the course of this study. Regardless of the effect of dietary supplemental organic acids, growth performance of rabbits was not significantly affected by stocking density during the whole experimental period, whereas means of daily feed intake, daily weight gain and performance index of rabbits insignificantly decreased when stocking density reached 17.2 rabbits/m^2. Neither carcass traits nor blood parameters of rabbits, measured herein, was affected by stocking density. Irrespective of the effect of stocking density, added dietary organic acids did not significantly affect growth performance, carcass traits or blood parameters of the experimental rabbits. No significant interaction effects of stocking density and added dietary organic acids were detected for all criteria examined in the present study. Taking the performance of rabbits and economic aspect into account, the results revealed that the maximum rate of cage density (17.2 rabbits/m^2) had no adverse effects under the condition of the present experiment during the spring season. The dietary inclusion of Salkil at a level of 0.4% was an extravagance; because it had no positive effects on either growth performance or economic efficiency of rabbit production, under the conditions of the present study.
Keywords: Stocking density, added dietary organic acids, performance, carcass traits, blood parameters, fattening rabbits.

INTRODUCTION

Stocking density can be defined as the number of animals per square meter in a cage, pen or building. It is an important factor that can affect labor, investment cost, performance, and accordingly, profitability of rabbit production. In the semi-humid tropics, Grace and Olorunju (2005) recommended that the optimum stocking density for rabbits is 13.3 rabbits/m^2. In Europe, cage density varies in commercial farms from 14 to 23 rabbits/m^2 (Trocino and Xiccato, 2006). But densities higher than 19 rabbits/m^2 may reduce feed intake and growth rates of rabbits, with no effect on feed efficiency or mortality (Aubret and Duperray, 1992). Based on production parameters, Maertens and De Groote (1984) suggested that the maximum load of fattening rabbits in small cages is 40 kg/m²; *i.e.* 16 fattening rabbits of 2.5 kg per m². Recently, Szendrő and Dalle Zotte (2011), based on several studies, concluded that that optimal stocking density is 16-18 rabbits/m^2, depending on final body weight of rabbits.

The use of organic acids in animal nutrition appears interesting, even though scientific data concerning their effect on microflora population, mucosal immunity and growth performance of rabbits are scarce and often contradictory (Falcao-e-Cunra *et al.*, 2007). The mode of action of supplemental dietary organic acids on caecal microflora is also incompletely understood. According to the available scientific literature, the effects of dietary supplementation with organic acids on growth performance of rabbits are inconsistent. Improvements in daily weight gain of rabbits due to incorporation of organic acids into their diets have been reported in many studies (Hullar et *al*., 1996; Cesari *et al*., 2008), but no beneficial effects were recorded in that respect by others (Hollister *et al*., 1990).

Therefore, the objective of the present study was to investigate the influence of stocking density and dietary supplementation with organic acids on growth performance, carcass characteristics and some blood parameters of fattening rabbits.

MATERIALS AND METHODS

The fieldwork of the present study was carried out at the Research Rabbitry, Center of Agricultural Researches and Experiments, Faculty of Agriculture, Mansoura University, Egypt, during the period from March to April, 2011. The objective of study was to investigate the influence of stocking density and dietary supplementation with organic acids on growth performance, carcass characteristics, and some blood parameters of fattening rabbits.

Housing and feeding of the experimental rabbits:

Fifty four 7-week-old (unsexed) New Zealand White × California rabbits were randomly divided into 6 experimental groups of three replicates of 2, 3 or 4 rabbits each. Three stocking densities (2, 3 and 4 rabbits per cage, corresponding to 8.6, 12.9 and 17.2 rabbits/m^2) were used in presence or absence of dietary supplementation with organic acids. All rabbits were housed in galvanized-wire cages (cage dimensions are 44 cm width × 35 cm height × 53 cm depth) fitted with feeders, automatic nipple drinkers. All cages were set up in an open-sided well-ventilated rabbitry. Two experimental diets were formulated and processed as pellets (3.5 mm diameter) to meet the nutrient requirements of growing rabbits as specified by NRC (1977). A basal diet was compounded without any supplement to serve as a control diet. The second diet was compounded using the same feed ingredients plus 0.4%

Salkil at the expense of wheat bran content of the basal diet. Salkil is a mixture of buffered formic and propionic acids. Composition and calculated analyses of the experimental diets are shown in Table 1. All the experimental groups of rabbits were fed their respective experimental diets and managed similarly from 7 to 13 weeks of age.

Criteria of response of the experimental rabbits:

Criteria of response included data on growth performance of rabbits, carcass characteristics, and some blood parameters. The growth performance of rabbits, as affected by stocking density and dietary supplementation with organic acids throughout the fattening period, was evaluated in terms of feed intake, live body weight, body weight gain, feed conversion ratio, performance index and mortality rate as well as economic efficiency of feeding. Individual live body weights of rabbits were recorded at the beginning of the experiment (7 weeks old) and on a weekly basis thereafter. Weekly records on feed intake and body weight gain of rabbits were also maintained on a replicate group basis. Accordingly, feed conversion ratio was calculated as the amount of feed consumed per unit of BWG. However, mortality of rabbits was monitored and recorded daily. Performance index was calculated as live body weight (kg) times 100 divided by feed conversion ratio (North, 1984). The economic efficiency of feeding (EEF) was also calculated for the whole experimental period.

Table 1: Composition and calculated analysis of the experimental diets fed to growing rabbits from 7 to 13 weeks of age

Ingredients %	Control diet	Salkil-diet
Wheat bran	27.50	27.10
Alfalfa hay	20.00	20.00
Soy bean meal (44%)	15.20	15.20
Caraway straw	15.00	15.00
Yellow corn	10.00	10.00
Barley grains	10.00	10.00
Limestone	1.70	1.70
Common salt	0.30	0.30
Vit. & Min. Premix[§]	0.30	0.30
Silkal[¶]	0.00	0.40
Total	100	100
Calculated analysis: As fed basis (NRC, 1977)		
Crude protein (%)	17.38	17.32
Ether extract (%)	3.10	3.08
Crude fiber (%)	14.93	14.89
Calcium (%)	1.24	1.24
Phosphorous (%)	0.58	0.57
Lysine (%)	0.85	0.85
Methionine (%)	0.21	0.21
Methionine + Cystine (%)	0.48	0.48
Digestible energy (kcal/kg)	2694	2683
Cost per kg diet (EGP)	2.06	2.13

§: Each 3 kg of the product contains: Vit. A, 12,000,000 IU; Vit. D_3, 2,500,000 IU; Vit. E, 10 g; Vit. K, 2.5 g; Vit. B_6 1.5 g; Vit. B_{12}, 10 mg; Biotin, 50 mg; Folic acid, 1.0 g; Nicotinic acid, 30 mg; Pantothenic acid, 10 g; Antioxidant, 19 g; Mn, 60 g; Cu, 10 g; Zn, 55 g; Fe, 35 g; I, 1.0 g; Co, 250 mg and Se, 150 mg.

¶: Salkil is a mixture of buffered formic and propionic acids.

At the end of the experiment (13 weeks of age), three rabbits from each treatment were randomly chosen and slaughtered after fasting for 18 hours. Just after estimating the live body weight at slaughter, rabbits were carefully sacrificed, skinned and emptied. The individual weights of hot carcass (HCW, eviscerated carcass including head), liver, heart, kidneys and perirenal fat were recorded. The total edible parts were calculated as HCW plus total giblets (*i.e.* the sum of liver, heart and kidneys). Relative weights of HCW, liver, heart, kidneys, total giblets and perirenal fat were also calculated. During slaughtering, three blood samples per treatment were taken in heparinized test tubes. Blood samples were immediately centrifuged at 3000 rpm 15 minutes in order to separate blood plasma. Plasma samples were frozen at –20°C in pledge of analysis. The concentrations of plasma glucose (Trinder, 1969), cholesterol (Allain *et al.*, 1974), total protein (Doumas *et al.*, 1981), albumin (Doumas *et al.*, 1971) and triglycerides (Fossati and Prencipe, 1982) were determined using commercial kits. Activities of ALT and AST in blood plasma were also estimated (Reitman and Frankel, 1957).

Statistical analysis:

A completely randomized design with a factorial arrangement of treatments (3×2), three stocking densities by two levels of dietary supplementation with organic acids (zero or 0.4% Salkil) was used. Data were statistically processed by a multifactor analysis of variance using the Statgraphics Program (Statistical Graphics Corporation, 1991), with $P \leq 0.05$ considered to be significant. Means were compared by a Duncan's multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

It is interesting to note that no deaths of rabbits occurred during the course of this study (from 7 to 13 weeks of age). In addition, no significant differences were detected due to the interactions between the effects of cage density and added dietary organic acids for all the measured variables were not significant.

Growth performance of rabbits:

Effect of stocking density:

Criteria of growth performance of rabbits as affected by cage density and dietary supplementation with organic acids for the entire experimental period (from 7 to 13 weeks of age) are presented in Table 2. Irrespective of the effect of added dietary organic acids, none of the examined growth performance criteria of rabbits was affected by the stocking density applied in the present study (8.6, 12.9 and 17.2 rabbits/m^2) for the entire experimental period. The lack of a negative impact of cage density on growth performance of rabbits in the present study could indicate that rabbits stocked at the highest cage density (17.2 rabbits/m^2) had a cage space to move freely, as enough as that allowed for rabbits stocked at the lowest density (8.6 rabbits/m^2), and consequently, neither feed intake nor body weight gain was significantly affected. In addition, feed conversion is a growth and feed intake-correlated trait. So, when both feed intake and growth rate (*i.e.* body weight gain) of rabbits are not significantly affected by stocking density of rabbits, lack of significant differences in feed conversion is expected, as is the case in the present study. The insignificant differences in the economic efficiency of feeding for rabbits stocked at different cage densities, in the present study, are mainly due to that they consumed approximately similar amounts of feed and achieved body weight gains with insignificant differences during the whole experimental period.

Table 2: Growth performance of rabbits as affected by cage density and dietary supplementation with organic acids from 7 to 13 weeks of age

Treatments	IBW[1] (g)	FBW[2] (g)	DFI[3] (g)	DWG[4] (g)	FCR[5] (g:g)	PI[6] (%)	EEF[7] (%)
	7 weeks old	13 weeks old	7-13 weeks old	7-13 weeks old	7-13 weeks old	7-13 weeks old	7-13 weeks old
Cage density: A							
8.6 Rabbits/m^2	1008	2225	109.9	29.0	3.791	58.82	152.0
12.9 Rabbits/m^2	1000	2192	107.2	28.4	3.793	57.84	152.3
17.2 Rabbits/m^2	987	2088	99.6	26.2	3.802	54.98	151.1
SEM[§]	91	63	3.6	1.1	0.05	2.0	3.52
Significance	NS	NS	NS	NS	NS	NS	NS
Organic acids (B)							
0.0%	991	2149	104.7	27.6	3.807	56.55	155.2
0.4%	1006	2188	106.4	28.1	3.784	57.88	148.3
SEM[§]	75	52	3.0	0.9	0.04	1.63	2.90
Significance	NS	NS	NS	NS	NS	NS	NS
AB Interaction							
A1×B1	997	2244	111.5	29.7	3.759	59.82	158.4
A1×B2	1020	2207	108.2	28.3	3.824	57.83	145.7
A2×B1	982	2160	105.8	28.0	3.792	57.03	156.5
A2×B2	1019	2224	108.6	28.7	3.795	58.66	148.1
A3×B1	995	2043	96.6	25.0	3.870	52.81	150.7
A3×B2	979	2134	102.2	27.5	3.734	57.16	151.6
SEM[§]	129	90	5.1	1.6	0.07	2.82	5.00
Significance	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

[§]: Standard errors of the means. NS: Not significant.
[1-7]: Refer to initial body weight, final body weight, daily feed intake, daily weight gain, feed conversion ratio, performance index and economic efficiency of feeding respectively.
EEF = 100 × [net revenue/total feed cost].

Perusal of data presented in Table 2 revealed that daily feed intake, daily weight gain and performance index of rabbits insignificantly decreased (P>0.05) during the whole experimental period with increasing stocking density from 8.6 to 17.2 rabbits/m^2. This slight reduction in feed intake and body weight gain and performance index of rabbits, observed herein, is in line with conclusions of other studies (Maertens and De Groote, 1984; Aubret and Duperray, 1992; Grace and Olorunju, 2005; Villalobos *et al.*, 2008a, b). On the other hand, the present results are in harmony with the findings of other investigators (Trocino *et al.*, 2004; Trocino and Xiccato, 2006; Trocino *et al.*

(2008), who reported that neither feed intake nor body weight gain of rabbits was significantly affected by stocking density**.**

As discussed in the aforementioned paragraphs, the effects of stocking density on growth performance of rabbits are variable among the different studies present in the scientific literature. In the present study, cage density ranged from 8.6 to 17.2 rabbits per square meter exerted no significant effects on the growth performance of rabbits. However, in other studies when stocking density was higher than 15–17 rabbits/m^2, daily weight gain, final body weight and feed intake of rabbits declined by 1.2–3.3 g per day, 120–177 g and 5–15 g per day, respectively (Maertens and De Groote, 1984; Aubret and Duperray, 1992; Szendrő and Dalle Zotte (2011), whereas when stocking density was lower than 15–17 rabbits/m^2, only a random fluctuation was observed (Maertens and De Groote, 1984; Trocino *et al.*, 2004, 2008; Szendrő *et al.*, 2009). In partial concurrence with the present results, other reports concluded that feed conversion of rabbits was independent of stocking density, as feed intake and weight gain changed in parallel (Trocino *et al.*, 2004, 2008; Szendrő *et al.*, 2009). Aubret and Duperray (1992) demonstrated that it is not the number of animals per square meter, but rather the total weight of the animals per square meter that induces lower feed intake and weight gain, if density is higher than optimal. When the total weight of rabbits per square meter was higher than 45 kg, daily weight gain declined (Szendrő and Dalle Zotte, 2011).

Effect of added dietary organic acids:

Dietary supplementation with organic acids had no significant effect (P>0.05) on DFI, FBW, DWG, FCR, PI or EEF of rabbits during the entire experimental period (Table 2). According to the scientific literature, the effects of dietary supplementation with organic acids on productive performance of rabbits are inconsistent and incompletely understood (Maertens *et al*., 2006; Falcao-e-Cunha *et al.*, 2007). However, improvements in daily weight gain have been reported in several studies (Hullar *et al*., 1996; Cesari *et al*., 2008), but no positive effects were recorded by others (Hollister *et al*., 1990).

The present results are in agreement with the findings of Carraro *et al.* (2005), using sodium butyrate (28-70 days of age), and Cesari *et al.* (2008), using a blend of formic and lactic acids (30-84 days of age), who found that dietary inclusion of organic acids had no effect on daily feed intake or growth rate of the fattening rabbits. In harmony also with the present results, Ribeiro *et al.* (2012), using coated sodium butyrate (23-63 days of age), and Romero *et al.* (2012), using a blend of esterified caproic and caprylic acids (28-56 days of age), found that dietary supplementation with organic acids did not affect growth rate of fattening rabbits. Contrary to the current results, other investigators observed that added dietary organic acids had a positive effect on body weight gain of rabbits (Kamal *et al*., 2008, using single or combined addition of citric, fumaric and malic acids from 4 to 12 weeks of age; Debi *et al*., 2010, using citric acid from 30 to 86 days of age; Romero *et al.*, 2011, using a blend of microencapsulated formic and citric acids from 28 to 77 days of age) or depressed the feed intake of rabbits (Kamal *et al.*, 2008; Ribeiro *et al.*, 2012). In general, the lack of consistency among different studies concerning the response of animals to the inclusion of organic acids into their diets is related to uncontrolled variables such as buffering capacity of dietary ingredients, presence of other antimicrobial compounds, cleanliness of the production environment, and heterogeneity of gut microbiota (Dibner and Buttin, 2002). Other factors such as age, species and health status of gastrointestinal tract of the animal, and type and concentration of the added organic acid and feed processing can also be involved in the variability of response to dietary supplementation with organic acids.

Carcass traits of rabbits:

Effect of stocking density:

Data on carcass traits of 13-week-old rabbits as affected by cage density and dietary supplementation with organic acids are given in Table 3. Stocking density, applied in the present study, had no significant effect (P>0.05) on the relative weights of hot carcass, liver, heart, kidneys, total giblets, total edible parts or perirenal fat of rabbits, independently from the effect of added dietary organic acids. Since stocking density, evaluated herein, did not significantly affect the growth rate of the experimental rabbits (Table 2); and accordingly, their slaughter weights were approximately similar, consequently no differences were detected in carcass traits of rabbits. This observation was justified by Trocino *et al*. (2004), who noted that rabbits of similar body weights are not expected to differ in carcass traits.

Similarly to the present findings, Villalobos *et al.* (2008a) investigated the effect of four cage densities (3, 6, 9 and 12 rabbits/cage: each cage of 0.5 m^2) on carcass characteristics of rabbits and found that cage density did not modify dressing out percentage and hot or chilled carcass weights. In another study, Villalobos *et al.* (2008b) reported that cage density (6, 12, 18 and 24 rabbits/m^2) had no effect on carcass weight, dressing out percentage, viscera weight or the proportion of separable fat weight in rabbits. In harmony also with the present results, Yakubu and Adua (2010) and Baiomy (2012) observed no effect of stocking density on carcass characteristics of fattening rabbits.

On the contrary, Lambertini *et al.* (2001) evaluated the effects of two stocking densities (8 or 16 rabbits/m^2) and found that hot carcass weight of rabbits stocked at the lower density was significantly higher than that of rabbits kept at the higher stocking density. On the other hand, **Pla (2008)** reported that as stocking density increases, hind leg proportion decreases in hybrid rabbits.

Effect of added dietary organic acids:

Apart from the effect of stocking density, dietary supplementation with organic acids did not significantly affect (P>0.05) carcass traits of rabbits, measured in the present study (Table 3). The present results harmonize with the findings of Abd El-Rahim *et al.* (1994; using 0.5% citric acid), Carraro *et al.* (2005; using sodium butyrate at levels of 0.5, 1.0 or 2.0 g/kg), Radwan, and Abdel-Khalek (2007; using 0.5% acetic or lactic acids) and Amaefule *et al.* (2011; using 0.5% of acetic, citric or formic acids), who reported that carcass traits of rabbits were not affected by dietary supplementation with organic acids.

Table 3: Relative weights of carcass traits of 13-week-old rabbits as affected by cage density and dietary supplementation with organic acids

Treatments	LBW[1] (g)	HCW[2] (%)	LW[3] (%)	KW[4] (%)	HW[5] (%)	GW[6] (%)	TEP[7] (%)	PF[8] (%)
Cage density: A								
8.6 Rabbits/m^2	2158	57.5	3.59	0.73	0.32	4.64	62.1	0.84
12.9 Rabbits/m^2	2149	56.4	3.30	0.78	0.31	4.39	60.8	0.79
17.2 Rabbits/m^2	2072	56.7	3.14	0.85	0.35	4.34	61.0	0.70
SEM[§]	50.0	0.70	0.16	0.07	0.01	0.20	0.70	0.06
Significance	NS	NS	NS	NS	NS	NS	NS	NS
Organic acids (B)								
0.0 %	2109	56.7	3.39	0.81	0.32	4.52	61.2	0.70
0.4 %	2143	57.0	3.29	0.75	0.34	4.39	61.4	0.85
SEM[§]	41.0	0.50	0.13	0.06	0.01	0.17	0.60	0.05
Significance	NS	NS	NS	NS	NS	NS	NS	NS
AB Interaction								
A1×B1	2175	56.8	3.52	0.76	0.30	4.59	61.4	0.74
A1×B2	2140	58.2	3.65	0.70	0.34	4.69	62.9	0.94
A2×B1	2138	56.5	3.58	0.85	0.30	4.73	61.2	0.79
A2×B2	2160	56.3	3.01	0.70	0.32	4.04	60.4	0.79
A3×B1	2015	56.9	3.05	0.83	0.36	4.24	61.1	0.58
A3×B2	2128	56.5	3.22	0.86	0.35	4.43	60.9	0.83
SEM[§]	71.0	1.0	0.22	0.10	0.02	0.29	1.0	0.09
Significance	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

[§]: Standard errors of the means. NS: Not significant.
[1-8]: Refer to live body weight at slaughter and relative weights of hot carcass, liver, kidneys, heart, giblets, total edible parts and perirenal fat (% of LBW), respectively.

Blood parameters of rabbits:
Effect of stocking density:

The effects of cage density and dietary supplementation with organic acids on blood parameters of rabbits are presented in Table 4. Regardless of the effect of added dietary organic acids, cage density had no significant effect (P>0.05) on all examined blood parameters of 13-week-old rabbits in the present study.

The present results harmonize with the findings of Onbasılar and Onbasılar (2007), who found that serum levels of cholesterol and triglycerides in young rabbits were not affected by cage density (2.4, 7.1 or 11.9 rabbits/m^2). In partial accordance with the present results, Kalaba (2012) found that levels of albumin, total lipids, high-density lipoproteins and low-density lipoproteins, and activity of ALT in blood plasma of rabbits were not affected by stocking density (4, 8, 12 or 16 rabbits/m^2); but levels of total protein, globulin, creatinine, cholesterol and triglycerides were significantly lower in rabbits stocked at the highest density (16 rabbits/m^2) than in those kept at the lower stocking densities. However, Fuentes and Newgren (2008) compared the serum chemistries, antibody production, physiologic plasma cortisol levels, and white blood cell counts of female New Zealand White rabbits housed in two different housing systems. They found that the group-housed rabbits had lower leukocytes counts and higher levels of plasma cortisol than did rabbits individually housed, while antibody production did not differ between the two groups.

Table 4: Blood plasma parameters of 13-week-old rabbits as affected by cage density and dietary supplementation with organic acids

Treatments	GLU[1] (mg/dL)	CHO[2] (mg/dL)	TRI[3] (mg/dL)	TPR[4] (g/dL)	ALB[5] (g/dL)	ALT[6] (U/L)	AST[7] (U/L)
Cage density: A							
8.6 Rabbits/m^2	111.2	73.1	126.1	5.98	3.65	80.1	37.67
12.9 Rabbits/m^2	106.9	73.9	122.8	6.23	3.62	82.0	37.83
17.2 Rabbits/m^2	109.9	72.6	124.4	6.03	3.65	80.1	36.50
SEM§	3.05	0.99	1.37	0.16	0.08	1.46	1.35
Significance	NS	NS	NS	NS	NS	NS	NS
Organic acids (B)							
0.0 %	113.5^a	74.1	124.6	6.21	3.63	80.0	37.11
0.4 %	105.2^b	72.3	122.2	5.96	3.64	81.5	37.56
SEM§	2.49	0.81	1.12	0.13	0.06	1.19	1.10
Significance	*	NS	NS	NS	NS	NS	NS
AB Interaction							
A1×B1	117.2	72.3	125.6	6.10	3.50	78.3	36.33
A1×B2	105.2	73.8	126.6	6.87	3.80	81.8	39.00
A2×B1	111.9	75.9	122.2	6.40	3.60	81.6	37.33
A2×B2	102.0	72.0	123.4	6.07	3.63	82.4	38.33
A3×B1	111.5	74.0	126.0	6.13	3.80	80.0	37.67
A3×B2	108.3	71.2	122.7	5.93	3.50	80.2	35.33
SEM§	4.32	1.4	1.93	0.23	0.11	2.07	1.91
Significance	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

§: Standard errors of the means. NS: Not significant. *: Significant at P≤0.05.
[1-7]: Denote to glucose, cholesterol, triglycerides, total protein, albumin, alanine aminotransferase and aspartate aminotransferase in blood plasma, respectively.

Effect of added dietary organic acids:

Irrespective of the effect of stocking density, dietary supplementation with organic acids did not significantly affect (P>0.05) blood parameters of rabbits, measured in the present study (Table 4). In accordance with the present results, Radwan and Abdel-Khalek (2007) found that dietary organic acids (0.5% acetic or lactic acids) did not affect blood plasma parameters (total protein, albumin, globulin and total lipids) of rabbits. The present findings are also in line with those of Brzóska *et al.* (2013), who found that blood constituents (plasma levels of glucose, total protein, triglycerides, total cholesterol and high density lipoprotein) of broiler chicks were not affected by dietary acidifier (20.7% butyric acid, 17.5% ammonium propionate, 12.5% propionic acid, and 4.2% ammonium propionate).

Contrary to the present results, Abd El-Rahim *et al.* (1994) found that dietary citric acid (0.5%) caused a significant reduction in blood serum levels of total lipids and total cholesterol in New Zealand White rabbits while those of calcium and inorganic phosphorus increased significantly but creatinine concentration and activity of transaminases were not affected by added citric acid. In addition, Kamal *et al.* (2008) fed male New Zealand White rabbits diets supplemented with organic acids (citric, fumaric and malic acids, singly or in combination) and found significant reductions in serum levels of cholesterol, total lipid and low density lipoprotein as well as activity of alkaline phosphatase, while levels of calcium, phosphorus, magnesium and triiodothyronine significantly increased due to dietary acidification.

In general, the lack of effect of the experimental treatments, applied herein, on the biochemical blood parameters of rabbits coincided with the absence of significant differences among the experimental rabbits in growth performance, with no mortality or morbidity, may give an indicator for their good health and welfare, and/or normal physiological status. Regardless of the effect of treatments, means of blood parameters of rabbits, measured in the present study, fell within the normal blood analyte reference values for rabbits (Kaneko *et al.*, 2008).

Conclusively, the obtained results showed that the maximum rate of cage density of 17.2 rabbits/m^2 had no adverse effect on the performance of rabbits during the spring season under the conditions of the present study. The inclusion of 0.4% Salkil (a blend of formic and propionic acids) in rabbits' diet was not effective because it had no positive effects on either growth performance or economic efficiency of rabbit production.

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المظاهر الإنتاجية لأرانب التسمين تحت تأثير كثافة الإسكان وإضافة الأحماض العضوية للغذاء

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أجريت تجربة عاملية (٣×٢) لبحث تأثير كثافة الإسكان وتدعيم العليقة بالأحماض العضوية على المظاهر الإنتاجية وخصائص الذبيحة وبعض قياسات الدم لأرانب التسمين. استخدم في الدراسة عدد ٥٤ أرنبا عمر ٧ أسابيع من خليط كاليفورنيا مع النيوزيلندي الأبيض، قسمت عشوائيا إلى ٦ مجموعات تجريبية تضمنت كل منها ٣ مكررات (تضمنت المكررة ٢ أو ٣ أو ٤ أرانب). تم تكوين عليقتين تجريبيتين في صورة محببات إحداهما قاعدية (كنترول) والأخري دعمت بإضافة ٠,٤% من مستحضر السالكيل (مزيج لحامضي الفورميك والبروبيونيك). تم وزن الأرانب فرديا وسكنت في أقفاص بطاريات بثلاثة معدلات من كثافة الإسكان (٨,٦ أو ١٢,٩ أو ١٧,٢ أرنبا في المتر المربع)، وغذيت كل مجموعة على العليقة التجريبية الخاصة بها، وخضعت جميع الأرانب التجريبية لنفس ظروف الرعاية حتى عمر ١٣ أسبوع. وتضمنت معايير الإستجابة المظاهر الإنتاجية

للأرانب فـي صـورة النمـو وإسـتهلاك الغذاء والتحويـل الغـذائي ومعـدل النفـوق والكفـاءة الإقتصــادية للتغذية، وبعض صـفات الذبيحـة. كمـا تـم تقدير بعض معـايير بلازمـا الـدم (تركيـز كـل مـن الجلوكـوز، والبـروتين الكلـي والألبيـومين والجليسـريدات الثلاثيـة والكوليسـتيرول وكـذلك نشـاط إنزيمـي ألانـين أمينوترانسفيريز وأسـبرتيت أمينوترانسفيريز فـي البلازمـا). وتـتلخص النتـائج المتحصـل عليهـا فيمـا يلي: لم تحدث حالات نفوق للأرانب التجريبية طوال فترة التجربة. بغض النظر عن تـأثير الأحمـاض العضوية المضافة للغذاء، فإن المظاهر الإنتاجية للأرانب لم تتأثر معنويا بكثافة الإسكان، بينمـا لـوحظ نقص غير معنوي في متوسطات إستهلاك الغذاء اليومي، الزيـادة المكتسبة فـي الـوزن، و دليل الأداء عندما وصلت كثافة الإسكان ١٧,٢ أرنبا في المتر المربع. لم يكن لكثافة الإسكان تـأثير معنوي علـى صـفات الذبيحـة أو قياسـات الـدم المـأخوذة. وبغض النظر عن تـأثير كثافـة الإسكان، لـم يكـن لإضـافة الأحمـاض العضـوية للعليقـة تـأثير معنـوي علـى المظـاهر الإنتاجيـة أو صـفات الذبيحـة أو قياسـات الـدم المأخوذة لأرانب التجربـة. كذلك لم يكن للتداخل بين كثافـة الإسكان والأحمـاض العضـوية المضـافة للغـذاء تـأثير معنـوي علـى جميـع الصـفات المنوطـة بالدراسـة. وبأخـذ المظـاهر الإنتاجيـة للأرانـب والناحيـة الإقتصـادية فـي الإعتبـار، أظهـرت النتـائج أن أقصـى معـدل لكثافـة الإسـكان فـي الأقفـاص (١٧,٢ أرنبا/م^{٢}) لم يكن له تأثير سلبي على الأرانب تحت ظروف هذه الدراسـة خلال فصل الربيـع. ولـيس هنـاك جدوى من تدعيم عليقـة الأرانـب بمستحضـر السـالكيل نظـرا لأنـه لـم يحـدث أيـة تـأثيرات إيجابية على نمو الأرانب أو الكفاءة الإقتصادية للإنتاج.

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