J. of Animal and Poultry Production, Mansoura Univ., Vol . 16 (5):51 - 60, 2025

Journal of Animal and Poultry Production

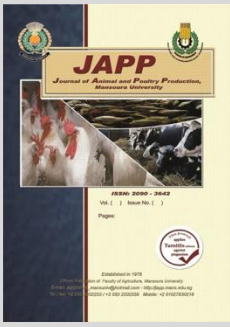
Journal homepage & Available online at: www.jappmu.journals.ekb.eg

Effect of Cage Density and Dietary Thyme Meal on Growth Performance, Nutrient Digestibility and Carcass Traits of Rabbits

Rehab F. S. A. Ismail[1*] and Marwa M. H. Rabie[2]

[1]Animal Production Dept., Faculty of Agriculture, Mansoura University, Egypt
[2]Poultry Production Dept., Faculty of Agriculture, Mansoura University, Egypt

Cross Mark



ABSTRACT

The current investigation was carried out to assess the impact of stocking density (SD: 1, 2 or 3 rabbits/cage) and dietary dried thyme meal (DTM) fortification on male rabbits' growth performance, blood parameters, carcass characteristics, meat composition, and nutrient digestibility in a hot climate. A total of 132 5-wk-old APRI rabbits were randomly divided into two groups, each was subdivided to three subgroups and kept at battery cages. Two experimental diets containing two levels of DTM (0.0 or 2.0 g/kg) were created and employed for the study rabbits between the ages of five and eleven weeks. All rabbits were managed similarly. Growth rate and carcass traits, nutrient digestibility, meat composition and selected blood parameters were determined. Independently from SD, feeding the DTM-containing diets positively affected growth performance of rabbits but daily feed intake was not affected. Apart from dietary DTM supplementation, the final live body weight, daily weight gain, and feed conversion ratio of developing rabbits were adversely affected by an increase in cage SD while daily feed intake was not altered. Nutrient digestibility, carcass traits, meat composition and rabbits' parameters of blood weren't significantly influenced by dietary DTM, cage SD or their interaction. The growth performance of rabbits was not significantly influenced by dietary DTM by cage SD interactions. In conclusion, the obtained results indicate that dietary thyme supplementation (2.0 g/kg) can exert a positive impact on the growth performance, but cage SD should not exceed one rabbit per cage to obtain optimal performance of APRI male rabbits.

Keywords: Dietary thyme, stocking density, growth performance, carcass traits, APRI rabbits.

INTRODUCTION

Nowadays, the use of herbs and herbal products in diets of rabbits to improve their ability to reproduce and be productive. Inclusion of herb leaves in diets of rabbits may alleviate the effects of many diseases. The herbal extracts can beneficially affect health, welfare and performance of poultry reared under summer season (Attia *et al*. 2017; Ahmed *et al*., 2020). The scientific literature states that the Lamiaceae family of plants includes the aromatic thyme (*Thymus vulgaris* L.). Thymol and carvacrol are the primary bioactive components of thyme oil which have antioxidant, antifungal and antibacterial characteristics (El-Ghousein and Al-Beitawi, 2009; Toghyani *et al*., 2010). Thymol and carvacrol, two of the bioactive components of thyme, have been shown to have antiviral, antibacterial, and aroma-regulating properties in addition to antioxidant ones (Kachur andSuntres, 2020). Because thyme contains phenolic compounds, it has been shown to enhance the production of digestive enzymes and boost poultry's immune systems (Naderiboroojerdi *et al*., 2022). The antimicrobial and antioxidant properties of these active constituents of thyme have a primary role in promoting the rabbits' appetite and growth rate, (Abdel-Wareth *et al*., 2018; Abd El-Azeem *et al*. 2019; Al-Desoki *et al*. 2019), broiler chickens (Vlaicu*et al*., 2023; Eldeeb *et al*., 2024) and Japanese quail (Soliman *et al*., 2024). As stated by Khafar *et al*. (2019), dietary supplementation with thyme essential oil (150 and 200 mg/kg) is suggested for enhancing the immunological responses and development performance of broiler chicks under heat stress. However, other studies failed to detect beneficial effects on poultry performance due to feeding thyme-enriched diets (Mehdipour *et al*., 2014; Saleh *et al*., 2014; Popović *et al*., 2016). On the other hand, the effectiveness of phytogenic substances or herbs as feed supplements for poultry may depend on a variety of factors such as plant components, including the entire plant, leaves, flowers, and seeds, plant-based extract, the added dose, the processing method, avian age, gender and species, and duration of study.

In rabbit industry, stocking density (SD) can be expressed in three ways: the first, as number of animals that can be stocked in a square meter of cage or floor pen, the second, as the pen or cage available surface area (m^2) per rabbit, and the third as kilograms of the final LBW of rabbits kept in one m^2 of a cage or floor pen. Increasing the SD in keeping enterprises of rabbits may be used as a logic managerial means for reducing their production costs and increasing the profitability, particularly in temperate climate. But over-crowding of rabbits can adversely affect their behaviors, health, welfare, immune status and productive performance. However, Verspecht *et al.* (2011) demonstrated that decreasing the SD of rabbits from 15 to 10 rabbits/m^2 reduced the added value by €22 per doe. Surveying the previous studies in the scientific literature has revealed that growing rabbits can be caged in a wide range of SD (10 to 18 rabbits/m^2) with no adverse effect on their performance (Trocino and Xiccato, 2006; Verspecht *et al*., 2011; Dorra *et al*., 2013; Sherif, 2018). Therefore, the present investigation was undertaken to assess the effect of cage stocking density and the addition of dried thyme meal on post-

[*] Corrected author.

weaning APRI rabbits' performance, nutrient digestibility, carcass characteristics, meat composition, and blood parameters in hot climates.

MATERIALS AND METHODS

Location and Duration of Experiment:

This investigation was conducted in the Dakahlia Governorate at a private rabbitry, Mansoura, Egypt, under summer season conditions.

Experimental Diets and Management of Rabbits:

One-hundred thirty-two weaned 5-wk-old APRI rabbit bucks were split into two equal groups at random, each was subdivided to three equal subgroups and kept at three cage densities (1, 2 or 3 rabbits/cage: equivalent to 3.64, 7.27 and 10.91 rabbits/m^2), with eleven replications each. The cage dimensions are 55, 50 and 40 cm for length, width and height, respectively. A basal diet was prepared to contain the essential nutrients required by rearing rabbits, as specified by the National Research Council (NRC, 1977). The basal diet was supplemented with dried thyme meal (DTM) at a level of 2 g/kg; thus, between the ages of 5 and 11 weeks; two experimental diets were created and utilized. Before the beginning of this study, the rabbitry and its equipments such as cages, feeders and nipple drinkers were carefully disinfected and the other managerial practices and biosecurity instructions were also performed. The feeds (as pellets) and the experimental rabbits had access to fresh water whenever they desired. Each set of rabbits received its own diets and managed similarly throughout the whole period of study. Table 1 summarizes the nutritional analysis and composition of the basal diet.

Table 1. Composition and nutrient calculated analysis of the basal diet fed to the experimental rabbits in this study

Ingredients	%	Nutrient calculated analysis (As fed basis: NRC, 1977)	
		Nutrients	**Content**
Alfalfa hay	30.00		
Wheat bran	27.00		
Yellow corn	16..00	Digestible energy, kcal/kg	2503
Barley grains	12.00	Crude protein (%)	16.08
Soybean meal (44% CP)	10.00	Ether extract (%)	2.75
Molasses	3.00	Crude fiber (%)	12.99
Ground limestone	0.50	Ca (%)	0.79
Dicalcium phosphate	0.40	Total P (%)	0.63
Common salt (NaCl)	0.50	Lysine (%)	0.72
Vit. & Min. Premix[§]	0.50	Methionine (%)	0.31
DL-Methionine	0.10	Methionine + Cystine (%)	0.62
Total	100		

[§]Each kilogram contains: Vit. A, 12,000 IU, Vit.D_3, 2,200 IU, Vit.E, 10.0 mg, Vit. K, 2.0 mg, Vit. B_1, 4.0 mg, Vit.B_2, 1.5 mg, Pantothenic acid, 6.3 mg, Vit.B_6, 1.7 mg, Vit. B_{12}, 0.03 mg, Biotin, 3.3 mg, Folic acid, 0.83 mg, Choline chloride, 200 mg, Zn, 11.79 mg, Mn, 5.00 mg, Fe, 12.5 mg, I, 0.33 mg, Se, 0.65 mg and Mg 66.79 mg.

Criteria of Growth Performance:

Throughout this study, records on live body weight (LBW) and feed intake (FI) of each replicate group per treatment were weekly measured. Before being given any food in the morning, each replication of rabbits was weighed separately. Therefore, at 5-8, 8-11, and throughout the entire study period, the means of daily weight gain (DWG), daily FI (DFI), and feed conversion ratio (FCR) were computed. The FI was estimated by deducting the amount of feed that is left over from the amount that is offered. For the whole experimental period, means of body weight gain (BWG) were computed as final LBW minus initial LBW, and FCR was estimated as FI ÷ BWG. Mortality of rabbits was also monitored during this study.

Digestibility Trials on Rabbits:

Digestion trials were performed at the last week of study by using nine rabbits per treatment, as recommended by the European Reference Method (Perez *et al.,* 1995). The rabbits were selected at random and kept in separate metabolic cages for four days as an adaptation period, and for three days as a test phase, during which time measurements of daily FI and voided feces were made. The daily collected feces per rabbit were freshly weighed, then they were pooled during the collection period. Fecal subsamples were kept for further analysis after being oven-dried for 24 hours at 60°C. The chemical analyses for duplicate samples of the tested diets and dried excreta were carried out according to the Official Methods of Analysis (AOAC, 2012). Both food and excrement were tested for organic matter (OM), crude protein (CP), ether extract (EE), crude fiber (CF), and ash. Dietary nutrient digestibility was determined as the percentage of nutrient intake to the nutrient excreted.

Carcass Characteristics of Rabbits:

Upon completion of the feeding trial (11 weeks of age), three rabbits were selected at random from every treatment, weighed separately and slaughtered after a 12-hour fast. As soon as the bleeding stopped, they were weighed and disemboweled. The weights of carcass yield (CY: hot carcass weight including head; HD), forelegs (FL), loin (LO), hind legs (HL), liver (LI), heart (HT), kidneys (KI) and lungs (LU) were estimated. Also, weights of pelt distal legs and full digestive tract were also estimated. All characteristics of the carcass were computed as a proportion of the live weight prior to slaughter. The dressing-out percentage (DP) was determined by dividing the weights of CY plus the edible organs multiplied by 100 on the weight before slaughter.

Chemical Composition of Rabbit Meat:

Immediately following slaughter, five samples per treatment were obtained from the muscles of forelegs, hind legs and loin of the rabbit carcass. These meat samples were dehydrated at 60ºC for 48 h; then, they were ground for later nutrient analysis (AOAC, 2012).

Blood Biochemical Parameters:

At the termination of study, three blood samples per treatment were obtained from rabbits during slaughtering into clean non-heparinized test tubes. After being centrifuged for 15 minutes at 3500 r.p.m., the blood sera were separated and stored at -20°C until analysis. Blood serum levels of total protein (TP: Doumas *et al.*, 1981), albumin (ALB: Doumas*et al.*, 1971) and creatinine (CRE: Lyman, 1986) were estimated. However, blood globulin (GLO) level was computed by difference between serum contents of TP and ALB. Also, the albumin: globulin ratio (A:G) was also calculated. The Reitman and Frankel (1957) method was also used to measure the serum activity of alanine aminotransferase (ALT) and aspartate aminotransferase (AST).

Statistical Analysis of Data:

The SAS Program was used to statistically process the data through a two-way analysis of variance (SAS, 2006). Two amounts of dietary DTM were administered by three rates of cage SD (1, 2, and 3 rabbits/cage: corresponding to 3.64, 7.27, and 10.91 rabbits/m2) in a completely randomized design with a factorial arrangement of treatments (2×3). Significant differences among variables were identified by the use of Duncan's multiple range test (Duncan, 1955), with P≤0.05 considered to be significant.

RESULTS AND DISCUSSION

It is interesting to observe no mortality was observed in rabbit bucks during the course of this study.

Growth Performance of Rabbits:

Tables 2 and 3 show the impact of feeding diets enhanced with dried thyme meal (DTM) on the growth performance of APRI rabbit bucks from 5 to 11 weeks of age over the summer. Apart from the effect of stocking density (SD), the initial LBW, the LBW (at 8 weeks of age), DWG (5-8 weeks of age), DFI (5-11 weeks of age) and FCR (during the first three weeks of study) of rabbits were not affected (P>0.05) by added dietary DTM (Tables 2 and 3). However, feeding the diets containing DTM (2.0 g/kg) to growing rabbits significantly improved (P≤0.05) the final LBW and in the DWG and FCR during the second three study weeks (8–11 weeks of age) and the entire study period (Tables 2 and 3). The dietary DTM by cage SD interactions had no significant impacts on rabbits' growth performance.

Regardless of the effect of added dietary DTM, increasing the SD from one to 3 rabbits per cage (equivalent to: 3.64, 7.27 and 10.91 rabbits/m^2) impaired (P≤0.05) the final LBW, and in the DWG and FCR during the second three study weeks (8–11 weeks of age) and the entire study period (Tables 2 and 3). Conversely, however the rates of SD, applied herein, had no significantly impact (P>0.05) the initial LBW, the LBW (at 8 weeks of age), DWG (5-8 weeks of age), DFI (5-11 weeks of age) and FCR (during the first three weeks of study) of rabbits. Under the circumstances of this investigation, the DTM by SD interaction had no significant impact on the rabbits' growth performance (P>0.05).

The growth promoting effect of dietary DTM of rabbits, observed herein, might be related to the potential of thymol and carvacrol active components present in thyme. They active component can stimulate the activity of digestive enzymes, leading to improving the nutrient digestibility and absorbability; thus, enhancing the feed efficiency of rabbits (Abdel-Wareth *et al.*, 2020; El-Kaiaty *et al.*, 2020; Naderiboroojerdi *et al.*, 2022) and poultry (Hashemipour *et al.*, 2013; Soliman *et al.*, 2024). Thymol, the main polyphenolic ingredient in thyme can lower oxidative stress and stop inflammation-related reactions in hyperlipidemic rabbits (Yu *et al.* 2016). The antioxidant, antibacterial, and antifungal qualities of thyme may generally be linked to the positive impact of giving DTM-enriched meals on the performance of chickens and rabbits (El-Ghousein and Al-Beitawi, 2009; Toghyani *et al.*, 2010; Khan *et al.* 2012; Hashemipour *et al.* 2013; Abd El-Hack *et al.* 2016; Aljabeili *et al.*, 2018). On the other hand, the observed improvement in FCR of rabbits fed the DTM-enriched diets in this research, given that the rabbits' feed consumption was unaltered, this could be explained by superior body weight gain and/or improved nutrient digestibility.

Concerning the growth-promoting effect of dietary thyme, the results are consistent with other rabbit investigations (Abdel-Wareth *et al.*, 2018; Abd El-Azeem *et al.* 2019; Al-Desoki *et al.* 2019; Abdel-Wareth and Metwally, 2020; Ahmed *et al.*, 2020; El-Kaiaty *et al.*, 2020; Naderiboroojerdi *et al.*, 2022) and poultry (Noruzi *et al.*, 2022; Zaazaa *et al.*, 2022; Vlaicu *et al.*, 2023; Eldeeb *et al.*, 2024; Hassan et al., 2024; Hassanin *et al.*, 2024). Conversely, some researchers failed to find any beneficial effects of supplementing rabbits' diets or drinking water with thyme on their growth performance (Dalle Zotte *et al.*, 2013; Benlemlih *et al.*, 2014; Todorova *et al.*, 2022) and poultry (Amouzmehr *et al.*, 2012; Hosseini *et al.*, 2013; Mehdipour *et al.*, 2014; Saleh *et al.*, 2014; Fallah and Mirzaei, 2016; Popović *et al.*, 2016; Abdel-Ghaney *et al.* 2017). The inconsistent responses of rabbits and poultry to thyme supplementation (*via* diet or drinking water) may be relevant to diet composition, added thyme dose, its extraction method, period of study, animal or poultry species, animal age and gender, and environmental and managerial conditions.

Table 2. Effects of dietary dried thyme meal (DTM) and cage stocking density (SD)on LBW and DWG of rabbits from 5-11 weeks of age during the summer season

Main effects	LBW (g)			DWG (g)		
	5 wk	8 wk	11 wk	5-8 wk	8-11 wk	5-11 wk
DTM Level: A						
0.0 g/kg: A1	719.7±5.684	1366±11.48	1913±19.63^b	30.78±0.481	26.03±0.548^b	28.41±0.433^b
2.0 g/kg: A2	718.3±5.072	1389±11.05	2101±21.65^a	31.93±0.489	33.90±0.920^a	32.92±0.498^a
Sig. Level	NS	NS	*	NS	*	*
Cage SD: B						
One/Cage: B1	717.5±8.82	1358±15.17	2112±51.90^a	30.49±0.689	35.92±2.161 ^{a}	33.20±1.224^a
Two/Cage: B2	717.7±6.99	1370±15.36	1994±29.09^b	31.06±0.612	29.70±1.049 ^{b}	30.38±0.644^b
Three/Cage: B3	720.4±5.30	1389±11.15	1980±19.84^b	31.85±0.506	28.15±0.635 ^{b}	30.00±0.455^b
Sig. Level	NS	NS	*	NS	*	*
AB Interaction:						
A1B1	718.2±13.23	1346±21.07	1905±36.42	29.89±0.953	26.64±1.162	28.27±0.796
A1B2	716.8±11.80	1355±22.58	1866±30.18	30.39±0.832	24.35±0.662	27.37±0.575
A1B3	722.2±7.19	1380±15.90	1946±30.79	31.34±0.723	26.94±0.893	29.14±0.715
A2B1	716.8±12.31	1370±22.23	2319±38.03	31.08±1.007	45.20±1.021	38.14±0.886
A2B2	718.6±7.80	1385±20.85	2121±31.77	31.73±0.895	35.06±1.156	33.39±0.710
A2B3	718.6±7.88	1398±15.74	2015±24.04	32.35±0.708	29.37±0.865	30.86±0.533
Sig. Level	NS	NS	NS	NS	NS	NS

a-b: In each of main effects, means in the same column bearing different superscripts differ significantly (P≤0.05). NS: Not significant. *: Significant at P≤0.05.

Table 3. Effects of dietary DTM and cage SD on DFI and FCR of rabbits from 5-11 weeks of age during the summer season

Main effects	DFI (g)			FCR (g feed: g gain)		
	5-8 wk	8-11 wk	5-11 wk	5-8 wk	8-11 wk	5-11 wk
DTM Level: A						
0.0 g/kg: A1	107.1±1.487	158.6±2.740	132.9±1.808	3.512±0.054	6.145±0.065[a]	4.697±0.043[a]
2.0 g/kg: A2	110.3±2.245	164.1±4.365	137.2±2.958	3.493±0.082	5.023±0.160[b]	4.193±0.082[b]
Sig. Level	NS	NS	NS	NS	*	*
Cage SD: B						
One/Cage: B1	105.8±3.42	159.6±7.893	132.7±5.139	3.505±0.139	4.718±0.276[b]	4.070±0.161[b]
Two/Cage: B2	111.0±2.47	160.4±5.095	135.7±3.453	3.606±0.081	5.587±0.185[a]	4.505±0.101[a]
Three/Cage: B3	108.1±1.81	162.6±2.929	135.4±2.007	3.433±0.066	5.871±0.106[a]	4.531±0.048[a]
Sig. Level	NS	NS	NS	NS	*	*
AB Interaction:						
A1B1	103.1±2.871	152.6±4.665	127.9±2.970	3.471±0.114	5.768±0.121	4.537±0.085
A1B2	111.2±2.909	152.8±2.554	132.0±2.541	3.675±0.070	6.337±0.138	4.834±0.062
A1B3	105.7±1.962	164.5±4.817	135.1±3.017	3.417±0.086	6.142±0.071	4.659±0.067
A2B1	108.6±6.285	166.6±15.171	137.6±9.867	3.539±0.261	3.667±0.292	3.603±0.241
A2B2	110.7±4.075	167.9±9.712	139.3±6.409	3.536±0.146	4.837±0.260	4.175±0.166
A2B3	110.6±3.010	160.6±3.378	135.6±2.694	3.450±0.102	5.599±0.189	4.400±0.063
Sig. Level	NS	NS	NS	NS	NS	NS

[a-b]: In each of main effects, means in the same column bearing different superscripts differ significantly (P≤0.05). DTM: Dried thyme meal, SD: Stocking density. NS: Not significant. *: Significant at P≤0.05.

The negative consequences of raising SD on rabbits' growth performance, observed here, were unexpected because the highest SD level was 3 rabbits/cage (equivalent to: 10.91 rabbits/m^2) which still in the normal range of SD. In this regard, Verspecht *et al.* (2011) declared that the standard level of SD for rabbits is 15 per square meter. It seems that the severity of high SD on rabbits may vary with housing system (floor pens *vs*. cages), welfare, managerial and environmental conditions, and animal factors like age, gender and breed. Contrarily to our results, Dorra *et al*. (2013) found that SD (8.6, 12.9 and 17.2 rabbits/m^2) did not adversely affect the rabbits' growth performance between weeks 7 and 13.

On the other hand, the growth depressing effect of high SD of rabbits, observed in the current investigation, concurs with the findings of Trocino *et al.* (2015), Bhattacharjya *et al.* (2017), Abdel-Hamid (2018) and Amber *et al.* (2018) in rabbits. In this connection, Trocino *et al.* (2015) demonstrated that increasing the SD (16 *vs.*12 rabbits/m^2) impaired daily growth and feed intake of rabbits from 55 to 83 days of age. Similarly, Bhattacharjya *et al.* (2017) found that NZW rabbits stocked at 0.38 m^2/animal displayed better growth performance (LBW, BWG and FCR) than those kept at 0.19 or 0.12 m^2/animal under the climatic condition of Assam, India. Similar response was noticed by Abdel-Hamid (2018), who evaluated three levels of SD (8, 12 or 20 rabbits/m^2) on rabbit performance and reported that keeping rabbits at the highest level of SD significantly depressed final LBW, BWG and FCR. Also, Amber *et al.* (2018) stocked APRI line rabbits at 3 SD (2, 4 or 6 rabbits/cage- equivalent to: 12.5, 25.0 or 37.5 rabbits/m^2) from 5 to 13 weeks of age, and found that increasing SD from 2 to 6 rabbits per cage adversely affected their LBW, DWG, RGR, FCR and performance index.

Our results concur also with the results of El-Bayoumi *et al.* (2018) that NZW rabbits kept at 12 rabbits per m^2 achieved the highest means of LBW, DWG, FI and the best FCR compared with those caged at 28 rabbits per m^2. In addition, Sherif (2018) indicated that Californian rabbits stocked at 10 animals/m^2 attained significantly better final LBW and DWG, and consumed more feed than those kept at 15 animals/m^{2}but FCR was not affected. Furthermore, Yaranoğlu *et al.* (2023) kept NZW rabbits at three SD (1, 2 or 3/cage: equivalent to 0.43, 0.21 or 0.14 m^2/rabbit) between 30 and 86 days of age, and found that increasing SD from one to three rabbits per cage depressed their growth performance final LBW, DWG and FCR but did not significantly affect daily FI.

Nutrient Digestibility of Rabbits:

The impact of feeding DTM-enriched diets on the total tract nutrient digestibility of APRI rabbit bucks during the summer season are introduced in Table 4. The obtained data on the digestibility coefficients of the experimental diets revealed that dietary supplementation with DTM, cage SD and their interactions had no significant impact (P>0.05) apparent Nitrogen-free extract, ether extract, crude fiber, crude protein, and organic matter digestibility. The insignificant effects of the applied treatments on the digestibility of nutrients might be related to a possible interaction among some factors like the good health status of rabbits, the optimal diet composition and processing, the normal cage SD and the ideal hygienic and managerial protocols.

Similarly to our findings, Dalle Zotte *et al*. (2013) concluded that dietary fortification with thyme leaves (2.5%) exerted no positive effect on nutrient digestibility in dwarf rabbits. Similarly, Gerencser *et al.* (2014) found that added dietary thyme (3.0%) did not affect the apparent digestibility of DM, OM, acid detergent fiber, gross energy and digestible energy. In, addition, digestibility of all nutrients and nutritive values were not affected by giving water thyme extract to NZW male rabbits (Said *et al*., 2016). Also, Singh *et al.* (2018) reported that feeding thyme-enriched diets (3.0%) had no significant impact on apparent digestibility of DM, CP, EE and NFE in NZW rabbits. Consistent with the present findings, Abd El-Azeem *et al*. (2019) showed that feeding diets supplemented with thyme oil (1.0 g/kg) to NZW rabbits had no significant impact on the digestibility of OM, CP and EE, and the nutritive value (*i.e.* digestible CP and total digestible nutrients) but led to an improvement in the digestibility of DM and NFE, and digestible energy. On the contrary, Abdel-Wareth *et al.* (2020) indicated that dietary supplementation with thyme (0.5 g/kg) resulted in significant enhancements in apparent digestibility of DM, CP, EE and CF in rabbit bucks.

Regarding the response of growing rabbits to cage SD, the insignificant differences in the apparent digestibility of all nutrients, reported in this research, accepts the findings of Boontiam *et al*. (2019) that the digestibility of DM, CP, EE and ash retention were unaffected by the cage SD (17 vs. 23 birds/cage) in Japanese quails. On the contrary, the current findings don't match those of Rabie et al. (2013), they found that CF and EE digestibility and ash retention were unaffected, but lowering the SD of broiler chicks greatly enhanced the digestibility of DM, OM, CP and NFE, and nitrogen retention.

Table 4. Effects of dietary DTM and cage SD on total tract nutrient digestibility of 11-wk-old rabbits during the summer season

Main effects	Nutrient Digestibility (%)				
	OM	CP	EE	CF	NFE
DTM Level: A					
0.0 g/kg: A1	69.56±0.645	75.32±0.559	82.34±1.369	33.24±1.734	74.01±0.164
2.0 g/kg: A2	70.65±0.431	76.36±0.439	84.04±0.784	37.35±1.636	74.45±0.173
Sign. Level	NS	NS	NS	NS	NS
Cage SD: B					
One/Cage: B1	69.99±0.996	75.66±0.846	82.77±1.932	35.35±2.722	74.25±0.221
Two/Cage: B2	70.06±0.617	75.92±0.674	83.55±1.264	34.30±2.359	74.10±0.290
Three/Cage: B3	70.26±0.490	75.94±0.442	83.24±1.006	36.24±1.682	74.34±0.161
Sig. Level	NS	NS	NS	NS	NS
AB Interaction:					
A1B1	68.72±1.702	74.61±1.452	81.24±3.947	31.31±3.863	73.91±0.306
A1B2	69.55±0.699	75.31±0.658	82.42±1.173	31.21±0.872	73.68±0.078
A1B3	70.42±0.940	76.04±0.841	83.34±2.101	37.19±2.946	74.45±0.256
A2B1	71.27±0.665	76.71±0.610	84.29±0.870	39.39±2.414	74.60±0.176
A2B2	70.58±1.071	76.52±1.213	84.68±2.311	37.38±4.188	74.51±0.488
A2B3	70.11±0.543	75.84±0.511	83.14±0.796	35.29±2.136	74.23±0.228
Sign. Level	NS	NS	NS	NS	NS

NS: Not significant. DTM: Dried thyme meal, SD: Stocking density. OM: Organic matter. CP: Crude protein. EE: Ether extract. CF: Crude fiber. NFE: Nitrogen-free extract.

Rabbit Carcass Characteristics:

Information depicted in Table 5 outline the impact of cage SD and feeding the DTM-enriched-diets on carcass characteristics of APRI male rabbits during the summer season. The dressing-out percentage of male rabbits and the relative weights of forelegs, loin, hind legs, head, lungs, heart, kidneys, and liver did not change substantially (P>0.05) in response to dietary DTM, cage SD, or their combination. The insignificant differences in carcass traits of rabbits in response to feeding the tested diets might reflect a good health status and welfare of rabbits which efficiently metabolized the nutrients among the diets used in our experiments independently from the level of cage SD.

Similarly with our findings, Benlemlih *et al*. (2014) detected no positive impact of dietary thyme fortification on carcass yield of NZW rabbits. Our findings are consistent with those of Said *et al*. (2016) that carcass traits (percentages of dressing, viscera, liver, kidney, and heart, abdominal of NZW rabbits were not affected by water thyme extract. Similarly, Abd El-Azeem *et al*. (2019) reported that feeding the diets supplemented with thyme oil (1.0 g/kg) to NZW rabbits had no significant impact on their carcass characteristics. Similar response was found by Todorova *et al.* (2022), who found that feeding NZW rabbits thyme leaves had no significant effect on their carcass characteristics. In harmony also with our results, Amouzmehr *et al*. (2012) showed that feeding broiler chicks diets with thyme extract had no effect on their carcass characteristics. Similarly, Raya *et al.* (2014) observed no significant effect of feeding thyme-containing diets (0.50, 1.0, 1.50 and 2.0%) on carcass characteristics of quails. In addition, Kheiri *et al*. (2018) recorded no beneficial effects on carcass traits of Japanese quails due to feeding thyme-enriched diets. Similarly, Naderiboroojerdi *et al*. (2022) reported that feeding thyme ether extract-enriched diets (0.25, 0.05, or 0.75%) did not affect carcass characteristics of broiler chickens.

On the contrary, Abdel-Wareth *et al.* (2018) reported that dietary incorporation of thyme oil (50-150 g/kg) had positive impacts on Californian rabbit carcass criteria. In addition, Soliman *et al.* (2024) found an increase in the percentages of carcass yield and front parts and a decrease in the weight of abdominal fat in Japanese quails due to feeding diets containing thyme leaves powder. Also, in an early study, El-Ghousein and Al-Beitawi (2009) demonstrated that feeding crushed thyme-containing diets (1.0, 1.5. and 2.0%) to broiler chickens led to significant improvements in dressing percentage and breast yield while percentages of legs and wings were improved only with the highest two levels of crushed thyme.

The observed insignificant impact of cage SD on rabbit carcass characteristics agree with the results of other investigators (Trocino *et al.*, 2008; Abo Egla *et al.*, 2013; Dorra *et al*., 2013; Sherif, 2018). Trocino *et al*. (2008) reported that SD (12 *vs.*16 rabbits/m^2) did not modify carcass traits or muscle pH and color of rabbits. Abo Egla *et al.* (2013) observed that increasing the cage SD from 1.0 to 4.0 rabbits per cage (equivalent to: from 6.6 to 26.67 kg/m^2) did not adversely affect carcass yield weights, forelegs, hind legs and edible organs (liver, lungs and kidneys) of NZW rabbits. In addition, Dorra *et al.* (2013) showed that SD had no effect on carcass characteristics of rabbits. Similarly, Yaranoğlu *et al.* (2023) kept NZW rabbits at three SD (1, 2 or 3/cage) and observed no significant differences in dressing-out percentage, weights of hot carcass, chilled carcass, as well as reference carcass but percentages of head and hind part were higher for the groups reared at two and three rabbits per cage.

Similar response was obtained by Rabie *et al*. (2013), who proved that SD did not impact carcass traits of broiler chickens. Conversely, El-Bayoumi *et al*. (2018) discovered that NZW rabbits kept at 12 rabbits per m^2 achieved the best means of dressing-out percentage, liver weight, and the lowest percentages of head and kidneys compared with those kept at 20 or 28 rabbits per m^2but other carcass characteristics remained unaffected. In addition, Omar *et al*. (2020) stocked rabbits at three cage SD (8, 16, and 24 rabbits/m^2) and found that the highest level of SD (24 rabbits/m^2) depressed the dressing-out and liver percentages compared with those kept at 8 or 16 rabbits/m^2.

Table 5. Effects of dietary DTM and cage SD on carcass characteristics of rabbits at 11 weeks of age during the summer season

Main effects	% of Weights of Total Edible Parts								
	DP[1]	FL[3]	LO[4]	HL[5]	HD[6]	LU[7]	HT[8]	KI[9]	LI[10]
DTM Level: A									
0.0 g/kg: A1	57.83±0.526	27.28±0.513	21.63±0.084	33.47±0.556	12.36±0.024	0.673±0.010	0.586±0.009	0.938±0.016	3.06±0.013
2.0 g/kg: A2	61.40±0.479	24.62±0.785	21.49±0.072	36.36±0.848	12.42±0.031	0.677±0.007	0.584±0.008	0.851±0.026	2.89±0.101
Sig. Level	NS	NS	NS	NS	NS	NS	NS	NS	NS
Cage SD: B									
One/Cage: B1	60.89±0.728	24.14±0.676	21.59±0.096	36.79±0.752	12.42±0.043	0.672±0.007	0.570±0.007	0.847±0.022	2.988±0.015
Two/Cage: B2	59.34±1.164	26.88±1.073	21.48±0.096	34.01±1.163	12.39±0.027	0.670±0.014	0.598±0.009	0.915±0.040	2.887±0.161
Three/Cage: B3	58.62±0.841	26.83±0.760	21.62±0.110	33.94±0.864	12.37±0.037	0.683±0.008	0.587±0.012	0.922±0.026	3.050±0.019
Sig. Level	NS	NS	NS	NS	NS	NS	NS	NS	NS
AB Interaction:									
A1B1	59.29±0.149	25.64±0.130	21.69±0.085	35.13±0.217	12.38±0.015	0.680±0.000	0.570±0.006	0.893±0.003	3.020±0.012
A1B2	56.83±0.177	28.50±0.255	21.53±0.124	32.30±0.251	12.36±0.020	0.650±0.020	0.600±0.012	0.973±0.007	3.090±0.006
A1B3	57.37±1.268	27.72±0.944	21.68±0.233	32.97±1.189	12.35±0.076	0.690±0.017	0.587±0.026	0.947±0.038	3.070±0.025
A2B1	62.49±0.248	22.63±0.120	21.48±0.165	38.44±0.202	12.46±0.087	0.663±0.012	0.570±0.015	0.800±0.015	2.957±0.003
A2B2	61.85±0.679	25.27±1.757	21.44±0.168	35.71±1.947	12.42±0.049	0.690±0.015	0.597±0.017	0.857±0.067	2.683±0.297
A2B3	59.87±0.602	25.95±1.104	21.56±0.050	34.91±1.169	12.39±0.020	0.677±0.003	0.587±0.007	0.897±0.035	3.030±0.026
Sig. Level	NS	NS	NS	NS	NS	NS	NS	NS	NS

[1-10]: Refer to dressing-out percentage, forelegs, loin, hind legs, head, lungs, heart, kidneys and liver, respectively. NS: Not significant. DTM: Dried thyme meal, SD: Stocking density.

Meat Chemical Composition in Rabbits:

The consequences of consuming DTM-enriched diets on the chemical composition of meat (forelegs, loin and hind legs) of 11-wk-old APRI rabbit bucks are shown in Table 6. The obtained data on the chemical components of meat (DM, CP, EE and ash) indicated that dietary DTM supplementation, cage SD and DTM by cage SD interactions had no significant impacts (P>0.05) on meat chemical composition of rabbit bucks. In terms of meat quality, Abdel-Wareth *et al.* (2018) reported that feeding thyme oil-supplemented diets led to increasing water holding capacity of rabbit meat compared with their control counterparts. In broiler chickens, Vlaicu *et al.* (2023) demonstrated that birds fed thyme essential oil (0.05%)-enriched diets exhibited higher contents of antioxidant capacity, total polyphenols and n-3 and n-6 polyunsaturated fatty acids in their thigh meat compared with the control chicks. In accordance with our results, Volek *et al*. (2012) discovered that hind legs meat composition of the Czech White rabbits was unaffected by cage SD.

Biochemical Characteristics of Rabbit Blood:

The effects of cage SD and feeding the DTM-enriched-diets on serum blood biochemical parameters of 11-wk-old APRI male rabbits during the summer season are displayed in Table 7. All estimated blood parameters, including TP, ALB, GLO, A: G ratio, CRE, AST, and ALT, were shown to be unaffected (P>0.05) by dietary DTM, cage SD or their interaction.

Our findings concur with those of Abd El-Azeem *et al*. (2019), who demonstrated that counts of white blood cells (WBCs), red blood cells (RBCs), lymphocyte, hemoglobin, platelets, and hematocrit % and blood glucose concentration were not altered by dietary thyme supplementation to growing rabbits. However, Toghyani *et al*. (2010) observed that dietary thyme powder addition (10 g/kg) caused a significant increase in serum high-density lipoprotein cholesterol concentration but levels of TP, ALB, triglyceride, total and low-density lipoprotein cholesterol were not differed.

In contrast to our results, Abdel-Gabbar *et al*. (2019) documented that the oral administration of thyme aqueous extracts to growing rabbits increased serum protein profile but reduced serum levels of urea, uric acid and creatinine as compared to the control group. Similar results were obtained by Abdel-Wareth and Metwally (2020), who reported that dietary supplementation of thyme essential oil caused a significant decrease in the activities of AST and ALT and serum levels of urea and creatinine but significantly increased serum testosterone concentration in male Californian rabbits compared with control group. Similarly, Abdel-Wareth *et al*. (2020) demonstrated that feeding thyme oil-enriched diets to male Californian rabbits led to significant improvements in activity of ALT and AST, and levels of serum urea, and creatinine compared to the control group. In addition, El-Kaiaty *et al.* (2020) found that adding thyme oil in drinking water to V-Line male rabbits resulted in significant improvements in blood plasma parameters (RBCs, WBCs, kidney function, triglycerides, total cholesterol, sheep RBC's titer and liver antioxidant and hormones markers) when compared to the control group. Furthermore, Ahmed *et al.* (2020) indicated that feeding thyme leaves-containing diets to male NZW rabbits led to improving the serum biomarkers of liver (AST and ALT) and kidney functions (urea and creatinine) and serum testosterone concentrations. In growing Japanese quail, Raya *et al*. (2014) found that dietary thyme supplementation significantly decreased plasma levels of ALB, GLO, triglycerides, total cholesterol, low-density lipoprotein cholesterol, and AST activity, but increased concentrations of TP and HDL- cholesterol and had no effect on ALT activity.

Table 6. Effects of dietary DTM and cage SD on meat chemical composition (%) of rabbits at 11 weeks of age during the summer season

Main effects	Forelegs Meat				Loin Meat				Hind Legs Meat			
	DM[1]	CP[2]	EE[3]	Ash	DM	CP	EE	Ash	DM	CP	EE	Ash
DTM Level: A												
0.0 g/ kg: A1	25.71 ±0.028	18.54 ±0.048	4.584 ±0.125	1.983 ±0.009	24.86 ±0.025	20.04 ±0.014	2.892 ±0.084	1.567 ±0.004	25.57 ±0.033	18.68 ±0.037	3.547 ±0.042	1.997 ±0.015
2.0 g/ kg: A2	25.68 ±0.038	18.57 ±0.033	4.313 ±0.146	1.960 ±0.036	24.82 ±0.042	20.06 ±0.014	2.7178 ±0.098	1.5633 ±0.004	25.51 ±0.096	18.69 ±0.026	3.4711 ±0.022	1.982 ±0.010
Sig. Level	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Cage SD: B												
One/ Cage: B1	25.67 ±0.057	18.53 ±0.058	4.295 ±0.203	2.005 ±0.016	24.86 ±0.049	20.05 ±0.013	2.698 ±0.137	1.563 ±0.006	25.43 ±0.131	18.64 ±0.035	3.460 ±0.030	1.977 ±0.014
Two/ Cage: B2	25.69 ±0.038	18.60 ±0.032	4.362 ±0.147	1.977 ±0.015	24.78 ±0.046	20.08 ±0.021	2.748 ±0.093	1.565 ±0.003	25.64 ±0.048	18.72 ±0.033	3.543 ±0.063	1.988 ±0.012
Three/ Cage: B3	25.72 ±0.023	18.53 ±0.056	4.690 ±0.139	1.933 ±0.049	24.88 ±0.024	20.04 ±0.014	2.968 ±0.093	1.567 ±0.006	25.64 ±0.048	18.69 ±0.044	3.523 ±0.022	2.003 ±0.021
Sig. Level	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
AB Interaction:												
A1B1	25.65 ±0.049	18.49 ±0.076	4.410 ±0.309	1.993 ±0.012	24.86 ±0.057	20.04 ±0.025	2.777 ±0.205	1.563 ±0.003	25.58 ±0.071	18.64 ±0.044	3.470 ±0.046	1.980 ±0.020
A1B2	25.73 ±0.055	18.61 ±0.052	4.410 ±0.017	1.987 ±0.024	24.81 ±0.023	20.07 ±0.022	2.770 ±0.012	1.567 ±0.007	25.62 ±0.034	18.71 ±0.064	3.613 ±0.113	1.993 ±0.019
A1B3	25.74 ±0.042	18.51 ±0.121	4.933 ±0.009	1.970 ±0.012	24.91 ±0.029	20.02 ±0.023	3.130 ±0.017	1.570 ±0.012	25.49 ±0.047	18.69 ±0.094	3.557 ±0.024	2.017 ±0.042
A2B1	25.69 ±0.116	18.57 ±0.098	4.180 ±0.311	2.017 ±0.032	24.85 ±0.093	20.05 ±0.013	2.620 ±0.215	1.563 ±0.012	25.29 ±0.243	18.65 ±0.066	3.450 ±0.049	1.973 ±0.024
A2B2	25.65 ±0.052	18.59 ±0.049	4.313 ±0.324	1.967 ±0.020	24.76 ±0.096	20.09 ±0.041	2.727 ±0.206	1.563 ±0.003	25.66 ±0.101	18.72 ±0.038	3.473 ±0.045	1.983 ±0.019
A2B3	25.69 ±0.018	18.55 ±0.018	4.447 ±0.192	1.897 ±0.103	24.84 ±0.026	20.05 ±0.013	2.807 ±0.131	1.563 ±0.003	25.59 ±0.035	18.68 ±0.026	3.490 ±0.026	1.990 ±0.015
Sig. Level	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[1-3]: Refer to dry matter, crude protein and ether extract, respectively. SEM: Standard errors of the means. DTM: Dried thyme meal, SD: Stocking density. NS: Not significant.

Table 7. Effects of dietary DTM and cage SD on serum blood biochemical parameters of rabbits at 11 weeks of age during the summer season

Main effects	TP g/dL	ALB g/dL	GLO g/dL	A:G	CRE mg/dL	AST U/L	ALT U/L
DTM Level: A							
0.0 g/kg: A1	6.652±0.117	3.472±0.103	3.287±0.075	1.146±0.046	1.726±0.004	62.19±0.014	28.80±0.040
2.0 g/kg: A2	7.052±0.145	3.786±0.083	3.268±0.086	1.186±0.029	1.718±0.007	62.24±0.009	28.86±0.006
Sig. Level	NS	NS	NS	NS	NS	NS	NS
Cage SD: B							
One/Cage: B1	6.927±0.187	3.597±0.148	3.330±0.047	1.110±0.043	1.722±0.005	62.22±0.022	28.85±0.009
Two/Cage: B2	6.937±0.212	3.737±0.141	3.368±0.116	1.188±0.048	1.720±0.012	62.22±0.016	28.79±0.063
Three/Cage: B3	6.693±0.140	3.553±0.106	3.133±0.095	1.198±0.047	1.723±0.005	62.21±0.012	28.84±0.006
Sig. Level	NS	NS	NS	NS	NS	NS	NS
AB Interaction:							
A1B1	6.753±0.344	3.453±0.282	3.300±0.075	1.073±0.087	1.727±0.009	62.20±0.044	28.84±0.018
A1B2	6.737±0.133	3.623±0.163	3.447±0.167	1.210±0.104	1.727±0.009	62.20±0.017	28.72±0.120
A1B3	6.467±0.054	3.340±0.017	3.113±0.074	1.153±0.047	1.723±0.009	62.18±0.009	28.83±0.003
A2B1	7.100±0.161	3.740±0.095	3.360±0.067	1.147±0.015	1.717±0.007	62.24±0.007	28.86±0.006
A2B2	7.137±0.409	3.850±0.244	3.290±0.183	1.167±0.019	1.713±0.023	62.23±0.027	28.86±0.018
A2B3	6.920±0.210	3.767±0.103	3.153±0.197	1.243±0.084	1.723±0.007	62.23±0.009	28.85±0.009
Sig. Level	NS	NS	NS	NS	NS	NS	NS

DTM: Dried thyme meal, SD: Stocking density. NS: Not significant. TP: Total protein, ALB: Albumin, GLO: Globulin, A:G Albumin: globulin ratio, CRE: Creatinine, AST: Aspartate aminotransferase, and ALT: Alanine aminotransferase.

The insignificant impact of cage SD on rabbit blood parameters, observed herein, concurs with the results of other investigators (Dorra *et al*., 2013; Rabie *et al*., 2013; Abdel-Hamid, 2018; Sherif, 2018). On the other hand, El-Bayoumi *et al.* (2018) evaluated three levels of SD (12, 20 or 28 rabbits/m^2) for growing rabbits and found that hemoglobin (Hb) concentration, packed cell volume (PCV: %), the mean corpuscular volume and lymphocytes (%) were significantly higher in rabbits stocked at 12 rabbits/m^2 than those stocked at 20 or 28 rabbits/m^2 while rabbits kept at 28 rabbits/m^2 displayed the highest counts of platelets and WBCs as compared to other groups, but the mean corpuscular hemoglobin, the mean corpuscular hemoglobin concentration and RBCs count were not affected by stocking density. They came to the conclusion that raising SD by 20 rabbits/m^2 can create a stressful condition that raises counts of platelets and leukocytes. Omar *et al*. (2020) stocked rabbits at three cage SD (8, 16, and 24 rabbits/m^2) and found that rabbits stocked at the highest level of SD exhibited significantly lower means of RBCs counts, Hb, PCV, TP, GLO, urea and CRE than those of rabbits kept at 8 and 14 rabbits/m^2. Abo Egla *et al.* (2013) evaluated four cage SD (1, 2, 3 or 4 rabbits/cage) for growing rabbits and observed that rabbits kept at 2 rabbits/cage possessed the greatest erythrocytes counts and the lowest mean of platelets, while the highest WBCs counts was found in rabbits stocked at 4 rabbits per cage. They also found that serum concentrations of TP, GLO, CRE were higher in rabbits stocked at 1 and 2 rabbits/cage than other groups while activities of AST and alkaline phosphatase were higher in rabbits stocked at 3 and 4 rabbits/cage than the others groups but low-density lipoprotein, high-density lipoprotein and activity of ALT were not affected.

In conclusion, the obtained results indicate that dietary thyme supplementation (2 g/kg) can beneficially affect the growth performance of APRI male rabbits and cage SD should not exceed one rabbit per cage in order to obtain optimal performance, during the summer season.

REFERENCES

Abd El-Azeem, A.E.; A.A. Al-Sagheer; A.H. Daader and S.M. Bassiony (2019). Effect of dietary supplementation with betaine, thyme oil and their mixtures on productive performance of growing rabbits. Zagazig J. Agric. Res., 46(3): 815-828.

Abdel-Gabbar, M.; R.R. Ahmed; M.A. Kandeil; A.H. Mohamed and S.M. Ali (2019). Administration of ginger and/or thyme has ameliorative effects on liver and kidney functions of V-line rabbits: Histological and biochemical studies. J. Anim. Physiol. Anim. Nutr., 103 (6): 1758–1767.

Abdel-Ghaney, D.M.; A.H. El-Far; K.M. Sadek; Y.S. El-Sayed and M.A. Abdel-Latif (2017). Impact of dietary thyme (*Thymus Vulgaris*) on broiler chickens concerning immunity, antioxidant status, and performance. Alex. J. Vet. Sci., 55 (1): 169-179.

Abd El-Hack, M.E.; M. Alagawanya; M.R. Farag; R. Tiwaric; K. Karthik; K. Dhama; J. Zorriehzahra and M. Adel (2016). Beneficial impacts of thymol essential oil on health and production of animals, fish and poultry: a review. J. Essential Oil Res., 28(5): 365-382.

Abdel-Hamid, T.M. (2018). Effect of stocking density on growth performance, some blood parameters and carcass traits in purebred Californian and crossbred rabbits. J. Adv. Vet. Anim. Res., 5(3): 265-274.

Abdel-Wareth, A.A.A. and A.E. Metwally (2020). Productive and physiological response of male rabbits to dietary supplementation with thyme essential oil. Animals (Basel), 10(10): 1-10.

Abdel-Wareth, A.A.A.; E.M.M. Taha; K.H. Sudekum and J. Lohakare (2018). Thyme oil inclusion levels in a rabbit ration: Evaluation of productive performance, carcass criteria and meat quality under hot environmental conditions. Anim. Nutr., 4(4):410-416.

Abdel-Wareth, A.A.A.; M.A. Al-Kahtani; K.M. Alsyaad; F.M. Shalaby; I.M. Saadeldin; F.A. Alshammari; M. Mobashar; M.H.A. Suleiman; A.H.H. Ali; M.O. Taqi; H.G.M. El-Sayed; M.S. Abd El-Sadek; A.E. Metwally and A.E. Ahmed (2020). Combined supplementation of nano-zinc oxide and thyme oil improves the nutrient digestibility and reproductive fertility in the male Californian rabbits. Animals (Basel) 10(12): 1-12.

Abo Egla, E.H.A.; Z.M. Kalaba and L.Y.Y. El-Bnawy (2013). Effect of rearing stocking density on growth performance and some blood parameters of growing rabbits. J. Anim. Poultry Prod., Mansoura Univ., 4(5): 285- 295.

Ahmed, A.E.; M.A. Alkahtani and A.A.A. Abdel-Wareth (2020). Thyme leaves as an eco-friendly feed additive improves both the productive and reproductive performance of rabbits under hot climatic conditions. Vet. Med., 65(12): 553–563.

Al-Desoki, A.; S. Abdelaziz and M.O. Ratib (2019). Effect of thyme, ginger and boldenone as growth promoters on some biochemical blood parameters in white male New-Zealand rabbits. Benha Vet. Med. J., 37(2): 6-13.

Aljabeili, H.S.; H. Barakat and H.A. Abdel-Rahman (2018). Chemical composition, antibacterial and antioxidant activities of thyme essential oil (*Thymus vulgaris*). Food and Nutr. Sci., 9(5): 433-446.

Amber, Kh.; Y.Z. Eid; A.A. Azoz and M.M. El-Gebaly (2018). Effect of stocking density and dietary phytobiotics on growth performance in rabbit during summer season. J. Sus. Agric. Sci., 44(1): 13 -20.

Amouzmehr, A.; B. Dastar; J.G. Nejad; K.I. Sung; J. Lohakare and F. Forghani (2012). Effects of garlic and thyme extracts on growth performance and carcass characteristics of broiler chicks. J. Anim. Sci. Technol., 54(3): 185-190.

AOAC; Association of Official Analytical Chemists (2012). Official Methods of Analysis, 19th Edition, Association of Official Analytical Chemists, Washington, D.C., USA.

Attia, Y.A.; A.A. Bakhashwain and N.K. Bertu (2017). Thyme oil (Thymus vulgaris L.) as a natural growth promoter for broiler chickens reared under hot climate. Ital. J. Anim. Sci., 16(2): 275-282.

Benlemlih, M.; A. Aarab; M. Bakkali; A. Arakrak and A. Laglaoui (2014). The effect of supplementing diets with dried fennel and thyme on the zootechnical parameters and caecal microflora of growing rabbit. J. Anim. Feed Sci., 23(4): 346-350.

Bhattacharjya, R.; A. Haque; D.C. Mili; A.M. Ferdoci and J. Sarma (2017). Effect of stocking density on the performance of New Zealand white breed of broiler rabbit in Assam. J. Entomol. Zool. Studies, 5(4): 1301-1303.

Dalle Zotte, A.; A. Sartori; P. Bohatir; H. Remignon and R. Ricci (2013). Effect of dietary supplementation of spirulina (*Arthrospira platensis*) and thyme (*Thymus vulgaris*) on growth performance, apparent digestibility and health status of companion dwarf rabbits. Livest. Sci., 152(2-3): 182–191.

Boontiam, W.; S. Sangsoponjit and A. Klompanya (2019). Effects of dietary crude protein level and stocking density on growth performance, nutrient retention, blood profiles, and carcass weight of growing-meat quails. Iran. J. Appl. Anim. Sci., 9(4): 755-762.

Dorra, T.M.I.; F.S.A. Ismail; Kh. El. Sherif and M.M.H. Rabie (2013). Growth performance of fattening rabbits as affected by stocking density and added dietary organic acids. J. Anim. Poult. Prod., Mansoura Univ., 4(5): 249-262.

Doumas, B.T.; D.D. Bayse; R.J. Carter; T. Peters and R. Schaffer (1981). A candidate reference method for determination of total protein in serum. I. Development and validation. Clin. Chem., 27(10): 1642-1650.

Doumas, B.T.; W.A. Watson and H.G. Biggs (1971). Albumin standards and the measurement of serum albumin with bromocresol green. Clin. Chim. Acta, 31(1): 87-96.

Duncan, D.B. (1955). The multiple range and multiple F tests. Biometrics, 11(1): 1-42.

El-Bayoumi, Kh. M.; M.S. El-Tarabany; T.M. Abdel-Hamid and W.R.I.A. Sherieff (2018). Effect of stocking density on growth performance, carcass traits and some hematological parameters of New Zealand White rabbits. Global Vet., 20(1): 1-5.

Eldeeb, S.; E.A. Ashour; M.E. Abd El-Hack; M. El-Maaty; I.M. Youssef; S. Adil; A.A. Elolimy and A.A. Swelum (2024). Impacts of dietary different levels of thyme leave powder as a natural growth promoter on growth performance, carcass characteristics, and blood indices of broilers, Poultry Sci., 2024: Article104396.

El-Ghousein, S.S. and N.A. Al-Beitawi (2009). The effect of feeding crushed thyme (*Thymus vulgaris* L.) on growth, blood constituents, gastrointestinal tract and carcass characteristics of broiler chickens. J. Poult. Sci., 46(2): 100-104.

El-Kaiaty, A.M.; G.M. El-Moghazy; M.A.F. El-Manylawi and M.G.Y. Abdel-Mageed (2020). Impact of thyme oil and *Lactobacillus acidophilus* as natural growth promoters on performance, blood parameters and immune status in growing rabbits. World Vet. J., 10(1): 1-11.

Fallah, R. and E. Mirzaei (2016). Effect of dietary inclusion of turmeric and thyme powders on performance, blood parameters and immune system of broiler chickens. J. Livestock Sci., 7: 180-186

Hashemipour, H.; H. Kermanshahi; A. Golian and T. Veldkamp (2013). Effect of thymol and carvacrol feed supplementation on performance, antioxidant enzyme activities, fatty acid composition, digestive enzyme activities, and immune response in broiler chickens. Poultry Sci., 92(8): 2059-2069.

Hassan, A.H.A.; I.M.I. Youssef; N.S. Abdel-Atty and A.S.A. Abdel-Daim (2024). Effect of thyme, ginger, and their nano-particles on growth performance, carcass characteristics, meat quality and intestinal bacteriology of broiler chickens. BMC Vet. Res., 20(1): 1-13.

Hassanin, O.; A. El-Sebai; S. Abd El-Motaal and H.A. Khalifa (2024). Experimental trials to assess the immune modulatory influence of thyme and ginseng oil on NDV-vaccinated broiler chickens.Open Vet. J., 14(1): 398-406.

Hosseini, S.A.; A. Meimandipour; F. Alami; A. Mahdavi; M. Mohiti-Asli; H. Lotfollahian and D. Cross (2013). Effects of ground thyme and probiotic supplements in diets on broiler performance, blood biochemistry and immunological response to sheep red blood cells. Ital. J. Anim. Sci., 12(1): 116-120 (Article: e19).

Kachur, K. and Z. Suntres (2020). The antibacterial properties of phenolic isomers, carvacrol and thymol. Crit. Rev. Food Sci. Nutr., 60(18): 3042-3053.

Khafar, K.R.; A. Mojtahedin; N. Rastegar; M.K. Neytali and A. Olfati (2019).Dietary inclusion of thyme essential oil alleviative effects of heat stress on growthperformance and immune system of broiler chicks. Iran. J. Appl. Anim. Sci., 9(3): 509-517.

Kheiri, F.; M. Faghani and N. Landy (2018). Evaluation of thyme and ajwain as antibiotic growth promoter substitutions on growth performance, carcass characteristics and serum biochemistry in Japanese quails (*Coturnix japonica*). Anim. Nutr., 4(1): 79-83.

Khan, R.U.; S. Naz; Z. Nikousefat; V. Tufarelli and V. Laudadio (2012). *Thymus vulgaris*: alternative to antibiotics in poultry feed. World's Poult. Sci. J. 68(3): 401-408.

Lyman, J.L. (1986). Blood urea nitrogen and creatinine. Emerg. Med. Clin. North Am., 4(2): 223-233.

Mehdipour, Z.; M. Afsharmanesh and M. Sami (2014). Effects of supplemental thyme extract (*Thymus vulgaris* L.) on growth performance, intestinal microbial populations, and meat quality in Japanese quails. Comp. Clin. Pathol., 23(5): 1503-1508.

Naderiboroojerdi, N.; A. Zeinali and A. Hoseini (2022). Comparison of different levels of thyme and rosemary ether extracts on growth performance and carcass characteristics of broiler chickens. J. Food Sci. Nutr. Res., 5(4): 682–689.

National Research Council; NRC (1977). Nutrient requirement of rabbits. 2nd Revised Edition, National Academy of Sciences, National Research Council, Washington, DC., USA.

Noruzi, S.; M. Torki and H. Mohammadi (2022). Effects of supplementing diet with thyme (*Thymuas vulgaris* L.) essential oil and/or selenium yeast on production performance and blood variables of broiler chickens. Vet. Med. Sci., 8(3): 1137–1145.

Omar, M.A.E.; M. El-Shahat and F.A.M. Hassan (2020). Impact of stocking density on growth performance, carcass traits, and economic feasibility of growing rabbits. J. Anim. Health Prod., 9(S1): 50-55.

Perez, J.M.; F. Lebas; T. Gidenne; L. Maertens; G. Xiccato, R. Parigi Bini; A. Dalle Zotte; M.E. Cossu; A. Carazzolo; M.J. Villamide; R. Carabano; M.J. Fraga; M.A. Ramos; C. Cervera; E. Blas; J. Fernandez; E.C.L. Falcao and J. Bengala Freire (1995). European reference method for in vivo determination of diet digestibility in rabbits. World Rabbit Sci., 3(1): 41-43.

Popović, S.; N. Puvača; L. Kostadinović; N. Džinić; J. Bošnjak; M. Vasiljević and O. Djuragic (2016). Effects of dietary essential oils on productive performance, blood lipid profile, enzyme activity and immunological response of broiler chickens. Europ. Poult. Sci., 80:1-12.

Rabie, M.H.; E.H.A. Abo-Egla; F.S.A. Ismail and S. Kh. Sherif (2013). Effect of dietary sunflower oil on growth performance of broiler chicks kept at two cage densities during summer season. J. Anim. Poult. Prod., Mansoura Univ., 4(7): 395-409.

Raya, A.H.; Kh. El. Sherif; M.H. Rabie and H.F. Bedair (2014). Effect of dietary supplementation with dried garlic and thyme on growth performance of Japanese quail. J. Anim. Poult. Prod., Mansoura Univ., 5(2): 73-85.

Reitman, S. and S. Frankel (1957). A colorimetric method for the determination of serum glutamic oxalacetic and glutamic pyruvic transaminases. Amer. J. Clin. Pathol., 28(1): 56-63.

Said, M.M.A.; S.A. Shehata and B.A. Khalil (2016). Effect of water thyme extract on growing rabbits performance. Zagazig J. Agric. Res., 43(6A): 2023-2035.

Saleh, N.; T. Allam; A. Abd El-Latif and E. Ghazy (2014). The effects of dietary supplementation of different levels of thyme (*Thymus vulgaris*) and ginger (*Zingiber officinale*) essential oils on performance, hematological, biochemical and immunological parameters of broiler chickens. Global Veterinaria, 12(6):736-744.

SAS Institute (2006). SAS/STAT User's Guide. Release 9.1.SAS Inst. Inc., Cary, NC.

Sherif, Sara Kh. (2018). Response of growing rabbits to stoking density and dietary supplementation with ascorbic acid, and vitamin E under summer conditions. Egypt. Poult. Sci., 38(III): 831-846.

Singh, N., H. Gulati; S. Sihag; S. Kumar; S. Khanna and S. Sandeep (2018). Effect of supplementing spirulina and thyme on nutrient digestibility and FCR in New Zealand white rabbits. Int. J. Livestock Res., 8(1): 67-72.

Soliman, S.I.R.; M.S. Bahnas and A.A.A. Aly (2024). Effect of different levels of thyme leaves powder on productive and physiological performance of growing Japanese quail. Egypt. Poult. Sci., 44(II): 203-218.

Todorova, M.; M. Ignatova and K. Velikov (2022). Influence of thyme (*Thymus vulgaris* L.) supplementation in feed on fattening rabbit's performance. Tradit. Mod. Vet. Med., 7(2): 71–75.

Toghyani, M.; M. Tohidi; A.A. Gheisari and S.A. Tabeidian (2010). Performance, immunity, serum biochemical and hematological parameters in broiler chicks fed dietary thyme as alternative for an antibiotic growth promoter. Afr. J. Biotechnol., 9(40): 6819-6825.

Trocino, A. and G. Xiccato (2006). Animal welfare in reared rabbits: a review with emphasis on housing system. World Rabbit Sci., 14(2): 77–93.

Trocino, A.; G. Xiccato; D. Majolini and M. Fragkiadakis (2008). Effect of cage floor and stocking density on growth performance and welfare of group-housed rabbits. In: Proc. 9th World Rabbit Congress – June 10-13, 2008, Verona, Italy.

Trocino, A.; E. Filiou; M. Tazzoli; M. Birolo; A. Zuffellato and G. Xiccato (2015). Effects of floor type, stocking density, slaughter age and gender on productive and qualitative traits of rabbits reared in collective pens. Animal, 9(5): 855-861.

Verspecht, A.; L. Maertens; F. Vanhonacker; F.A.M. Tuyttens; G. Van Huylenbroeck and W. Verbeke (2011). Economic impact of decreasing stocking densities in broiler rabbit production based on Belgian farm data. World Rabbit Sci., 19(3): 123-132.

Vlaicu, P.A.; A.E. Untea; T.D. Panaite; M. Saracila; R.P. Turcu and M. Dumitru (2023). Effect of basil, thyme and sage essential oils as phytogenic feed additives on production performances, meat quality and intestinal microbiota in broiler chickens. Agriculture, 13(4):874-887.

Volek, Z.; D. Chodová; E. Tůmová; L. Volková; E. Kudrnová and M. Marounek (2012). Effect of stocking density on growth performance, meat quality and fibre properties of biceps femoris muscle of slow-growing rabbits. In: Proc. 10th World Rabbit Cong.: Sept. 3 - 6, Sharm El-Sheikh-Egypt, pp. 891-895.

Yaranoğlu, B.; M.H. Yaranoğlu; S. Uysal and A.A. Hişmioğullari (2023). Evaluation of different stocking densities on fattening performance, slaughter, carcass, meat quality characteristics, and fatty acid composition in New Zealand rabbits. Turk. J. Vet. Anim. Sci., 47(4): 345-355.

Yu, Y.M.; T.Y. Chao; W.C. Chang; M.J. Chang and M.F. Lee (2016). Thymol reduces oxidative stress, aortic intimal thickening, and inflammation-related gene expression in hyperlipidemic rabbits. J. Food and Drug Analysis, 24(3): 1-8.

تأثير كثافة تسكين الأرانب بالأقفاص وتدعيم الغذاء بمسحوق الزعتر على أداء النمو ومعاملات هضم العناصر الغذائية وصفات الذبيحة

رحاب فوزي صديق[١] ومروة محمود ربيع[٢]

[١]قسم إنتاج الحيوان، كلية الزراعة، جامعة المنصورة، مصر
[٢]قسم إنتاج الدواجن، كلية الزراعة، جامعة المنصورة، مصر

الملخص

أجريت هذه الدراسة لتقييم تأثير كثافة التسكين (١، ٢ أو ٣ أرانب/قفص) وإضافة مسحوق الزعتر للغذاء (٢ جرام/كجم) على أداء النمو، كفاءة هضم العناصر الغذائية، صفات الذبيحة، التركيب الكيماوي للحم وبعض معايير الدم في ذكور أرانب (سلالة APRI) خلال فصل الصيف. تم تقسيم عدد ١٣٢ أرنباً عمر ٥ أسابيع إلى مجموعتين: وقسمت كل مجموعة إلى ٣ مجموعات بكل منها ٣ مكررات تم تسكينها في أقفاص (بطاريات). تم تكوين عليقتين تجريبيتين: الأولى قاعدية والثانية تحتوي على مسحوق الزعتر وتم تغذية الأرانب عليهما طوال فترة الدراسة (٥-١١ أسبوعا من العمر). تم تعريض جميع الأرانب التجريبية لظروف رعائية متماثلة. تم تقدير أداء النمو للأرانب، صفات الذبيحة، معاملات هضم العناصر الغذائية، والتركيب الكيماوي للحم، وبعض معايير الدم. أوضحت النتائج المتحصل عليها أنه بغض النظر عن كثافة التسكين، أدى تدعيم الغذاء بمسحوق الزعتر إلى تحسين أداء النمو للأرانب بينما لم يتأثر إستهلاك الغذاء اليومي لها. بينما أدت زيادة كثافة تسكين الأرانب إلى ٣ أرانب بالقفص إلى إضعاف أداء النمو للأرانب دون أن يتأثر إستهلاك الغذاء اليومي لها، بصرف النظر عن تدعيم الغذاء بمسحوق الزعتر. لم يكن لتدعيم الغذاء بمسحوق الزعتر أو كثافة تسكين الأرانب أو التداخل بينهما تأثير معنوي على معاملات هضم العناصر الغذائية، صفات الذبيحة، التركيب الكيماوي للحم، وقياسات الدم للأرانب. كذلك لم يكن للتداخل بين تدعيم الغذاء بمسحوق الزعتر و كثافة التسكين تأثير معنوي على أداء النمو للأرانب. وختاما، تشير النتائج المتحصل عليها أن تدعيم الغذاء بمسحوق الزعتر (٢ جرام/كجم) يمكن أن يحسن من أداء نمو الأرانب بشرط عدم زيادة معدل تسكين الأرانب عن أرنب واحد بالقفص (٥٥*٥٠*٤٠ سم) من أجل تحقيق أفضل أداء نمو لذكور الأرانب في فصل الصيف.