EFFECT OF ANTIOXIDANTS SUPPLEMENTATION ON GROWTH PERFORMANCE AND MEAT QUALITY OF GROWING RABBITS.

H. A. Abo-Eid; M. S. Abousekken and M. M. El-Rashedey

Sustainable Development Department, Environmental Studies and Research Institute (ESRI), University of Sadat City, Menofiya, Egypt.

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SUMMARY

This experiment was conducted in Alkeraam farm (A private rabbit's farm at Sadat area on the Deser*et Al*ex. Road) cooperating with Environmental Studies and Research Institute farm belonging to University of Sadat City, Menufiya Governorate, Egypt. The aim of this study was to determine the effect of adding natural antioxidant (Senecio glaucus) of 5 or 10 g of powder or extract per kg of basal diet and Butylated Hydroxytoluene (BHT) as industrial antioxidantat a rate of 150 ppm/kg of basal diet on the performance of growing New Zealand White rabbits. A total of 42 rabbits aged 5 weeks were used in this study, with an average weight of 746.8g. The results indicated that the digestion coefficients were insignificantly differed between the experimental groups and the control positive group (T1), except the control negative group (T2) which significantly lower. Also, the results of TDN and DCP showed insignificantly diffracts among the experimental groups except, group T2. Adverse reactions of lipid oxidation test indicated that the extent of fat oxidation in thigh meat after 7 days of refrigerated storage did not differ between all treatments. While, the concentration of mononaldehyde after 90 days of freezing storage of rabbit meat fed on diet containing 5 g of Senecio glaucus / kg (T5) and 1 ml of Senecio glaucus (T7) extract was significantly lower compared with other groups. Also, the rabbits fed on T6 and T7 groups showed the highest value for meat color, taste, odder, flavor and overall acceptance. Improvements in mean of net revenue, economic efficiency and relative economic efficiency in groups fed on Senecio glaucus either powder or extract supplementation and industrial antioxidant compared to control groups. It could be concluded that, the use of Senecio glaucus plant either powder or extract (5 or 10 g/kg ration) as alternative to industrial antioxidants improves growth performance, quality of meat, duration of its frozen storage and reduces nitrogen feces, which preserves the environment and achieves high returns in the economic efficiency of the production process.

Keywords: *Antioxidants, digestibility, growing rabbits, performance and blood parameters, lipid oxidation, carcass characteristics.*

INTRODUCTION

Rabbits have a higher efficiency in meat production than other animals. Therefore, rabbits can be considered as a source of animal protein and can be subjected to local conditions (Stephen *et al*., 2013). Increased consumer awareness of food safety and health regarding the use of antibiotics as growth promoters in animal farming, banned by the European Union in 2006 (De Marco *et al*., 2015). In the same time, consumers are increasingly concerned with natural alternative animal feeding strategies (Hosseini *et al*., 2013). On the other hand, the feed industry has begun looking for alternative food additives, which can replace antibiotics in ensuring satisfactory production performance. Therefore, to help meet these demands, a new research has been conducted towards natural food supplements suitable for animal feeding (Tosi *et al*., 2013; Mahmoudi *et al*., 2015). The use of probiotics, prepiotic, synbiotics, (in) organic acids, plants and their extracts, enzymes and immune modulators could be used to reduce the use of antibiotics in the production of rabbits (Bovera *et al*., 2012). Increased addition of the antioxidant is useful for improving meat quality during storage. Fat oxidation was reduced by the addition of synthetic antioxidants in broiler ration due to antioxidants that prevented more damage to ingredients of the ration (Mc Geachin *et al*., 1992). An important factor influencing the shelf life and meat quality of poultry is lipid oxidation. It occurs undesirable changes in the taste, odor, texture, flavor, the appearance of foods, and also, breaks down fat-soluble vitamins. Also, fat oxidative degradation can damage biological membranes, proteins and enzymes, which may be harmful to human health (Yang *et al*., 2016; Candan and Bağdatlı, 2017).

Antioxidants prevent biological targets damage and free radical-induced cell through preventing the forming of radicals, cleaning them, or through enhancing their degradation (Young and Woodside 2001; Taghvaei and Jafari, 2015). Generally, antioxidants can be considered as two main groups, natural and synthetic. Within the synthetic types, the most frequently used are butylated hydroxyl anisole (BHA), butylated hydroxyl toluene (BHT). Natural antioxidants of plant origin have been introduced for improving the stability of lipid and enhance the sensory properties of poultry meat (Mohamed and Mansour, 2012; Candan and Bağdatlı, 2017).

Therefore, the objective of this study is to investigate the effect of supplemented natural antioxidants Senecio glaucus (SG) as a dietary powder or extract and synthetic antioxidants (Butylated Hydroxytoluene (BHT)) on rabbits performance, digestive tract environment, meat quality, oxidative stability of meat during storage and economical efficiency.

MATERIALS AND METHODS

The experiment was carried out at Alkeraam farms (A private rabbit farm at Sadat area on the Deser*et Al*ex. road) cooperating with Environmental Studies and Research Institute farm belonging to University of Sadat City, Menufiya Governorate, Egypt, during November and December, 2017. The laboratory work was done at Rabbit Research Department, Animal Production Research Institute and the Regional Center for Food and Feed.

Animals, housing and experimental design

A total number of 42 growing New Zealand White (NZW) rabbits of 5 weeks old with average weight of 746.8g± 28.2 divided into 7 groups. Then each group was allotted into 6 replicates of each. The experimental rabbit housed in galvanized wire cages with standard dimensions provided with a feeder and automatic nipple drinker, and were kept under the same managerial conditions. Two diets of 17% and 14% crude protein were formulated, the diet containing 17% CP (control positive, T_1), the basal diet which reduced in CP content (14%) was investigated as a control negative or basal diet (T_2).

Five experimental diets were formed as follows: T3 (basal diet T2 + 150 ppm BHT/kg feed); T4 (basal diet T2 + 5g of Senecio glaucus powder /kg feed); T5 (basal diet T2 + 10g of Senecio glaucus powder / kg feed (T_5); T6 (basal diet T2 + 0.5 ml of Senecio glaucus extract (100 mg/l) and T7 (basal diet T2 + 1ml of Senecio glaucus extract (100 mg/l).

Feed and water were offered ad libitum throughout the experimental period (5 to 13 weeks of age). The ingredients of the control positive and negative diets were presented in Table (1).

Preparation of the Senecio glaucus powder (SGP)

The Senecio glaucus used for this study were collected from Wadi Elnatron Desert, Elbehera, Egypt. Senecio glaucus fresh plants were harvested under the control conditions. The plants were collected from June to August, as described by Morton (1991), were separated from branches, spread out and dried under shade at room temperature for one week, so they can be crispy for easy milling. The whole plants were then ground into a meal using a hammer mill of mesh size 3m to make the Senecio glaucus powder (SGP), which were incorporated to the experimental diets.

Ethanolic extract Preparation of Senecioglaucus

The ethanolic extract of Senecio glaucus (SGE) was prepared by mixing 4g from (SGP) with 40 ml of 80% ethanol. Extraction was carried out with shaking at room temperature during 1 hr. Extract was separated by filtering through the filter paper (Whatmann, Grade 4 Chr, UK), and procedure was repeated with 40 ml of ethanol two times. Ethanolic extracts of Senecio glaucus (3 × 40 ml) were combined, and solvent was removed under vacuum at 40°C to obtained 25 ml volume.

The phytochemical analysis of Senecio glaucus

The amount of total phenols; flavonoid content; alkaloid; the amount of tannins and saponin content in the Senecio glaucus extracts were estimated by spectrophotometrically according to the methods described by El-Amier *et al*. (2014).

Table (1). Composition of control and basal diet.

Item	Control+ 17.0 % CP	Control- 14 % CP (Basal diet)
Clover hay	25	24.95
Wheat bran	26	28.90
Barley grains ,Ground	20	24.00
Soybean meal (44% CP)	13.5	4.00
Yellow corn, ground	10.00	13.00
Wheat straw	1.50	1.00
Clover straw	-	0.50
Dl-Methionine	0.35	0.15
Premix*	0.50	0.50
NaCl	0.35	0.20
Dicalcium phosphate	1.90	1.90
CaCO3	0.90	0.90
Total	100.00	100.00
Calculating chemical analysis		
Crude protein %	17.24	14.23
Crude fiber %**	12.00	12.35
Ether extract %	2.59	2.34
Calcium %	1.1	1.32
Available phosphorus	0.41	0.45
Lysine %	0.81	0.79
Methionine	0.60	0.63
DE(Kcal/Kg) diet) ***	2520	2540
ME, kcal/kg diet	2490	2450
Cost/kg of diet in L.E. ****	3.85	3.20

** Each one kg of vitamin & mineral mixture contains: Vit.A 4000000 IU; Vit D_3 50000IU; Vit E 16.7 g.; Vit K_3,0.67 g.; Vit.B_1 67 g; VitB_2 2.00 g; Vit. B_6 0.67 g; Vit B_{12} 3.33 mg ; Cholin chloride 400 g.; Biotin 0.07 g; Niacin 16.7 g.; pantothenic acid 6.7 g; Folic acid 1.7 g;; Copper 1.7 g; Iron 25.00 g; Manganese 10.00 g; Iodine 0.25 g; Selenium 33.3 g; Zinc 23.3 g and Magnesium 133.3 g. According to NRC (1977) and Feed Composition Tables for animal & poultry feedstuffs used in Egypt (2001).*

***The prepared diets were iso-nitrogenous, iso- caloric and had nearly equal level of CF.*

****DE (Kcal/kg) = 4.36 - 0.0491 x NDF% & NDF% = 28.924 + 0.657 x CF%, according to (Cheeke, 1987).*
*****According to market prices of the year 2017.*

Growth performance

Rabbits were individually weighed at the end of each week, during the whole trial period of 8 weeks for the nearest gram. Weekly individual live body weight and feed intake were calculated. The performance index (PI) was calculated according the equation reported by North (1981) as follows:

PI = (Live body weight (kg) / Feed conversion) x 100

Digestibility trial

Digestibility trials were conducted at the end of growth trials, to determine the digestion coefficients values of dry matter (DM), organic matter (OM), crude protein (CP), crude fiber (CF), ether extract (EE), nitrogen free extract (NFE) and the nutritive values of the experimental diets expressed as total digestible nutrients (TDN), and digestible crude protein (DCP). Three animals representing each group were individually, housed in metabolic cages equipped with a stainless- steel screen and 4 mm mesh to retain feces, but allow free passage of urine. Feed and water intake were offered to rabbits ad-libtum during the digestibility trials.

The digestibility trial lasted for 10 days as preliminary period, while the collection period lasted for 5 days in which feces was collected daily before the morning meal, weighted fresh and sprayed with 2% boric acid for trapping any ammonia released from feces and dried at 60 ◦C for 48 hrs. in an air drying oven. The feces were then ground and mixed, stored for subsequent chemical analysis. Feed and feces samples were chemically analyzed to determine the digestion coefficients and nutritive values of the experimental diets according to AOAC. (2000).

Blood Parameters

Blood samples were collected from each rabbit (3 rabbits /group) into dry clean tubes containing heparin and centrifuged at 3000 rpm for 15 min. The plasma was collected and stored at -20˚C to estimate some blood constituents as total protein (Amstrong and Corri, 1960), albumin (Doumas et al., 1971), transaminase (aspartate aminotransferase (AST) and alanine aminotransferase (ALT)) (Reitman and Frankel, 1957), triglycerides (Royer, 1969), cholesterol (Zlatkis et al., 1953), urea nitrogen and creatinine. The globulin values were obtained by subtracting the albumin values from the corresponding values of total proteins.

Carcass traits

At the end of trial (13 weeks of age), 21 rabbits (3 rabbits/treatment) were slaughtered according to the standard technique of Cheeke (1987). After complete bleeding, skinning, and removing of viscera, weight of hot carcass was determined. Weights of internal organs including liver, kidney, spleen, heart, lung, pancreas, abdominal fat, full stomach, full intestine, caecum and thyroid were also determined, and their relative weights to the live body weight were calculated. The lengths of the elementary tract and carcass were also recorded.

The pH value of the caecum content was measured using pH- meter, HANNA Instruments (Italy), Woon Socket, R1202895 pHep® Pocketsized. The total volatile fatty acids (TVFA´s) were determined by steam distillation using Micro Kjeldlahl distillation unit.

Economical efficiency

An input-output analysis and economic efficiency were calculated. Economic efficiency was calculated by the following equation:

Economic efficiency = (selling price of 1kg live body weight (LBW) - feeding cost of 1kg live body weight)/ feeding cost of 1kg live body weight) × 100.

Statistical analysis

Data collected in this study were statistically analyzed using the generalized linear models (GLM) of SAS (2003).Separation among means was achieved using the Duncan's of multiple range test (Duncan, 1955).The model was as follows:

$$Y_{ij}=\mu+T_i+ e_{ij}$$

Where: Y_{ij}= The observation on the i^{th} treatment, μ = overall mean, T_i= Effect of the i^{th} treatment and e_{ij}= residual error.

RESULTS AND DISCUSSION

Chemical composition

The concentration of the active constituents of Senecio glaucous

The concentrations of the active constituents of Senecio glaucous in mg/g dry weight for the whole plant are shown in Table (2). These results are consistent with those reported by El-Amier *et al*. (2014) who found that the Senecio glaucus extract was high in saponins (26.53 and 23.52 mg/g dry weight in the root and stem, respectively), phenolic compounds (27.80 and 23.52 mg/g dry weight in the root and shoot, respectively), tannins (19.18 and 17.61 mg/g dry weight in the root and shoot, respectively), alkaloids (11.03 and 8.09 mg/g dry weight in root and shoot, respectively) and Flavonoids (21.62 and 18.51mg/g dry weight in the root and shoot, respectively).

Chemical composition of tested diets

The proximate compositions of experimental diets are presented in Table (3).

Nutrients digestibility, Nutritive values and Nitrogen balance

Nutrients digestibility%

Results of Table (4) indicated that there were no significant differences between the groups, T1, T3, T4, T5, T6 and T7 in digestion coefficients of dietary OM, CP, EE and NFE. Whereas, T_7 group was significantly

Table (2): Concentration of the active constituents in mg/g dry weight for the Senecio glaucus (a whole plant).

Active constituents	constituent (mg/g dry weight)
Tannins	18.40 ± 0.19
Saponins	24.48± 0.23
Flavonoids	20.07±0.35
Alkaloids	9.57±0.32
Total phenol	25.67±0.16

Table (3): Proximate analysis of experimental diets (as fed).

Item	DM%	Moisture%	OM%	CP%	CF%	EE%	NFE%	Ash%	DE (Mcal/kg)*
Ration1	92.23	7.77	79.37	17.43	12.74	3.11	46.09	12.86	2.37
Ration2	89.85	10.15	78.10	13.98	12.53	2.55	46.04	11.75	2.54
Ration3	90.86	9.14	76.83	14.33	13.54	2.86	43.10	14.03	2.51
Ration4	91.97	8.03	77.84	14.36	14.01	3.01	43.46	14.13	2.49
Ration5	92.86	7.14	78.93	14.45	13.82	2.76	45.60	13.93	2.50
Ration6	92.33	7.67	79.5	14.47	12.64	2.69	49.70	12.83	2.54
Ration7	91.46	8.54	77.91	14.45	12.56	2.61	34.74	13.55	2.54

**DE (Mcal/kg) = 4.36 – 0.049 x NDF, NDF% = 28.924 +0.657 (CF %) according to Cheeke (1987).*

Table (4). Effect of supplemented dietary Senecio glaucus (SG) powder or extract and Butylated Hydroxytoluene (BHT) on digestion coefficients, nutritive values and nitrogen balance for growing rabbits.

Item	Tested diets*								Sig
	T_1	T2	T_3	T_4	T_5	T_6	T_7	± SE	
Digestion coefficients (%)									
DM	74.20	69.79	71.04	71.68	74.66	72.41	74.66	2.82	NS
OM	69.69^{ab}	63.03^{b}	72.15^{a}	67.37^{ab}	72.32^{a}	70.67^{ab}	72.32^{a}	3.32	*
CP	85.50^{ab}	83.62^{b}	85.15^{ab}	85.32^{ab}	85.63^{ab}	85.63^{ab}	87.31^{a}	1.67	*
CF	50.25	42.50	47.10	40.32	51.62	48.71	51.62	7.21	NS
EE	81.53^{ab}	78.82^{b}	84.93^{ab}	83.17^{ab}	83.17^{ab}	85.64^{ab}	87.31^{a}	3.11	*
NFE	72.53^{ab}	62.31^{b}	68.12^{ab}	66.1^{ab}	72.53^{ab}	71.76^{ab}	73.85^{a}	3.31	*
Nutritive values									
TDN	67.88^{a}	63.62^{b}	65.96^{a}	64.57^{ab}	67.43^{a}	67.43^{a}	69.34^{a}	2.95	*
DCP	15.52^{ab}	15.13^{b}	15.39^{ab}	15.65^{ab}	15.64^{a}	15.64^{a}	15.67^{a}	0.27	*
Nitrogen balance (g/h/d)									
N I	3.15	2.99	3.00	3.42	2.8	3.4	2.8	0.3	NS
F N	0.50	0.43	0.38	0.51	0.36	0.50	0.36	0.8	NS
Urinary N	0.76^{ab}	0.59^{b}	0.99^{a}	0.68^{ab}	0.95^{a}	0.82^{ab}	0.95^{a}	0.23	*
NB	1.89^{ab}	1.67^{b}	1.84^{ab}	2.10^{a}	1.91^{ab}	1.51^{b}	2.24^{a}	0.11	*
NB/NI	59.93^{ab}	55.74^{b}	59.60^{ab}	65.23^{a}	63.26^{a}	61.44^{a}	65.26^{a}	2.10	*

** T_1 Control positive. (17% CP) ; T_2 Basal diet (BD) 14% CP (control negative);T_3 Basal diet + 150 ppm BHT; T_4 Basal diet + 5g of Senecio glaucus powder /kg feed; T_5 Basal diet + 10g of Senecio glaucus powder /kg feed; T_6 Basal diet + 0.5ml of Senecio glaucus extract (100 mg/l) ;T_7 Basal diet + 1ml of Senecio glaucus extract (100 mg/l).*

**a and b : Means within the same row differ significantly (P< 0.05); NS = Not significant (P>0.05).*

($P<0.05$) higher compared to T_2 group. This increase could be due to the improvement in experimental rabbits fed normal antioxidants substances in Senecio glaucus (SG) powder or extract (T_3 and T_4 or T_6 and T_7 groups) which stimulate anaerobic fermentation of OM that improve efficiency of nutrients utilization. Also, the digestion coefficients of DM and CF in the T_7 group were higher than other groups, but with no significant difference (Table 4). This increase could be due to the improvement in the environment of digestive tract of experimental rabbits which fed on normal antioxidants that stimulate groups. These results were consistent with those obtained by Abo-Donia *et al*. (2005).

Nutritive values

Results of nutritive values as TDN and DCP are presented in Table (4). Data of TDN and DCP cleared that a significant increase in T_7 group rather than tested groups followed by T_6, T_5, T_3 and T_4, while, T_2 recorded the lowest value. The increase in TDN of these tested groups may be due to the significant improvement in the digestion coefficients of most nutrients. These results are in agreement with Dung *et al*. (2010).

Nitrogen balance (NB)

Results of nitrogen balance presented in Table (4) showed that there was a significant ($P<0.05$) increase in NB with T_7 groups compared with control and other experimental groups. The highest values of nitrogen balance were significantly ($P<0.05$) recorded by T_7 group followed by T4 (contained antioxidant substances). These results are in agreement with those obtained by Pineda *et al*. (2012) evaluated the potential of silver nanoparticles (AgNPs) as an antimicrobial growth-promoting supplement for broiler chickens and demonstrated that Ag NPs affects N utilization and plasma IgG concentration; however, it does not influence the microbial populations in the digestive tract.

Growth performance

Final body weight (g) as effected by supplemented dietary Senecio glaucus (SG) powder or extract and Butylated Hydroxytoluene (BHT) is presented in Table (5). Results indicated that the lowest body weight was achieved with T2 group being 2357.5g, while, the highest body weight value (2536.3g) was significantly ($P<0.05$) recorded with T_7 group. But there were no significant differences in final body weight between T_3, T_4, T_5, T_6 and T_7 groups.

Results of live body weight gain as affected by supplemented dietary Senecio glaucus (SG) powder or extract and Butylated Hydroxytoluene (BHT) are presented in Table (5). Data indicated that the best total gain value was significantly ($P<0.05$) achieved by T_7 group, whereas, the T_2 group present the worst one (1548.1g). It was observed that the total gain of rabbits fed T_7 group was significantly ($P<0.05$) higher than the other groups. While, there was no significant differences in total gain values between T_3, T_4, T_5, T_6 and T_7. The same trend was observed with the results of Wang *et al*. (2008) who reported that an increase in weight and FCR was found to be better than negative control diet (without vitamin C) using a rich antioxidant extract. Results of feed intake in Table (5) showed that adding Senecio glaucus extract or powder caused a significant ($P<0.05$) increment in the feed intake values of T_7 group compared with rabbit control groups (T_1 and T_2). The results showed insignificant ($P>0.05$) differenced in the feed intake between groups T_3, T_4, T_5, T_6 and T_7 (Table 5).

Feed conversion ratio (FCR):

Results in Table (5) indicated that values of feed conversion (g feed/g gain) for T3 and T4 groups were significantly ($P<0.05$) lower than those obtained from other groups. This improvement of FCR showed in these diets may be due to the reduced in feed intake in relation to the higher body weight gain which, caused some improvements in digestive tract environment of experimental rabbits fed antioxidants substances in Butylated Hydroxytoluene (BHT) (T_3 group) and Senecio glaucus (SG) powder(T_4 group). These results were in agreement with those obtained by Biswas and Wakita (2001), who found that the use of different levels of green tea powder up to 1.5% resulted in an improvement in the FCR.

Table (5): Effect of supplemented dietary Senecio glaucus (SG) powder or extract and Butylated Hydroxytoluene (BHT) on live body weight (g).

Item	T_1	T_2	T_3	T_4	T_5	T_6	T_7	± SE	sign
I L BW (g)	762.3	759.4	736.9	731.3	751.3	738.8	747.5	28.20	NS
F LBW (g)	2420.9^{b}	2357.5^{c}	2496.3^{ab}	2496.9^{ab}	2500.1^{ab}	2510.5^{a}	2536.3^{a}	60.90	*
TG (g)	1658.6^{b}	1548.1^{c}	1759.4^{ab}	1765.6^{a}	1748.8^{ab}	1771.7^{a}	1788.8^{a}	55.8	*
TFI (g)	5504^{b}	5208.3^{c}	5639.3^{ab}	5767^{a}	5808.1^{a}	5961.5^{a}	6023.3^{a}	250.8	*
FCR	3.32^{a}	3.36^{a}	3.21^{b}	3.27^{b}	3.32^{a}	3.36^{a}	3.37^{a}	0.12	*
PI%	72.92	70.16	77.77	76.36	75.30	74.72	75.62	7.89	NS

**T_1 (Control positive). (17% CP) ;T_2 Basal diet (BD) 14% CP (control negative); T_3 Basal diet + 150 ppm BHT; T_4 Basal diet + 5g of Senecio glaucus powder /kg feed; T_5 Basal diet + 10g of Senecio glaucus powder /kg feed; T_6 Basal diet + 0.5ml of Senecio glaucous extract (100 mg/l) ;T_7 Basal diet + 1ml of Senecio glaucous extract (100 mg/l).*
a, b and c : Means within the same row differ significantly (P<0.05); NS =not significant (P>0.05).
ILBW (g): Initiallive body weight (g); FLBW: Final live body weight (g); TG: Total gain; TFI: Total feed intake (g); FCR: Feed conversion ratio and PI%: Performance Index %

Performance index (PI %):

The results of performance index (PI) were presented in Table (5). The results illustrated that there was no significant difference between all groups and the highest value was recorded in T3 group (77.77%), while the worst value achieved in T_2 (70.16%). The increase of PI in T_3 group may be due to the improvement of the feed conversion. These results are in agreement with Musa (2008) and Ahmed (2010) who reported that the better PI value was observed with the group that fed on a mixture of medicinal plants.

Cecal activity

Results of cecal activity and cecal length are presented in Table (6). Results showed that the values of cecal weight and cecal length of T6 were the highest (10.13g and 11.50 cm), while the lowest values (7.07 g and 10.00 cm) were achieved by T2 group (control) with no significant differences between all groups. Similar results were obtained by Ahmed *et al*. (2010) when fed NZW growing rabbit's diets with medical plant, the caecum length was ranged from 9.5 – 14.0 cm. The results in Table (6) showed significant differences (P<0.05) in cecal pH and TVFA's between all experimental diets. T6 and T7 groups showed significantly (P<0.05) the lowest cecal pH values compared with other groups being (6.94, 6.07, respectively).

The same Table showed that the total VFA's tended to be significantly higher (P<0.05) in the caecum content of T6 and T7 groups compared with T2 and T3 groups. It is clear that the concentration of VFA's was in the opposite direction with pH values as expected. These results are consistent with those reported by Abd El-Nabi (2007) who reported that dietary sprouted –fenugreek, barley mixture increased TVFA's in rumen of sheep. In contrary, El- Manylawi *et al*. (2005) found that cecal concentration of VFA's was not increased in rabbits fed medicinal plants.

Carcass characteristics

Results of carcass characteristics of growing rabbits as affected by supplemented dietary Senecio glaucus (SG) powder or extract and Butylated Hydroxytoluene (BHT) are presented in Table (7). The Results indicated that the heaviest (P<0.05) weight was recorded for T6 (2687.02g) and T7groups (2637.58g) compared with control positive, T1. The lightest weight was recorded for T_1 group (2228.82g). Empty carcass in groups T6 and T7 was significantly (P<0.05) higher than control groups (T1 and T2). In this concern El-Manyalawi *et al*. (2005) and Musa (2008) reported that rabbits fed on medicinal plant by-product had insignificant differences in empty carcass and dressing percentage. Also, Results in Table (7) indicated that the rabbits groups of T1 and T2 (control) had significantly (P<0.05) higher abdominal fat compared to T4, T5, T6 and T7. These results are in agreement with Khalifa (2009). Regarding edible giblets (g), it was noticed that T5, T6 and T7 groups had the significantly (P<0.05) highest values than T2 group. Results indicated that there were no significant difference (P>0.05) observed for heart weight (g), liver weight, kidney weight, body length, breast curriculum, leg curriculum and spleen weight between all treatments. These results are in accordance with those obtained by Ahmed *et al*. (2005) who reported that carcass traits including heart and kidney percent were not significantly different when rabbits fed on medical plant leaves.

Table 6

Table 7

Table 8

Plasma biochemical parameters

The results in Table (8) summarizes some blood parameters of growing NZW rabbits as affected by supplemented dietary Senecio glaucus (SG) powder or extract and Butylated Hydroxytoluene (BHT). The results indicated that Urea (mg/dl), Albumin (g/dl), Total protein (mg/dl), Globulin (g/dl), Cholesterol (mg/dl) and Triglycerides (mg/dl) concentrations significantly (P< 0.05) decreased in T5, T6 and T7 compared to T1 and T2 groups. These values were in the range of normal values defined for these parameters by previous studies in rabbits (Elmas *et al*., 2006; Melillo, 2007 and Özkan *et al*., 2012). There is an inverse relationship between A/G ratio and immunoglobulin level where, low A/G ratios, indicating high immunoglobulin level in plasma (Ismail *et al*., 2002).

Lipid oxidation study (TBARS)

TBA-reactive substances (TBARS) of thigh muscle (g kg-1 malonaldehyde) of rabbits fed dietary treatments present in Table (9). Results indicated that the extent of lipid oxidation (TBA number) in thigh meat after 7 d of refrigerated storage was not differed between all treatments. However, malonaldehyde concentration after 90 d of refrigerated storage of rabbit meats of T7 and T5 had less (P<0.05) TBA number, while rabbits fed on control group showed the highest TBA number. We can possible report that utilization of antioxidants (synthetic or natural) in the rabbit diets decreased TBA number of thigh meat at 90 days after freezing storage. These results are in agreement with those obtained by Bartov and Bornstein (1981) who reported that synthetic antioxidants improved stability of poultry meat.

Table (9). TBA-reactive substances (TBARS) of thigh muscle (g kg-1malonaldehyde) of rabbits supplemented dietary Senecio glaucus (SG) powder or extract and Butylated Hydroxytoluene (BHT).

Item		Treatment							Sig.
		T_1	T_2	T_3	T_4	T_5	T_6	T_7	
Days after storage	7	0.45 ±0.05	0.47 ±0.14	0.58 ±0.09	0.71 ±0.03	0.45 ±0.11	0.55 ±0.11	0.43 ±0.10	NS
	90	0.78^{a} ±0.05	0.69^{ab} ±0.14	0.60^{ab} ±0.09	0.58^{ab} ±0.01	0.47^{b} ±0.11	0.53^{ab} ±0.08	0.44^{c} ±0.12	*

** T_1 (Control positive). (17% CP) ; T_2 Basal diet (BD) 14% CP (control negative);T_3 Basal diet + 150 ppm BHT; T_4 Basal diet + 5g of Senecio glaucus powder /kg feed; T_5 Basal diet + 10g of Senecio glaucus powder /kg feed; T_6 Basal diet + 0.5ml of Senecio glaucus extract (100 mg/l) ;T_7 Basal diet + 1ml of Senecio glaucus extract (100 mg/l).*
**a, b and c: Means within the same row differ significantly at P< 0.05; NS =not significant, = P< 0.05.*

Organoleptic evaluation of cooked rabbit's meat

Organoleptic evaluation values of cooked meat in terms of color, odor, taste, texture, flavor and overall acceptance are illustrated in Table (10). The results showed significant effects (P<0.05) in organoleptic evaluation parameters (color, taste, odder, flavor and over all acceptability) in all experimental groups and the values of control negative (T2) were the lowest. Moreover, insignificant differences were observed among the groups of T1, T3, T4, T5, T6 and T_7. For overall acceptability, T6 and T7 significantly (P<0.05) recorded the best values compared with control group (T2) and other groups. On this concept, Govaris *et al*. (2004) reported that use of natural antioxidants can prolong the shelf life and increase the acceptability of meat and its economic value in the marketplace.

Table 10

Economic Efficiency

The effect of dietary Senecio glaucus (SG) powder or extract and Butylated Hydroxytoluene (BHT) supplementation on the economical efficiency is presented in Table (11). Results showed an improvement in the average values of net revenue, economical efficiency and relative economic efficiency due to feeding growing rabbits the diets supplemented with Senecio glaucus (SG) powder or extract and BHT compared to the control group (T2), which recorded the lowest values of net revenue and economic efficiency. These results indicated that dietary Senecio glaucus powder or extract from the economical point of view tend to improve the net revenue compared with control positive and basal diets (control negative).

Table (11): Economic efficiency of growing rabbits as affected by supplemented dietary Senecio glaucus (SG) powder or extract and BHT.

Item	Tested diet						
	T_1	T_2	T_3	T_4	T_5	T_6	T_7
Av. feed intake (Kg/rabbit) (a)	5.50	5.24	5.64	5.77	5.77	5.96	6.02
Price/ Kg feed (PT)* (b)	3.90	3.3	3.35	3.320	3.325	3.335	3.340
Total feed cost (LE) (a x b = c)	21.47	17.29	18.89	19.16	19.19	19.88	20.11
Av. Body weight gain (Kg/rabbit) (d)	1.66	1.20	1.76	1.77	1.75	1.78	1.79
Price/Kg live body weight (LE)** (e)	50.00	50.0	50.00	50.00	50.00	50.00	50.00
Total revenue (LE) (d x e = f)	83.00	60.00	88.00	88.50	87.50	89.00	89.50
Net revenue (LE) (f – c =g)	61.53	42.71	69.11	69.34	68.31	69.12	69.39
Economic efficiency *** (g/c)	2.87	2.47	3.66	3.62	3.56	3.48	3.45
Relative economic efficiency****	100.00	86.06	127.53	126.13	124.04	121.25	120.23

**: According to the price of different ingredients available in the market at the experimental time (2017).*
***: According to the local market price at the experimental period.*
****: Net revenue per unit cost.*
*****: Compared to the economical efficiency of the control (positive).*

CONCLUSION

Based on the results obtained from the current study, it is demonstrated that, 5g or 10g of Senecio glaucus powder or extract can be added in growing rabbit diets to achieve improvements in growth performance parameters, digestibility coefficients hematological and biochemical parameters, malonaldehyde concentration of frozen storage rabbit meat, overall acceptability for Organoleptic evaluation of cooked rabbit's meat, increase nitrogen balance, and economic efficiency. From economical point of view, these findings indicated that as general, rabbits groups fed on diet containing basal diet + 150 ppm BHT (T3) and basal diet + 5g of Senecio glaucus powder /kg feed (T4) tend to improve the net revenue and economic efficiency.

REFERENCES

AOAC. (2000). Official methods of Analysis. 13th Ed. Association of Official Agricultural Chemists, Washington, DC., USA.

Abd EL-Nabi, H. A. S. (2007). Using sprouted barley and fenugreek on rice straw to replace berseem hay in growing lambs rations. M.Sc. Thesis, Faculty of Agriculture, Cairo University, Egypt.

Abo-Donia, F. A.; G. H. Zaza and F. A. Saleh (2005). Effect of using natural antioxidant on growth of young chicks. Poult. Sci., 64:22-87.

Ahmed, M.; M. S. Akter and J. B. Eun (2010). Impact of a-amylase and maltodextrin on physicochemical, functional and antioxidant capacity of spray-dried sweet potato flour. Journal of the Science of Food and Agriculture, 90:494-502.

Ahmed, N.; S. Haldar; M. C. Pakhira and T. K. Ghosh (2005). Growth performances, nutrient utilization and carcass traits in broiler chickens fed with a normal and a low energy diet supplemented with inorganic chromium (as chromium chloride hexahydrate) and a combination of inorganic chromium and ascorbic acid. J. Agric. Sci., 143:427-439.

Armstrong, W. D., C. W. Corri (1960). Physiological Chemistry. Laboratory Diction, 3rd Edition, P. 75. Punges publishing Co., Minneapolis, USA.

Bartov, I. and S. Bornstein (1981). Stability of abdominal fat and meat of broilers: Combined effects of dietary vitamin E and Synthetic antioxidants. Poult. Sci., 60:1840-1845.

Biswas, M. A. H. and M. Wakita (2001). Effect of Japanese green tea powder supplementation on feed utilization and carcass profile in broilers. J. Poul. Sci., 38:50-57.

Bovera, F.; A. Lestingi, F. Iannacone; A. Tateo and A. Nizza (2012). Use of dietary mannan oligosaccharides during rabbit fattening period: effects on growth performances, feed nutrient digestibility, carcass traits and meat quality. J. Anim. Sci., 90:3858-3866.

Candan, T. and A. Bağdath (2017). Use of natural antioxidants in poultry meat. CBÜ F Bil. Dergi.,Cilt 13, Sayı 2:279-291.

Cheeke, P. R. (1987). Rabbit feeding and nutrition. Academic Press. INC. Orlando Florida.

De Marco, M.; W. Lopez Salcedo; G. Pastorelli, R. Rossi; C. Corino; S. Bergagna, E. Mellia; M. S. Gennero; E. Biasibetti; M. T. Capucchio; S. Nurisso; M. Tarantola; G. Forneris and A. Schiavone (2015). Effects of verbascoside supplemented diets on growth performance, blood traits, meat quality, lipid oxidation and histological features in broiler chickens. Ital. J. Anim. Sci., 14:172-178.

Doumas, B., W. Watson and H. Biggs (1971) Albumin standards and the measurement of serum albumin with bromcresol green. Clinical Chimistry Acta, 31:37.

Duncan, D. B. (1955). Multiple ranges and multiple F- test. Biometrics, 11:1-42.

Dung, D. D.; I. R. Godwin and J. V. Nolan (2010). Nutrient content and in sacco digestibility of barley grain and sprouted barley. Journal of Animal and Veterinary Advances, 9(19):2485-2492.

El-Amier, Y. A.; A. M. Abdelghany and A. Abed Zaid (2014). Green synthesis and antimicrobial activity of senecioglaucus- mediated silver nanoparticles. Res. J. of Pharma., Bio. and Chem. Sc., 5(5): 631.

El-Manylawi, M. A.; M. R. M. Ibrahim; G, Fatma and A. Walaa (2005). Performance of growing rabbits fed diets containing geranium and spearmint by-products. Egyp. J. Rabbit Sci., 15(1):13-26.

Elmas, M.; E. Yazar; K. Uney and A. Karabacak (2006). Pharmacokinetics of flunixin after intravenous administration in healthy and endotoxaemic rabbits. Vet.Res. Commun., 30:73-81.

Govaris A.; N. Botsoglou; G. Papageorgiou; E. Botsoglou and I. Ambrosiadis (2004). Dietary versus post-mortem use of oregano oil and/or α-tocopherol in turkeys to inhibit development of lipid oxidation in meat during refrigerated storage. Int. J. Food Sci., Nutr., 55:115-123.

Hosseini, S. A.; A. Meimandipour; F. Alami; A. Mahdavi; M. Mohiti-Asli; H. Lotfollahian and 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., 12:116- 120.

Ismail A. M.; M. A. Abou-El-Ellaa and A. A. Sedki (2002). Blood metabolites, growth and reproductive performance and immune responsiveness in growing and doe rabbits as affected by Acitrol treatments. Egyptian J. Agric. Res., 80:1789-1808.

Khalifa, A. S. (2009). The use of medical herbs in animal nutrition. MSc. Thsis, Faculty of Agric., Minufiya Univ., Egypt.

Mahmoudi, M.; P. Farhoomand and R. Nour Mohammadi (2015). Effects of different levels of hemp seed (*Cannabis sativa L.*) and dextran oligosaccharide on growth performance and antibody titer response of broiler chickens. Ital. J. Anim. Sci., 14:114-119.

Mc Geachin, R. B.; L. J. Srinivasan and C. A. Bailey (1992). Comparison of the effectiveness of two antioxidants in a broiler type diet. J. Appl. Poult. Res., 1:355–359.

Melillo, A. (2007). Rabbit clinical pathology. J. Exot. Pet Med., 16:135-145. doi:10.1053/j.jepm.2007.06.002.

Mohamed, H. M. H. and H. A. Mansour (2012). Incorporating essential oils of marjoram and rosemary in the formulation of beef patties manufactured with mechanically deboned poultry meat to improve the lipid stability and sensory attributes. LWT – Food Science and Technology, 45:79–87.

Morton, J. F. (1991). The Horseradish tree, Moringa pterygosperma (Moringaceae) - A boon to arid lands. Econ. Bot., 45:318-333.

Musa, A. M. Z. (2008). The nutritive value of some common plants growing in the arid area. M.Sc. Thesis, Animal Production Dept., Faculty of Agriculture, Minufiya University, Egypt.

NRC. National Research Council (1977). Nutrient requirements of rabbits. National Academy of Science, Washington, DC, USA.

North, M. O. (1981). Commercial Chicken Production. Manual 2nd Edition, ANI publishing Company ING, USA.

Özkan, C.; A. Kaya and Y. Akgül (2012). Normal values of haematological and some biochemical parameters in serum and urine of New Zealand White rabbits. World Rabbit Sci., 20:253-259.

Pineda L, Sawosz E; A. Hotowy; J. Elnif; F. Sawosz; A. Ali and A. Chwalibog (2012). Effect of nanoparticles of silver and gold on metabolic rate and development of broiler and layer embryos. Comp Biochem Physiol A Mol Integr. Physiol., 161:315–319.

Reitman S, Frankel S (1957) A colorimetric method for determination of serum glutamate oxaloacetate and glutamic pyruvate transaminase. Am. J. Clin. Pathol. 28: 56-58.

Royer, M. F. (1969). Determination of triglycerides. Annual Biochemistry, 29:405.

SAS (2003). Statistical Analysis System, User's Guide, Statistics, SAS Institute, Carry, North Carolina.

Stephen, M.; M. Wanyoike and J. Serem (2013). Rabbit breed characteristics, farmer objectives and preferences in Kenya: A correspondence analysis. Munich Personal RePEc Archive, Paper No. 48476.

Taghvaei, M. and S. M. Jafari (2015). Application and stability of natural antioxidants in edible oils in order to substitute synthetic additives. Journal of food science and technology, 52(3):1272-1282.

Tosi, G.; P. Massi; M. Antongiovanni; A. Buccioni; S. Minieri; L. Marenchino and M. Mele (2013). Efficacy test of a hydrolysable tannin extract against necrotic enteritis in challenged broiler chickens. Ital. J. Anim. Sci., 12:386-389.

Wang, L.; X. L. Piao; S. W. Kim; X. S. Piao; Y. B. Shen and H. S. Lee (2008). Effects of Forsythia suspense extract on growth performance, nutrient digestibility, and antioxidant activities in broiler chickens under high ambient temperature. Poultry Science, 87:1287–1294.

Yang, M.; J. T. Wang; T. Han; Y. N. Yang; X. Y. Li and Y. D. Jiang (2016). Dietary protein requirement of juvenile bluegill sunfish (Lepomis macrochirus) Aquaculture, 459(6):191-197.

Young, I. S. and J. V. Woodside (2001). Antioxidants in health and disease. Journal of Clinical Pathology, 54(3):176-186.

Zlatkis, A, B. Zak, A. J. Boyle (1953). A new method for the direct determination of serum cholesterol. J Lab Clin Med., 41(3):486–492.

تأثير إضافة مضادات الأكسدة على أداء النمو وجودة اللحوم في الأرانب النامية

حسنى السيد احمد أبوعيد و **محمود سعد أبوسكين** و **محمد الرشيدى**

قسم التنمية المتواصلة للبيئة وإدارة مشروعاتها – معهد الدراسات والبحوث البيئية – جامعة مدينة السادات – المنوفية - مصر

أجريت هذه التجربة بمزارع الكرام (مزرعة أرانب خاصة بمنطقة السادات - طريق الإسكندرية الصحراوى) بالتعاون مع مزرعة ومعامل معهد الدراسات والبحوث البيئية - جامعة مدينة السادات، محافظة المنوفية، مصر. كان الهدف من هذه الدراسة هو تحديد تأثير إضافة مضادات الأكسدة الطبيعية بنسبة 5 أو 10جم من مسحوق أو 0.5 مل أو 1 مل مستخلص نبات الجعضيض الصحراوى/ كجم علف من العليقة القاعدية ومضاد أكسدة صناعي Butylated Hydroxytoluene (BHT) بمعدل 150 جزء فى المليون/ كجم علف من العليقة القاعدية على أداء الأرانب النيوزيلندي البيضاء النامية. أستخدم فى هذه الدراسة عدد 42 أرنب نيوزيلاندى عمر 5 أسابيع بمتوسط وزن 746.8 جم.

أوضحت النتائج أن معاملات الهضم فى جميع العناصر الغذائية لم تختلف معنويا بين المجاميع التجريبية مقارنة بمجموعة الكنترول, عدا المجموعة التجريبية T2 التى انخفضت معنويا فيها قيم معاملات الهضم. المركبات الكلية المهضومة والبروتين المهضوم % لم بظهر إختلافات معنوية بين المجاميع التجريبية مقارنة بمجموعة الكنترول عدا المجموعة التجريبية T2 التى أظهرت إنحفاضا معنويا. كذلك أشارت نتائج التفاعلات العكسية لأكسدة الدهون فى عضلة فخذ الأرانب التي تغذت على المعاملات الغذائية أن مدى أكسدة الدهون في لحم الفخذ بعد 7 أيام من التخزين بالتجميد لم يختلف بين جميع المعاملات. بينما كان تركيز المالونالدهايد بعد 90 يومًا من التخزين بالتجميد للحوم الأرانب المغذاه على العلائق المضاف لها 5 جرام من مسحوق الجعضيض البرى /كجم عليقة (المجموعة الخامسة) والعلائق المضاف لها ١ مل من مستخلص الجعضيض البرى (المجموعة السابعة) منخفض معنويا بالمقارنة بباقى المجموعات التجريبية .

أيضا سجلت الأرانب المغذاه على العليقة السادسة والسابعة معنويا أفضل قيمة للون اللحم والطعم والأفضلية والنكهة والقبول العام مقارنة مع مجموعتى الكنترول وغيرها من المجموعات التجريبية الأخرى. كما أظهرت النتائج تحسناً في متوسط قيم صافي الربح والكفاءة الإقتصادية والكفاءة الاقتصادية النسبية في المجموعات التي غذيت على عليقة مضاف لها مسحوق أو مستخلص الجعضيض البرى ومضاد الأكسدة الصناعي مقارنة بمجموعتى الكنترول. نستخلص من هذه الدراسة أن إستخدام مسحوق نبات الجعضيض الصحراوى أو مستخلصه (بمعدل 5 أو 10 جم / كجم عليقة) بديلا عن مضادات الأكسدة الصناعية المخلقة، يحسن أداء النمو وجودة اللحوم الناتجة ومدة حفظها مجمدة ويخفض نيتروجين الروث مما يؤدى للحفاظ على البيئة ويحقق مردود عالى على الكفاءة الإقتصادية للعملية الانتاجية.