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

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SUMMARY

This experiment was conducted in Al’keraam farm (A private rabbit's farm at Sadat area on the Deseret Alex. Road) cooperating with Environmental Studies and Research Institute farm belonging to University of Sadat City, Menoufeya 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 antioxidant at 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, prebiotic, symbiotics, (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 Bağdathlı, 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 Deseret Alex. 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, T1), the basal diet which reduced in CP content (14%) was investigated as a control negative or basal diet (T2).

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 (T5); 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 Senecio glaucus**

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

| Item                        | Control+ 17.0 % CP | Control- 14 % CP (Basal diet) |
|-----------------------------|--------------------|-------------------------------|
| 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 D3 50000IU; Vit E 16.7 g.; Vit K3 0.67 g.; Vit B1 67 g.; Vit B2 5.00 g.; Vit B3 3.33 mg.; Cholin chloride 400 g.; Biotin 0.07 g.; Niacin 16.7 g.; pantothenic acid 6.7 g.; Folic acid 0.17 g.; Copper 1.7 g.; Iron 25.00 g.; Manganese 10.00 g.; Iodine 0.23 g.; Selenium 33.3 g.; Zine 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-libitum during the digestibility trials.
The digestibility trial lasted for 10 days as a 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 Kjeldahl distillation unit.

**Economical efficiency**

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

\[
\text{Economic efficiency} = \frac{\text{(selling price of 1kg live body weight (LBW) - feeding cost of 1kg live body weight)/ feeding cost of 1kg live body weight)}}{× 100}.
\]

**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, \(\mu\) = overall mean, \(T_i\) = Effect of the \(i^{th}\) treatment and \(e_{ij}\) = residual error.

**RESULTS AND DISCUSSION**

**Chemical composition**

The concentrations 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 18.51 mg/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, T7 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* | T1 | T2 | T3 | T4 | T5 | T6 | T7 | ± SE | Sig |
|------|---------------|----|----|----|----|----|----|----|-----|-----|
| Digestion coefficients (%) | | 74.20 | 69.79 | 71.04 | 71.68 | 74.66 | 72.41 | 74.66 | 2.82 | NS |
| DM | 69.69 b | 63.03 b | 72.15 a | 67.37 ab | 72.32 a | 70.67 b | 72.32 a | 3.32 | * |
| OM | 85.50 ab | 83.62 ab | 85.15 ab | 85.32 ab | 85.63 ab | 85.63 ab | 85.63 ab | 1.67 | * |
| CP | 70.25 | 42.50 | 47.10 | 40.32 | 51.62 | 48.71 | 51.62 | 7.21 | NS |
| CF | 81.53 ab | 78.12 a | 84.93 ab | 83.17 ab | 83.17 ab | 85.64 ab | 87.31 a | 3.11 | * |
| EE | 72.53 ab | 62.31 b | 68.12 ab | 66.1 ab | 72.53 ab | 71.76 ab | 73.85 a | 3.31 | * |
| NFE | 67.88 a | 63.62 b | 65.96 a | 64.57 ab | 67.43 a | 67.43 a | 69.34 a | 2.95 | * |
| TDN | 15.52 ab | 15.13 b | 15.39 ab | 15.65 ab | 15.64 a | 15.64 a | 15.67 a | 0.27 | * |
| DCP | 5.15 a | 2.99 | 3.00 | 3.42 | 2.8 | 3.4 | 2.8 | 0.3 | NS |
| Nitrogen balance (g/h/d) | | 3.15 | 2.99 | 3.00 | 3.42 | 2.8 | 3.4 | 2.8 | 0.3 | NS |
| N I | 0.50 | 0.43 | 0.38 | 0.51 | 0.36 | 0.50 | 0.36 | 0.8 | NS |
| F N | 0.76 ab | 0.59 b | 0.99 a | 0.68 ab | 0.95 a | 0.82 ab | 0.95 a | 0.23 | * |
| Urinary N | 1.89 ab | 1.67 b | 1.84 ab | 2.10 a | 1.91 ab | 1.51 b | 2.24 a | 0.11 | * |
| NB | 59.93 ab | 55.74 a | 59.60 ab | 65.23 a | 63.26 a | 61.44 a | 65.26 a | 2.10 | * |

*T1 Control positive. (17% CP); T2 Basal diet (BD) 14% CP (control negative); T3 Basal diet + 150 ppm BHT; T4 Basal diet + 5g of Senecio glaucus powder /kg feed; T5 Basal diet + 10g of Senecio glaucus powder /kg feed; T6 Basal diet + 0.5ml of Senecio glaucus extract (100 mg/l); T7 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).
Abo-Eid et al.

(P<0.05) higher compared to T2 group. This increase could be due to the improvement in experimental rabbits fed normal antioxidants substances in Senecio glaucus (SG) powder or extract (T3 and T4 or T6 and T7 groups) which stimulate anaerobic fermentation of OM that improve efficiency of nutrients utilization. Also, the digestion coefficients of DM and CF in the T7 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 T7 group rather than tested groups followed by T6, T5, T3 and T4, while, T2 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 those obtained by Abo-Donia et al. (2005).

Nitrogen balance (NB)

Results of nitrogen balance presented in Table (4) showed that there was a significant (P<0.05) increase in NB with T7 groups compared with control and other experimental groups. The highest values of nitrogen balance were significantly (P<0.05) recorded by T7 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 affected 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 T7 group. But there were no significant differences in final body weight between T3, T4, T5, T6 and T7 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 T7 group, whereas, the T2 group present the worst one (1548.1g). It was observed that the total gain of rabbits fed T7 group was significantly (P<0.05) higher than the other groups. While, there was no significant differences in total gain values between T3, T4, T5, T6 and T7. 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 T7 group compared with rabbit control groups (T1 and T2). The results showed insignificant (P>0.05) differenced in the feed intake between groups T3, T4, T5, T6 and T7 (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) (T3 group) and Senecio glaucus (SG) powder(T4 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.
a, b and c : Means within the same row differ significantly (P<0.05); diet + 0.5ml of Senecio glaucous extract (100 mg/l); T7 Basal diet + 1ml of Senecio glaucous extract (100 mg/l).

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

| Item               | T1     | T2     | T3     | T4     | T5     | T6     | T7     | ± SE | sign |
|--------------------|--------|--------|--------|--------|--------|--------|--------|------|------|
| ILBW (g)           | 762.3  | 759.4  | 736.9  | 731.3  | 751.3  | 738.8  | 747.5  | 28.20| NS   |
| FLBW (g)           | 2420.9 | 2357.5 | 2496.3 | 2496.9 | 2500.1 | 2510.5 | 2536.3 | 60.90| *    |
| TG (g)             | 1658.6 | 1548.1 | 1759.4 | 1765.6 | 1748.8 | 1771.7 | 1788.8 | 55.8 | *    |
| TFI (g)            | 5504^a | 5208.3 | 5639.3 | 5767^a | 5808.1 | 5961.5 | 6023.3 | 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   |

*T1 (Control positive), (17% CP); T2 Basal diet (BD) 14% CP (control negative); T3 Basal diet + 150 ppm BHT; T4 Basal diet + 5g of Senecio glaucus powder/kg feed; T5 Basal diet + 10g of Senecio glaucus powder/kg feed; T6 Basal diet + 0.5ml of Senecio glaucous extract (100 mg/l); T7 Basal diet + 1ml of Senecio glaucous extract (100 mg/l).

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 T2 (70.16%). The increase of PI in T3 group may be due to the improvement of the feed conversion. These results are in accordance with those obtained by 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 achieved 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- Manyalawi 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 T7 groups (2637.58g) compared with control positive, T1. The heaviest weight was recorded for T1 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

| Column 1 | Column 2 | Column 3 |
|----------|----------|----------|
| Value 1  | Value 2  | Value 3  |
| Value 4  | Value 5  | Value 6  |
| Value 7  | Value 8  | Value 9  |

*Note: The table data is not visible in the image.*
Table 7
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 |
|--------------------|-----------|
|                    | T₁        | T₂        | T₃        | T₄        | T₅        | T₆        | T₇        |
| Days after storage | 7         |           |           |           |           |           |           |
|                    | 0.45      | 0.47      | 0.58      | 0.71      | 0.45      | 0.55      | 0.43      |
|                    | ±0.05     | ±0.14     | ±0.09     | ±0.03     | ±0.11     | ±0.11     | ±0.10     |
| 90                 | 0.78a     | 0.69ab    | 0.60ab    | 0.58ab    | 0.47b     | 0.53ab    | 0.44c     |
|                    | ±0.05     | ±0.14     | ±0.09     | ±0.01     | ±0.11     | ±0.08     | ±0.12     |

* T₁ (Control positive) (17% CP) ; T₅ Basal diet (BD) 14% CP (control negative); T₃ Basal diet + 150 ppm BHT; T₄ Basal diet + 5g of Senecio glaucus powder/kg feed; T₅ Basal diet + 10g of Senecio glaucus powder/kg feed; T₆ Basal diet + 0.5ml of Senecio glaucus extract (100 mg/l); T₇ 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, odor, 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 T7. 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 |
|-----------------------------------|-------------|
|                                  | T1          | T2          | T3          | T4          | T5          | T6          | T7          |
| 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        | 50.0        | 50.0        | 50.0        | 50.0        | 50.0        |
| 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.

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تأثر إضافة مضادات الأكسدة على أداء النمو ووجودة اللحم في الأرانب النامية

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أجريت هذه التجربة بمزرع الكرام (مزرعة أرانب خاصة بنظام المزرعة)، بالتعاون مع مزرعة ومعامل معهد الدراسات والبحث البيئي - جامعة مدينة السادات، محافظة المنوفية، مصر. كان الهدف من هذه الدراسة هو تحديد تأثير إضافة مضادات الأكسدة الطبيعية بنسبة 5 أو 10 جم من مسحوق أو 0.5 مل أو 1 مل مستخلص نبات الجمعيض الصحرائي / كجم علف من العلقة القاعدية مع مساعد أكسدة صناعي (BHT) بكميات 150 جرجم في المليون / كجم علف من العلقة القاعدية على أداء الأرانب. استخدمت هذه الدراسة عدد 42 أرنب بوزن متوسط 746.8 جم. 

أظهرت النتائج أن معاملات الأكسدة في جميع العناصر الغذائية لم تختلف معنويًا بين المجموعات التجريبية مقارنة بمجموعة الدروى. تبين النتائج تأثير مضادات الأكسدة على جودة اللحم ونسبة الكرمات الكلية في العلقة القاعدية. ورغم أنه لم يتم تأثير تأثير معين على محتوى البروتين، إلا أن الفروقات بين المجموعات التجريبية وال kontrolية كانت واضحة. كما أن تأثير مضادات الأكسدة على النترات والنيتروجين الأيضي كان إيجابيًا. 

أيضًا، سجلت الأرانب المعلاة على العلقة القاعدية السامة معنويًا أفضل قيمة للوزن الجسم والصلاة والأفضلية والنكهة والقولب. بالإضافة إلى ذلك، لم تؤثر مضادات الأكسدة على نسبة الكرمات الكلية في العلقة القاعدية. كان أداء الأرانب المعلاة مع مضادات الأكسدة الصناعي هو الأفضل. 

ما يودي للحفاظ على البيئة ويجعل مردود عالي على الكفاءة الاقتصادية للعملية الإنتاجية.