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Effect of Green Algae and Natural Antioxidant Additioin to the Growing Rabbit's Diet on Productive Performance and Economic Efficiency

Samy Zakarya Sayed Ahmed[1]; Mahmoud Saad Mahmoud Abousekkin[1]; Kamal Mohamed Abd El-Rahman[2] , Hosny El Sayed Ahmed Abo-Eid[1]

[1]Environmental Studies & Research Institute, University of Sadat City
[2]Faculty of Agriculture, Menoufia University

Abstract

The experiment was conducted in the rabbit's farm belonging to Environmental Studies and Research Institute, University Sadat City, Menoufia Governorate, Egypt. This study aimed to investigate the effect of supplementing green algae (Pediastrum spp) and natural antioxidants (Senecio glaucus) in the form of powder or extract on the growth performance of New Zealand white rabbits aged 4 weeks with an average weight of approximately 600 gram.A number of 36 rabbits were used in this experiment, divided randomly into six groups, each group consisting of 6 rabbits. The first group (D1) was fed on commercial diet 17% protein (positive control), the second group (D2) was fed on a basic diet 14% protein (control negative), the third and fourth groups (D3 and D4) were fed on a basic diet supplemented with *Pediastrum* algae in the form of extract and powder and the fifth and sixth groups (D5 and D6) were fed *Senecio glaucus* in the form of extract and powder. The experiment lasted 10 weeks period. The obtained results showed that the addition 10g of *Pediastrum* powder /kg of feed to growing rabbits led to a significant increase in the growth performance (final body weight, daily weight gain, feed conversion ratio and performance index), followed by those fed D6 diet (Basal diet + 10 g of Senecio glaucus powder /kg feed.), while rabbits fed the D5 diet (Basal diet + 10 ml of Senecio glaucus extract /kg feed) had the lowest feed consumption. In general, there was an improvement in some characteristics of the carcass, blood and microbial activity in the cecum in the groups D4 and D6. There was also an improvement in the economic efficiency by adding *Pediastrum* and *Senecio glaucus* compared to the control groups.

Keywords: green algae, antioxidants, rabbits perforamnce, blood parameters and carcass characteristics.

Introduction

In recent decades, rabbits production development has been influenced by various factors such as nutrition, health, environment, genetics, management and other convincing techniques **(Trocino *et al.*, 2019)**. Rabbit production is an important source of animal protein in Africa **(Amaefule *et al.*, 2005).** In addition, rabbit farms play a very imperative role in the national economy of North African countries **(Ayyat *et al.*, 2018).** However, the high cost of feed is the main problem with production of rabbits, which accounts for about 65-75% of the total cost of rabbits production. Reducing high feed costs for rabbit production can be achieved by using inexpensive non-traditional feed or by adding some natural feed additives to rabbit food **(Risam *et al.*, 2005)**. Incorporation of microalgae into animal feed can not only benefit animal performance but can also add value to end products, thus stimulating human health **(Lum *et al.*, 2013).** Pediastrum is a green microalga use primarily as a food supplement due to its potential properties as antioxidant as well as animal feed, and that It has a high protein content of up to 30%. In addition, **Holman and Malau-Aduli (2013)** stated that microalgae species are a suitable food supplement for various farm animals due to their high vitamin content. Therefore, seaweed is suggested to be used as a high-quality additive for animal and poultry feed because of the high content of essential amino acids, vitamins and trace minerals **(Güroy *et al.*, 2007)**. In general, antioxidants can be considered two main groups, natural and synthetic. 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 aim of this study is to investigate the effect of supplemented natural antioxidant *Senecio glaucus* as a dietary powder or extract and green algae (*Pediastrum spp*) on rabbits performance, digestive tract environment, meat quality and economical efficiency.

Materials and Methods

Seaweeds preparation

Green algae (*Pediastrum spp*) were obtained from Algae Technology Unit National Research Center in Giza while, *Senecio glaucus* was collected from the desert of Sadat City. Algae and Senecio glaucus were washed with fresh water 3 times to remove impurities, dried and ground into powder. The experimental materials were used in two forms, the first in the form of a powder and the second in the form of an extract. An extract was prepared from the experimental materials by mixing 100 gm of dried algae powder and *Senecio glaucus* with 1 liter of distilled water separately and then boiled for one hour. The extract was filtered through a clean white cloth. The filter product was taken as 100% concentrated algae extract. the extract that was prepared was sprayed on the base diet 14% protein at a rate of 10 ml per 1 kg of feed immediately before feeding on it, while Powder of experimental materials was added to the amount of 10 g per 1 kg of the base diet containing 14% protein during the manufacture of diets in the form of pellets. after the feed has been prepared, it is packed in clean and dry plastic bags.

Animals, housing and experimental design

A number of 36 growing New Zealand White (NZW) rabbits of 4 weeks old with average weight of approximately 600 grams were used in this experiment, divided randomly into six groups, each group of 6 rabbits was divided into 3 replicates. Experimental rabbits were housed in standard dimension galvanized wire cages fitted with feeder and an automatic nipple drinker, and were kept under the same management conditions throughout the entire experimental period that lasted for 10 weeks. The treatments were as follow: control group fed commercial diet 17% CP, (control positive), the basal diet which reduced in CP content (14%) was investigated as a control negative or basal diet with no seaweeds supplementation; treatments 3 and 4 were fed the basal diet supplemented with 10 ml extract Pediastrum per 1 kg of feed and 10 g Pediastrum Powder per 1 kg ; treatments 5 and 6 were fed the basal diet supplemented with 10 ml extract Senecio glaucus per 1 kg of feed and 10 g Senecio glaucus Powder per 1 kg. Diets were nearly iso-nitrogenaus, iso-fibrus and iso-caloric to meet the nutritional requirements of growing rabbits according to **NRC (1977).** Feed and water were offered ad libitum throughout the experimental period. The ingredients of the control positive and negative diets were presented in **Table 1**.

Table 1. Composition of control and basal diet.

Ingredients	Control (+)17.0 % CP	Control (-)14 % CP
Alfalfa, hay	28.00	20.00
Wheat bran	26.00	28.00
Barley grains ,Ground	20.00	32.00
Soybean meal (44% CP)	10.00	3.00
Yellow corn, ground	10.00	13.00
Wheat straw	2.00	-
Dl-Methionine	0.35	0.35
Premix*	0.50	0.50
Na Cl	0.35	0.35
Di calcium phosphate	1.90	1.90
CaCO3	0.90	0.90
Total	100.00	100.00
Calculating chemical analysis		
Crude protein %	17.02	14.09
Crude fiber % **	13.10	10.72
Ether extract %	2.90	3.02
Calcium %	1.20	1.07
Available phosphorus	0.96	0.98
Lysine %	0.80	0.61
Methionine	0.24	0.20
DE(Kcal/Kg) diet***	3030	3180
ME, kcal/kg diet	2630	2770
Cost/kg of diet in L.E. ****	5.00	4.40

* Each one kg of vitamin & mineral mixture contains: Vit. A 4000000 IU; Vit D_3 50000IU; Vit E 16.7g.; Vit K_3,0.67g.; Vit.B_1 67g; VitB_2 2.00g; Vit. B_6 0.67g; Vit B_{12} 3.33mg; Cholin chloride 400g.; Biotin 0.07g; Niacin 16.7g.; pantothenic acid 6.7g; Folic acid 1.7g; Copper 1.7g; Iron 25.00g; Manganese 10.00g; Iodine 0.25g; Selenium 33.3g; Zinc 23.3g and Magnesium 133.3g 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) =4.36-0.0491xNDF%&NDF%=28.924+0.657xCF%.According to **(Cheeke, 1987)**. ****According to market prices of the year 2020.

Measurements

The change in body weight (CBW) and feed consumption (FC) for rabbits in each replicate were recorded weekly during the trial period of 8 weeks for the nearest gram. Both feed conversion ratio and performance index (PI) were calculated according to the equation mentioned by **North (1981)** as follows: FCR = total feed intake g /g growth PI = (live body weight (kg) / feed conversion) x 100.

Digestibility trial

At the end of the growth experiment conducted digestibility experiments to determine the values of digestion coefficients for dry matter (DM), organic matter (OM), crude fiber (CF), crude protein (CP), nitrogen free extract (NFE), ether extract (EE) and the nutritive values of the experimental diets expressed as total digestible nutrients (TDN) and digestible crude protein (DCP). Three rabbits were randomly selected from each group and housed individually in metabolic cages fitted with a stainless steel mesh and 4 mm mesh to feces retention, while allowing urine to pass freely. rabbits were offered feed and water *ad-libtum* during digestion experiments. The digestion experiment lasted for 10 days as an initial period, while the collection period lasted for 5 days in which faeces were collected daily before the morning meal, freshly weighed and sprayed with 2% boric acid to trap any ammonia exited from the faeces and dry it at 60 ◦C for 48 hours in an air drying oven. Then, the feces were ground and mixed, stored for 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).**

Carcass traits

At the end of the experiment (13 weeks) 18 rabbits (3 rabbits/treatment) were slaughtered according to the standard technique **Cheeke (1987)**. After complete bleeding and removal of the skin and viscera, the hot carcass was weighted. The weights of the internal organs including liver, kidney, spleen, heart, lung, pancreas, abdominal fat, full stomach, whole intestine, and cecum were determined and weighted relative to body weight. The lengths of the elementary tract and carcass were also recorded. The *pH* value of the caecum content was measured using a *pH* meter and the total volatile fatty acid (*TVFA΄s*) were determined by steam distillation using a Micro Kjeldahl distillation unit.

Economical efficiency

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 with using the General Linear Models by **(SAS, 2003)** and simple one-way analysis of variance. Duncan's new multiple range test **(Duncan, 1955)** was applied to separated differences among treatment means. The following model used was: $Y_{ij}=\mu+T_i+ e_{ij}$ whereY_{ij} refers to the observed dependent variable, μ refers to the overall mean, T_i is the main effect of i the different types of algae, and e_{ij} is the random residual error. Comparisons with $p<.05$ were considered significant, and all statements of statistical differences were based on this level unless otherwise noted.

Results and discussion

Chemical composition

The chemical composition of *Pediastrum algae* and *Senecio glaucus* are shown **Table 2**. The chemical composition showed that *Pediastrum algae (ps)* was high content of protein (CP) and ash (31.3 and 18.1) % respectively, while its content of fiber (CF) was low (1.5 %). This is consistent with what was mentioned by **Lee *et al*., 2009; Tippawan and Yuwadee, 2016; Sassi *et al.* (2019)** who reported nearly the same results. **Tippawan and Yuwadee (2016)** also reported that Protein and carbohydrate were the major components in (*Pediastrum tetras, Pediastrum duplex and Pediastrum simplex*) and the value of carbohydrates such as polysaccharides was interesting as a source of antioxidants. **Corrêa da Silva *et al.* (2022)** mentioned that *Pediastrum boryanum* could be a source of phenolic compounds with potential antioxidant activity. The chemical composition of *Senecio glaucus* was CP, CF, Lipid and ash 12.4 ,21.5,2.5 and 9 % for respectively. While, **El-Amier and Abdullah (2015)** mentioned that the chemical composition of *Senecio glaucus* was 9.94, 6.90, 1.40 and 9.27 % for CP, CF, Lipid and ash respectively. also they found that the *Senecio glaucus* extract was high in saponins, phenolic compounds, tannins, alkaloids and flavonoids.

Table 2. Proximate Analysis of *Pediastrum* Algae and *Senecio glaucus*.

Ingredient	DM%	OM%	CP%	CF%	EE%	NFE%	Ash%	DE Kcal/Kg*
Pediastrum spp(PS)	88.1	70	31.3	1.5	18.4	18.8	18.1	2894
Senecio glaucus(SG)	90.3	81.3	12.4	21.5	2.5	44.9	9	2251

* Calculated according to **Cheeke (1987)** DE (Mcal/kg) = 4.36 – 0.049 x NDF, NDF% =28.92 +0.657xCF%

Chemical composition of tested diets

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

Table 3. Chemical composition of the experimental diets (%).

Diets*	DM%	Chemical composition on DM basis						
		OM%	CP%	CF%	EE%	NFE%	Ash%	DE Kcal/Kg
Control diet (+)(D1)	89.2	89.4	17	13.8	2.5	56.0	10.6	2498
Control diet (-)(D2)	89.1	92.1	14.3	10.7	3.6	63.6	7.9	2598
Diet3 (D3)	89.0	92.0	14.3	11.0	3.4	63.4	8.0	2589
Diet4 (D4)	89.8	91.4	14.3	11.9	3.3	61.9	8.6	2560
Diet5(D5)	89.3	91.9	14.2	11.4	3.6	62.7	8.1	2576
Diet6(D6)	90.2	92.2	14.2	11.3	3.0	63.7	7.8	2579

*D1(17% CP) (Control positive); D2 Basal diet (BD) 14% CP (control negative); D3 Basal diet + 10 ml of *Pediastrum* extract/kg feed; D4 Basal diet + 10 g of *Pediastrum* powder/kg feed; D5 Basal diet + 10 ml of *Senecio glaucus* extract /kg feed D6 Basal diet + 10 g of *Senecio glaucus* powder /kg feed.

Growth performance

Growth performance of growing rabbits fed on the experimental diets are presented in **Table 4**. Results indicated that rabbits fed on D4 group had the highest final body weight (FBW) and daily weight gain (DWG), followed by those fed D6. But rabbits fed D2 diet had the lowest FBW and DWG. This increase in weight and live body weight gain may be due to the algae containing some polysaccharides, antioxidants and minerals that improve the environment of the gut, which improves the efficiency of digestion and the weight and health of rabbits. This agrees with what was mentioned by both **El-Banna 2003; El-Banna *et al.* (2005)** who reported that including macro algae in rabbit diets improves the productive performance of growing rabbits in terms of body weight gain (BWG).

Table 4. Growth performance of growing rabbits fed on the experimental diets.

Items	D1	D2	D3	D4	D5	D6	±SE
Initial body weight, g	627.50	624.17	621.67	625.83	629.17	620.00	± 8.16
final body weight, g	1852.50^{ab}	1720.83^{b}	1896.67^{ab}	2035.83^{a}	1729.17^{b}	2007.50^{a}	±62.88
Total weight gain, g	1225.00^{ab}	1096.67^{b}	1275.00^{ab}	1410.00^{a}	1100.00^{b}	1387.50^{a}	±73.74
Total Feed intake, g	5092.5^{a}	5093.3^{a}	4593.5^{ab}	4623.5^{ab}	4410.8^{b}	4702.0^{ab}	±159.00
Total Feed conversion ratio	4.173^{ab}	4.653^{a}	3.610^{bc}	3.303^{c}	4.013^{abc}	3.470^{bc}	± 0.238
Total Performance Index %	89.23^{ab}	74.21^{b}	105.39^{ab}	125.48^{a}	86.54^{ab}	121.91^{a}	±12.65

*D1(17% CP) (Control positive); D2 Basal diet (BD) 14% CP (control negative); D3 Basal diet + 10 ml of ***Pediastrum*** extract/kg feed; D4 Basal diet + 10 g of ***Pediastrum*** powder/kg feed; D5 Basal diet + 10 ml of ***Senecio glaucus*** extract /kg feed D6 Basal diet

+ 10 g of ***Senecio glaucus*** powder /kg feed. **a, b and c: Means within the same row differ significantly (P<0.05); NS =not significant (P>0.05).

Feed intake

Results in **Table 4** indicated that the rabbits received the D5 diet consumed less feed, while there were no significant differences between the rabbits fed on the D3, D4, D6 and the control groups.**Banna *et al.* (2005)** reported that the control group had more feed intake than rabbit group fed on *Ulva lactuca* and *Gntromorpha intestinalis* group. While, **Abo-Eid *et al.* (2019)** showed that adding *Senecio glaucus* extract or powder caused a significant (P<0.05) increment in the feed intake values compared with rabbit control groups.

Feed conversion ratio

Results in **Table 4** showed that The feed conversion ratio (FCR) was the best in rabbits fed on the D4 diet compared to the control group, followed by those fed on the D6 and D3 diets. **Al-Banna 2003; Al-Banna *et al.* (2005)** reported that adding seaweed supplementation to the diet of growing rabbits improved the feed conversion ratio possibly because including macroalgae in the rabbit's diet improves feeding efficiency by enhancing gut integrity, nutrient absorption and infection resistance, which improves the productive performance of the growing rabbits.

Performance Index %

The performance index (PI) was the best in rabbits fed on the D4 diet, but rabbits fed on D2 diet had the lowest PI. This increase in PI values may be due to the improvement of the feed conversion as well as higher live body weight of those groups. **Abo-Eid *et al.* (2019)** reported that there was no significant difference (P>0.05) between all groups in performance index and the highest value was recorded in T3 group (Basal diet + 150 ppm BHT) being (77.77%), while the worst value achieved in T2 (Basal diet 14% CP) being (70.16%). The increase of PI in T3 group may be due to the improvement of the feed conversion.

Nutrients digestibility, Nutritive values and Nitrogen balance

The results of **Table 5** indicated that the rabbits fed on the D4 diet were higher significantly (P < 0.05) compared to the control groups in OM, CP and CF of digestibility followed by those fed on D6. Whereas, D6 group was significantly (P<0.05) higher compared to the control groups in NFE and EE digestibility. This

Table 5. Digestibility coefficients, nutritive values, and nitrogen balance of growing rabbits fed on the experimental diets.

Items	D1	D2	D3	D4	D5	D6	±SE
OM	66.67^{c}	64.67^{c}	71.67^{b}	76.33^{a}	67.33^{c}	76.00^{a}	±1.17
CP	74.67^{a}	57.33^{c}	70.33 ^{ab}	75.67^{a}	64.33 ^{b}	72. 00^{a}	±2.21
CF	43.33^{b}	13.33^{d}	34.33^{c}	56.00^{a}	29.33 ^{c}	46.67 ^{a}	±2.58
EE	82. 67^{d}	88.00^{c}	91.00^{abc}	89.33 ^{bc}	93.67^{ab}	95.00^{a}	±1.56
NFE	69.33^{d}	72.67^{c}	77.00^{b}	79.33^{ab}	73.33^{c}	81.33^{a}	±1.07
DCP	12.72 ^{a}	8.17^{d}	10.03^{bc}	10.79^{b}	9.14^{c}	10.22^{b}	± 0.31
TDN	62.00^{d}	63.33^{cd}	69.67^{b}	73.67^{a}	66.00^{c}	73.67^{a}	±1.09
DE(Kcal/Kg)	2754.33^{d}	2799.33^{cd}	3081.67^{ab}	3258.67^{a}	2928.00^{c}	3259.67^{a}	±46.78
N-Balance g/rabbits	3.24 ^{a}	1.07^{c}	2.54 ^{ab}	3.19^{a}	2.07^{bc}	2.73 ^{ab}	±0.33

*D1(17% CP) (Control positive); D2 Basal diet (BD) 14% CP (control negative); D3 Basal diet + 10 ml of ***Pediastrum*** extract/kg feed; D4 Basal diet + 10 g of ***Pediastrum*** powder/kg feed; D5 Basal diet + 10 ml of ***Senecio glaucus*** extract /kg feed D6 Basal diet + 10 g of ***Senecio glaucus*** powder /kg feed. **a, b and c: Means within the same row differ significantly (P<0.05); NS =not significant (P>0.05).

increase could be due to the improvement in experimental rabbits fed on normal antioxidants substances in *Pediastrum Sp.* and *Senecio glaucus* powder (D4 and D6 groups) which stimulate anaerobic fermentation of OM that improve efficiency of nutrients utilization. This increase could be due to the improvement in the digestive environment of the experimental rabbits fed the natural antioxidants that stimulate the groups. These results were in agreement with those obtained by **Abu Donia *et al.* (2005).** Also, the results in table (5) showed that the rabbits fed on the D4 diet were higher significantly (P < 0.05) compared to the control groups in TDN, DE and N-Balance, followed by those fed on D6. The increase in TDN of these groups may be due to the significant improvement in the digestion coefficients of most nutrients, and these results are consistent with that reported by **Dung *et al.* (2010).**

Carcass characteristics

Results presented in **Table 6** indicated that the heaviest empty carcass weight (kg) was recorded for D4 (1.27) and D6 (1.23). While, the lightest weight was recorded for D2(1.0). This is in agreement with **Chermiti *et al.* (2009)** who observed a reduction in carcass adiposity when up to 30% of dried *Ulva* species were included in rabbit diets. the group fed on D5 had significantly (P<0.05) higher Deboning% values being (48.57). **GU *et al.* (1988)** concluded that 2% seaweed inclusion on the broiler feed improved dressing percentage. For abdominal fat, the results indicated that the group fed on D6 had the highest value (4.10), while the groups D4 and D5 had the lowest value (1.9 and

Table 6. Carcass characteristics of rabbits fed diets containing *Pediastrum* (PS) and *Senecio glaucus* (SG) (Means ±SE).

Items	D1	D2	D3	D4	D5	D6	±SE
Pre-slaughter wt.(kg)	1.97^{ab}	1.75^{b}	1.98^{ab}	2.14^{a}	1.92^{ab}	2.11^{a}	±0.087
Empty carcass (Kg)	1.10^{ab}	1.00^{b}	1.17^{ab}	1.27^{a}	1.17^{ab}	1.23^{a}	±0.068
Dressing %	61.57	62.20	62.43	63.23	64.53	63.23	±1.05
Deboning %	44.67^{b}	47.37^{ab}	47.50^{ab}	47.77^{ab}	48.57^{a}	48.37^{ab}	±1.14
Total giblets %	36.33^{a}	26.90^{b}	28.20^{b}	27.97^{b}	27.27^{b}	27.27^{b}	±2.07
Edible giblets %	10.67^{a}	7.60^{b}	7.40^{b}	7.23^{b}	7.47^{b}	7.23^{b}	± 0.76
Abdominal fat %	2.50^{ab}	2.23^{b}	2.87^{ab}	1.90^{b}	1.97^{b}	4.10^{a}	±0.62
Liver %	7.73^{a}	5.37^{b}	5.13^{b}	4.57^{b}	4.93^{b}	4.80^{b}	±0.62
Heart %	1.73	1.40	1.50	1.70	1.67	1.50	± 0.15
Spleen %	0.13^{ab}	0.10^{b}	0.13^{ab}	0.20^{a}	0.10^{b}	0.13^{ab}	± 0.02
Body length (cm)	61.33^{a}	44.00^{b}	48.33^{b}	47.67^{b}	45.00^{b}	47.00^{b}	±1.53
Small ints.Length (cm)	292.00	268.33	275.00	278.33	262.33	280.0	± 26.45
Large ints.Length (cm)	124.00^{ab}	133.33^{ab}	117.00^{b}	160.00^{a}	151.00^{ab}	162.33^{a}	±11.60

*D1(17% CP) (Control positive); D2 Basal diet (BD) 14% CP (control negative); D3 Basal diet + 10 ml of ***Pediastrum*** extract/kg feed; D4 Basal diet + 10 g of ***Pediastrum*** powder/kg feed; D5 Basal diet + 10 ml of ***Senecio glaucus*** extract /kg feed D6 Basal diet + 10 g of ***Senecio glaucus*** powder /kg feed.
**a, b and c: Means within the same row differ significantly (P<0.05); NS =not significant (P>0.05).

1.97) %. **Abu Hafsa *et al.* (2019)** also observed lower abdominal fat in the *Ulva fasciata* and *Sargassum cinereum* treatment groups compared to the control group as for there was a consistent decrease in the relative weights of liver and abdominal fat upon using of *Ulva fasciata* and *Sargassum cinereum* at 1.5 and 3% in the laying quail's diet. As for the spleen, the results indicated that the group fed on D4 was significantly (P < 0.05) higher (0.20%) compared to D2 and D5 (0. 1%). There were no significant differences(P > 0.05) in heart weight among the treatment groups. The results indicated that the group fed on D6 was significantly(P<0.05) higher in the length of the large intestine compared to D3 and D1, which had the lowest values. In calves, the addition of algae to the diet improved carcass characteristics **(Christaki and Florou-Paneri, 2010)**. Incorporation of 3% *U. lactuca* in broiler chickens increased breast muscle yield compared to birds solely fed corn diet **(Abudabos, 2013)**.

Blood parameters

Table 7 illustrate a summary of the results of some blood parameters for growing NZW rabbits as affected by supplemental *Pediastrum (PS)* and *Senecio glaucus (SG)* powder or extract. The results indicated that groups fed on diet D3, D4 and D6 recorded significantly ($P<0.05$) highest plasma values of total protein compared with group fed

Table 7. Blood parameters as affected by using of *Pediastrum* (PS) and *Senecio glaucus* (SG) (Means ±se).

Items	D1	D2	D3	D4	D5	D6	±SE
Total protein	5.37^{ab}	4.00^{b}	6.37^{a}	6.73^{a}	5.00^{ab}	6.40^{a}	± 0.63
Albumin	3.1	2.67	3.30	3.90	3.17	3.43	± 0.39
Globulin	2.27	1.33	3.07	2.83	1.83	2.97	± 0.57
A/G Ratio	1.56	1.98	1.15	1.38	1.94	1.25	± 1.03
Urea	34.33^{abc}	30.33^{bc}	29.67^{c}	31.0^{bc}	39.0^{ab}	34.0^{abc}	± 2.66
Total lipids	192.67^{ab}	152.67^{b}	228.0^{a}	173.00^{ab}	175.33^{ab}	160.00^{b}	± 19.91
Tri-glycerides	46.00^{b}	50.67^{ab}	61.67^{ab}	56.00^{ab}	52.67^{ab}	55.00^{ab}	± 7.67
Cholesterol	46.33^{b}	44.67^{b}	73.00^{a}	51.33^{ab}	53.67^{ab}	46.00^{b}	± 7.64
LDL	36.67^{ab}	26.67^{abc}	40.00^{a}	29.00^{abc}	35.33^{abc}	24.33^{c}	± 4.59
HDL	30.33	27.33	34.67	38.67	33.33	35.33	± 5.06
AST µ/L	40.67	35.67	46.00	48.00	49.00	32.33	± 5.73
ALT	40.00	46.67	59.00	60.67	69.33	39.33	±0.32
Creatinine	1.10	1.10	1.31	1.15	1.36	1.18	± 0.13
Antioxidant capacity	1.19^{a}	1.14^{a}	1.09^{a}	1.03^{ab}	1.19^{a}	1.14^{a}	± 0.095

*D1(17% CP) (Control positive); D2 Basal diet (BD) 14% CP (control negative); D3 Basal diet + 10 ml of ***Pediastrum*** extract/kg feed; D4 Basal diet + 10 g of ***Pediastrum*** powder/kg feed; D5 Basal diet + 10 ml of ***Senecio glaucus*** extract /kg feed D6 Basal diet + 10 g of ***Senecio glaucus*** powder /kg feed.
**a, b and c: Means within the same row differ significantly ($P<0.05$); NS =not significant ($P>0.05$).

on D2 (Basal diet 14%CP). Also, the results indicated that the group fed on the D3 diet was significantly ($P < 0.05$) higher in total cholesterol, LDL, total lipids and tri-glycerides compared to the control groups. While the group fed on the D2 and D6 diets were significantly ($P < 0.05$) lower in total lipids. **Abu Hafsa *et al.* (2021)** found that the consumption of macroalgae decreased blood lipid and cholesterol levels. The results indicated that there were no significant ($P > 0.05$) differences between the experimental groups for both albumin, globulin, A/G ratio, HDL, ALT, creatinine and anti-oxidant capacity. **El-Deek *et al.* (2011)** found that incorporation of different levels of brown algae (*Sargassum spp.*) into broiler feed had a significant effect on HDL and LDL values. Recent studies have demonstrated that seaweed contains health-promoting nutrients and phytochemicals with good antioxidant and cholesterol-lowering properties **(Patara *et al*., 2011).**

Caecum characteristics, microflora and activity

Data presented in **Table 8** showed that rabbits fed on (D6) were higher in caecum weight full and empty caecum weight (10.5 and 8.43) respectively. while, caecum length was significantly (P<0.05) increased with group fed on diet contained

Table 8. Caecum characteristics, microflora and activity.

Items	D1	D2	D3	D4	D5	D6	±SE
Caecum weight full%	9.40^{ab}	7.03^{bc}	8.97^{abc}	10.33^{a}	6.17^{c}	10.50^{a}	± 0.89
Caecum weight empty%	8.00^{a}	5.73^{ab}	6.63^{ab}	7.97^{a}	4.30^{b}	8.43^{a}	± 0.80
Caecum length	10.90^{bc}	12.17^{b}	14.00^{a}	14.67^{a}	10.33^{c}	13.67^{a}	± 0.42
Caecum pH	6.71^{ab}	6.80^{a}	6.55^{ab}	6.01^{d}	6.46^{bc}	6.19^{cd}	± 0.09
Total anaerobic bacterial count (log cfu/g)	5.00^{bc}	4.65^{c}	4.87^{bc}	6.24^{a}	4.72^{c}	5.22^{b}	± 0.12
Anaerobic cellulytic bacterial count (log cfu/g)	3.94^{c}	3.29^{c}	4.07^{c}	6.81^{a}	3.44^{c}	5.51^{b}	± 0.41
E.coli count (log cfu/g)	5.13^{a}	5.30^{a}	4.58^{b}	4.08^{c}	5.00^{a}	4.19^{c}	± 0.01
TVFA meq/ 100ml caecum juice	2.95^{c}	2.84^{c}	2.97^{c}	4.00^{a}	2.79^{c}	3.65^{b}	± 0.10

*D1(17% CP) (Control positive); D2 Basal diet (BD) 14% CP (control negative); D3 Basal diet + 10 ml of *Pediastrum* extract/kg feed; D4 Basal diet + 10 g of *Pediastrum* powder/kg feed; D5 Basal diet + 10 ml of *Senecio glaucus* extract /kg feed D6 Basal diet + 10 g of *Senecio glaucus* powder /kg feed.
**a, b and c: Means within the same row differ significantly (P<0.05); NS =not significant (P>0.05).

Pediastrum Powder (D4) (14.67). Group fed on *Pediastrum* Powder (D4) was the lowest caecum *PH* (6.01) while, was high in group fed on (D2) being (6.80). Results showed that Number of TBC were the highest of group fed on D4 (6.24) compared to control diets (D1 and D2) (5 and 4.65) respectively.

The highest number for anaerobic cellulytic bacterial count were significantly (P<0.05) observed for group fed on (D4) being (6.81) while the lowest number was recorded with group fed on (D2) being (3.29). The data in Table (8) indicated that caecum count of E. coli significantly (P<0.05) decrease with group fed on D4 being (4.08) followed by group fed on D6 being (4.19) compared to control diets. Results showed that (*TVFA*) for growing rabbits were affected by supplementation of *Pediastrum* and *Senecio glaucus* in the diets.

Results Indicated that group fed on D4 recorded significantly (P<0.05) highest *TVFA* (4.00) compared with group fed on control groups (D1, D2) (2.95, 2.84). In general, it is observed from the previous results that rabbits fed with algae and *Senecio glaucus*, have the highest weight and longest caecum and produce more concentration of *VFA*, which indicating a higher fermentation rate and explaining the higher nutritional values for digestion and for rabbits fed on the diet containing antioxidants.*VFA* are produced as end products of bacterial fermentation in the caecum of rabbits **(Cheek, 1987)**. It has been estimated that the use of *VFA* as an energy

Table 9. Economic efficiency of growing rabbits as affected by *Pediastrum* (PS) and *Senecio glaucus* (SG).

Items	D_1	D_2	D_3	D_4	D_5	D_6
Total weight gain /rabbit (Kg)	1.23	1.10	1.28	1.41	1.10	1.39
Total revenue /rabbit (LE)	55.35	49.35	57.38	63.45	49.50	62.44
Total feed intake/rabbit (Kg)	5.10	5.20	4.59	4.62	4.41	4.70
Price of feeding/kg (LE)	5.00	4.40	4.80	4.80	4.60	4.60
Total feed cost /rabbit (LE)	25.50	22.88	22.05	22.19	20.29	21.63
Net revenue/rabbit (LE)	29.85	26.47	35.33	41.26	29.21	40.81
Economic efficiency	1.17	1.16	1.60	1.86	1.44	1.89
Relative economic efficiency	100	98.80	136.87	158.81	122.98	161.18

*D1(17% CP) (Control positive); D2 Basal diet (BD) 14% CP (control negative); D3 Basal diet + 10 ml of *Pediastrum* extract/kg feed; D4 Basal diet + 10 g of *Pediastrum* powder/kg feed; D5 Basal diet + 10 ml of *Senecio glaucus* extract /kg feed D6 Basal diet + 10 g of *Senecio glaucus* powder /kg feed.

Economic efficiency

The effect of dietary *Pediastrum (PS) and Senecio glaucus (SG)* (powder or extract) supplementation on the economic efficiency is presented in **Table 9**. 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 *Pediastrum spp(PS)* compared to the control group (D1 and D2), which recorded the lowest values of net revenue and economic efficiency. These results indicated that dietary *Senecio glaucus* and *Pediastrum* (powder or extract) from the economical point of view tend to improve the net revenue compared with control positive and basal diets (control negative).These results are consistent with what was reported by **Kumar and Kaladharan (2007)** who found that Seaweeds being rich in minerals, vitamins, polyunsaturated fatty acids as well as phycocolloids, partial substitution of costly protein sources in animal feeds with seaweed protein may improve feed quality while reducing the cost. Also, **Abo Eid *et al.* (2019)** found that there was an improvement in the average values of net revenue, economic efficiency and relative economic efficiency due to feeding growing rabbits with supplemented diets Senecio glaucus powder or extract compared to the control group.

Conclusion

Finally, we conclude that incorporation of Pediastrum algae and Senecio glaucus in powder form at 10 g/kg in the diet of growing rabbits improves the productive and economic performance of growing rabbits without increasing feed intake. There was also an improvement in some characteristics of the carcass, blood and bacterial activity in the cecum when these additives were used. However, more research is needed to determine the most effective algae and the optimal level of inclusion for rabbit feeding.

References

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

Abo-Eid, H. A., Abousekken, M. S. and El-Rashedey, M. M. 2019. Effect of antioxidants supplementation on growth performance and meat quality of growing rabbits. Egyptian Journal of Nutrition and Feeds, 22(3), 561-576.

Abu Hafsa, S.H., Zeweil, H.S., Zahran, S.M., Ahmed, M.H., Dosoky, W. and Rwif, N.A. 2019. Effect of dietary supplementation with green and brown seaweeds on laying performance, egg quality, blood lipid profile and antioxidant capacity in Japanese quail. EPSJ. 39(1):41–5.

Abu Hafsa, S. H., Khalelb, M. S., El-Gindyc, Y. M. and Hassanb, A. A. 2021. Nutritional potential of marine and freshwater algae as dietary supplements for growing rabbits. Italian Journal of Animal Science, VOL. 20, NO. 1, 784–793.

Abudabos, A.M., Okab, A.B., Aljumaah, R.S., Samara, E.M., Abdoun, K.A., and Al-Haidary, A.A. 2013. Nutritional value of green seaweed (Ulva lactuca) for broiler chickens. Ital. J. Anim. Sci. 12(2):28.

Amaefule, K. U., Iheukwumere, F. C. and Nwaokoro, C. C. 2005. A note on the growth performance and carcass characteristics of rabbits fed graded dietary levels of boiled pigeon pea seeds (Cajanus cajan). Livest. Res. Rural Dev., 17 (5): 48.

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

Ayyat, M. S., Al-Sagheer, A. A., Abd El-Latif, K. M., Bakry, A., and Khalil, B. A. 2018. Organic selenium, probiotics, and prebiotics effects on growth, blood biochemistry and carcass traits of growing rabbits during summer and winter seasons. Bio. Trace Element Res., 186:162–173.

Candan, T. and Bağdath, A. 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.

Chermiti, A., and Rjiba, S., Mahouachi, M. 2009. Marine plants: a new alternative feed resource for livestock. FAO/IAEA international symposium on sustainable improvement of animal production and health; 2009 June 8–11; Vienna, Austria. p. 240.

Christaki, E., Karatzia, M. and Florou-Paneri P. 2010. The use of algae in animal nutrition. Journal of the Hellenic Veterinary Medical Society , 61(3):267-276.

Corrêa da Silva, M. G., Pires Ferreira, S., Dora, C. L., Hort, M. A., Giroldo, D., Prates, D. F. and Muccillo-Baisch, A. L. 2022. Phenolic compounds and antioxidant capacity of Pediastrum boryanum (Chlorococcales) biomass. International Journal of Environmental Health Research, 32(1), 168-180.

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

Dung, D. D., Godwin, I. R. and Nolan, J. V. 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., and Abdullah, T. J. 2015. Evaluation of nutritional value for four kinds of wild plants in Northern sector of Nile Delta, Egypt. Open Journal of Applied Sciences, 5(07), 393.

El-Banna, S.G. 2003. Sea algae supplementation of Baladi rabbits diet and its implication on certain biochemical parameters. Pesticide Control Environ Sci. 11:81–96.

El-banna, S.G., Hassan, A.A. Okab, A.B. Koriem, A.A. and Ayoub, M.A. 2005. Effect of feeding diets supplemented with seaweed on growth performance and some blood hematological and biochemical characteristics of male Baladi rabbits. In Proceedings of the 4th

International Conference on Rabbit Production in Hot Climates, Sharm Elsheikh, Egypt, 24–27 February 2005, Egyptian Rabbit Science Association. pp. 373–382.

El-Deek, A.A., Al-Harthi, M.A., Abdalla, A.A. and Elbanoby, M.M. 2011. The use of brown algae meal in finisher broiler diets. Egypt Poult Sci. 31(IV):767–781.

Gu, H.Y., Shu, Z.Z. and Liu, Y.G. 1988 Nutrient composition of marine algae and their feeding on broilers. Chin. J.Anim. Sci., 3, 12–14.

Güroy, B. K., Cirik, Ş. Ü. K. R. A. N., Güroy, D., Sanver, F., and Tekinay, A. A. 2007. Effects of Ulva rigida and Cystoseira barbata meals as a feed additive on growth performance, feed utilization, and body composition of Nile tilapia, Oreochromis niloticus. Turkish Journal of Veterinary & Animal Sciences, 31(2), 91-97.

Holman, B. W. B. and Malau- Aduli, A. E. O. 2013. Spirulina as a livestock supplement and animal feed. A review. J Anim Physiol Anim Nutr., 97: 615 –623.

Kumar, V., and Kaladharan, P. 2007. Amino acids in the seaweeds as an alternate source of protein for animal feed. Journal of the Marine Biological Association of India, 49(1), 35-40.

Lee, S. H., Kim, A. D., Kang, M. C., Lee, J. B. and Jeon, Y. J. 2009. Potential antioxidant activities of enzymatic digests from fresh water microalgae, Pediastrum duplex and Dactylococcopsis fascicularis. Algae, 24(3), 169-177.

Lum, K. K., Kim, J. and Lei, X. G. 2013. Dual potential of microalgae as a sustainable biofuel feedstock and animal feed. J Animal Sci Biotechnol . , 4:53 – 59.

Marty, J. and Vernay, M. 1984. Absorption and metabolism of the volatile fatty acids in the hind-gut of the rabbit. Br J Nutr. Mar;51(2):265-77. doi: 10.1079/bjn19840031. PMID: 6704374.

Mohamed, H. M. H. and Mansour, H. A. 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.

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

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

Patarra, R.F., L., Paiva, A.I., Neto Lima, E. and Baptista J. 2011. Nutritional value of selected macroalgae. J Appl Phycol. 23(2):205–208

Risam, V., Bhasin, G. K. and Das, K. S. 2005. Rabbit for meat and wool production: A review. Indian J. Animal Sci., 75: 365- 382.

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

Sassi, K. K. B., J. A. D., Silva, C. D., Calixto, Sassi, R., and Sassi, C. F. D. C. 2019. Metabolites of interest for food technology produced by microalgae from the Northeast Brazil. Revista Ciência Agronômica, 50, 54-65.

Tippawan, P., and Yuwadee, P. 2016. Isolation and cultivation of green alga, Pediastrum spp. for nutritional value study. Journal of Pure and Applied Microbiology, 10(3), 1787-1796.

Trocino, A., Cotozzolo, E., Zomeño, C., Petracci, M., Xiccato, G. and Castellini C. 2019. Rabbit production and science: the world and Italian scenarios from 1998 to 2018, Ital. J. Anim. Sci., 18 (1):1361- 1371.