International Journal of Environmental Studies and Researches (2022), 1(2):222-236

Effect of brown algae and natural antioxidants Supplementation in 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] and 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 rabbits farm belonging to of Environmental Studies and Research Institute, University of Sadat City, Menoufia Governorate, Egypt. The aim of this study was to study the effect of adding brown algae (*Sargassum muticum*) and natural antioxidants (Senecio glaucus) in powder or extract form on the growth performance of growing New Zealand white rabbits aged 4 weeks with an average weight of approximately 600 grams. 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 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 *Sargassum* 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 results indicated that the addition of Senecio glaucus powder to the feed of growing rabbits with a level of 10g of *Senecio glaucus* powder/kg of feed led to a significant increase in the growth performance variables (final body weight, daily weight gain, feed conversion ratio and performance index), while rabbits fed on the D5 diet (Basal diet + 10 ml of Senecio glaucus extract /kg feed) had the lowest feed consumption. Also, there was an improvement in some characteristics of the carcass, blood and microbial activity in the cecum. Also, observed

an improvement in the economic efficiency by adding *Senecio glaucus* and *Sargassum* algae compared to the control groups.

Keywords: Brown algae, antioxidants, rabbits performance ,blood parameters and carcass characteristics.

Introduction

Seaweed is a renewable natural resource, growing in large quantities along the coasts of Egypt such as the coasts of the Red Sea, the Mediterranean Sea and the Nile River. The main uses of seaweed are as sources of plant colloids, as a feed, as a fertilizer and for direct use in human nutrition **(Abbott, 1996).** Animal nutrition plays an important role in animal production projects because it accounts for 65-70% of the total costs of these projects. Therefore, there is interest in using seaweed in the development of low-cost, high nutritional value diets for human and animal nutrition, especially animal nutrition because sea vegetables are able to accelerate the growth of oysters, tilapia, salmon, etc., all of which are of great commercial importance **(Fleming et al., 1996; Horn, 1989).** Marine macroalgae could be a potential low-cost source of protein for animals. Higher feed costs for rabbit production can be reduced by using inexpensive non-traditional feed or by adding some natural feed additives to rabbits food **(Risam et al., 2005).** 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). Kumar and Kaladharan (2007)** found that seaweeds could be a complementary source of food proteins for human and animal nutrition. Besides as source of proteins, they can be used as excellent binders in formulated feeds as majority of them contain phycocolloids such as agar, algin and carrageenan. The main objective of this study is to know the effect of adding brown algae (*Sargassum muticum*) and natural antioxidants (*Senecio glaucus*) on growth performance, meat quality and economic efficiency of rabbits.

Materials and methods

Seaweeds preparation

Brown algae (*Sargassum muticum*) (SM) was collected from Marsa Alam, Red sea, Egypt 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 Sargassum extract per 1 kg of feed and 10 g Sargassum 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**.

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

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.

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 at60 ◦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 cecum content was measured using a pH meter and the total volatile fatty acid (TVFA´s) was determined by steam distillation using a Micro Kjeldahl distillation unit.

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: $Y_{ij}=\mu+T_i+ e_{ij}$ where Y_{ij} refers to the observed dependent variable, μ refers to the overall mean, T_i is the main effect of i th 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.

Economic 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.

Results and discussion

Chemical composition

The chemical composition of *Sargassum algae* and *Senecio glaucus* are shown in **Table 2**.

Table 2. Proximate Analysis of Sargassum muticum algae and Senecio Glaucus.

Ingredient	DM%	OM%	CP%	CF%	EE%	NFE%	Ash%	DE Kcal/Kg*
Sargassum muticum (SM)	87.2	59.1	8.4	17.9	3.1	29.7	28.1	2366
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%.

Azad and Teo Zhi Xiang (2012) found that *Sargassum sp.* contains CP, CF, EE, NFE and ash (13.85, 7.58, 0.48, 53.21 and 24.88) respectively. While, **Muraguri (2016)** found that *Sargassum oligocystum* contains CP, CF, EE and ash (5.64,9.40,0.4 and 13.18) respectively. **Arguelles et al. (2019)** mentioned that *sargassum vulgare* contains CP, CF, NFE and ash (7.69,22.59,34.18 and 27.09) respectively. **El-Amier and Abdullah (2015)** found that *Senecio glaucus* extract contains CP, CF, EE and ash (9.94,6.90,1.40 and 9.27) respectively. Also found that the *Senecio glaucus* extract was high in saponins, phenolic compounds, tannins, alkaloids and Flavonoids.

Chemical composition of tested diets

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

Growth performance

Growth performance of growing rabbits fed on the experimental diets are presented in **Table 4**. The results indicated that rabbits fed D6 diet had the highest final body weight (FBW) and body weight gain (BWG). But rabbits fed on D2 and D5 diets had the lowest FBW and BWG. This agrees with what was mentioned by **Abo-Eid et *al.*, (2019)** who found that including 1 mL of Senecio glaucous extract (100 mg/L) in rabbit diets improved the performance of growing rabbits in terms of final body weight (FBW) and body weight gain (BWG).

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)	89.9	91.4	14.3	9.5	3.6	64.0	8.6	2637
Diet4 (D4)	89.7	91.6	14.2	10.7	3.5	63.3	8.4	2598
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 Sargassum extract/kg feed; D4 Basal diet + 10 g of Sargassum 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.

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}	1878.33^{ab}	1793.33^{b}	1729.17^{b}	2007.50^{a}	±65.49
Total weight gain, g	1225.00^{ab}	1096.67^{b}	1249.17^{ab}	1169.17^{ab}	1100.00^{b}	1387.50^{a}	±69.24
Total Feed intake, g	5092.5^{a}	5093.3^{a}	4661.8^{ab}	4578.2^{ab}	4410.8^{b}	4702^{ab}	±180.98
Total Feed conversion ratio	4.17^{ab}	4.65^{a}	3.73^{b}	3.93^{ab}	4.01^{ab}	3.47^{b}	± 0.23
Total Performance Index %	89.23^{ab}	74.21^{b}	100.86^{ab}	92.08^{ab}	86.54^{b}	121.91^{a}	±11.40

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

The results in **Table 4** indicated that the rabbits received the D5 diet consumed less feed compared to the control groups. This is inconsistent with what was reported by **Abo-Eid et al. (2019)** who found that adding Senecio glaucus extract or powder caused a significant ($p < 0.05$) increase in feed intake values compared to control groups in rabbits.

Feed conversion ratio

Results in **Table 4** showed that the feed conversion ratio (FCR) was the best in rabbits fed on the D6 and D3 diets compared to the control group. This improvement in the feed conversion rate apparent in these diets may be due to the reduced feed intake in relation to the higher body weight gain which caused some improvements in digestive tract environment of experimental rabbits fed with antioxidants in Sargassum extract (group D3) and Senecio glaucus powder (Group D6). **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 D6 diet (121.91), but rabbits fed D2 diet had the lowest PI (74.21). 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%) and the increase of PI in T3 group may be due to the improvement of the feed conversion.

Nutrients digestibility, Nutritive values and Nitrogen balance

Digestibility coefficients, nutritive values and nitrogen balance of growing rabbits fed on the experimental diets are presented in **Table 5**. The results indicated that the rabbits fed on the D6 diet were higher significantly (P < 0.05) compared to the control groups in OM, CP, CF, EE and NFE digestibility. Whereas, D4, D5 and D2 groups were higher significantly (P<0.05) compared to D1 (control group) in EE digestibility. This increase could be due to the improvement in the digestive environment experimental rabbits fed on normal antioxidants substances in (*Senecio glaucus*) powder (D6 group) which stimulate anaerobic fermentation of OM and CF that improve efficiency of nutrients utilization. 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 D6 diet were higher significantly (P < 0.05) compared to the control groups in TDN and DE Whereas, D1 group was higher compared to D6 in N-Balance and DCP. 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).**

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^{bc}	64.33^{c}	69.00^{b}	67.00^{bc}	67.33^{bc}	76.00^{a}	±1.27
CP	74.67^{a}	57.33^{d}	67.67 ^{abc}	62.33^{cd}	64.33 ^{bcd}	72. 00^{ab}	±2.48
CF	43.33^{a}	13.33^{d}	17.67^{cd}	23.00^{bc}	29.33 ^{b}	46.67 ^{a}	±2.79
EE	82. 67^{b}	88.00^{ab}	69.33^{c}	94.33 ^{a}	93.67^{a}	95.00^{a}	±2.54
NFE	69.33^{d}	72.67^{cd}	77.00^{b}	73.67^{bc}	73.33^{c}	81.33^{a}	±1.12
DCP	12.72 ^{a}	8.17^{d}	9.76^{bc}	8.80^{cd}	9.14^{bcd}	10.22^{b}	± 0.35
TDN	62.00^{c}	63.33^{bc}	66.00^{b}	65.33^{bc}	66.00 ^{b}	73.67^{a}	±1.13
DE(Kcal/Kg)	2754.33^{c}	2799.33^{bc}	2938.00^{b}	2890.33^{bc}	2928.00^{b}	3259.67^{a}	±50.14
N-Balance g/rabbits	3.24 ^{a}	1.07^{c}	2.38 ^{ab}	2.06 ^{bc}	2.07 ^{bc}	2.73 ^{ab}	±0.31

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

Carcass characteristics

Carcass characteristics of rabbits fed diets containing *Sargassum muticum and Senecio glaucus (SG)* presented in **Table 6**. Results Indicated that the heaviest empty carcass weight (kg) was recorded for D6 (1.23). while, the lightest weight was recorded for D2. The group fed on Senecio glaucus extract or powder (D5 and D6) had significantly (P<0.05) higher the dressing% and deboning% values. For abdominal fat, the results indicated that the group fed on D6 had the highest value (4.10), while the groups D3 and D4 had the lowest value (1.67 and 1.57) %. 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 rabbits diet. **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 with D3 was higher significantly (P < 0.05) than the rest of the groups. There were no significant differences in heart weight among the treatment groups. The results indicated that the group fed on D6 was significantly higher in the length of the large intestine compared to D1, which had the lowest values.

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}	1.76^{b}	1.98^{ab}	1.93^{ab}	1.92^{ab}	2.11^{a}	±0.088
Empty carcass (Kg)	1.10^{ab}	1.00^{b}	1.10^{ab}	1.13^{ab}	1.17^{ab}	1.23^{a}	±0.067
Dressing %	61.57^{bc}	62.20^{bc}	60.67^{c}	63.00^{ab}	64.53^{a}	63.23^{ab}	±0.69
Deboning %	44.67^{c}	47.37^{a}	44.83^{bc}	47.10^{ab}	48.57^{a}	48.37^{a}	±0.74
Total giblets %	36.33^{a}	26.90^{b}	34.43^{a}	26.23^{b}	27.27^{b}	27.27^{b}	±1.75
Edible giblets %	10.67^{a}	7.60^{bc}	9.27^{ab}	6.73^{c}	7.47^{bc}	7.23^{c}	± 0.61
Abdominal fat %	2.50^{b}	2.23^{b}	1.67^{b}	1.57^{b}	1.97^{b}	4.10^{a}	±0.44
Liver %	7.73^{a}	5.37^{bc}	6.10^{b}	4.33^{c}	4.93^{bc}	4.80^{bc}	±0.50
Heart %	1.73	1.40	1.80	1.53	1.67	1.50	± 0.16
Spleen %	0.13^{b}	0.10^{b}	0.20^{a}	0.10^{b}	0.10^{b}	0.13^{b}	± 0.019
Body length (cm)	61.33^{a}	44.00^{b}	58.67^{a}	45.00^{b}	45.00^{b}	47.00^{b}	±1.39
Small ints.Length (cm)	292.00^{a}	268.33^{ab}	210.67^{b}	290.00^{a}	262.33^{ab}	280.00^{a}	± 19.84
Large ints.Length (cm)	124.00^{b}	133.33^{ab}	140.00^{ab}	128.33^{ab}	151.00^{ab}	162.33^{a}	±11.12

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

Blood parameters

Table 7 illustrate a summary of the results of some blood parameters for growing NZW rabbits as affected by supplemental (*Sargassum muticum*) (SM) and *Senecio glaucus* (SG) powder or extract. The results indicated that groups fed on diet D3, D6 recorded significantly (P<0.05) highest plasma values of total protein and globulin compared with group fed on D2(Basal diet 14%CP) While the group fed on D6 recorded the lowest significant value for A/G Ratio compared to the rest of the groups. 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).** The results indicated that there were no statistically significant (P > 0.05) differences between the experimental groups in the rest of the blood parameters.

Caecum characteristics, microflora and activity

Table 8 shows the characteristics of Caecum and the microbial activity of rabbits fed on diets containing *Sargassum muticum* and *Senecio glaucus*. The results showed that caecum weight and empty caecum weight for the groups fed on D3 and D6 are higher than other groups. while, caecum length was significantly (P<0.05) increased with supplemental *Sargassum muticum* (D4) and *Senecio glaucus* powder(D6), caecum

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	5.33^{ab}	4.00^{b}	6.17^{a}	5.37^{ab}	5.00^{ab}	6.40^{a}	± 0.63
Albumin	3.1^{ab}	2.67^{b}	3.33^{ab}	3.90^{ab}	4.17^{a}	3.43^{ab}	± 0.37
Globulin	2.27^{ab}	1.33^{ab}	2.83^{a}	1.47^{ab}	0.83^{b}	2.97^{a}	± 0.56
A/G Ratio	1.56	1.98	3.00	3.36	1.94	1.25	± 1.03
Urea	34.33^{abc}	30.33^{bc}	35.67^{abc}	38.0^{abc}	39.0^{ab}	34.0^{abc}	± 2.66
Total lipids	192.67^{ab}	152.67^{b}	194.67^{ab}	194.57^{ab}	175.1^{ab}	160.07^{b}	± 19.88
Tri-glycerides	46.00^{b}	50.67^{ab}	46.00^{b}	65.33^{ab}	52.67^{ab}	55.00^{ab}	± 7.67
Cholesterol	46.33^{b}	44.67^{b}	45.33^{b}	56.67^{ab}	53.67^{ab}	46.00^{b}	± 7.64
LDL	36.67^{ab}	26.67^{abc}	30.33^{abc}	32.00^{abc}	35.33^{abc}	24.33^{bc}	± 4.59
HDL	30.33	27.33	39.67	32.67	33.33	35.33	± 5.06
AST µ/L	40.67^{ab}	35.67^{ab}	43.00^{ab}	51.33^{a}	49.00^{ab}	32.33^{ab}	± 5.73
ALT	40.00	46.67	44.33	64.00	69.33	39.33	± 10.80
Creatinine	1.10	1.05	1.22	1.24	1.36	1.18	± 0.13
Antioxidant capacity	1.19^{a}	1.14^{a}	1.03^{ab}	1.02^{ab}	1.19^{a}	1.14^{a}	± 0.10

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

length decreased with control group. PH of caecum was high in group fed on *Sargassum* extract (D3) being (7.06) compared to other experimental groups.

Also, the results in **Table 8** indicated that rabbits fed on the D6 diet had the highest values for the total number of anaerobic bacteria (TBC), the number of cellular anaerobic bacteria (CBC) and total volatile fatty acids (TVFA) compared to the rest of the groups, although there were no significant differences between all groups experimental groups in these parameters. The data indicated that caecum count of E. coli significantly (P<0.05) decrease with group fed on (D6) being (4.19) followed by group fed (D3) being (4.57) compared with control groups. 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

Table 8. Caecum characteristics, microflora and activity.

Items	D1	D2	D3	D4	D5	D6	±SE

Items	D1	D2	D3	D4	D5	D6	
Caecum weight full%	9.40^{ab}	7.03^{bc}	11. 70^{a}	9.63^{ab}	6.17^{c}	10.50^{a}	± 0.85
Caecum weight empty%	8.00^{ab}	5.73^{bc}	9.60^{a}	7.77^{ab}	4.30^{c}	8.43^{a}	± 0.80
Caecum length	10.90^{c}	12.17^{b}	13.17^{ab}	14.00^{a}	10.33^{c}	13.67^{a}	± 0.41
Caecum pH	6.71^{bc}	6.80^{ab}	7.06^{a}	6.84^{ab}	6.46^{cd}	6.19^{d}	± 0.10
Total anaerobic bacterial count (log cfu/g)	5.00^{ab}	4.65^{cd}	4.96^{abc}	4.56^{d}	4.72^{bcd}	5.22^{a}	± 0.11
Anaerobic cellulytic bacterial count (log cfu/g)	3.94^{ab}	3.29^{b}	3.55^{b}	2.70^{b}	3.44^{b}	5.51^{a}	± 0.52
E.coli count (log cfu/g)	5.13^{a}	5.30^{a}	4.57^{b}	5.17^{a}	5.00^{a}	4.19^{b}	± 0.13
TVFA meq/ 100ml caecum juice	2.95^{b}	2.84^{b}	2.74^{b}	2.60^{b}	2.79^{b}	3.65^{a}	± 0.14

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

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 source provides 40% of the maintenance energy source for posterior intestinal tissue metabolism **(Marty and Vernary, 1984).**

Economic Efficiency

The effect of dietary Sargassum muticum and Senecio glaucus (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 Sargassum muticum 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 Sargassum muticum (powder or extract) from the economical point of view tend to

Conclusion

Finally, we conclude that the addition of *Senecio glaucus* and *Sargassum* algae are beneficial to improve the productive and economic performance of rabbit growth at 10g/kg powdered feed. However, more research is needed to determine the most effective algae and the optimal level of inclusion for rabbit feeding.

Table 9. Economic efficiency of growing rabbits as affected Sargassum (SS), Senecio *glaucus* (SG).

Total weight gain /rabbit (Kg)	1.23	1.10	1.25	1.17	1.10	1.39
Total revenue /rabbit (LE)	55.35	49.35	56.21	52.61	49.50	62.44
Total feed intake/rabbit (Kg)	5.10	5.20	4.66	4.58	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	22.38	21.98	20.29	21.63
Net revenue/rabbit (LE)	29.85	26.47	33.84	30.64	29.21	40.81
Economic efficiency	1.17	1.16	1.51	1.39	1.44	1.89
Relative economic efficiency	100	98.80	129.17	119.10	122.98	161.18

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

References

Abbott, A. I. 1996. Ethnobotany of seaweeds:clues to uses of seaweeds.Hydrobiologia, 326:15-20.

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.

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

Arguelles, E. D. L. R., Monsalud, R. G. and Sapin, A. B. 2019. Chemical composition and in vitro antioxidant and antibacterial activities of Sargassum vulgare C. Agardh from Lobo, Batangas, Philippines. Journal of the International Society for Southeast Asian Agricultural Sciences (ISSAAS), 25(1), 112-122.

Azad, S. A. and Xiang, T. Z. 2012. Suitability of seaweed meal incorporated with Rhodovulum sp. bacterium as feed supplement for finfish larvae. Borneo Science, 30, 57-61.

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

Chermiti, A., Rjiba, S. and 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.

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.

Fleming, A.E., Barneveld, R.J. and Hone, P.W. 1996. The development of artificial diet for abalone. Aquaculture, 140: 5-53.

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.

Horn, M.N. 1989. Biology of marine herbivorous fishes. Oceanogr. Mar. Biol. Ann. Rev., ,27: 167-272.

Ismail, A. M., Abou-El-Ellaa, M. A. and Sedki, A. A. 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.

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.

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.

Muraguri, E. N., Wakibia, J. G. and Kinyuru, J. N. 2016. Chemical composition and functional properties of selected seaweeds from the Kenya coast. J Food Res, 5(6), 114.

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.

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.