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Effect of Partially Substitution of Soybean Protein with Azolla (*Azolla pinnata*) on Productive Performance and Carcass Traits of Growing Rabbits

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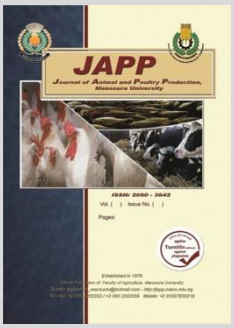

ABSTRACT

The present experimental work investigated partially substituting soybean protein with different levels of dried Azolla' effect on productive performance, carcass traits and economic efficiency of growing rabbits. A number of 36 local Black Balady rabbits, 5 weeks' old were weighed and divided into four equal groups (3 replicates each). The 1st group fed a basal diet (without Azolla), while the 2nd,3rd and 4th groups were fed diets contained 20, 30 and 40%, respectively dried Azolla substituted for soybean protein. All Azolla diets resulted in the highest (P<0.05) final body weight values at 14 weeks' age over the control. Weight gain from 5 to 14 weeks' age took the same trend. No significant alternations of dietary Azolla levels was noticed on feed intake, feed conversion ratio and performance index. Viability percentage recorded the highest percent for group fed 30% Azolla compared with the control. Rabbits fed Azolla at 20 and 30% of soybean protein recorded lower serum cholesterol values than the control. The different levels of Azolla, especially 10.08% Azolla (40% of soybean protein) resulted in improving serum HDL. Most blood hematology traits were not affected by dietary Azolla inclusion in the rabbits' diets. Carcass traits were not influenced by different levels of Azolla substitution. Conclusively, the inclusion of dried Azolla substitution up to 40% of soybean protein in the diet of growing rabbits positively affected growing rabbits' productive performance and had no adverse influence on blood biochemical and carcass traits under Egyptian environmental condition.

Keywords: Azolla, Carcass, Growth, Hematology, Rabbits, Serum.

INTRODUCTION

In Egypt the shortage of fodder and increased feeding costs especially from feed ingredients such as soybean and barley pushed scientists to find alternatives that can commercially compensate these resources to reduce costs in meat production. Rabbits called pseudo-ruminants, they can utilize forage protein more efficiency than other livestock. Thus, growing rabbits can play a major role as an alternative source of white meat. Adams (2001) reported that nutrition is not only crucial for optimum growth, but it is also important for the optimum expression of growth potential. The feed conversion efficiency of nutrients to animal products e.g. meat, eggs, milk, etc. depends on stress factors for immune and health status of the animal resulted from the housing of animals, feed quality, feed intake capacity of animals, rate of digestion and rate of nutrients absorption and sufficiency of nutrient elements (Babinszky, 2013). So, the essential role of nutritionists is to reduce the costs of ingredients/feedstuffs with optimizing growth and productive performance and try to decrease its possible adverse effects (Zeng *et al.*, 2015).

Under these circumstances, various locally available low cost feed resources such as Azolla was assessed in the past for reducing the feed cost in the rations of livestock. Protein is the most important component in the diet, which commonly depends on the traditional sources of protein such as soybean meal, which are costly pose a major problem. To make rabbit rearing more profitable in a small scale enterprise, there is a need for the development of cheap sources of feed as an alternative to replace expense protein sources in their diet. Azolla is a small aquatic fern (Mohamed *et al.*, 2018) which flows on the water surface and has the ability to grow easily in the tropics and subtropics with minimum investment cost, since it grows naturally in stagnant water of river, canal, ponds etc. (Debashis *et al.*, 2016). Azolla can voluntarily inhabit in fresh water with potent of speed growing to double its biomass within two or three days.

Azolla is one of the locally available aquatic *Pteridophyte* which is rich in protein and almost all essential amino acids (Alalade and Iyayi, 2006 and Mandal *et al.*, 2012). It is also found to contain vitamins (vitamin B_{12}, A and beta-carotene), growth promoter intermediaries and minerals like calcium phosphorous, iron, copper and magnesium (Pillai *et al.*, 2002). Regarding phytochemical properties of Azolla, Mithraja *et al.* (2011) reported that it contains flavonoids, phenolic, tannins and saponins that a diverse pharmacological properties including antioxidant, anti-carcinogenic, anti-allergic and anti-inflammatory. Azolla utilization was rational in broiler chicken, laying

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hens and rabbits (Balaji *et al.*, 2009, Alalade *et al.*, 2007 and Anitha *et al.*, 2016).

Therefore, the current study was performed to investigate the effect of graded dietary levels of sun dried Azolla as a substitute source of soybean protein on growth performance of Black Balady rabbits.

MATERIALS AND METHODS

This experiment implemented at rabbit branch, El-Serw Research Station, Animal Production Research Institute, Agriculture Research Center, Ministry of Agriculture, Egypt. Thirty-six Black Balady rabbits of Five weeks' age were randomly distributed into four equal dietary groups (each of three replicates and 3 rabbits/replicate) based on average body weight (508±4 g) and reared till 14 weeks' age. The rabbits housed on a grower cages of 50 x 50 x 35 cm dimensions and fed their respective experimental diets with available drinking water via stainless-steel nipple all the time in the same environmental conditions. Samples of dried Azolla were taken to determine approximate analysis according to AOAC (1990) method Table (1).

Table 1. Chemical analysis of dried Azolla.

Nutrients	%
Crude protein	28.0
Ether extract	2.0
Crude ash	25.8
Digestible energy	2438 (Kcal/kg)
Carbohydrates	26.2
Crude fiber	18.0

The basal and experimental diets:

The dietary experimental diets were formulated as follow: The 1st diet served as a control (basal diet without Azolla), while the 2nd, 3rd and 4th diets were formulated by substituting soybean protein with dried Azolla at the rates of 5.03, 7.54 and 10.08% that represents 20, 30 and 40% of soybean protein, respectively. The ingredients, composition of the tested diets and calculated analysis of the basal diet according to feed composition tables for rabbits' feedstuffs established by feed composition tables for animal & poultry feedstuffs used in Egypt (2001) and NRC (1994) are presented in Table (2).

Growth performance traits:

Live body weight (LBW), feed intake (FI) and number of dead rabbits were recorded. Weight gain (WG) and feed conversion ratio (FCR, %) were calculated every three weeks and viability percent was calculated for the whole period. The performance index was computed using the formula of Amber *et al.* (2004) on a group basis:

Performance index (%) = Final live body weight (Kg) / Feed conversion ratio x 100.

Serum biochemical parameters and Hematology:

During slaughter for three rabbits per treatment, two samples of blood were collected from each rabbit, the first sample was collected in tubes without anticoagulant and kept at room temperature until centrifuged at 3500 rpm for 20 minutes for serum separation. Afterwards blood serum was used for the determination of total protein, triglycerides, total cholesterol and liver enzymes activities (alanine aminotransferase, ALT and aspartate aminotransferase, AST) by using commercial kits. The second blood sample was taken in tubes containing EDTA (anticoagulant) to determine some hematological traits which included red blood cells ($RBCx10^6$), hematocrit (HCT, %), hemoglobin (Hb, g/dl), white blood cells ($WBC x10^3$), Neutrophils (N, %), Lymphocytes (L, %), N/L %, Monocytes (M, %), Basophils (B, %) and Eosinophils (E, %) according to Moore *et al.* (2015).

Carcass quality:

At 14 weeks' age (end of the experiment), three rabbits from each treatment were randomly reserved and fasted for 12 hrs., thereafter weighed and slaughtered for studying carcass traits. Carcass parts, included heart, liver, edible parts, back quarters, front quarters, lumber, spleen and kidney were presented as a percent of LBW. Dressing percentage was calculated according to Lukefar *et al.* (1982).

Economic efficiency:

Economical efficiency for weight gain was expressed as rabbit production thought the study and estimated using kilmer and Armbruster (1984) equation as follows:

Economic efficiency (%) = (Net return, EGP / Total feed cost, EGP).

Where: Net return = Total return – Total feed cost.

Table 2. Feed ingredients and calculated analysis of the experimental diets.

Item	Control	Azolla substitution (% of soybean meal protein)		
		20	30	40
Ingredients				
Yellow corn	8.00	8.00	8.00	8.00
Barley	20.00	20.00	20.00	21.70
Wheat bran	23.00	23.00	22.00	20.00
Soy bean meal (44%)	16.00	13.20	12.00	10.80
Dried Azolla	00.00	5.03	7.54	10.08
Alfalfa hay	25.00	25.00	25.00	25.00
Mint straw	5.00	2.77	2.46	1.42
Di-calcium phosphate	1.20	1.20	1.20	1.20
Limestone	1.00	1.00	1.00	1.00
Vit. & Min. premix[1]	0.30	0.30	0.30	0.30
NaCl	0.40	0.40	0.40	0.40
DL- Methionine (99%)	0.10	0.10	0.10	0.10
Total	100	100	100	100
Calculated Analysis[2]				
Crude protein (%)	18.17	18.17	18.17	18.16
DE (Kcal / kg)	2784.15	2775.92	2766.89	2775.07
Crude fiber (%)	13.44	13.05	13.06	12.81
Ether extract (%)	2.57	2.71	2.73	2.75
Ca (%)	1.11	1.16	1.18	1.20
Av. Phosph. (%)	0.49	0.51	0.51	0.51
Lysine (%)	0.89	0.81	0.76	0.72
Methionine (%)	0.42	0.41	0.39	0.38
Meth. + Cyst. (%)	0.66	0.62	0.60	0.58
Price (EGP/kg) [3]	5.24	5.25	5.27	5.28

[1] **Each one kilogram of mineral–vitamin premix includes: Vitamin A, 160,000 IU; Vitamin E, 125 mg; Vitamin K_3, 17 mg; Vitamin B_1, 13 mg; Vitamin B_2, 43 mg; Vitamin B_6, 18 mg; Pantothenic acid, 85 mg; Vitamin B_{12}, 0.17 mg; Niacin, 230 mg; Folic acid, 12 mg; Biotin, 0.6 mg; Choline chloride, 4300 mg; Fe, 0.37 mg; Mn, 670 mg; Cu, 56 mg; Co, 3 mg; Se, 2.2 mg and Zn, 480 mg.**

[2] **According to Feed Composition Tables for Animal & Poultry Feedstuffs used in Egypt (2001) and NRC (1994).**

[3] **Price of one Kg (EGP), at time of experiment, for various used ingredients: Yellow corn, 5.5; Barley, 4.5; Soybean meal, 8.1; Wheat bran, 3.3; Alfalfa hay, 3.6; Azolla, 5.0; Mint straw, 1.6; Di-calcium, 12; Limestone, 0.50; Vit. & Min., 35; Nacl,1.5 and Meth.,40.0.**

Statistical analysis:

Statistical analysis of data was performed using the General Linear Models Procedure utilizing Statistical Package of Social Sciences' computer software (SPSS, 2008). The following model was used as follows:

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

Where: Y_{ijk}**=An observation;** μ **= Overall mean;** T_i **= Effect of Azolla levels and** e_{ij}**= Experimental error. Differences among treatments were subjected to Duncan´s Multiple Range Test (Duncan, 1955).**

RESULTS AND DISCUSSION

Chemical analysis of Azolla:

The proximate analysis of Azolla powder is presented in Table (1). The chemical analysis of the tested Azolla elucidated that crude protein (CP), ether extract (EE), ash, carbohydrates (NFE) and crude fiber (CF) were 28.00, 2.00, 25.80, 26.20 and 18.00%, respectively with digestible energy (DE) of 2438 Kcal/Kg of Azolla powder. According to the chemical composition of *Azolla pinnata* published by Anitha *et al.* (2016) in terms of dry matter (DM), organic matter (OM), CP, EE, CF, ash and NFE content, being 4.6, 82.66, 22.48, 4.50, 14.70, 17.34 and 40.98%, respectively, the used source in the present work contained higher proportions of CP, CF and ash.

Productive performance:

The productive performance of broiler rabbits fed diets with various levels of Azolla from 5 to 14 weeks' age is shown in Table (3). The obtained data showed significant (P<0.05) differences among values of BW at 8 and 11 weeks of age than the control diet when the rabbits fed diets contained substitution percent of 30 and 40% Azolla from soybean protein. In addition, the growing rabbits received 20, 30 and 40% Azolla as a partial replacement for soybean protein recorded high (P<0.05) values of LBW at 14 weeks of age as compared to the control diet. The same trend was observed in total weight gain from 5 to 14 weeks of age. There are no significant alternations of dietary various levels of Azolla on feed intake (FI) and feed conversion ratio (FCR). Feed intake slightly decreased and FCR slightly improved in 20 and 30% Azolla substitution groups than the control one. Jiao *et al.* (2014) indicated that there is a moderate positive genetic correlation between growth and FI as well as average daily gain (ADG) and FCR. Moreover, it is well known that several factors affect the DMI of animals, e.g. breed, age, physiological status, palatability of the feed and others. In the present study the non-significant changes in FI may reflect the possibility of weight gain due to the better utilization of Azolla tested diets which were formulated to be almost similar in CP, CF and energy content (Table 2). Feed conversion ratios obtained in the present study were within the range and in consistency with the values reviewed and published by Gidenne and Maertens (2016).

Table 3. Effect of soybean meal protein substitution levels with dried Azolla on growth performance of growing rabbits

Characteristics	Control	Azolla (% of soybean protein)			SEM	Sig.
		20	30	40		
BW at 5weeks (g)	500.0	500.0	506.7	523.3	7.3	NS
BW at 8 weeks (g)	1031.1^{b}	1045.0^{b}	1177.8^{a}	1165.6^{a}	23.8	*
BW at 11 weeks (g)	1406.7^{b}	1514.4^{ab}	1645.6^{a}	1666.4^{a}	41.4	*
BW at 14 weeks (g)	1826.7^{b}	1997.7^{a}	2013.3^{a}	2038.^{3a}	32.8	*
Total weight gain (g)	1326.7^{b}	1497.8^{a}	1506.7^{a}	1505.0^{a}	30.42	*
Total feed intake (kg)	4.84	4.67	4.76	4.88	0.10	NS
FCR (g feed/g gain)	3.69	3.11	3.16	3.25	3.05	NS
Performance index	50.72	64.21	63.99	62.81	2.41	NS
Viability (%)	77.80	77.80	100	88.89	4.74	NS

$^{a, b}$ Means in the same row having different superscripts are significantly different (P≤0.05).

NS= Not significant; SEM = Standard Error of Mean; Sig. = Significance level; * = Significant at P≤0.05.

The improvement in final LBW and total WG due to inclusion of dried Azolla substitution up to 40% from soybean protein probably due to *Azolla pinnata* is a good source of protein (Indira *et al.*, 2009). Azolla high nutritive value referred back to its content of most essential amino acids (Alalade and Iyayi, 2006), minerals (e.g., iron, calcium, magnesium, potassium, phosphorus and manganese) and adequate levels of vitamin A precursor (beta carotene) and vitamin B_{12}. In addition to its content from probiotic and bio polymers (Pillai *et al.*, 2002). This trend came on line with findings of Debashis *et al.* (2016) who found that 5% *Azolla pinnata* replacement for concentrate mixture improved feed conversion efficiency and growth rate of Hariana heifers without any harmful effect on feed consumption, digestibility and blood constituents profile.

Regarding weight gain, the current results are in consistency with those obtained by Sireesha *et al.* (2017a) who concluded that replacement of conventional protein source by sun-dried Azolla in the rabbit diets up to10% improved the average body weight gains and lowered the FCR in New Zealand white rabbits under tropical conditions. Also, body weight of birds significantly improved with incorporation of Azolla meal up to 5% in the diet of poultry (Shoukat *et al.*, 2015 and Shamna *et al.*, 2013). On contrary, Anitha *et al.* (2016) reported that the inclusion of Azolla in the diets of rabbits as replacement to dry matter at 1.5 and 3% levels did not affect body weight gain of rabbits.

In respect of FI, Anitha *et al.* (2016) reported that the average daily feed consumption was slightly reduced when Azolla was fed at 3% level as replacement to dry matter in the basal diet. On the other hand, Ramesh *et al.* (2011) reported that rabbits fed 100% concentrate feed gave significantly (P<0.05) lower FI with better FCR and higher DWG than Azolla fed groups at the rates of 10, 15 and 20%. However, Gidenne and Lebas (2006) decided that daily FI and consequently FCR is more correlated with the less digestible fiber than with the DE content of diets because of the close relationship between dietary fiber and

DE content. They added that the FCR decreases linearly with increasing DE concentration in the diet.

Performance index (PI) and viability:

As shown in Table (3), no significant effect due to dietary treatments could be demonstrated on performance index and viability. However, in respect of viability, it is noticed that the most pronounced sequent effect was in viability of rabbits where the best value (ranged from 100 to 88.9%) was achieved by feeding diets contained Azolla at the substitution rate reached 30 and 40% form soybean protein, while it was 77.8% for those fed the control diet. This positive effect during the growing period on viability could be attributed to the constituents of Azolla from vitamins (vitamin B_{12}, A and beta-carotene), growth promoter intermediaries and minerals (Pillai *et al.*, 2002) and its nutrient content (Alalade and Iyayi 2006 and Balaji *et al.*, 2009). In addition to the phytochemical properties of Azolla due to its content of flavonoids, phenolic, tannins and saponins which has diverse pharmacological properties throughout its antioxidant, anti-carcinogenic, anti-allergic and anti-inflammatory properties (Mithraja *et al.*, 2011).

It is clear that, earlier studies reported by Turrens *et al.* (1984) confirmed the antioxidant function of Azolla which act as a synchronized and sensible system to prevent damage of tissues and body fluids which induced by free radicals that physiologically produced or in response to stress agents, e.g. inflammation infection or disease. Moreover, Halliwell (1996) reported thereafter that the stability between free radicals and the defenses of antioxidant are able to fulfill their biological roles because it proceeds slightly the reactive species. Even in healthy individuals, repairing system happens at a low level and handle damage. This may explain the better viability level in groups of growing rabbits fed dried Azolla in their diets than that in the control group.

Serum biochemical:

The results in Table (4) described the effect of different levels of Azolla in rabbit's diets on serum biochemical traits at the end of study. Serum biochemical data were within the normal range for growing rabbits. Generally, no significant differences were found among the groups fed diets contained Azolla that replaced 20, 30 and 40% of soybean protein compared to the control group. However, the rabbits fed Azolla diets (20 and 30% of soybean protein) recorded lower value of serum cholesterol than the control rabbits. Also, it is noticed that most pronounced effect was in HDL and LDL where the high Azolla replacement (40%) resulted in improving serum HDL and decreasing LDL level. Other blood biochemical measurements such as total protein, albumin, globulin, triglycerides, and VLDL, were found similar to control. It seems that the inclusion of Azolla in diets of rabbits reduced liver activity enzymes (AST and ALT) to be within the normal range than the control group which was higher than it. Total serum protein is utilized, generally, for determination of body condition and albumin helps as the most amino acids' promising source for tissue proteins' synthesis (Yaman *et al.*, 2000). In the present study, no significant differences were observed among the experimental groups of total serum protein (g/dl), albumin, globulin, AST and ALT as presented in Table (4) and falls within the normal range which was reported by Özkan *et al.* (2012).

Table 4. Effect of soybean meal protein substitution levels with dried Azolla on serum biochemical traits of growing rabbits.

Characteristics	Control	Azolla (% of soybean protein)			SEM	Sig.
		20	30	40		
Serum biochemical						
Total protein (g/dL)	6.33	6.33	7.33	6.33	0.19	NS
Albumin (g/dL)	4.23	4.17	4.60	4.11	0.12	NS
Globulin (g/dL)	2.37	2.40	2.67	2.63	0.06	NS
Triglycerides (mg/dL)	84.67	89.67	80.67	92.33	4.45	NS
Cholesterol (mg/dL)	55.00	49.67	45.33	56.67	2.54	NS
VLDL (mg/dL)	17.00	18.00	16.00	18.33	0.93	NS
HDL (mg/dL)	48.67	50.33	49.33	66.67	6.43	NS
LDL (mg/dL)	120.00	113.67	117.67	60.93	10.67	NS
AST (U/L)	92.33	71.33	60.67	60.33	50.57	NS
ALT(U/L)	75.67	59.67	51.67	53.33	4.25	NS

NS= Not significant; SEM = Standard Error of Mean.; Sig. = Significance level.

These results have support from a study by Mishra *et al.* (2016) who found similar values and within the normal values of blood cholesterol, total protein, albumin, and triglycerides in all broiler chicken groups fed diets replaced with 5%, 7.5% and 10% levels Azolla meal. They also reported that liver enzymes in blood was found similar in all treatment groups. Also, Anitha *et al.* (2016) reported that Azolla meal support a normal blood profile and all animals had normal metabolic profile. Therefore, it can be used as good ingredient in rabbit feeding up to the level of three percent of dry Azolla (60 percent of fresh Azolla). Leja *et al.* (2007) and S˘aric´ *et al.* (2009) indicated that the reduction in AST and ALT used as indicator of rabbit liver functions enhancement which they attributed to balanced nutrient profiles and antioxidant components of feed ingredients.

Hematology traits:

Generally, the data concerning the hematology traits were within the normal range of growing rabbits fed diets with different levels of Azolla as presented in Table (5).

Table 5. Effect of soybean meal protein substitution levels with dried Azolla on blood hematology traits of growing rabbits

Characteristics	Control	Azolla (% of soybean meal protein)			SEM	Sig.
		20	30	40		
Red blood cells ($x10^6$/L)	6.33	6.67	6.00	7.67	0.28	NS
Hematocrit (%)	49.00	39.33	37.00	46.67	2.48	NS
Hemoglobin (g/dl)	11.33	11.33	10.33	12.67	0.40	NS
White blood cells($x10^3$/µl)	4.67	4.00	3.67	4.00	0.38	NS
Neutrophils (%)	44.67^{a}	39.67^{ab}	30.00^{b}	27.00^{b}	2.76	*
Lymphocytes (%)	41.00^{b}	47.00^{ab}	56.33^{a}	59.67^{a}	2.79	*
N / L	1.18^{a}	0.85^{ab}	0.53^{b}	0.47^{b}	0.11	*
Monocytes (%)	9.00	10.00	9.33	10.00	0.23	NS
Eosinophil (%)	3.33	3.00	3.00	3.00	0.08	NS
Basophil (%)	1.00	0.67	1.00	1.00	0.08	NS

[a, b]: Means in the same row with different superscripts are significantly different (P≤0.05).

NS = Not significant; SEM = Standard Error of Mean; Sig. = Significance level; * = Significant at P≤0.05.

No significant differences were detected among rabbits fed dietary treatments in red blood cells (RBC), hematocrit (HCT), hemoglobin (Hb) and total count of white blood cells (WBC). Neutrophils (N%) and lymphocytes

(L%) were (P<0.05) affected by dietary treatments, which N% was significantly decreased by feeding diet contained medium and high levels of Azolla, but L% was increased in the opposite. Generally, these results indicated that most hematology traits were not affected by the dietary Azolla inclusion in growing rabbit's diets. The values obtained herein are in the range published by Melillo (2007) and Moore *et al.* (2015). Similarly, Dhumal *et al.* (2009) reported feeding Azolla meal in broiler improved the antibody titer values as compared to control group at 35th days of age in commercial broilers. Anitha *et al.* (2016) concluded that the inclusion of sun dried Azolla in broiler rabbits' diet up to 3% does not affect its hematological parameters.

Carcass traits:

Different dietary levels of Azolla did not appear to influence all studied carcass traits (Table 6). However, it is interesting to note that relative dressing, back and front quarter percentages were insignificantly increased by feeding diet contained high level of Azolla (40% of soybean protein) by about 3.62, 3.54 and 12.31%, respectively compared to the control diet. Dressing % in present study ranged from 54.3 to 57.3% which is almost similar to 54.8 and 57.29% reported by Agrahar-murugkar *et al.* (2000) and Rahman *et al.* (2013) under conservative feeding schemes. They also noticed a significant improvement in carcass characteristics of New Zealand white rabbits fed 10% Azolla in its diets. They added that the scope for inclusion of sun-dried Azolla as an unconventional natural protein feed source in diets of rabbits is feasible up to 10% and recommended without any negative harmful effects. On contrary, Ramesh *et al.* (2011) found that feeding Azolla for broiler rabbits of 6 weeks' age at the rate of 10, 15 and 20% of the concentrate feed had no significant effect on dressing % and other all carcass traits. They found also that there were no significant differences among groups in terms of edible and inedible offal's.

Table 6. Effect of soybean meal protein substitution levels with dried Azolla on carcass traits of growing rabbits (% from LBW).

Characteristics	Control	Azolla (% of soybean meal protein)			SEM	Sig.
		20	30	40		
Live body weight (g)	2153	2498	2083	2405	99.16	NS
Dressing (%)	55.3	55.0	54.3	57.3	1.00	NS
Heart (%)	0.29	0.24	0.26	0.29	0.01	NS
Liver (%)	4.12	4.18	3.89	3.62	0.15	NS
Edible parts (%)	4.31	4.35	4.08	3.78	0.16	NS
Back quarter (%)	17.80	18.06	17.87	18.43	0.34	NS
Front quarter (%)	18.03	19.98	19.73	20.25	0.40	NS
Lumber (%)	15.45	12.46	11.10	14.27	0.94	NS
Spleen (%)	0.06	0.06	0.06	0.04	0.01	NS
Kidney (%)	0.81	0.75	0.67	0.73	0.03	NS

NS= Not significant; SEM = Standard Error of Mean; Sig. = Significance level.

Economic efficiency (EE):

Data as shown in Table (7), from the values of EE it could be noticed that all different levels of Azolla caused positive insignificant influence on EE of feeding as compared to the control diet. However, the growing rabbits fed diet contained Azolla at the replacement rate of 40% from soybean protein recorded the lowest EE value.

Table 7. Effect of soybean meal protein substitution levels with dried Azolla on economic efficiency of growing rabbits.

Characteristic	Control	Azolla (% of soybean meal protein)			SEM	Sig.
		20	30	40		
Total feed intake (Kg/rabbit)[1]	4.84	4.67	4.76	4.88	-	-
Total weight gain (Kg/rabbit)	1.327	1.498	1.507	1.505	-	-
Price/Kg feed (EGP)	5.24	5.25	5.27	5.28	-	-
Total feed cost (EGP)[2]	25.38	24.51	25.09	25.79	0.53	NS
Price/kg live body weight (EGP)	40.00	40.00	40.00	40.00	-	-
Total return (EGP)[3]	53.07^{b}	59.91^{a}	60.27^{a}	60.3^{a}	1.22	*
Net return (EGP)[4]	27.69^{b}	35.41^{a}	35.18^{a}	34.41^{ab}	1.34	*
Economic efficiency (EE)[5]	1.11	1.45	1.41	1.35	1.18	NS
Relative economic efficiency (REE)[6]	100	130.63	127.03	120.72	1.18	NS

1. Total feed intake (Kg/rabbits) = Daily feed intake x 63 days.
2. Total feed cost (EGP) = Total feed intake (Kg) x price / Kg feed (EGP).
3. Total return/ rabbits (EGP) = Total weight gain / rabbits (Kg) x Price / Kg live body weight (EGP).
4. Net return / rabbit (EGP) = Total return / rabbit (EGP) – Total feed cost / rabbit (EGP).
5. Economic Efficiency (E.E) = Net return per rabbit (EGP) / Total feed cost per rabbit (EGP).
6. Relative Economic Efficiency (REE) = (E.E / E.E of control) x 100.
$^{a, b}$: Means in the same row with different superscripts are significantly different (P≤0.05);
NS= Not significant; SEM = Standard Error of Mean; Sig. = Significance level; * = Significant at P≤0.05.

Ahmed *et al.* (2010) concluded that ensiled Azolla can be economically included in rabbit's diets up to 30% with agricultural roughages without adverse effects on rabbit's performance under the local Egyptian condition. In this concern, Sireesha *et al.* (2017b) considered the parameters of economic importance, e.g. cost of ration and cost per kg gain and concluded that the inclusion of 10% Azolla in rabbit diets was beneficial in reducing the cost of feed per kg gain.

CONCLUSION

Results in the current study imply an important inclusion of dried Azolla substitution up to 40% from soybean protein in growing rabbit's diet during 5-14 weeks of age, where it resulted in positive effects on productive performance and feeding economic efficiency. Furthermore, it didn't have any adverse influence on serum biochemical, hematology traits and carcass quality.

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تأثير الاستبدال الجزئي لبروتين فول الصويا بالأزولا (*Azolla pinnata*) على الأداء الإنتاجي وصفات الذبيحة للأرانب النامية

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تم تصميم الدراسة الحالية لمعرفة تأثير الاستبدال الجزئي لبروتين فول الصويا بمستويات مختلفة من الآزولا المجففة على الأداء الإنتاجي ، وصفات الذبيحة والكفاءة الاقتصادية للأرانب النامية. تم وزن ٣٦ أرنب محلي بلدي أسود ، عمر ٥ أسابيع ، وقسمت إلى أربع مجموعات (كل مجموعة من ٣ مكررات). المجموعة الأولى (الكونترول) تم تغذيتها على العليقة الأساسية (بدون أزولا) ، بينما تم تغذية المجموعات الثانية والثالثة والرابعة على علائق تحتوي على ٢٠ و ٣٠ و ٤٠ ٪ أزولا مجففة بدلا من بروتين فول الصويا على التوالي.أعطت جميع مستويات الـ Azolla أعلى قيم لوزن الجسم النهائي ($P<0.05$) عند عمر ١٤ أسبوعًا عن مجموعة الكونترول. أخذت زيادة الوزن من ٥ إلى ١٤ أسبوعًا نفس الاتجاه. لم تلاحظ أية فروق معنوية لمستويات الآزولا الغذائية بين الغذاء المأكول ، معدل التحويل الغذائي ومؤشر الأداء. سجلت نسبة الحيوية أعلى قيمة للمجموعة التي تغذت على ٣٠٪ أزولا مقارنة مع مجموعة الكونترول. الأرانب التي تغذت على الأزولا بنسبة ٢٠ و ٣٠٪ من بروتين فول الصويا سجلت قيم كوليسترول أقل من مجموعة الكونترول. أدت المستويات المختلفة من الآزولا وخاصة ١٠،٠٨٪ أزولا (٤٠٪ من بروتين فول الصويا) إلى تحسين HDL في الدم. لم تتأثر معظم خصائص الدم وصفات الذبيحة بمستويات استبدال الأزولا في غذاء الأرانب.يستنتج أن استبدال الأزولا المجففة حتى مستوى ٤٠٪ لبروتين فول الصويا في عليقة الأرانب النامية كانت ذات تأثير إيجابي على الأداء الإنتاجي دون أية تأثيرات سلبية على الصفات البيوكيميائية للدم وصفات الذبيحة في ظل الظروف البيئية المصرية.