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Partial Replacement of Soybean Meal with Some Medicinal Plant Seed Meals and their Effect on the Performance of Rabbits

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ABSTRACT

A total number of 60 males of New Zealand White rabbits were weighed and randomly divided into 5 equal groups to study the effects of using radish, rocket, black cumin and a mixture of these meals at 50% crude protein level as a replacement of soybean meal on growth performance, digestibility, carcass yield and economic evaluations. Each group received experimental diets containing nearly equal ratio of calorie:protein ratio (C:P) under the same managerial conditions. Analysis of radish (*Raphanus sativus*), rocket (*Eruca sativa*) or black cumin (*Nigella sativa*) meals indicated that they contained reasonable amount of protein and nitrogen free extract. Significant increment of daily body gain, daily feed intake, feed conversion, apparent digestibility of nutrients, feeding values and carcass characteristics with radish, rocket and mixed diet and significant decrease by black cumin diet compared to the control diet. Caecum and stomach pH were not affected by different diets, showing better feed utilization for these treatments. Relative economic efficiency improved by inclusion of radish, rocket and mixture meals diets. However, black cumin meal gave the lower economic efficiency as compared to the control group. It was concluded that radish, rocket seed meals or mixture of these meals could be used for partial replacement up to 50% of soybean meal protein to improve their performance with best economical return.

Key Words: Growing rabbits; Radish; Rocket; Black cumin; Productive performance

INTRODUCTION

Soybean meal is the main plant protein in rabbit diets, but due to its high price and limiting local production in developing countries, search for cheap and locally available alternative vegetable protein sources has become imperative to achieve a suitable and economic efficiency of production. Production of radish (*Raphanus sativus*), rocket (*Eruca sativa*) and black cumin (*Nigella sativa*) meals in Egypt has steadily increased during the last few years. This increase has resulted primarily from the strong demand to its volatile oil as a pharmaceutical purpose. These materials are listed as natural sources of flavoring and may be considered as a good vegetable protein sources for inclusion in rabbit diets in the regions where they are readily available and relatively inexpensive (Craig, 1999).

Radish is well reputed in the folkloric system of medicine for the treatment of gastrointestinal and cardiovascular disorders. It is anti-stomachic, anti-diarrhoeal and anti-inflammatory (Zaman, 2004). Rocket or taramira seeds or meals also contain some medicinal substances. It's a good source of β-carotene (Rinzler, 1990) and contains a number of health promoting agents including carotenoids, vitamin C, fibers, glucoerucin and flavonoids (Barillari *et al*., 2005). The major constituent of rocket seed volatile oil is isothiocyanates, which has antioxidant, antimicrobial and anticarcinogenic activities (Badee *et al*., 2003; Haristoy *et al*., 2005; Barillari *et al*., 2005). Rocket contains flavonoids such as appiin and luteolin, beside volatile oils like myristicin, apiole and β-phellandrene, fats as the furocoumarin, bergapten, polyynes protein, sugars and vitamin A and C (Bradley, 1992; Leung & Foster, 1996). Flavonoids have antiviral activity (Hertog *et al*., 1993).

Black cumin seed meal is a herb and contains high protein, crude fat and minerals such as Ca, P, K, Mg and Na (Abdel-Aal & Attia, 1993). It has nigellon, thymoquinone and thymohydroquinone, which are known to possess antimicrobial effect and enhance production of interleukin-3 and 2 beta by lymphocytes and having an effect on macrophages (Haq *et al.*, 1995). Moreover, it improves health by increasing hematocrite and hemoglobin values (Zaoui *et al*., 2002). These ingredients, like natural feed additives, stimulate the activity of digestive system, improving diet palatability, enhance appetite of poultry and increase the amount of feed consumed (Namur *et al*., 1988). Research reports on using radish, rocket, or black cumin or mixture of these meals as non-conventional feed ingredients in rabbit diets are rare. The present study was aimed at to shed some light on the effects of partial substitution of soybean meal protein by radish, rocket, black cumin or mixed of these meals in diets of growing rabbits as a cheap nontraditional sources of protein diets on the growth, performance, digestibility, carcass characteristics and economical efficiency of broiler rabbits.

MATERIAL AND METHODS

The present study was carried out in the National Research Center, Experimental Farm Station (Abou

Rawash, Giza, Egypt), feed stuffs and tested materials (black cumin, radish & rocket meals) were obtained from commercial supplier. They were grinded to fine particles and chemically analyzed for moisture, crude protein (CP), crude fiber (CF), ether extract (EE) and ash according to the procedure of AOAC (1995) (Table I).

A total number of sixty male weaning New Zealand White rabbits with an average body weight of 650 gm, (5 weeks old) were divided into five equal groups of 12 each. The five experimental rations (Table II) was formulated and pelleted at Meladico company to cover the requirements of rabbits according to NRC (1977). Radish, rocket and black cumin seed meals or their mixtures were incorporated to the control diet on the expense of soybean meal protein at a level of 50% composing 4 dietary treatments (Table II). Each group of experimental diet contained nearly equal CP ratio under the same managerial conditions. The experiment lasted for 8 weeks. New Zealand White rabbits were housed in galvanized metal wire cages provided with feeder and automatic drinkers. Rabbits of all groups were kept individually under the same managerial conditions. Feed were offered *ad-libitum*. Individual live body weight, feed consumption and feed conversion ratio were recorded weekly during the experimental period.

Three males of each group treatment were kept individually in metabolic cages. Faeces were collected separately without urine. Feed and water were offered *ad-libitum*. Feed intake and excreted faeces were recorded daily for 5 days before the end of experiment. The total excreted faeces during the 5 days period were pooled, mixed, weighed and sampled for analysis. Chemical composition of feed and dried excreta was determined according to AOAC (1995). Total digestible nutrients (TDN) were calculated according to formula described by Cheeke *et al*. (1982). At the end of the experimental period, 4 males of each rabbit's treatment were randomly chosen for slaughter test, carcass and head weight were calculated as a percentage of live body weight. Giblets (heart, kidneys & liver) were weighed. Dressing percentage included relative weights of carcass, head and giblets. Non-edible organs (skin & tail, end of leg, ears, lungs, blood, spleen, digestive tract full & caecum full) were calculated also as a percentage of live body weight.

The pH of stomach and caecum was measured immediately. The economical efficiency (EE) of the tested diets was calculated from the input-output analysis, based on difference in total body gains and feeding cost.

Statistical analysis. Data were statistically analyzed adopting one way ANOVA for the general linear model (GLM) by employing using in the (SAS) guide (v. 6.04, 1988). The LSD was used for comparing the significance difference between group means at a confidence limit of 95% (Snedecor & Cochran, 1980).

RESULTS AND DISCUSSION

Chemical composition of the tested meals. Radish, rocket and black cumin meals contained a reasonable amount of protein, nitrogen free extract with little amount of crude fiber and promising sources of energy (Table II). These ingredients may be considered as a preliminary indication of their feeding values for rabbits. The results of this study did not vary far from those of Osman *et al*. (2004), who reported that radish meals contained 5.52% moisture, 24.90% crude protein, 6.71% ether extract, 10.07% crude fiber, 50.40% nitrogen free extract and 7.92% ash, while rocket meals contained 7.24% moisture, 36.03% crude protein, 7.64% ether extract, 7.69% crude fiber, 36.81% nitrogen free extract and 11.83% ash. Srinibas *et al*. (2001) showed that ether extract content of rocket full fat seeds was 24.87%, while the crude protein content was 30.24% on dry matter basis. Also, El-Adawy

Table I. Chemical analysis of feed stuffs of tested diets

Item	DM	Chemical analysis % (D M basis)						
	%	OM	CP	CF	EE	NFE	ASH	DE*
Feed stuffs:								
Yellow corn	89.00	98.50	8.47	2.19	4.37	83.47	1.50	3965
Soybean meal	98.00	94.50	44.00	7.10	0.70	42.70	5.50	3227
Wheat bran	89.00	88.70	14.00	11.00	3.00	60.70	11.30	2262
Clover hay	89.00	87.49	14.80	24.10	2.70	45.89	12.51	1660
Radish seed meal	94.80	94.80	35.30	4.80	10.67	44.03	5.20	3345
Rocket seed meal	94.30	92.20	32.20	4.24	10.85	44.91	7.80	2988
Black cumin meal	92.00	90.40	33.80	5.20	14.20	37.20	9.60	2697

DE*(Kcal/Kg DM)= 4253 - 32.6 (CF %) - 144.4 (Ash %), according to Fekete and Gippert (1986).

Table II. Composition and chemical analysis of tested diets

Ingredients	Control diet	Radish diet	Rocket diet	Black cumin diet	Mixed diet
Clover hay	33.00	33.00	33.00	33.00	33.00
Yellow corn	21.00	19.00	19.00	19.00	19.00
Wheat bran	30.10	30.10	30.10	30.10	30.10
Soybean meal	14.00	7.00	7.00	7.00	7.00
Radish seed meal	--	9.00	--	--	3.00
Rocket seed meal	--	--	9.00	--	3.00
Black cumin seed meal	--	--	--	9.00	3.00
Limestone	1.13	1.13	1.13	1.13	1.13
Vit+Min-Mix*	0.30	0.30	0.30	0.30	0.30
Common salts	0.30	0.30	0.30	0.30	0.30
DL-Methionine	0.17	0.17	0.17	0.17	0.17
Total	100.00	100.00	100.00	100.00	100.00
Chemical analysis determined (DM% basis)					
Dry matter (DM)	88.57	88.57	88.51	88.20	88.40
Organic matter (OM)	89.48	89.54	89.24	89.14	89.33
Crude protein (CP)	17.03	17.01	16.72	16.91	16.92
Crude fiber (CF)	12.73	12.70	12.60	12.80	12.70
Ether extract (EE)	2.79	3.80	3.70	3.90	3.80
Crude ash	10.53	10.46	10.76	10.86	10.67
Nitrogen free extract (NFE)	56.92	56.03	56.22	55.53	55.91
Calculated analysis DE** (Kcal/Kg)	2513	2508	2480	2450	2480
Calcium	0.92	0.87	0.87	0.87	0.87
Total phosphorus	0.50	0.45	0.45	0.45	0.45

* One kilogram of Premix provides: 2000000 IU vit.A, 150000 IU vit. D, 8.33 g vit. E, 0.33 g vit. K, 0.33 g vit. B_1, 1.00 g vit. B_2, 0.33 g vit. B_6, 8.33 g vit. B_5, 1.70 mg vit. B_{12}, 3.33 g Pantothenic acid, 33.00 mg Biotin, 0.83 g Folic acid, 200.00 g Choline chloride, 11.70 g Zinc, 12.50 g Iodine, 16.60 mg Selenium, 16.60 mg Cobalt, 66.70 g Magnesium and 5.00 g Manganese.

Table III. Growth performance of growing rabbits fed radish, rocket, black cumin and mixed cakes

Item	Control diet	Radish Diet	Rocket Diet	Black cumin diet	Mixed diet
Initial live body weight (g)	637.50a ± 68.45	606.25a ± 67.74	649.00a ± 50.17	637.50a ± 63.79	628.25a ± 15.67
Final live body weight (g)	1790.00bc ± 70.83	1945.00ab ± 92.06	2042.50a ± 88.16	1572.50c ± 87.31	1912.50ab ± 17.50
Daily feed intake (g)	109.65bc ± 3.14	113.58ab ± 2.25	120.90a ± 4.35	101.13c ± 3.22	113.50ab ± 4.57
Daily body weight gain (g)	20.54b ± 0.25	23.90a ± 0.73	24.85a ± 1.29	16.69c ± 0.70	22.90a ± 0.52
Feed conversion ratio	5.34b ± 0.10	4.75c ± 0.11	4.86c ± 0.15	6.06a ± 0.14	4.95bc ± 0.12

a, b and c means in the same row bearing different letters that differ significantly at *P<0.05*.

Table IV. Nutrients digestibility coefficients and nutritive values as affected by different experimental diets

Item	Control diet	Radish diet	Rocket diet	Black cumin diet	Mixed diet
			Digestion coefficient (%)		
OM	62.00^{b} ± 0.40	63.87^{a} ± 0.38	63.60^{ab} ± 0.35	58.03^{c} ± 0.49	64.97^{a} ± 0.96
CP	63.20^{a} ± 0.25	63.77^{a} ± 1.10	63.73^{a} ± 0.96	56.87^{b} ± 0.43	64.47^{a} ± 0.72
EE	72.17^{b} ± 0.44	75.17^{a} ± 0.60	75.33^{a} ± 0.44	72.47^{b} ± 1.19	76.10^{a} ± 0.21
CF	34.67^{b} ± 0.38	38.93^{a} ± 0.23	38.57^{a} ± 0.41	35.37^{b} ± 0.70	40.20^{a} ± 1.04
NFE	67.33^{b} ± 0.60	68.53^{ab} ± 0.26	68.33^{ab} ± 0.80	62.57^{c} ± 0.52	69.93^{a} ± 0.96
			Nutritive values (%)		
TDN	58.03^{b} ± 0.36	60.62^{a} ± 0.26	60.18^{a} ± 0.66	55.20^{c} ± 0.49	61.71^{a} ± 0.81
DCP	10.76^{a} ± 0.04	10.85^{a} ± 0.19	10.66^{a} ± 0.16	9.61^{b} ± 0.08	11.24^{a} ± 0.36

a, b and c means in the same row bearing different letters that differ significantly at *P<0.05*.

(2004) reported that black cumin seed meal contained 6.5% moisture and remaining components on dry matter basis were 94.5%. Aherne and Kenelly (1982) and Ravindran and Blair (1992) reported that the differences between chemical composition of oil seed meals may be due to type of seeds, processing method and the analyst.

Rabbit performance. Daily body weight gain for rabbit fed experimental diets showed a significant ($p < 0.05$) change from controls due to radish, rocket, mixed meal diet and black cumin diet (Table III). Daily feed intake for rabbits received rocket diet showed a significant ($p < 0.05$) increment by 10.2% compared to the control diet. However, no significant difference were detected between radish or mixed meals diet. Feeding black cumin diet insignificantly lower daily feed intake compared to the control diet.

Feed conversion ratio for rabbit received different diets showed a significant ($p < 0.05$) increased by 11.0 and 8.9% for radish or rocket, respectively compared to the control diet, indicating that these diets singly or their mixture improved body weight. El-Alaily *et al.* (2001) and Ibrahim *et al*. (2005) they found that addition of radish extract to high fiber poultry diets contained artificial dried Miskawi berseem or wheat bran as a source of fiber increased body weight gain. Osman *et al*. (2004) found that by feeding either radish or rocket meals up to 15% instead of a part of soybean meal had no effects on broiler chicks live body weight. Abdo (2003) found that the best body weight gain in broiler rations were for rocket seed meal at levels of 0 and 25% substitution of soybean protein. In their research, Amber *et al*. (2001) indicated that live body weight and daily weight gain of rabbits fed control diet were significantly greater ($p < 0.01$) than those fed the other diets supplemented with crude protein using soybean meal in control diet. The reduction may be due to lower feed intake and decreasing digestibility of nutrients. Concerning feed conversion ratio it is clear that replacing up to 50% of soybean meal by radish or rocket cakes gave the best feed conversion values. Such improvement may be attributed to the properties of those materials of rocket or radish that could act as anti-bacteria, anti-protozoal and anti-fungal and antioxidants. Thus incorporation of such non-conventional cakes protein had no adverse effect on palatability and voluntary feed intake in rabbit.

Digestibility coefficients and nutritive values. Apparent digestibility of almost nutrients OM, EE, CF and NFE were significantly increased with radish, rocket and mixed diet compared with the control diet, while those of OM, CP and NFE were significantly decreased ($p < 0.05$) by black cumin diet compared with the control diets (Table IV). Similar results observed with El-Alaily *et al*. (2001) found that addition of radish extract to high fiber poultry diets contained artificial dried Miskawi berseem improved digestibility of all nutrients. In this respect, radish, rocket or mixed cakes diets contains the flavonoids such as carotenoids, vitamin C and isothiocyanate, which has antioxidant and antimicrobial effects. These ingredients as those of natural feed additives had beneficial effect for stimulation and activity of digestive system by improving digestibility of all nutrients. Ibrahim (2005) found that crude fiber digestion percentage of rabbits receiving 1% of rocket seed as a supplement was significantly increased. This may be due to flavonoids and essential oils, which had beneficial effect or stimulation and activity of digestive system (Namur *et al*., 1988; Bradley, 1992).

Rabbits fed with radish, rocket and mixed cakes diets significantly ($p < 0.05$) increased TDN and DCP. The TDN and DCP values were significantly ($p < 0.05$) decreased in group fed black cumin meal than control diet (Table IV). Similar results were observed with Amber *et al*. (2001) and El-Adawy (2004) while replacing (25 - 75%) of soybean meal protein with black cumin cake protein in rabbit diet. A lower DCP may be due to the depression of CP digestibility. This may be due to the presence of natural substances in the meals enhance the activity of digestive system enzymes.

Carcass characteristics. Inclusion of radish, rocket or mixed meal diets improved but decreased ($p < 0.05$) with

Table V. Carcass characteristics of rabbits fed different experimental diets

Item	Control diet	Radish diet	Rocket diet	Black cumin diet	Mixed diet
Carcass + head (%)	52.75^{b} ± 0.10	57.23^{a} ± 0.52	57.72^{a} ± 0.56	48.60^{c} ± 1.12	58.33^{a} ± 0.84
Dressing (%)	55.81^{c} ± 0.26	61.02^{b} ± 0.08	61.58^{ab} ± 0.36	51.78^{d} ± 0.74	62.44^{a} ± 1.32
Heart (%)	0.26^{a} ± 0.03	0.27^{a} ± 0.04	0.25^{a} ± 0.04	0.23^{a} ± 0.04	0.25^{a} ± 0.05
Liver (%)	2.26^{a} ± 0.26	2.90^{a} ± 0.50	2.91^{a} ± 0.20	2.24^{a} ± 0.39	3.16^{a} ± 0.15
Kidneys (%)	0.54^{a} ± 0.05	0.62^{a} ± 0.08	0.70^{a} ± 0.02	0.71^{a} ± 0.11	0.70^{a} ± 0.30
Total giblets weight (%)	3.06^{a} ± 0.31	3.79^{a} ± 0.59	3.86^{a} ± 0.22	3.18^{a} ± 0.54	4.11^{a} ± 0.48
Skin and tail (%)	16.87^{a} ± 0.55	12.99^{bc} ± 1.01	15.13^{ab} ± 0.99	17.40^{a} ± 1.07	11.64^{c} ± 1.55
End of legs (%)	3.01^{a} ± 0.17	2.71^{a} ± 0.13	3.19^{a} ± 0.36	3.43^{a} ± 0.28	3.21^{a} ± 0.31
Ears (%)	1.32^{a} ± 0.08	1.26^{a} ± 0.14	1.27^{a} ± 0.10	1.21^{a} ± 0.18	1.24^{a} ± 0.26
Lungs (%)	0.70^{a} ± 0.10	0.63^{a} ± 0.08	0.65^{a} ± 0.03	0.76^{a} ± 0.15	0.64^{a} ± 0.08
Blood (%)	3.11^{a} ± 0.20	3.19^{a} ± 0.16	3.75^{a} ± 0.76	3.06^{a} ± 0.26	3.47^{a} ± 0.27
Spleen (%)	0.07^{a} ± 0.01	0.06^{a} ± 0.10	0.06^{a} ± 0.01	0.07^{a} ± 0.10	0.08^{a} ± 0.01
Digestive tract (full) (%)	18.65^{ab} ± 0.25	17.75^{b} ± 1.05	14.07^{c} ± 0.65	21.84^{a} ± 1.37	16.83^{b} ± 1.36
Caecum (%)	0.46^{a} ± 0.03	0.39^{a} ± 0.06	0.30^{a} ± 0.06	0.45^{a} ± 0.08	0.45^{a} ± 0.10
Total non edible weight (%)	44.19^{b} ± 0.47	38.98^{c} ± 0.35	38.42^{c} ± 0.36	48.22^{a} ± 0.78	37.56^{c} ± 1.32
Caecum pH	6.23^{a} ± 0.15	6.25^{a} ± 0.04	5.92^{a} ± 0.07	6.10^{a} ± 0.05	6.11^{a} ± 0.17
Stomach pH	2.98^{a} ± 0.12	3.16^{a} ± 0.62	2.98^{a} ± 0.04	2.72^{a} ± 0.63	3.20^{a} ± 0.70

a, b and c means in the same row bearing different letters that differ significantly at *P<0.05*.

Table VI. Effect of experimental diets on relative revenue of growing rabbits at 13 weeks of age

Items	Control Diet	Radish Diet	Rocket Diet	Black cumin diet	Mixed Diet
Body gain (kg)	1.150	1.338	1.393	0.935	1.284
Body revenue (LE)	13.80	16.05	16.71	11.22	15.40
Feed intake (kg)	6.140	6.360	6.770	5.663	6.356
Price /kg (LE)	1.127	1.055	1.055	1.082	1.064
Feed cost (LE)	6.92	6.709	7.142	6.127	6.762
Net rev. (LE)	6.88	9.341	9.568	5.09	8.638
Economic-Efficiency	99.40	139.20	133.90	83.07	127.70
Relative EEF (%)	100.00	140.00	134.70	83.57	128.40

Price of kg live body weight gain was 12.0 LE at experimental time.
Net revenue = body revenue - feed cost
Relative EEF (%) = (Net revenue / feed cost) x 100
Price of kg soybean was 1.8 LE
Price of kg rocket or radish were 0.60 LE
Price of kg black cumin was 0.90 L.E.

black cumin diet carcass and dressing percentage compared with the control diet (Table V). The increment of dressing may be due to the higher nutritive values with radish and rocket diets. The effect of dietary different treatments did not affect total giblets weight (heart, liver & kidneys), but reduced the non-edible weight. However, a significant increase in non-edible weight was observed in black cumin compared to the control group. Gowda *et al*. (1996) found that urea (2% w/w) ammoniated deoiled mustered meal, which belongs to the same family of rocket resulted in a higher ($p < 0.05$) dressing percentage of rabbits. On the other hand, Abdo (2003) found that there was no significant difference between the carcass value of the 0% and 25% rocket seed meal diets substitution with soybean meal protein (71.2%) in broiler ration. Ibrahim *et al.* (2005) found that the addition of radish extract to control diet, caused a significant ($p < 0.01$) increase of edible parts compared to control diet of broiler chicks. Zeweil (1996) found that carcass percentage significantly ($p < 0.01$) decreased for groups fed 38 and 48% black cumin meal as a replacement of dietary protein. Taha (1997) also found that dressing percentage was the lowest value in rabbit fed diet with 9% black cumin meal.

Economical evaluation. There was considerable cost saving with inclusion level of radish, rocket, black cumin and mixed meals as compared to the control group (Table VI). Differences in relative economic efficiency showed that diet containing radish, rocket or mixed meals replacement from soybean meal had the best values (140.0 & 134.7) and 128.4%, respectively compared to the control diet. However black cumin meals gave the lower economic efficiency (83.57%) than the control diet.

In general, it is recommended that use of radish and rocket at 50% replacement level of soybean meal protein in broiler rabbit diets as cheap non-conventional source in order to get higher economical efficiency without adverse effects on the rabbit performance. Black cumin meal is advisable to be added with rocket and radish cakes with about 17% of 50% soybean meal protein to achieve a good performance in rabbit production. However, use non-conventional feed proteins in rabbit diets are rare. Further studies are needed to study the long term effects of these cakes on immunity and reproduction of rabbit bucks.

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