International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.9, No.12 pp 68-80, 2016

Prolonged effect of some plant seeds meals supplementation on the performance and serum parameters in male rabbits

Yasser A. A. El-Nomeary[1], R. I. El- Kady[1], A. A. El-Shahat[1], Walid S. El-Nattat[2]

[1]Animal Production Department, National Research Centre, Dokki, Egypt.
[2]Animal Reproduction and Artificial Insemination Department, National Research Centre, Dokki, Egypt.

Abstract : Twenty white New-Zealand bucks, aged 7 weeks, were randomly alienated into five groups (n=4), subjected to the same management, to investigate the prolonged effects (120 days) of using black cumin (*Nigella sativa*), mustard (*Sinapis alba*), sesame (*Sesamum indicu*m) and rocket (*Eruca sativa*) seeds meals as feed additives on growth performance, carcass yield and some serum parameters. Experimental diets were fed to their corresponding groups containing nearly an equal calorie: protein ratio (C:P). Analysis of black cumin, mustard, sesame and rocket seeds meals showed a sensible amount of protein and nitrogen free extract. Significant ($P<0.05$) augmentation of daily body gain and feed conversion and significantly ($P<0.05$) decrease in daily feed intake were detected between different feed addition and control group. Moreover, carcass characteristics (dressing percentages) as $DP_2=CW_1/EBW$ and $DP_3=CW_2/EBW$ with rocket group was significantly ($P<0.05$) increased than that of sesame group. However, no significant differences were detected between black cumin, mustard and control groups. Carcass cuts (fore part and middle part) showed no significant differences between different experimental groups. Moreover, mustard group showed the higher significant ($P<0.05$) in (hind, head and neck) than the other experimental groups. Chemical analysis of the 9, 10 and 11th ribs (CP and EE contents) most of them had apparently increased the CP content while the EE was significantly ($P<0.05$) decreased with the different supplements compared to the control group. A non significant changes in biochemical parameters were recorded in serum glucose, triglycerides, cholesterol, protein, albumin, globulin and A/G ratio indicating the stability of the body homeostasis of rabbits fed black cumin, mustard, sesame or rocket seeds meals. On the other hand, a significant ($P<0.05$) decrease of malondialdehyde (MDA) indicated the diminution of cellular lipid peroxidation when bucks fed the sesame seeds meals compared to the control group. It is concluded that the addition of 3% of black cumin or mustard or sesame or rocket seeds meals to the basal commercial rabbit ration have an ameliorating effect on the performance of the rabbit meat production.

Key words: growing rabbit, black cumin, mustard, sesame, rocket, carcass yield, serum parameters.

Introduction

Due to the lack of sufficient feed for animal production, many attempts have been made for using feed additives or agriculture by-products (Ismaiel et al., [1]) that are added to animal feed to improve their nutritive value, increasing growth rate and better feed conversion efficiency (Pluske, [2]). The use of antibiotics as growth promoters has been reduced in many countries in the world, as they pose an elevated risk of cross-resistance amongst pathogens, as well as leaving residues in tissues. This has prompted the search for alternative natural growth promoters has been reduced or banned in many countries in the world. Black cumin seed meal (*Nigella sativa*) (NS) is considered one of the most important medicinal plants in the world due to its beneficial actions. It has been proposed as a natural alternative to antibiotics in order to improve the health status of animals and to increase the production and quality of animal products. The seeds and oil of NS have a broad range of activities against a number of microbes, and are thus capable of inhibiting gram-positive and gram-negative bacteria (Morsi,[3]), coccidian (Rhaman and Nada,[4]; Baghdadi and Al-Mathal,[5]) and helminthes (Maqubool et al.,[6]). Studies on NS seeds and NS-derived oil have provided scientific support for their traditional use in treatment, due to their anti-diabetic activity (Bamosa et al.,[7]), anticancer activity (Pichette et al.,[8]). Cardiovascular-protective activity (Bamosa et al.,[9]), gastro-protective and antiasthmatic activity (Kanter,[10]) and neurological activity (Perveen et al.,[11]). Moreover, NS oil has an important radical scavenging activity, and its antioxidant properties have been reviewed by Alenzi et al.[12].

Mustard seed meal (*Sinapis alba*) (SA) is obtained from mustard seeds after oil extraction. The utilization of the mustard meal (MM) in rabbit feeding is limited as a consequence to its content of glucosinolates. The later content made from mustard varieties range from 12 to 90 g/kg DM (Chauhan et al.,[13]). Glucosinolates are non-toxic, while their end products thiocyanate, isothiocyanates, nitriles, and others are toxic to animals. These end products suppress thyroidal uptake of iodine (Duncan,[14]) and so it induces metabolic disorders such as liver and thyroid hypertrophy (Bell,[15]). SA has been reported to possess anticancer properties (Eskin et al.,[16]). Sinapine is the effective component that has great potential in the field of antiageing drugs (Liu et al.,[17]) and considered as an important natural antioxidant (Müller et al.,[18]). SA is a good candidate to use for immunotherapy purposes in future (Palomares et al.,[19]).

Sesame seed meal (*Sesamum indicum*) (SI) is an excellent source of edible nutrients especially after oil extraction. Extraction of oil has led to increased protein contents of defatted sesame meal (41.1 – 49.6%) and rich in essential amino acids namely methionine and cystine. Refined sesame oil is rich with antioxidant components like lignans allowing for greater shelf-life of foods. In addition to its use as an antioxidant, sesame oil contains large amount of linoleate in triglyceride form that selectively inhibits malignant melanoma growth. The oil is also known to maintain high density lipoprotein (HDL) cholesterol and lower density lipoprotein (LDL) cholesterol. The antibacterial activity of seeds against staphylococcus and streptococcus as well as common skin fungi has been well recognized (Anilakumar,[20]).

Rocket seed meal (*Eruka sativa*) (ES), their main fatty acids are palmitic, oleic, linoleic, linolenic and erucic acids. The seeds volatile oil produced mild hypotensive and diuretic effects associated with increase in Na^+, K^+ and Cl^- excretion (El Gengaihi et al.,[21]). ES seeds contained about 22.6% protein. Flanders and Abdulkarim [22] found that seeds of ES contained 4.1% moisture, 27.8% oil, 27.4% protein and 6.6% ash. They also contain some medicinal substances such s thiocyanate glycosides. Mahran et al. [23] revealed that the volatile oil of ES seed consisted of five isothiocyantes (as major component) and methyl thiopentyl isothiocyanate. Brassicae family plants had antioxidant activity (Matthaus,[24]) and anti-microbial properties (Packiyasothy and Kyle, [25]). ES mill belonged to family Brassicae to which belong mustard and rapeseed (Fernandez et al.,[26]). Rocket seed meal contain glucosinolates which found to have several biological activities including anti-carcinogenic, anti-fungal, and anti-bacterial plus its anti-oxidant action (Kim et al.,[27]).

The present study aimed to investigate the prolonged effect of black cumin, mustard, sesame and rocket seed meals on the performance and serum parameters of male rabbits.

Materials and Methods

A total number of 20 male New-Zealand white rabbits aged (7 weeks with an average body weight) were randomly divided into five equal groups of 4 rabbits in each.

The basal experimental diet was formulated and pelleted to cover the nutrient requirements of rabbits as a basal diet according to NRC [28] as shown in Table (2). The feeding period was extended for 120 days and the experimental groups were classified as follows (Table 1):

Table 1. Experimental design and feeding groups.

Group rank	Treatment
G1	Fed basal diet served as control
G2	Fed basal diet + 3% black cumin seed meal
G3	Fed basal diet + 3% mustard seed meal
G4	Fed basal diet + 3% sesame seed meal
G5	Fed basal diet + 3% rocket seed meal

Rabbits individually housed in galvanized wire cages (30 × 35 × 40 cm). Stainless steel nipples for drinking and feeder allowing recording individual feed intake for each rabbit were supplied for each cage. Feed and water were offered *ad lib*. Rabbits of all groups were kept under the same managerial conditions were weighed, and feed consumption was individually recorded weekly during the experimental period.

At the end of the experimental period, three representative rabbits from each treatment were randomly chosen and fasted for 12 hours before slaughtering according to Blasco et al.[29] to determine the carcass measurements. Edible offal's (giblets) included heart, liver, kidneys, lungs and spleen were removed and individually weighed. Full and empty weights of digestive tract were recorded. The 9, 10 and 11th ribs were frozen in polyethylene bags for later chemical analysis. The ribs of samples were dried at 60°C for 24 hrs.

The air-dried samples were analyzed for DM, EE, CP and ash according to the A.O.A.C. [30] methods. Composition of the experimental rations have been achieved according to the NRC [28] requirements as shown in table (2). Diets were offered pelleted at 4 mm diameter.

Table 2. Formulation and chemical analysis of the tested diets.

Ingredient	Control	Black Cumin seed meal	Mustard seed meal	Sesame seed meal	Rocket seed meal
Clover hay	33.00	33.00	33.00	33.00	33.00
Yellow corn	21.00	21.00	21.00	21.00	21.00
Wheat bran	30.00	30.00	30.00	30.00	30.00
Soybean meal	14.00	14.00	14.00	14.00	14.00
Black cumin seed meal	-	3.00	-	-	-
Mustard seed meal	-	-	3.00	-	-
Sesame seed meal	-	-	-	3.00	-
Rocket seed meal	-	-	-	-	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 salt	0.40	0.40	0.40	0.40	0.40
DL-Methionine	0.17	0.17	0.17	0.17	0.17
Total	100.00	103.00	103.00	103.00	103.00
Chemical analysis determined (DM%)					
Dry matter (DM)	92.49	92.49	92.43	92.46	92.44
Organic matter (OM)	90.41	90.70	91.00	90.81	90.86
Crude protein (CP)	17.00	18.07	18.50	18.39	18.47
Crude fiber (CF)	11.73	11.72	12.76	12.16	11.94
Ether extract (EE)	3.19	3.40	3.24	3.50	3.40
Crude ash	9.59	9.30	9.00	9.19	9.14
Nitrogen free extract(NFE)	58.49	57.51	56.50	56.76	57.05
Calculated analysis DE** (Kcal/Kg DM)	2485.8	2528.0	2537.4	2529.5	2543.9

* One kilogram of Premix provides: 20000000 IU vit.A, 150000 IU vit. D,8.33 g vit. E, 0.33 g vit. B1, 1.00 g vit. B2, 0.33 g vit. B6, 8.33 g vit. B5, 1.70 mg vit. B12, 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. **DE (Kcal/Kg DM))= 4253-32.6 (CF%) – 144.4 (ash%), according to Fekete and Gippert [31].

At the end of the experimental period, blood samples were collected from slaughtered rabbits (3 in each group) in clean sterile tubes for each animal at slaughtering. The serum was separated and stored at -20°C till analysis.

Biochemical analysis

Serum glucose concentrations was determined using the method adopted by Trinder[32]. The total proteins level was determined according to Gormall et al.[33]. Total albumins level was determined according to Doumas et al [34]. Globulins were determined according to the equation = total proteins - total albumins while the A/G ratio was determined by the equation = total albumins / total globulins. The triglycerides were determined according to the method approved by Fassati and Prencipe[35] while the cholesterol concentration was determined according to Richmond[36] method using an enzymatic assay. The malondialdehyde (MDA), a metabolite product of the lipid peroxidation executed from the oxidative stress activities, was determined according to the method accepted by Ohkawa et al [37].

Statistical analysis

Collected data were subjected to statistical analysis using one way analysis of variance in the general model procedure of SPSS [38]. Duncan's multiple range test [39] was used to separate means when dietary treatment effect was significant at P<0.05.

Results and Discussion

1- Chemical composition of the tested meals

Black cumin, mustard, sesame and rocket seeds meals contained a reasonable amount of protein, nitrogen free extract with little amount of crude fiber and promising source of energy (Table 3). Digestible energy values for the four tested meals were 2963, 2764, 2433 and 2949 (Kcal/Kg DM) for black cumin, mustard, sesame and rocket seeds meals, respectively. These variations were related to the differences in chemical composition of the tested meals. Our results didn't vary far from those of Mahmoud and Bendary [40] who reported that black cumin seeds meals contained 9.65% moisture with residual components (on dry matter basis) were 90.35%, also its meal contains most of the essential amino acids with crude protein about 33.13%, while OM, CF, EE, NFE and ash were 91.57, 10.96, 12.72, 34.76 and 8.45 respectively. While, mustard seeds meal where found to be 5.89, 93.84, 36.60, 18.38, 11.00, 27.86 and 6.16% for moisture, OM, CP, CF, EE, NFE and ash respectively (Table 3). This data agree with Tripathi and Singhal [41], they found that mustard seeds meal obtained from the Indian varieties contains 300 to 395 g CP/Kg DM and is also rich in sulphur content ranging from 14.3 to 23.0 g/Kg DM (Papas et al.,[42] and Tyagi et al.,[43]). In spite of its well balanced amino acid composition (Patuszewisk et al.,[44]).

Table 3. Chemical analysis of feed stuffs for tested diets.

Feed stuffs	DM %	Chemical analysis, % (DM basis)						
		OM	CP	CF	EE	NFE	Ash	DE*
Yellow corn	89.00	98.50	8.47	2.19	4.37	83.47	1.50	3965
Soyabean meal	98.00	94.50	44.00	7.10	0.70	42.70	5.50	3227
Wheat bran	89.00	88.70	14.00	24.10	2.70	47.90	11.30	1836
Clover hay	89.00	87.49	14.80	24.10	2.70	45.89	12.51	1660
Black cumin seeds meal	93.39	93.81	30.14	12.14	12.90	38.63	6.19	2963
Mustard seeds meal	94.11	93.84	36.60	18.38	11.00	27.86	6.16	2764
Sesame seeds meal	94.56	90.61	42.13	14.22	15.00	19.26	9.39	2433
Rocket seeds meal	93.70	94.26	37.11	14.56	19.90	22.69	5.74	2949

* DE (Kcal/Kg DM)=4253 – 32.6 (CF%) – 144.4 (ash%), according to Fekete and Gippert [31].

Proximate analysis of sesame seeds meal was found to be 5.44, 42.13, 15.00, 19.26, 14.22 and 9.39% for moisture, CP, EE, NFE, CF and ash, respectively (Table 3). This data nearly agree with Mahmoud and Bendary [40] who reported that sesame seeds meal contents were 93.85, 89.80, 10.20, 32.35, 15.45, 9.00 and

33.00 % for DM, OM, ash, CP, EE, CF and NFE respectively. The chemical composition of sesame seeds meal varies depending on the method of processing sesame seeds, mechanical or solvent extraction.

Rocket seeds meal contained 6.3, 37.1, 14.5, 19.9, 22.6 and 5.7% as moisture, CP, CF, EE, NFE and ash respectively. However, Abdo [45] showed that rocket meal contained on air dry basis 5.07, 94.93, 79.64, 23.29, 10.05, 18.72, 15.29 and 27.58% of moisture, dry matter, OM, CP, EE, CF, ash and NFE, respectively besides 1.198% calcium and 0.394% total phosphorus. Aherne and Kenelly [46] reported that the differences between chemical composition of oil seeds meal may be due to the type of seeds and processing method.

Rabbit performance

Total body weight gain and average daily gain followed nearly similar trend for rabbits nourished experimental diets showing a significant ($P<0.05$) difference from control due to black cumin, mustard, sesame and rocket diet (Table 4). Mustard diet was higher ($P<0.001$) than black cumin, sesame and rocket seeds meals diets in average daily body weight gain compared to the control diet.

Daily feed intake with black cumin and rocket diets were significantly lower ($P<0.05$) than mustard and sesame seeds meals diets in daily intake compared to the control diet. Feed conversion ratio for rabbits receiving different diets showed a significant ($P<0.05$) improved by 17.1, 23.4, 11.3 and 9.3% for black cumin, mustard, sesame and rocket seeds meals, respectively compared to the control diet indicating that their diets improved feed conversion ratio compared to the control diet.

The results of growth performance are in agreement with Omar et al. [47] who stated that the use of diet supplemented with black cumin seeds oil improved the growth performance and increased feed conversion efficiency, immune response and economic return of chickens. However, Abou El Soud [48] found that weight gain, feed intake and feed conversion were higher for quails received diet supplemented with 2% black cumin seeds. Though, El-Nomeary et al. [49] found that final body weight, total body weight gain, average daily gain and feed conversion ratio were improved significantly when rabbits fed diet supplemented with 3% black cumin seeds meals for 68 days.

The improvement of body function and performance by *Nigella sativa* may be due to its content of some active compounds such as: (1) nigellone, thymoquinon and thymohydroquinon as bacterial inhibitors (Abd El-Hakim et al.,[50]), (2) fat soluble unidentified factors and essential fatty and amino acids that play vital role in growth performance, (3) several macro and micro-elements liable for regulating all vital functions in the body and improve the immunity and (4) vitamins (thiamine, riboflavin, pyridoxine and niacin) that play an essential role in the growth performance (William, [51], Seleem and Rowida, [52] and Seleem et al., [53]).

However, Andrzej et al.[54] indicated that the addition of 1% mustard meal to the rabbit diets was palatable and this affected positively the health and performance conditions of rabbits, with lowering the coccidial infection rates. Moreover, Ibrahim et al. [55] observed that inclusion of mustard seeds meal at 0.5% or 1% significantly ($P<0.05$) enhanced the final weight, total body weight gain, average daily gain and feed conversion compared to the control group. However, El-Nomeary et al.[49] found that final body weight, total body weight gain, average daily gain and feed conversion ratio were improved significantly when rabbits fed on diet supplemented with 3% mustard seeds meal for 68 days.

Moreover, supplemented sesame seeds meal to rabbit diets improved daily gain and better feed conversion efficiency compared to control. Similar results were obtained by Rahimian et al. [56] who indicated consumption of sesame seeds meal increased body weight gain and live body weight of 6-weeks old broiler chicks than the control diet. Similar results obtained by El-Nomeary et al. [49] who found that total body weight gain, final body weight, average daily gain and feed conversion ratio were improved significantly when rabbits fed on diet supplemented with 3% sesame seeds meal for 68 days. However, El-Tohamy and El-Kady [57] found that the replacement of rocket meal to 50% crude protein level of soybean meal showed significant augmentation in the daily feed intake, feed conversion ratio and daily body gain of rabbits. Similar trend obtained by El-Nomeary et al. [49] who found that average daily gain, final and total body weight gain and feed conversion ratio were improved significantly when rabbits fed on diet supplemented with 3% rocket seeds meal for 68 days. Such improvement of tested materials may be attributed to the properties of those materials that could be considered as anti-bacteria, anti-protozoal, anti-fungal and anti-oxidants. Thus, such assimilation didn't affect the palatability and voluntary feed intake in rabbits.

Table4. Growth performance of growing rabbits fed black cumin, mustard, sesame or rocket seeds meals (120 days).

Parameter	Experimental diet					± SE	Sig.
	Control	Black cumin	Mustard	Sesame	Rocket		
Initial body weight (g)	805.00	800.75	803.75	812.50	800.50	7.40	NS
Final body weight (g)	2625.6^{c}	2750.00^{b}	3094.66^{a}	2796.50^{b}	2649.25^{c}	20.00	*
Total body weight gain (g)	1820.60^{c}	1949.25^{b}	2290.91^{a}	1984.00^{b}	1848.75^{c}	12.33	*
Average daily gain (g)	15.10^{c}	16.24^{b}	19.09^{a}	16.53^{b}	15.40^{b}	0.88	*
Daily feed intake (g)	86.02^{a}	76.35^{c}	83.00^{b}	83.27^{b}	79.26^{c}	4.04	*
Feed conversion ratio: (g DM intake/g gain)	5.67^{a}	4.70^{c}	4.34^{c}	5.03^{b}	5.14^{b}	0.28	*

*a, b and c…. means in the same row bearing different letters that differ significantly at $P<0.05$. NS: Non significant. * $P<0.05$.

3- Carcass characteristics and chemical composition of meat

Inclusion of black cumin, mustard, sesame and rocket seeds meals diets did not affect the empty body weight, carcass weight, carcass weight with the total giblets and dressing percentage CW/SW compared to the control diet (Table 5). On the other hand, there were no significant ($P<0.05$) differences detected between black cumin, mustard seeds meals supplemented and control group in dressing percentages as DP_2 and DP_3. These observations were below expectations, while rocket seeds meal showed significantly ($P<0.05$) the higher percentages for DP_2 and DP_3 than sesame seeds meal. This may be attributed to the presence of several biological antioxidant activities (Matthaus, [24]) and antimicrobial properties (Packiyasothy and Kyle, [25]) and anticarcinogenic, antifungal, and antibacterial plus its antioxidant action (Kim et al., [27]). Kanya and Urs [58] revealed that taramira (*Eruca sativa*) seeds meal is rich in Ca and protein, but its value as animal and poultry feed is limited because of the presence of bitter taste. No significant differences were detected between different experimental supplementation on carcass cut (fore and middle) parts. However, the highest values of carcass cuts as hind, head and neck were detected with mustard seeds meal than other different experimental supplementation and control diets. Similar results were observed by El-Nomeary et al. [49] who fed rabbits for 68 days on 3% mustard seeds meal supplementation carcass cuts (hind and head) showed a significantly higher than other experimental supplementations.

On the other hand, there were no significant ($P<0.05$) differences detected between the different experimental supplementations and the control groups concerning the slaughter weight. Total external offals (g) showed significantly ($P<0.05$) higher value than other experimental supplementations and control groups. However, El-Nomeary et al. [49] fed rabbits for 68 days without any significant ($P<0.05$) differences in the total external offals weight between the different experimental groups. In the same consent, there were no significant ($P<0.05$) differences detected between the different experimental and the control diets concerning the total edible offals. Similar results were obtained by El-Nomeary et al. [49] who reported that there were no significant ($P<0.05$) differences between the four meal treatments and the control diet group concerning the total edible offals.

Full digestive tract showed higher value in case of mustard seeds meal than that of rocket and control groups. However, no significant differences between black cumin and sesame seeds meal were detected in fully occupied digestive tract. No significant differences in digestive tract (empty and content) between different experimental groups. Similar results were obtained by El-Nomeary et al. [49] who fed rabbits for 68 days.

Meat composition

Chemical analysis (Table 5) of the 9, 10 and 11th ribs (CP and EE contents) were significantly increased CP content; while EE was significantly decreased with different supplementation than the control groups. Dry matter contents showed significant differences between experimental groups. The highest value were detected with sesame and rocket seeds meal however, no significant differences between black cumin and mustard seeds meals while the lowest value was the control group. No significant differences in ash content between all groups. However, there were significant ($P<0.05$) differences in the protein contents and the ether extract of meat among the different groups. Gaafar et al. [59] were fed rabbits in commercial pelleted diet without addition (control) and the control diet supplemented with 2.5 g pumpkin oil plus 2.5 g *Nigella sativa* oil showed significantly ($P<0.05$) the highest protein and the lowest EE content in rabbit meats. However, Ibrahim et al. [55] found that dietary 90% of protein requirements with 1% mustard seeds in rabbit diets increased CP content of meat and decreased EE content. Moreover, Abdo [45] used rocket seeds meal as a substitution for soybean meal protein in broiler ration. He found a clear trend only EE and CP, where EE values decreased while CP values were increased in the chicken meat. Similar trend observed by El-Nomeary et al. [49] who found that EE values decreased while CP values were increased in rabbit meat when rabbit fed for 68 days age on diet supplemented with 3% black cumin, mustard, sesame and rocket seeds meals compared to the control group. It's noticed that with advanced age of rabbits, meat composition tends to contain lower, protein% and higher fat % deposition in rabbits meat.

Table 5. Carcass characteristics of rabbit fed different experimental diets (120 days).

Parameter	Experimental diets					± SE	Sig.
	Control	Black cumin seeds meal	Mustard seeds meal	Sesame seeds meal	Rocket seeds meal		
Empty body weight (g)	2465.7	2489.7	2805.4	2535.8	2390.7	179.46	NS
Carcass weight (g)	1665.7	1766.0	1934.0	1702.7	1718.7	46.71	NS
Carcass weight + total giblets (g)	1774.0	1861.0	2038.7	1808.4	1827.7	49.18	NS
Dressing percentage							
DP_1	60.9	64.1	62.4	60.7	64.9	2.12	NS
DP_2	67.5^{ab}	71.0^{ab}	69.0^{ab}	65.7^{b}	71.8^{a}	0.86	*
DP_3	71.8^{ab}	74.7^{ab}	73.1^{ab}	71.3^{b}	76.3^{a}	0.72	*
Carcass cuts (g)							
Fore part	580.3	607.7	660.3	613.3	610.7	12.81	NS
Middle part	388.7	363.3	371.0	280.0	417.0	21.55	NS
Hind part	498.7^{ab}	542.3^{ab}	630.7^{a}	570.0^{ab}	481.3^{b}	21.42	*
Head	151.3^{b}	181.0^{ab}	184.7^{a}	170.3^{ab}	156.3^{ab}	5.05	*
Neck	43.0^{b}	60.3^{ab}	82.3^{a}	65.0^{ab}	49.7^{b}	4.51	*
Slaughter weight (g)	2728.0	2755.3	3104.7	2806.3	2645.7	68.91	NS
External offals (g)							
Blood	100.0^{a}	57.0^{b}	69.3^{b}	70.0^{b}	75.0^{a}	4.90	*
Fur	365.3^{c}	406.3^{bc}	549.0^{a}	459.7^{b}	430.7^{bc}	18.68	*
Legs	96.0	101.0	100.3	102.0	84.0	2.99	NS
Tail	17.0	21.0	24.0	18.3	17.0	1.18	NS
Ears	50.7^{b}	58.0^{ab}	67.7^{a}	52.7^{b}	52.3^{b}	2.13	*
Total	629.0^{b}	643.3^{b}	810.3^{a}	702.7^{b}	659.0^{b}	20.71	*
Edible offals (g)							

Kidneys	18.0	15.3	17.0	16.7	20.7	1.30	NS
Liver	65.3	53.0	59.7	56.3	59.7	2.33	NS
Heart	10.0	10.0	11.0	12.7	12.7	0.71	NS
Lungs	14.0	15.7	16.0	19.0	15.0	0.73	NS
Spleen	1.0	1.0	1.0	1.0	1.0	0.00	NS
Total	108.3	95.0	104.7	105.7	109.0	4.21	NS
Digestive tract (g)							
Full	386.3^{b}	405.0^{ab}	458.3^{a}	431.7^{ab}	399.7^{b}	9.43	*
Empty	124.0	139.4	159.1	161.1	144.7	7.97	NS
Content	262.3	265.6	299.2	270.5	255.0	6.65	NS
Chemical analysis of the 9, 10 and 11th ribs							
Dry matter	30.41^{b}	34.30^{ab}	34.51^{ab}	37.59^{a}	38.75^{a}	1.37	*
Chemical composition on DM basis							
Crude protein (CP)	44.2^{b}	54.90^{a}	49.1^{ab}	44.1^{b}	54.2^{a}	1.88	*
Ether extract (EE)	48.2^{a}	34.4^{c}	43.4^{b}	48.8^{a}	37.4^{c}	1.15	*
Ash	7.6	10.7	7.5	7.1	8.4	0.17	NS

$DP_1=CW_1/SW$ $DP_2= CW_1/EBW$ $DP_3=CW_2/EBW$

a and b: mean in the same row within each treatment having different superscripts differ significantly at $P<0.05$.

SE : standard

4- Blood biochemical parameter:

Feeding different medicinal plant seed meals additive are shown in table (6). In the present study, there were no significant differences in biochemical parameter indicating that the applied feed additives can't affect the homeostatus of animals, and it may maintain the blood biochemical parameters with different feed additive normal as that of the control group. Inclusion dietary supplementation of black cumin seeds (NS) showed non significantly increase in plasma glucose, total protein and globulin and non significantly decrease in cholesterol and triglycerides similar result obtained by (El-Bagir et al., [60] and Gaafar et al., [59]). In contrast with all these studies, Amber et al [61] reported that there was a significant increase in plasma cholesterol and triglycerides, white dietary supplementation with NS in the rabbit feed led to a significant decrease in plasma total protein and glucose. The hypolipidemia effect of this plant was probably due to the synergistic action of its different constituents, parliculary thymoquincore, nigellamine (Ali and Blunden, [62]). This effect was studied in rabbits fed with a hypercholesterolemia.

In these animals, this inclusion of NS seeds in the ration significantly reduced serum total cholesterol and low density lipoprotein levels, but it enhanced high density lipoprotein concentrations (Pourghassem-Gargari et al., [63]; Al-Naqeep., [64]; Asgary et al., [65]) Those results indicated that, when fed to rabbits, NS can transmit anti-atherogenic and cardio-protective properties and is able to inhibit the development of atherosclerosis (Asgary et al., [66]). However, Gaafar et al. [59] fed the control diet supplemented with 5g *Nigella sativa* seed oil/kg diet the biochemical concentration of total protein, albumin and globulin among groups were not significant compared to the control. However, concentration of total lipids, triglycerides, total cholesterol HDL and LDL as well as the activity of AST and ALT significantly (P<0-05) decreased in treatment group as compared to the control one. Mahmoud and Bendary [40] found that replacement of dietary protein by *Nigella Sativa* meal and sesame seed meal on the performance of the Egyptian lactating buffaloes, total protein, albumin, and globulin cleared that no adverse effect of *Nigella Sativa* meal and sesame meal on protein metabolism. Cholesterol and triglycerides had no bad effect of oil in tented meals on lipid metabolism. However, Gugolek et al. [67] indicate that diets supplemented with 1% mustard meal in rabbits fed diet. No significant differences in blood biochemical parameters as glucose, total cholesterol, HDL cholesterol, triglycerides were detected between diet supplemented with 1% mustard meal and control groups. However, Njidda and Isidahomen [68] fed rabbits diet containing 0, 4, 8 and 12 % of sesame seed meal (SSM). There were significant differences ($P<0.05$) for blood glucose serum globulin, cholesterol, creatininc and urea but there was no effect ($P>0.05$) on serum albumin and total protein among treatments. Moreover, Asgary et al [66] investigate the anti-hyperlipidemia effect of sesame in a high-fat fed rabbit model. Animals were randomly divided into four groups of eight animals each for 80 days as follows: normal diet, hypercholesterolemia diet (1% cholesterol), 1% cholesterol + sesame seed (10%) and (1% cholesterol) + sesame oil (5%) at the end of supplementation period. Hypercholesterolemia feeding resulted in a significant elevation of TC, TG, LDL-c, HDL-c, SGOT and SGPT as compared to the normocholesterolemia diet group (P<0.05). Supplementation with sesame seed did not cause any significant alteration in lipid profile parameters. While, supplementation with sesame oil, but not sesame seeds can ameliorate serum levels of lipids and hepatics enzymes in rabbits under a high-fat diet. Moreover, Kalita et al. [69] study the effects of combined sesame and olive oil as a dietary supplement on hypercholesterolemia Guinea pig for a period of 60 days. The sesame and olive oil are especially rich in mono-unsaturated fatty acids like Linoleic acid, oleic acid and palmitic acid which are absorbed in the blood stream and liberated out un-wanted cholesterol. On the other hand, Sesamol and sesaminol are phenolic antioxidants.

Antioxidants are known to reduce oxidation of low density lipoprotein cholesterol. Thus the combination of sesame and olive oils are thought to be helpful in maintaining good health or strong heart. On the other hand, feeding rocket seed meal group showed none significantly decrease by about 21.4% and 14.8% for triglycerides and cholesterol respectively than that of control group. El-Gengaihi et al. [21] appraised the hypolipidemia effect of two untraditional vegetable oil (rocket and borage oil), in addition to a traditional one (olive oil) in hyperlipidemic rats. The three tested oils led to a significant decrease in serum triglycerides, total cholesterol, total lipids, low density lipoprotein (LDL) and LDL/HDL ratio. Moreover, cholesterol and total lipids in hyperlipidemic rats were reduced by the treatment with the three oils.

In general, it is recommended that use of black cumin, mustard, sesame and rocket seed meals as feed additives at 3% level in rabbit diet to improve the performance such improvement of tested materials may be attributed to the properties of those materials that could act as anti-bacteria, anti-protozool, anti-fungal and anti-oxidant. It's noticed that with advanced age of rabbits, meat composition tended to contain lower protein and higher fat deposition.

Such feed additives in rabbit diets significantly low density lipoprotein levels, but enhance high density lipoprotein concentration and produces more healthy food for human consumption.

Table 6. Effect of some medicinal plants seed on blood serum parameters.

Parameter	Experimental diet					± SE	Sig.
	Control	Black cumin	Mustard	Sesame	Rocket		
Plasma glucose (mg/dl)	62.70	70.84	69.27	79.61	48.88	12.95	NS
Triglycerides (mg/dl)	105.90	108.84	96.03	100.36	83.21	10.36	NS
Cholesterol (mg/dl)	144.71	127.54	135.03	102.99	123.20	12.35	NS
Protein (g/dl)	6.85	7.76	7.90	6.90	7.37	0.65	NS
Albumin (g/dl)	2.74	2.59	2.27	2.57	2.94	0.214	NS
Globulin (g/dl)	4.12	5.16	5.63	3.50	4.42	0.754	NS
A/G ratio	0.71	0.51	0.43	0.85	0.69	0.098	NS
Malondialdehyde MDA (nmol/ml)	15.89^{ab}	17.80^{a}	12.76^{ab}	10.90^{b}	14.66^{ab}	1.446	*

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

The data of serum metabolites (Table 6) indicated that the majority of the feed additives used in this study had not significantly altered the homeostasis of the rabbit body. However, the MDA has significantly (P<0.05) decreased in case of sesame addition to the ration of the rabbits compared to the control group. This is due to the presence of potent contents of sesamin and sesamol (lignans group) in the edible seeds of sesame (Suja et al., [70]).

Collectively, it is concluded that the addition of 3% of black cumin or mustard or sesame or rocket seeds meals to the basal commercial rabbit ration have an ameliorating effect on the performance of the rabbit meat production and its body homeostasis.

References

1. Ismaeil, A.M.; A.H. Elfar and I.I. Abou-Ganema (2010). Effect of tonilisat and roemin w2 supplementation on performants of lambs. World Academy of Sci. Engineering and technology, 47: 11-29.
2. Pluske, J. R. (2013). Feed and feed additives related aspects of gut health and development in weanling pigs. J. Anim Sci. Biotec., 4:1
3. Morsi, N.M. (2000). Antimicrobial effect of crude extracts of *Nigella sativa* on multiple antibiotics-resistant bacteria. Acta Microbiol. Pol., 49: 63-74.
4. Rahman, M.A.M.A. and A.A. Nada (2006). Effect of black seed oil on rabbits infected with some intestinal *Eimeria* species. Vet. Med. J. (Cairo University), 54: 331-341.
5. Baghdadi, H.B. and E.M. Al-Mathal (2011). Anti-coccidial activity of *Nigella sativa L.* J. Food Agric. Environ., 9: 10-17.
6. Maqubool, A., C.S. Hayat and A. Tanveer (2004). Comparative efficacy of various indigenous and allopathic drug against fasciolosis in buffaloes. Vet. Archiv., 74: 107-114.
7. Bamosa, A.O., H. Kaatabi, F.M. Lebola, A.M. Elq and A. Al-Sultan (2010). Effect of *Nigella sativa* seeds on the glycemic control of patients with type 2 diabetes mellitus. Ind. J. Physiol. Pharm., 54: 344-354.
8. Pichette, A., B. Marzouk and J. Legault (2012). Antioxidant, anti-inflammatory, anticancer and antibacterial activities of extracts from *Nigella sativa* (Black cumin) plant parts. J. Food Biochem., 36: 539-546.
9. Bamosa, A.O., B.A. Ali and Z.A. Al-Hawsawi (2002). The effect of thymoquinone on blood lipids in rats. Ind. J. Physiol. Pharm., 46: 195-201.
10. Kanter, M. (2009). Effects of *Nigella sativa* seed extract on ameliorating lung tissue damage in rats after experimental pulmonary aspirations. Acta histochem., 111: 393-403.
11. Perveen, T., A. Abdullah, S. Haider, B. Sonia, A.S. Munawar and D.J. Haleem (2008). Long-term administration of *Nigella sativa* effects nociception and improves learning and memory in rats. Pak. J. Biochem. Mol. Biol., 41: 141-143.
12. Alenzi, F.Q., M.A.A. Altamimi, O. Kujan, B. Tarakji, W. Tamimi, O. Bagader, A. Al-Shangiti, A.N. Talahi, A.K. Alenezy, F. Al-Swailmi, D. Alenizi, M.L. Salem and R.K.H. Wyse (2013). Antioxidant properties of *Nigella sativa*. J. Mol. Genet. Med., 7:1-5.
13. Chauhan, J.S., S.K. Jha, S.K. Yadov, P.R. Kumar, A.K. Shukla and Y.P. Singh (1999). Quality rapeseed-mustard varieties in India. A perspective – Tachnical Bulletin No. 9. National Research Centre on Rapeseed – mustard, Sewar, Bharatpur, Rajasthan, India. Pp. 26.
14. Duncan, A.J. (1991). Glucosinolates. In: J. D'Mells and C. Duffus (eds) "Toxic substances in crop plants", Royal Soc. Chem., Cambridge. Pp. 581.
15. Bell, J.M. (1984). Nutrients and toxicants in rapeseed meal. A review. J. Anim. Sci., 4: 996-1010.
16. Eskin, N.A., J. Raju and R.P. Bird (2007). Noval mucilage fraction of *Sinapisalba* L. (mustard) reduces azoxymethane – induced colonic aberrant crypt foci formation in F344 and Zucker obese rats. Phytomedicine, 14(7-8): 479-485.
17. Liu, L., Y. Wang, H. Li and Y. Ji (2006). Study of distribution of sinapine in commonly used crude drugs from cruciferous plants. Sc. Pu. Jan., 24(1): 49-51.
18. Müller, C., N. Agerbirk, C.E. Olsen, J.L. Boeuá, U. Schaffner and P.M. Brakefield (2001). Sequestration of host plant glucosinolates in the defensive hemolymph of the sawfly Athaliarosae. J. Chem. Ecol. Dec., 27(12): 2505-2516.
19. Palomares O., J. Cuesta-Herranz, R. Rodriguez and M. Villalba (2005). A recombined precursor of the mustard allergen sin a 1 retains the biochemical and immunological features of the heterodimeric natine protein. Int. Arch. Allergy Immunol., 137(1): 18-26.

20. Anilakumar, K.R. (2010). Nutritional, medicinal and industrial uses of sesame (*Sesame indicum L.*) seeds. An Overview, 75(4): 159-168.
21. El-Gengaihi, S.E., A. Salem, S.A. Bashandi, N.A. Ibrahim and S.R. Abd El-Hamid (2004). Hypolipidemic effect of some vegetable oil in rats. Food Agric. Environ., 2(2): 88-93.
22. Flander, A. and S.M. Abdulkarim (1985). The composition of seed and seed oils of taramira (*Eruca sativa*). J. Am. Oil Chem. Soc., 62: 1134-1135.
23. Mahran, G.H., H.A. Kadry, C.K. Thabet, M.M. El-Olemy and M.M. Al-Azizi (1990). Investigation of certain diuretic drugs plants, II: GC/MS analysis of volatile oil of seeds of *Eruca sativa* Mill. Az. J. Nat. Prod., 4: 82-88.
24. Matthaus, B. (2002). Antioxidant activity of extracts isolated from residues of oilseeds, such as rapeseed or sunflower. Agric. Food. Indust. Hi Tech., 13: 22-25.
25. Packiyasothy, E.V. and S. Kyle (2002). Antimicrobial properties of some herb essential oil. Food Austr., 54: 384-387.
26. Fernandez-Martinez, J.M., M.-del Rio, L. Velarcs, J. Dominguez, A. de Haro, M. del Rio and A. De Haro (2001). Registration of zero erucic acid Ethiopian mustard genetic stock 25x-1. Crop Sci., 41: 282.
27. Kim, S.J., S. Jin and G. Ishii (2004). Isolation and structural elucidation of 4-(B-d-Lucopyranospyldisulfanyl) butyl glucosinolates from leaves of rocket salad (*Eruca sativa L.*) and its anti-oxidative activity. Bio. Sci. Biotechnol., 68: 2444-2450.
28. NRC (1977). National Research Council: Nutrient Requirements of Domestic Animal. Nutrient Requirements of Rabbits. Second revised edition. National Academy of Science, Washington DC, USA
29. Blasco, A., J. Quhayaum and G. Masoscro (1993). Harmonization of criteria and terminology in rabbit meat research. Wld. Rabbits Sci., 1: 3-10.
30. A.O.A.C. (2000). Official methods of analysis, 17th ed. Association of Official Analytical Chemists, Washington, D.C., USA.
31. Fekete, S. & Gippert, T. (1986). Digestibility and nutritive value of nineteen important feedstuffs for rabbits. J. Appli. Rabbit Res., 9 (3): 103-108.
32. Trinder P. 1969. Determination of glucose in blood using glucose oxidase with an alternative oxygen acceptor. Ann Clin Biochem; 6:24-25
33. Gormall AG, Bardwill CJ, David MM. 1949. Determination of serum proteins by the means of Biuret reaction. J. Biol. Chem., 177: 751-766.
34. Doumas BT., Watson WA. and Biggs HG. Albumin standards and the measurement of serum albumin with bromcresol green. Clin. Chim. Acta, 1971, 31: 87-96.
35. Fassati P. and Prencipe L. (1982). Triglycerides enzymatic colorimetric method. Clin Chem; 28: 2077-2081.
36. Richmond W. 1973. Preparation and properties of a cholesterol oxidase from *Nocardia* sp. and its application to the enzymatic assay of total cholesterol in serum. Clin Chem. 19(12): 1350-1356.
37. Ohkawa H., Ohishi W. and Yag K. (1979). Assay for lipid peroxides in animal tissues by thiobarbituric acid reaction. Anal Biochem; 95(2): 351-358.
38. SPSS (1998). Statistical Package for Social Sciences, Chicago, USA.
39. Duncan, D.B. (1955). Multiple range and multiple-F-test. Biometrics, 11: 1-42.
40. Mahmoud, A.E. and M.M. Bendary (2014). Effect of whole substitution of protein source by *Nigella sativa* meal and sesame seed meal in ration on performance of growing lambs and calves. Glob. Vet., 13(3): 391-396.
41. Tripathi, M.K. and K.K. Singhal (1994). Effect of processing and heat treatment on glucosinolates content in rapeseed meal. Proc. Nat. Symp. On Environmental related feeding strategies. 12-13 Dec., Hisar, India. pp. 35.
42. Papas, A., J.R. Ingalls and P. Cansfield (1978). Effect of tower and rapeseed meals and gums on milk yield, milk composition and blood parameters of lactating dairy cows. Can. J. Anim. Sci., 58: 671-679.
43. Tyagi A.K., M.K. Tripathi and S.A. Karim (1996). Evaluation of mustard cake as protein supplement in pregnant ewes. Wld. Rev. Anim. Prod., 30: 93-98.
44. Pastuszewisk, B., G. Jablecki, E. Swiich, L. Buraczewsk and L. Ochtabinska (2000). Nutritive value of rapeseed meal containing lecithin gums precipitated with citric acid. Anim. Feed Sci. Technol., 86: 117-123.
45. Abdo, Zeinab M.A. (2003). Using Egyptian *Eruca sativa* seed meal in broiler rations with or without microbial phytase. Egypt. J. Nutr. Feeds, 6 (special issue): 97-114.

46. Aherne, F.X. and J.J. Kenelly (1982). Oil seed meals for livestock feeding. In: Haresign W. (ed.), Rec. Adv. Anim. Nutr., pp: 39-89. Butterworths, London.
47. Omar, R.E.M., E.A. Mahmoud, M.M. Karousa and Randa S.A. Ismaeil (2002). Effects of additives propolis and *Nigella sativa* seed oil on some behavioral patterns, performance products and blood parameters in Sasso chickens. Egypt. Poult. Sci., 21: 140-151.
48. Abou El-Soud, S.B. (2000). Studies on some biological and immunological aspects in Japanese quail fed diets containing some *Nigella sativa* seed preparation. Egypt. Poult. Sci., 20: 757-776.
49. El-Nomeary, Y.A.A., R.I. El-Kady and A.A. El-Shahat (2015). Effect of some medicinal seed meals supplementation and their effects on the productive performance of male rabbits. Int. J. Chem. Tech. Res., 8(6): 401-411.
50. Abd El-Hakim, A.S., A.A. Sedki and A.M. Ismail (2002). Black seed forms and its effect on rabbit performance and blood constituents 3rd Science Conf. on Rabbit production in hot climate, 8-11 October, Hurghada, Egypt, pp. 579-588.
51. William, H.C. (1999). Organic minerals for pigs. Biotechnology in the feed industry, Proc. of 15th Annual Symposium pp: 51, Nottingham Univ., Press Nottigham, Lecis, UK.
52. Seleem, T.S.T. and Rowida M. Riad (2005). Enzymatic activity and fertilizing ability of rabbit semen supplemented with *Nigella sativa* extraction. The 4th International Conference on Rabbit Production in Hot Climate, Sharm El-Sheikh, Egypt, pp. 183-189.
53. Seleem, T.S.T., Abd El-Motaal A.E.M., Affaf I.M.M., Torkia A.M.A. and Leila B. Bahgat (2007). Some productive performance of rabbits as affected by supplementing *Nigella sativa* of the diet. The 5th Int. Conf. on Rabbit Prod. in Hot Clim., Hurghada, Egypt, pp. 273-286.
54. Andrzej Gugolek, P., M. Kowalska, J. Konstantynowicz, S. Strychalski and B. Bukowska (2011). Performance indicators, health status and coccidial infection rates in rabbits fed diets supplementation with white mustard meal. Ann. Anim. Sci., 11(3): 425-432.
55. Ibrahim, Sh. A. N., H.A.A. Omer, A.A. Abedo and F.A.F. Ali (2012). Response of growing rabbits to diets containing different levels of protein and mustard seed (*Sinapis alba Linn*.). J. Agric. Sci., 4(1): 190-201.
56. Rahimian, Y., S.N. Tabatabaie, M. Toghiani, S.M.R. Valiollahki, F. Keiri, A. Rafiee and Y. Miri (2013). Effect of use cumulative level of sesame (*Sesamum indicum L.*) meal with phytase enzyme on broiler chicks. Sci. Agric. : 1(3): 85-94.
57. El-Tohamy, M.M. and R.I. El-Kady (2007). Partial replacement of soybean meal with some medicinal plant seed meals and their effect on the performance of rabbits. Int. J. Agric. Biol., 9(2): 215-219.
58. Kanya, T.C.S. and M.K. Urs (1989). Studies on taramira (*Eruca sativa*) seed oil and meal. J. Am. Oil Chem. Soc., 66: 139-140.
59. Gaafar, H.M.A., Ayat A. Ragab and K.F.A. El-Reidy (2014). Effects of diet supplemented with pumphin (*Cucurbika moschata*) and black seed (*Nigella sativa*) oil on performance of rabbits: 1-Growth performance, blood haematology and carcass traits of growing rabbits. Report and opinion, 6(1).
60. El-Bagir, N.M., I.T.O. Farah, A. Alhaidary, H.E. Mohamed and A.C. Beynen (2010). Clinical laboratory serum values in rabbits fed diets containing black cumin seeds. J. Anim. Vet. Adv., 9: 2532-2536.
61. Amber, K.H., A.E. Abou-Zeid and Osman Mona (2001). Influence of replacing *Nigella sativa* cake for soybean meal on growth performance and caecal microbial activity of weanling New Zealand white rabbits. Egypt. J. Rabbit Sci., 11(2): 191-206.
62. Ali, B.H. and G. Bluden (2003). Pharmacological and toxicological properties of *Nigella sativa*. Phytother. Res., 17: 299-305.
63. Pourghassem-Gargari, B.V. Ibrahimzadeh-Attary, M. Rafraf and Gorbani (2009). Effect of dietary supplementation with *Nigella sativa L.* on serum lipid profile, lipid peroxidation and antioxidant defense system in hyperlipidemic rabbits. J. Med. Plants Res., 3: 815-821.
64. Al-Naqeep, G., A.S. Al-Zubairi, M. Ismail, Z.H. Amom and N.M. Esa (2011). Antiatherogenic potential of *Nigella sativa* seeds and oil in diet-induced hypercholesterolemia in rabbits. Evid. Based Compl. Alt., 2011: 213628.
65. Asgary, S., A. Ghannadi, G. Dashti, A. Helalat, A. Sahebkar and S. Najafi (2013a). *Nigella sativa L.* improves liquid profile and prevents atherosclerosis: evidence from an experimental study on hypercholesterolemic rabbits. J. Funct. Foods, 5: 228-234.

66. Asgary, S., M. Refieian-Kopaei, S. Najafi, E. Heidarian and A. Sahabkar (2013b). Antihyperlipidemic effects of *Sesamum indicum L.* in rabbits fed a high-fat diet. The Scientific World Journal volume 2013. Article ID 365892, 5 pages.
67. Gugolek, A., D. Kowalska, M. Konstantynowicz, J. Strychalski, and B. Bukowska (2011). Performance indicators, health status and coccidial infection rates in rabbits fed diets supplemented with white mustard meal. Ann. Anim. Sci., 11(2): 425-432.
68. Njidda, A.A. and C.E. Isidahomen (2011). Hematological parameters and carcass characteristics of weanling rabbits fed sesame seed meal (*Sesamum indicum*) in a semi-Arid region. Pak. Vet. J., 31(1): 35-39.
69. Kalita, B., D. Kusre and K.C. Bhuyan (2014). Effects of sesame oil and olive oil on the plasma total cholesterol, low density lipoprotein and high density lipoprotein cholesterol of guinea pig. Int. J. Eng. Sci. Innov. Tech., 3(5).
70. Suja KP, Jayalekshmy A and Arumughan C. (2004). Free radical scavenging behavior of antioxidant compounds of sesame (*Sesamum indicum*) in DPPH system. J. Agric. Food Chem.; 52: 912-915.

*****