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EFFECTS OF CLOVE (*Syzygium aromaticum*) ON PRODUCTIVE PERFORMANCE, NUTRIENTS VALUE AND DIGESTIBILITY, BLOOD LIPID PROFILE, ANTIOXIDANT STATUS AND IMMUNE RESPONSE OF GROWING RABBITS

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ABSTRACT: The current study evaluated the effect of feeding clove (*Syzygium aromaticum*) as a natural additive on productive performance, digestibility and nutritive value, antioxidant enzymes activities, and immune response of growing rabbits. A total of 48 New Zealand White (NZW) rabbits aged 6 weeks were randomly allocated to 4 groups (12 rabbits/group). Clove buds powder (CLP) was supplemented at 0.5, 1, and 1.5% of basal diet. Four tested diets formulated to contain basal diet without CLP (treatment 1, T1), 0.5% CLP (T2), 1% CLP (T3), and 1.5% CLP (T4). The animals were provided pelleted diets and fresh water *ad libitum* throughout the experimental period. The rabbits fed diets containing CLP improved FCR (P=0.007) and consumed (P<0.0001) less than those fed control group. The diet containing 1.5% CLP had the best feed conversion ratio (FCR) value (P<0.05). No significant differences were observed among experimental groups in all nutrients digestibility except CP digestibility significantly (P=0.0261) increased with 0.5 and 1% CLP groups compared to control group. Blood total lipid (TL) was significantly decreased (P<0.009) with increasing the dietary level of CLP, (being 379.17 and 361.11 mg/dl for 1% and 1.5% CLP groups vs. 470.84 for the control group). The catalase and total antioxidant capacity (TAOC) concentrations significantly (P<0.0001) increased with CLP groups compared to control group. The immunoglobulins titres (IgG and IgM) improved (P>0.05) with rabbits fed CLP diets when compared to those fed the control diet. In conclusion, using CLP as an alternative feed additive in rabbit's diets up to 1.5% without any adverse effect on productive performance and vital activities. The CLP inclusion in rabbit diets decreased feed intake (FI), improved FCR and increased profitability, moreover, had a positive effect on antioxidant enzyme activity and immunity (IgG and IgM) titres.

Keywords: Antioxidant status, Clove, Immune, Performance, Rabbits

INTRODUCTION

Phytogenic as herbs or spices is a natural growth promoters or non-antibiotics growth promoters which are used as feed additives in rabbit diets to improve the productive performance, health status and meat quality (Christaki et al., 2012; Ingweye et al., 2020; Nwachukwu et al., 2021). Moreover, phytogenic help to improving immune system performance in critical situation due to increase the intestinal availability of essential nutrients for absorption, therefore, helping animals to grow better within the framework of their genetic potential (Windisch et al., 2008).

The ban of using antibiotics in livestock nutrition as feed additives attributed to its residual effect which found in final products and increased the consumer's awareness about the health hazards occurs (Anadón et al., 2006; Silveira et al., 2021). Moreover, due to the use of antibiotics in livestock nutrition triggered searching for alternative natural and safe healthy for animals and human when used as feed additives, especially a source of antibiotic (Khamisabadi et. al., 2016). Like, herbs are often preferred because they are natural and do not put harmful chemicals into the body (Agrawal et al., 2014). Herbs considered as an alternative feed additive of antibiotics and drug that using in poultry diets to avoid the residual cumulative effect in final poultry products, which negatively affects human health (Ragab, 2012). Clove (*Syzygium aromaticum*) has potent as antioxidant and antimicrobial activities standing out among the other spices (Shan et al., 2005). The clove powder supplementation in broilers diet at 0.5% improved body weight gain and feed conversion ratio (Mahrous et al., 2017). Also, supplementation of 0.50% clove buds and aloe vera leaves improved dressing percentage and breast weight of Japanese quails (Tariq et al., 2015). In rabbit diets added clove a combination with onion, garlic, caraway, fennel, gentian, melissa, peppermint, anise, and oak bark decreased post-weaning mortality rate, improved feed utilization, and enhanced animal performance (Krieg et al., 2009). Sulieman et al. (2007) used clove (*Syzygium aromaticum*) as an antimicrobial, antiseptic, and preservative agent. Furthermore, clove essential oil exhibits a

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wide range of pharmacological and biological activities such as antioxidant (Gülçin et al., 2012), antifungicidal (Omidbeygi et al., 2007), and antiprotozoal effects (Machado et al., 2011).

Current study investigated effect of clove (CLP) supplementation in growing rabbit diets on productive performance, nutritive value, blood lipid profile, antioxidant enzymes activity, and immune response.

MATERIALS AND METHODS

The experiment was conducted in Borg El-Arab experiment station, Animal Production Research Institute (APRI), Agricultural Research Center (ARC), Giza, Egypt. The laboratory works were carried out at Utilization of By-products Research Department, APRI, Giza, Egypt. Feed mixing and pelleting processing were prepared at Nobaria feed manufactory, Nobaria experiment station, APRI, Alexandria, Egypt.

Ethical approval

This study was carried out after approved ethically from the APRI, Giza, Egypt under code No. 432429-21-6.

Diets and animals management

Clove buds (*Syzygium aromaticum*) grinded by hammer mill then was taken sample from clove buds powder (CLP) to determine the chemical analysis composition (A.O.A.C., 2000) and total antioxidant capacity (TAOC; Prieto et al., 1999) assayed by spectrophotometer (JENWAY 3600). Rabbit basal diet supplemented with 0.0, 0.5, 1.0 and 1.5% clove buds powder (CLP). Basal diet without CLP supplementation (T1) which considered as a control group, basal diet with 0.5% CLP (T2), 1.0% CLP (T3) and 1.50% CLP (T4). The experimental diets (Table 1) were meet the nutrients requirement of growing rabbits (Lebas, 2004) also, it were to be isonitrogenous and isocaloric.

The experimental New Zealand White (NZW) rabbits were randomly allocated to 4 groups, 12 rabbits for each group. Rabbits weighting averaged 652.81±33.43 g. the experiment lasted 8 weeks (6-14 weeks of rabbit age). The growing rabbits housed in metal battery cage (30 × 35 × 40 cm). The pelleted feed and fresh water provide *ad-libitum* access to separated feeders and automatic nipple fresh water throughout the tested period. The experimental rabbits were kept under the hygienic condition, vaccine program, and management.

Table 1 - Formulation and chemical composition of tested diets

Ingredients	Control diet	Clove buds powder addition levels		
		0.5%	1.0%	1.5%
Soybean meal (44% CP)	17.00	17.00	17.00	17.00
Yellow corn	13.00	13.00	13.00	13.00
Barley	12.95	12.95	12.95	12.95
Wheat bran	16.00	16.00	16.00	16.00
Clover hay	35.00	34.50	34.00	33.50
Clove buds powder (CLP)	0.00	0.50	1.00	1.50
Dl-methionine	0.20	0.20	0.20	0.20
Dicalcium phosphate	2.00	2.00	2.00	2.00
Salt (NaCl)	0.35	0.35	0.35	0.35
Vitamins and minerals mixture[1]	0.30	0.30	0.30	0.30
Anti-coccidia and fungi	0.20	0.20	0.20	0.20
Molasses	3.00	3.00	3.00	3.00
Total	100.00	100.00	100.00	100.00
Chemical analysis on DM basis [2]				
Dry matter (DM, %)	82.92	82.93	82.95	82.96
Organic matter (OM, %)	85.94	85.93	85.91	85.90
Crude protein (CP, %)	17.73	17.67	17.60	17.54
Crude fiber (CF, %)	14.12	14.08	14.04	14.00
Ether extract (EE, %)	2.13	2.19	2.25	2.31
Nitrogen free extract (NFE, %)	54.95	55.00	55.05	55.11
Ash (%)	5.14	5.13	5.13	5.12
Digestible energy (DE, kcal/kg)[3]	2605.44	2607.98	2610.54	2613.09

[1] Commercial vitamin and mineral premix contained (per 3 kg premix) vit. A 12000 000 IU, vit. D3 3000 000 IU, vit. E 10 000 mg, vit. K3 2000 mg, vit. B1 1000 mg, vit. B2 5000 mg, vit. B6 1500mg, vit. B12 10 mg, pantothenic acid 10 000 mg, nicotinic acid 30 000 mg, folic acid 1000 mg, biotin 75 mg, copper 4000 mg, manganese 80 000 mg, zinc 50 000 mg, iron 30 000 mg, iodine 500 mg, selenium 100 mg and cobalt 100 mg. [2]NRC (1977). [3]Digestible Energy (kcal/kg) = 4.36-0.049 × [28.924 + 0.657 (CF %)] according to Cheeke, (1987).

Productive performance measurements

Live body weight (BW, g/rabbit/day) of rabbits and feed intake (FI, g/rabbit/day) were recorded weekly. Then the feed conversion ratio (FCR, g feed: g gain) were calculated over an experimental period. The BW, FI, and FCR were calculated on per cage basis and then average by treatment.

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Digestion trial

According Perenze et al. (1995), 20 rabbits divided randomly into 4 groups (5 rabbits/group) to execution the digestion trial. Rabbits were allocated in metabolic cages (56 × 38 × 28 cm). The feces were collected daily before the morning meal. The fresh feces were weighed then dried in air-dry oven at 60 °C for 24 hour. The diets and dried feces ground samples used to estimate the moisture, ash, nitrogen, ether extract, and crude fiber (A.O.A.C., 2000). Those data were used to calculate the digestion coefficient of nutrients, nutritive value (Fekete, 1985), and digestible energy (Schneider and Flatt, 1975) for each tested diets.

Blood lipid profile, antioxidant enzymes activity, and immune response

The blood samples were collected during slaughtering time from five rabbits which randomly selected from each treatment at the end of growing period. The samples were collected in heparinized tubes and centrifuged at 3000 rpm for 20 minute, then transferred the plasma to tubes and stored at -20 °C till biochemical analysis. Plasma total lipids was determined according to Frings and Dunn (1970), cholesterol was estimated according to Young (1997), LDL cholesterol was determined according to Assmann et al. (1984) and HDL cholesterol was determined according to Lopez et al. (1977). The antioxidant enzymes as catalase concentration and total antioxidant capacity were determined according to Góth (1991) and Fischer et al. (2006). Immunoglobulin (IgG and IgM) responses were estimated according to Van der Zipp et al. (1983). All measurements were assayed by colorimetric methods. All kits were purchased from Bio-diagnostic Co, Egypt

Economic profit

Economic efficiency was calculated as a ratio between the return of weight gain and the cost of feed intake. The price of ingredients and selling of one kg live weight of rabbits ($2.55/kg) was calculated according to the price in local market at the time of experiment.

Statistical analysis

All data were subject to one-way analysis of variance (ANOVA). The data obtained herein were analyzed by the GLM procedure of SAS (2004, USA). Duncan's multiple range test (1955) was performed to separate means and significance accepted at P≤0.05.

RESULTS AND DISCUSSION

Nutritional analysis and total antioxidant of CLP

The nutritional analysis and total antioxidant capacity of CLP are presented in Table 2. The DM, OM, CP, CF, EE, NFE, ash, and DE values of CLP were 91.40, 94.36, 9.17, 13.50, 6.40, 64.80, 6.17%, and 2508.12kcal/kg, respectively. In contrary, the chemical analysis of clove buds were 90, 1.20, 20.10, 12.10 and 5.4% for DM, CP, CF, EE and ash, respectively (Sulieman et al., 2007); 85.20, 12.40, 17.50, 16.20 and 12.60%, respectively (Sulaiman and Anas, 2017).

The total antioxidant capacity (TAC) content of CLP was 1069.20 mg/100g (ascorbic acid equivalent). This TAC value is higher than those obtained by Ahmed et al. (2022) who found the TAC as form 2,2-diphenyl-1-picrylhydrazyl (DPPH%) radical scavenging activity in CLP was 83.90 mg/100g. However, Anita et al. (2015) who found the oxidized, reduced, and total ascorbate were 8084.40, 8014, and 6098.50 mg/100g dry wt., respectively. The DPPH scavenging of antioxidant content of CLP was 13660 mg/100mg according to Turgay and Esen (2015). The polyphenols and antioxidant content of CLP is higher than those in other spices (Pérez-Jiménez et al., 2010). The TAC in clove or their extract can promote health (Abo El-maati et al., 2016). Furthermore, it prevents the oxidation of lipids by chelating metal ions or inhibits the propagation reaction being hydrogen / electron donor (Shobana and Naidu, 2000). The active ingredients of clove buds and lemon balm extracts are able to scavenge the free radicals in *in vitro* trail (Petrovic et al., 2012).

Table 2 - Chemical analysis and total antioxidant capacity of clove powder

Items	Clove buds powder (CLP)
Chemical analysis on DM basis	
Dry matter (DM, %)	91.40
Organic matter (OM, %)	94.36
Crude protein (CP, %)	9.17
Crude fiber (CF, %)	13.50
Ether extract (EE, %)	6.40
Nitrogen free extract (NFE, %)	64.80
Ash (%)	6.17
Digestible energy (DE, kcal/kg)[1]	2508.12
Total antioxidant capacity mg/100 g (ascorbic acid equivalent)	
TAOC	1069.20

TAC: Total antioxidant capacity; [1]Digestible Energy (kcal/kg) = 4.36-0.049 × [28.924 + 0.657 (CF %)] according to Cheeke, (1987).

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Growth performance

The effect of CLP supplementation on growing rabbit's performance is presented in Table 3. No significant differences in FBW (P=0.7092) and BWG (P=0.6400) were found between the control group (T1) and treatment groups (T2-T4). Final body weight (FBW, g) and body weight gain (BWG, g/day/rabbit) increased with groups fed CLP more than 0.5% level addition (P>0.05). However, FI (g/rabbit/day) and FCR (g, feed: g, gain) were significantly (P<0.0001 and P=0.007, respectively) affected by inclusion of dietary CLP. Rabbits in dietary CLP treatments (T2, T3, and T4) decreased (P<0.0001) the FI consuming and improved (P<0.0078) FCR during the growing period as compared with control treatment (T1). The dietary 1.5% CLP group had the lowest FCR value (T4, 3.89), which was comparable to the control (T1, 4.70) and better than the 0.5% (T2, 4.15) and 1.0% (T3, 4.28) dietary CLP. The FCR of broiler at finisher period was improved (P<0.05) with clove essential oil (455ppm) addition (Mehr et al., 2014). Similarly with Petrovic et al. (2012) who showed slightly improvement (P>0.05) in broilers performance (BW, FI and FCR) which fed diets supplemented 1% clove bubs with 0.2% lemon balm extract. Mahrous et al. (2017) observed no significant differences in broilers performance indices (FBW, BWG, FI, and FCR) fed diets supplemented 0.5, 1.0, and 1.5% clove buds.

In present study, the improvements in FBW (P=0.7092), BWG (P=0.6400) and FCR (P<0.05) with increasing level of CLP than 0.5% due to increase the diets content of growth promoters properties such as antimicrobial (Dorman et al., 2000). Many studies confirmed the positive effect of spices or their active components on the digestion process, wherein they activate bile salts secretion and digestive enzyme activities in the intestinal mucosa and pancreas (Hernández et al., 2004) which reflect to broilers productive performance (Jang et al., 2007). In contrary, Al-Mufarrej (2019) who reported that negative effect of final live body (P<0.05) for broiler fed clove supplemented more than 2%. Hussein et al. (2019) added 1.5 ml clove oil/kg of Japanese quails diet, increased (P<0.05) performance in terms of BWG and FI, with no improvement (P>0.05) in FCR.

Table 3 - Effect of clove buds powder addition on growing rabbit's performance

Items	IBW (g)	FBW (g)	BWG (g/rabbit/day)	FI (g/rabbit/day)	FCR (g.feed : g.gain)
T1 (0.0% CLP)	650.83±35.17	2251.67±53.66	28.60±1.11	134.28 ±1.86 [a]	4.70±0.18 [a]
T2 (0.5% CLP)	655.42±32.40	2240.42±58.37	28.30±0.77	117.44±2.37 [c]	4.15±0.11 [b]
T3 (1.0% CLP)	651.67±32.90	2307.50±47.02	29.57±0.67	126.48±1.62 [b]	4.28±0.10 [b]
T4 (1.5% CLP)	653.33±33.25	2344.17±109.23	30.19±1.78	117.64±2.53 [c]	3.89±0.20 [b]
P-value	0.9997	0.7092	0.6400	<0.0001	0.0078

Mean values with different superscript letters in the same column are significantly different (P<0.05); CLP: clove buds powder, IBW: initial body weight, FBW: final body weight, BWG: body weight gain, FI: feed intake, FCR: feed conversion ratio

In vitro digestibility and nutritive values

The effect of CLP feeding on digestibility and nutritive values are presented in Table 4. There were slight increase (P>0.05) in digestion coefficients percentage of dry matter (DM; P=0.3476), organic matter (OM; P=0.2883), crude fiber (CF; P=0.1507), ether extract (EE; P=0.4753), nitrogen free extract (NFE; P=0.1507), also, nutritive value as a total digestible nutrients (TDN%, P=0.1107) and digestible energy (DE, Kcal/kg, P=0.1106) with 0.5 and 1.0% CLP groups compared to control group. Percentage of crude protein (CP) digestibility significantly (P=0.0261) increased with 0.5 and 1.0% CLP groups compared to control group. The diet containing 0.5% CLP recorded the best digestibility for all nutrients except % of NFE digestibility. Percentage of digestible crude protein (DCP) had significantly (P<0.0001) affected by dietary CLP addition. Percentage of DCP significantly (P<0.05) improved by 9.39% with 1.5%CLP addition, but 1.0% CLP inclusion significantly (P<0.05) decreased DCP% by 8.23% with relative control group. No significant difference in DCP% was found between 0.50% CLP group and the control group.

The results agreed with Dalkiliç and Güler (2009) who found DM, CP, and EE digestibilities significantly (P<0.05) improved by clove extract level up to 400 ppm in in broiler diets. Generally, when looking at either rabbit's performance (Table 3), the FCR improved and FI decreased or nutrient digestibility (Table 4), CP% and DCP% enhanced by dietary CLP addition. This refers to herbs bioactive substances that help to regulate the FI in animals by improving the flavor and regulate the functioning of digestive system (Mirzaei -Aghsaghali, 2012). Moreover, inhibit or enhance metabolism, shape of the sensory, and dietary properties of animal products (Meineri et al., 2010). The spices such as pepper, cinnamon, and clove stimulate the secretion of pancreatic enzymes (lipases, amylases, and proteases), and increase the activity of digestive enzymes of gastric (Srinivasan, 2005).

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Table 4 - Digestibility and nutritive values of growing rabbits

Items	Digestion coefficients (%)						Nutritive value		
	DM	OM	CP	CF	EE	NFE	DCP %	TDN %	DE Kcal/kg[1]
T1 (0.0% CLP)	68.05±1.25	71.17±1.32	67.66±0.71 [b]	40.57±1.69	89.32±1.35	72.17±1.24	12.46±0.13 [b]	68.43±0.86	3031.30±38.47
T2 (0.5% CLP)	69.90±3.91	72.74±3.59	75.71±2.47 [a]	58.60±5.27	91.45±1.01	71.31±3.67	12.29±0.14 [b]	68.63±2.61	3040.26±115.78
T3 (1.0% CLP)	68.14±3.97	72.62±3.13	73.26±0.91 [a]	42.54±7.93	90.34±3.31	74.12±2.68	11.33±0.08 [c]	69.08±2.52	3060.18±111.79
T4 (1.5% CLP)	61.43±3.34	64.77±3.67	71.62±1.08 [ab]	47.85±4.32	85.88±3.39	59.98±4.76	13.63±0.21 [a]	60.66±3.09	2687.35±136.70
P-value	0.3476	0.2883	0.0261	0.1507	0.4753	0.1507	<0.0001	0.1107	0.1106

Mean values with different superscript letters in the same column are significantly different (P<0.05); CLP: clove buds powder, DM: dry matter, OM: organic matter, CP: crude protein, CF: crude fiber, EE: ether extract, NFE: nitrogen free extract, DCP: digestible crude protein, TDN: total digestible nitrogen, DE: digestible energy. [1]DE (kcal/kg) =TDN x 44.3 (Schneider and Flatt, 1975).

Table 5 – Blood lipid profile, antioxidant enzymes activity, and immunoglobulin titres of growing rabbits

Items	Blood lipid profile				Antioxidant enzymes activity		Immunoglobulin titres	
	TL (mg/dl)	Cholesterol (mg/dl)	HDL (mg/dl)	LDL (mg/dl)	Catalase (U/L)	TAOC (mM/L)	IgG	IgM
T1 (0.0% CLP)	470.84±8.82 [a]	138.35±5.40	25.95±0.55	98.775±4.23	134.55±3.55 [c]	1.62±0.01 [d]	296.00±30.60	55.50±8.37
T2 (0.5% CLP)	425.00±25.66 [ab]	174.75±7.01	28.65±1.65	74.40±4.00	146.90±3.58 [c]	1.68±0.01 [c]	453.50±34.92	58.50±21.65
T3 (1.0% CLP)	379.17±8.82 [bc]	151.40±16.17	30.05±1.47	73.52±8.41	162.95±2.86 [b]	1.78±0.01 [b]	476.50±28.58	65.50±10.68
T4 (1.5% CLP)	361.11±20.85 [c]	157.95±7.01	31.00±3.00	69.84±17.14	218.50±6.41 [a]	1.83±0.01 [a]	719.00±192.26	76.50±10.10
P-value	<0.0090	0.1400	0.3220	0.2320	<0.0001	<0.0001	0.0910	0.7170

Mean values with different superscript letters in the same column are significantly different (P<0.05). CLP: clove buds powder, TL: total lipids, HDL: high density lipoprotein, LDL: low density lipoprotein, TAOC: total antioxidant capacity, IgG: immunoglobulin G, IgM: immunoglobulin M.

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Blood lipid profile, antioxidant enzymes activity and immune response in plasma

Blood lipid profile is shown in Table 5. Total lipid (TL) concentrations significantly (P=0.009) decreased with increasing the levels of CLP supplementation. However, no significant differences were observed between tested groups in cholesterol (P=0.1400), HDL (P=0.3220), and LDL (P=0.2320) values. Both cholesterol and HDL concentrations increased (P>0.05) with CLP diets, while LDL values were insignificantly lower (P>0.05) with rabbits fed CLP diets than control group. Addition of CLP by 0.5, 1.0 and 1.5% increased (P>0.05) HDL concentrations (10.40, 15.80, and 19.46%, respectively), however, decreased LDL concentrations (24.68, 25.60 and 29.30%, respectively). As the same trend, by increasing clove essential oil levels in Japanese quail diets, the concentrations of HDL increased (P<0.05) and LDL decreased (P<0.05) in plasma (Hussein et al., 2019). The decreasing of LDL in blood may due to bioactive substrate (Eugenol) in CLP which plays a vital role in reducing LDL concentrations (Harb et al., 2019). In broilers plasma, no significant differences (P>0.05) in concentrations of TL, total cholesterol, LDL and HDL due to feeding on 1% clove buds in diet and 0.2% lemon balm extract in drinking water (Petrovic et al., 2012). In contrast, total cholesterol significantly (P<0.05) decreased with supplementation 0.5, 1.0 and 1.5 g clove bud /kg broiler diets (Mahrous et al., 2017).

Antioxidant enzymes activity are presented in Table 5. Dietary CLP supplementation significantly increased (P<0.05) catalase and TAOC concentrations in growing rabbits plasma when compared with those in the control group. Rabbits fed on diet including 1.5% CLP gave the highest (P<0.05) catalase and TAOC concentrations (218.50 and 1.83, respectively) with compared to rabbits in control diet (134.55 and 1.62, respectively). Similarly, catalase concentration in quails blood significantly (P<0.05) increased with diets containing clove essential oils (Hussein et al., 2019). The improvement of catalase and TAOC concentrations in blood are attributed to eugenol (bioactive substrate) that forms iron-oxygen chelate complex through its allyl group and maintains iron and copper in their reduced forms (Ito et al., 2005). Moreover, clove supplementation can prevent hydroxyl radical's synthesis (the secondary products of lipid peroxidation; like clove oil may serve as an effective antioxidant even at the later stages of lipid peroxidation during beta-oxidation process (Jirovetz et al., 2006). In this study, antioxidant status improved (P<0.0001) by feeding growing rabbits on highest CLP level (1.5%), this improvement is due to clove active substances with the antioxidant properties (Dragland et al., 2003). A slightly increased in antioxidants (superoxide dismutase and glutathione peroxidase) due to feeding broilers on 1% clove buds and 0.2% lemon balm extract in drinking water (Petrovic et al., 2012).

Immunoglobulin responses are illustrated in Table 5. The immunoglobulin titres (IgG and IgM) recorded insignificantly (P=0.0910 and P=0.7170, respectively) improvement with CLP rabbit groups when compared to those in control group. Rabbits fed 1.5%CLP recorded the highest IgG and IgM values compared to the other tested groups including the control group. Furthermore, the concentrations of plasma IgG and IgM significantly (P<0.05) increased in broiler chickens (5 weeks of age) fed diets supplemented with 1.0 and 1.5% CLP (Mahrous et al., 2017). The improvement of IgG and IgM may be due to that clove act as additional bonds with immunoglobulin molecules at the Fc receptors, which stimulated the immune response (Ahmed et al., 2013).

Economic profit

Profitability and economic efficiency of tested diets are showed in Table 6. According the productive performance of rabbits (Table 3) showed improving in FBW (g) for rabbit's groups fed 1.0 and 1.5% CLP supplementation also, FCR improved with all CLP supplementation groups. The incoming selling price per rabbit recorded increasing with 1.5% CLP ($5.98) followed by 1.0% CLP ($5.88) supplementation. The net revenue and economic efficiency showed improving with all CLP supplementation levels. The best economic efficiency of tested diets showed with 1.5%CLP (270.63). Monsi and Onicihi (1991) found that addition of chamomile powder to chicken diets reduced the cost of diets. Karangiya et al. (2016) found that the spices (ginger) supplementation in broiler diets significantly increased incoming from birds selling and feed cost during whole test period while, decreasing the return over feed cost.

Table 6 - The economic profit for growing rabbit tested diets

Items \ Clove buds powder levels	0.0%	0.5%	1.0%	1.5%
Total average weight (kg)	2.25	2.24	2.31	2.34
Price of one kg body weight ($)	2.55	2.55	2.55	2.55
Selling price/rabbit ($)	5.74	5.71	5.88	5.98
Total feed intake (kg)	7.52	6.58	7.08	6.60
Price/kg feed ($)	0.36	0.32	0.28	0.24
Total feed cost/rabbit ($)	2.70	2.10	1.98	1.60
Net revenue ($)[1]	3.04	3.61	3.90	4.38
Economic efficiency[2]	112.91	174.23	196.10	270.63

[1]Net revenue = selling price/rabbit ($) – total feed cost/rabbit ($); [2]Economical efficiency (%) = (Net revenue / total feed cost/rabbit ($)) x 100

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CONCLUSION

It can conclude that using clove buds powder (CLP) as natural supplement in rabbit diets up to 1.5% without any adverse effect on productive performance and vital activities during growing period from 6-14 weeks of age. The supplementation of CLP in growing rabbit diets improved FCR and decreased FI, moreover, had been positive effect on antioxidant enzymes activity and immunity (IgG and IgM titres). Finally, using the CLP supplementation improved the net revenue and economic efficiency, especially at level of 1.5% CLP.

DECLARATIONS

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Authors' contribution

M. A. Suliman designed the experiment and drafted the manuscript; F.G. Ahmed collaborated the statistical analysis and participated in manuscript review; Kh. F. El-Kholy participated in manuscript review; R. A. Mohamed performed the practical part and laboratory analysis; L. Abdel-Mawla collaborated the laboratory analysis. All authors read and approved the final manuscript.

Conflicts of interests

The authors have declared that no competing interest exists.

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