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GROWTH PERFORMANCE, CARCASS TRAITS, IMMUNE RESPONSE AND ANTIOXIDANT STATUS OF GROWING RABBITS SUPPLEMENTED WITH PEPPERMINT AND BASIL ESSENTIAL OILS

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ABSTRACT: The effects of peppermint (*Mentha piperita*) and/or basil (*Ocimum basilicum*) essential oil supplementation on the productive performance of rabbits were evaluated. Forty-eight V-line rabbits at five weeks of age were randomly divided into four equal groups. The control group (1st group) was fed a basal diet without addition. The 2nd, 3rd, and 4th treatments were fed a basal diet supplemented with 400 mg of peppermint essential oil (PO), 400 mg of basil essential oil (BO), and 200 mg of PO plus 200 mg of BO/kg diet (essential oil blend; EOB), respectively. The results indicated that the significant ($P \leq 0.01$) decrease in the feed intake was observed in the groups fed PO and EOB compared to the control group. The essential oil blend had the most significant ($P \leq 0.01$) effect on the feed conversion ratio. Additionally, dietary supplementation with PO, BO and EOB significantly ($P \leq 0.01$) increased the serum total antioxidant capacity and reduced malondialdehyde level compared to the control group. Also, the immunological parameters (IgG and IgM) increased with different dietary supplementations. Nevertheless, the dietary addition of PO, BO and EOB did not significantly affect the final live body weight and average daily gain, nutrient digestibility, nutritive values, most carcass traits, haematological parameters and serum lipid profiles versus the control group measurements. In conclusion, the blend of peppermint and basil essential oils has a potential use as antioxidant and immunostimulant for growing rabbits.

Keywords: Essential oils- Growth performance- Immune response- Antioxidant status- Growing rabbits.

INTRODUCTION

Chemical feed additives, such as hormones and antibiotics, have been commonly used for several decades to improve growth performance of the farmed animals (Rice and Straw, 1996). However, the EU banned the use of antibiotics as feed additives in the animal diets due to their side effects, the potential for the appearance of residues in animal-derived foods (Russell and Houlihan, 2003) and the possible evolution of antibiotic-resistant bacteria, which pose great risks to human health (Benchaar et al., 2008). Subsequently, increasing public health concerns and demands for food safety and high-quality white meat has promoted a scientific drive to identify safe and natural alternatives (Cowan, 1999).

The herbal supplements secondary compounds, such as essential oils (EOs), saponins, and tannins, have become a primary source of feed additives and antioxidants to enhance general health conditions in humans and animals. Therefore, the efforts of many researchers directed to evaluate the use of herbal and plant secondary compounds as feed additives for rabbits and poultry, which represent good, fast and cheap sources of white meat. Moreover, herbal feed additives have been found to improve the average daily gain (ADG) and feed conversion ratio (FCR) reduce the mortality and increase the viability of rabbits (El-Kholy et al., 2012; Zeweil et al., 2013).

Peppermint (*Mentha piperita*) is a perennial herb belonging to the Lamiaceae family. The oil of *M. piperita* contains 1, 8-cineole, dihydrocavone, limonene, phytol, linalool, thymol, carveol, piperitenone, and eugenol as the primary components (Dorman et al., 2003; Mkaddem et al., 2009; Pudpila et al., 2011). Peppermint leaves and oil were used in ancient Greek, Roman, and Egyptian folk medicine and as flavouring agents and have been used in cosmetic and pharmaceutical products worldwide. Moreover, peppermint oil is used to treat respiratory disorders (Nishino et al., 1997), digestive complaints (Blumenthal, 1998), menstrual cramps (Foster and Tyler, 1999), neuralgia, myalgia, headaches, migraines and chicken pox (Blumenthal, 1998). Peppermint essential oil also has an antimicrobial effect (Trombetta et al., 2005; Pramila et al., 2012), a hepato-protective effect due to its antioxidant content and free radical scavenger properties (Khalil et al., 2015). In addition, the using of PO mainly under heat stress conditions improved some blood biochemical criteria of chicks (Akbari and Torki, 2014). Furthermore, Emami et al. (2012) concluded that PO at a dose of 200 or 400 mg/kg dry matter diet for chicks could be an effective alternative to an antibiotic (Virginiamycin®). In this concern, Abdel-Wahab et al. (2018) referred that peppermint can consider as an appropriate alternative to antibiotic (avilamycin) and promote the growth of growing quail. However, studies on the effect of peppermint as an antibiotic growth promoter alternative for the growth performance and digestibility of broilers are rare, and the results have been conflictual (Akbari and Torki, 2014; Arab Ameri et al., 2016; Asadi et al., 2017; Abdel-Wahab et al., 2018).

Basil (*Ocimum basilicum*), which is also called sweet or garden basil, belongs to the Lamiaceae family and is dispersed throughout the Mediterranean region (Abbas, 2010). The major compounds of the different types of *O. basilicum* oil are methyl chavicol, linalool, methyl cinnamate, methyl eugenol, eugenol and geraniol (Lachowicz et al., 1997). In folk medicine, the leaves and flowering of *O. basilicum* represents a carminative, galactogogue, stomachic and antispasmodic (Sajjadi, 2006). Moreover, basil essential oil is used as an antimicrobial and

antioxidant agent and has antifungal activity (Kocić-Tanackov et al., 2011). Furthermore, there are a beneficial effect of basil aqueous extract against nephrotoxicity in albino rats exposed to deltamethrin (Sakr and Al-Amoudi, 2012). Besides, treatment with basil aqueous extract leads to improvement in histological, morphometric and immuno-histochemical changes in rats with cadmium-induced testicular toxicity (Sakr and Nooh, 2013). In addition, sweet basil or its oils could be added as an adequate natural growth promoter to elevate growth and immune response of broiler chick (El-naggar and El-Tahawy, 2018).

Several researches documented that the effects of dietary EOs in individual or combination forms on the growth performance of poultry were varied and conflicted. Whereas, some reports demonstrated that EOs improve animal performance (Brenes and Roura, 2010; Bozkurt et al., 2012), other studies have reported that these additives are ineffective (Lee et al., 2003; Botsoglou et al., 2004). Moreover, EOs can improve the digestion, exclude intestine pathogenic bacteria, stimulate haemostasis and improve antioxidant and immune status (Brenes and Roura, 2010; Zeng et al., 2015). The widespread use of EOs from peppermint and basil in traditional medicines and their abundant beneficial effects on the mammalian digestive and immune systems inspired us to explore their potential biological activities in rabbits. The aim of the present study was to investigate the effects of PO, BO and EOB on the growth performance, carcass traits, haematology, serum biochemistry, and antioxidant and immune status of growing rabbits.

MATERIALS AND METHODS

Experimental animals, diets and management

Forty-eight growing V-line rabbits of both sexes at five weeks of age with initial live body weight (BW) of 704.9±67.9 g were used. The rabbits were randomly distributed into four experimental groups with 12 rabbits each. Each treatment was additionally sub-divided into 4 replicates of 3 rabbits. The rabbits were housed in wire floor batteries that were 45 x 36 x 36 cm in size and fed experimental diets for eight weeks through 13 weeks of age during the summer season (July to September) of 2016. All animals were maintained under similar hygienic conditions. The rabbits were housed in a well-ventilated block building. Fresh air was circulated in the building using exhaust fans. The rabbits were maintained under a 16-h light and 8-h dark cycle. The incidence of dangerous diseases was largely avoided, and the rabbits were never treated with any type of systematic vaccination or medication.

Four experimental groups were designed. The 1st group was fed the basal diet (18.87% CP and 2502 Kcal/ Kg DE) free of additives and served as the control group. The 2nd and 3rd groups were fed the basal diet supplemented with PO and BO, respectively, at a dose of 400 mg/kg diet. The 4th group received the basal diet supplemented with a combination of PO and BO at a dose of 200 mg of each/kg diet (essential oil blend, EOB). Fresh water was automatically accessible constantly through stainless steel nipples for each cage. The experimental diets were offered to the rabbits ad libitum. The basal experimental diet was formulated to meet all necessary nutrient requirements for growing rabbits according to NRC (1977)**.** The composition and chemical analysis of the basal experimental diet are presented in Table 1. Individual live body weight and feed intake (FI) were recorded weekly. The average daily gain was calculated on a group basis as follows: ADG = (final live BW - initial live BW during a certain period) / number of days for this period. Additionally, the

FCR was calculated on a group basis as follows:

FCR = feed consumed (g) during a certain period/body weight gain (g) during the same period. (1)

Digestibility trial

At 13 weeks of age, 16 male rabbits (four rabbits from each treatment) were randomly selected after termination of the fattening trial. Rabbits within each treatment were housed separately in metabolic cages that enabled separation of faeces and urine. The collection period was five days. During the collection period, the total excreted faeces were collected from each rabbit daily in buckets before offering the morning meal and weighing. Representative samples (10%) of the total quantities of faeces for each rabbit were oven-dried daily at 70°C for 48 h to determine total the DM of the faeces and to calculate the quantities of faeces on a DM basis. At the end of the collection period, the faecal samples from each rabbit were mixed thoroughly, and representative samples (10%) of the mixtures were ground through a 1-mm screen on a Wiley mill grinder and then stored frozen at -20°C prior to the chemical analysis. Representative samples of the offered feed and the faeces of each rabbit were chemically analysed to determine the DM, crude protein (CP), ether extract (EE), crude fibre (CF) and ash according to the AOAC (2006) methods. The nitrogen-free extract (NFE) was determined based on the difference. Nutritive values in terms of the total digestible nutrients (TDN, %) and digestible crude protein (DCP, %) were calculated using classic formulas (Cunha and Cheeke, 2012).

Carcass characteristics

At the end of the growing period, six rabbits were selected around the average of each treatment for carcass evaluations. The rabbits were fasted with a free water supply for 12 h before slaughter. The rabbits were weighed pre-slaughter, slaughtered for complete depletion, skinned, and eviscerated. The dressed carcass free from any internal organs was weighed (hot carcass weight without the head), and then the cold carcass without the head was weighed. The hot eviscerated carcass included liver, heart and kidney were weighted. The carcass yields were calculated as a percentage of the pre-slaughter live BWs of the rabbits. Additionally, the percentages of the total edible parts, non-edible parts and giblets were calculated as follows:

Giblets% = kidney% + heart% + liver% (2)

Total edible parts% = hot carcass% + kidney% + heart% + liver%. (3)

Non-edible parts% = 100 - total edible parts%. (4)

Haematological study

Before slaughter, a six-mL blood sample was taken from the ear vein with a sterile syringe. Three mL of blood was added to a Bijon bottle containing ethylenediaminetetraacetic acid (EDTA) as an anticoagulant for the haematological assay. The remaining three mL of the blood sample was placed into a sterile vacutainer tube without an anticoagulant for the serum biochemical analysis. The haemoglobin (Hb) concentration was estimated using the cyanomethe-myoglobin method according to Eilers (1967). Wintrobe haematocrit tubes were used to determine the packed cell volume (PCV, %). The blood was centrifuged for 20 minutes at 4000 rpm, and then the PCV was obtained using the PCV reading on the graduated haematocrit tubes. Red blood cells (RBCs) were counted manually using a standard Neubauer cell counting chamber after diluting the blood samples 200-fold with a diluting fluid (10% sodium sulphate, 2% sodium chloride and 1% mercuric chloride solution) according to the method of Sastry (1985). White blood cells (WBCs) were counted manually using

a standard Neubauer cell counting chamber after diluting the blood samples 20-fold with a diluting fluid (1.5% glacial acetic acid solution and a few crystals of gentian violet) according to the method of Sastry (1985).The differential leucocytic count was determined by preparing a blood film fixed in methyl alcohol for 3-5 min and then stained with Giemsa's stain for 20 minutes, followed by rinsing under a slow water current and gentle drying between two filter papers. A stained blood sample was examined using an oil immersion lens according to the method of Lucky (1977). The percentage of each cell type was calculated according to the method of Schalm et al. (1986).

Serum lipid profile

Total lipids, cholesterol and triglycerides (TG) were estimated according to Zollner and Kirsch (1962), Allain et al. (1974), Fossati and Prencipe (1982). High-density lipoprotein (HDL) was determined according to the methods of Grove (1979). Low-density lipoprotein (LDL) and Very low-density lipoprotein (VLDL) were calculated according to Warnick et al. (1983) as follow: LDL = cholesterol - (HDL + VLDL); VLDL=TG/5.

Immune response and antioxidant status

The serum IgG and IgM concentrations were determined using the ELISA technique described by Engvall and Perlmann (1972). Moreover, the total antioxidant capacity (TAC) was assayed using the method of Cao et al. (1995). The serum malondialdehyde (MDA) level was measured according to the method described by Jain (1988).

Statistical analyses

The results are expressed as the mean ± SE. All data were analysed in a completely randomized design with ANOVA using the SPSS (Standard Version 17.0 SPSS Inc. Chicago, Illinois). Significant differences between means were detected using Duncan's multiple range test (Duncan, 1955). The following model was used:

$Yi = \mu + ai + ei$

where Yi is the experimental observation, μ is the overall mean, ai is the treatment effect, and ei is the random error.

RESULTS

Growth performance

The effect of PO, BO and EOB supplementation on the growth performance of growing V-line rabbits was showed in Table 2. The different supplementations did not significantly influence the final BW and ADG of the V-line growing rabbits during the feeding period compared with those in the control group. The feed intake decreased significantly ($P \leq 0.01$) in the PO and EOB groups versus the BO and control groups. The decrease in FI reached 9.2% and 11.8% in the PO and EOB groups, respectively, versus the control animal. The feed conversion ratio improved significantly in the EOB supplemented group; however, the other treatments did not significantly affect FCR in comparison with the control group.

Digestion efficiency

Table 3 shows the effects of the different supplementations on the nutrient digestibility. The NFE digestibility increased significantly ($P \leq 0.05$) in the groups fed the PO and BO compared with the EOB group. However, the effect on this trait was not significant for the different treatments compared with that of the control group. Moreover, the effect of the different supplementations was not significant on the DM, OM, CP, EE and CF digestibility compared with the effect on the control group. Clearly, non-significant improvements in nutritive values for TDN and DCP occurred in all experimental groups compared with those of the control group.

Carcass traits

Table 4 presents the effects of the PO, BO and EOB supplementation on the carcass characteristics. No significant differences were found in the percentages of the cold and hot carcasses, the total edible and non-edible parts, the liver and giblets among the different treatment groups. However, the kidneys percentage decreased significantly ($P \leq 0.01$) in all experimental groups versus that of the control group. Additionally, the heart percentage decreased significantly in the group treated with the PO compared with the control group.

Haematological parameters

The results are presented in Table 5 depict changes in the haematological parameters of growing rabbits treated with the PO, BO and their combination. The Hb concentration, PCV value, RBC and WBC counts, and WBC differential percentages did not influence by the different experimental diets when compared with the control group values.

Serum lipid profile, immune response and antioxidant status

The data in Table 6 show the effects of PO, BO and EOB on the serum lipid profile, immune response and antioxidant status. In the present study, the different treatments had a non-significant effect on the blood serum total lipid, triglyceride, cholesterol, HDL, LDL and VLDL levels compared with those of the control group. However, the PO, BO and EOB supplementation induced numerical improvements in the serum IgG and IgM compared with the control group values. Moreover, the data showed that growing rabbits reared through the Egyptian summer season exhibited a significant decrease ($P \leq 0.001$) in the serum TAC based on the results obtained for the control group, whereas the PO, BO and EOB supplementation significantly ($P \leq 0.01$) ameliorated the effect of the high-temperature summer season. The serum MDA concentration decreased ($P \geq 0.05$) with the essential oil treatments compared with that of the control group.

DISCUSSION

Our results demonstrated many different effects of the *M. piperita* and *O. basilicum* EOs and their combination when administered with the diet of growing rabbits. The final BW and ADG of the V-line growing rabbits during the feeding period did not significantly influence by the different supplementations compared with those of the control group. The feed intake decreased significantly ($P \leq 0.01$) in the PO and EOB groups versus the BO and control group values. The feed conversion ratio improved significantly in the EOB supplemented group; however, the other treatments did not significantly affect the FCR compared with that of the control group.

In accordance with the present results, Demir et al. (2008); Ashayerizadeh et al. (2009); Toghyani et al. (2010) found no effects on the growth performance of broilers fed diets supplemented with 1 g/kg of mint powder (M. spicata), 1 g/kg of wild mint (M. longifolia), and 4 or 8 g/kg of peppermint. Moreover, Akbari and Torki (2014) showed that the average BW, ADG, and daily FI in female broiler chicks did not significantly affect by dietary supplementation with PO. In contrast to the above findings Emami et al. (2012) showed that the FCR tended to improve (P =0.039) with dietary supplementation with the PO at a dose of 200 mg/kg of DM in the diet of chicks compared with the FCR of the control group birds. Also, Arab Ameri et al. (2016) reported that supplementation with peppermint powder (1%) resulted in a reduced ADG in birds; however, increasing peppermint powder supplementation to 2% resulted in a higher ADG at 21 days of age versus that of birds fed the basal diet. Recently, Abdel-Wahab et al. (2018) showed that feeding quails with peppermint

improved significantly all growth performance traits.

Regarding the effect of BO on the growth performance, the present results agreed with those of Riyazi et al. (2015), who indicated that supplementation with the BO in the starter and grower diets of broilers had a non-significant effect on the ADG, FI and FCR. However, dietary supplementation with basil leaves and seeds had a beneficial effect on the FI, ADG and FCR (Abbas, 2010; Osman et al., 2010; Onwurah et al., 2011). Moreover, the final BW, FI and ADG of finishing broilers increased significantly with supplementation with basil leaf extract at doses of 100-300 g/mL (Bo and Ekwe, 2012). Lately, El-naggar and El-Tahawy (2018) indicated that BW and BW gain increased significantly by supplementation with BO in broiler diets.

The EOB significantly improve feed conversion ratio in the current findings, which could illustrate a synergetic effect of PO and BO on rabbit feed utilization. In accordance, Mathlouthi et al. (2012); Khattak et al. (2013) found that BW, weight gain and the feed to gain ratio increased significantly following supplementation with a blend of essential oils in growing birds compared to the control group values.

Furthermore, the decrease of FI in the EO supplemented treatment may be attributed to the tastes and odours emanated by the active substances contained in the plants, which inhibit intake by animals, consequently, some herbs may be barely appetizing (Jugl-Chizzola et al., 2006).

Our results showed that the PO, BO and EOB did not have deleterious effects on the nutrient digestibility and the nutritive values. These results are consistent with those presented by Khempaka et al. (2013), who showed that experimental diets containing 0.5–2.0% dried peppermint had no adverse effects on the DM, OM and CF digestibility and the nitrogen retention in comparison with the control diet. In contrast, Emami et al. (2012) found that the CP digestibility increased significantly ($P \leq 0.01$) by supplementation with the PO at a dose of 400 mg/kg in a broiler diet. However, information concerning the effects of basil on the nutrient digestibility and the nitrogen balance is rare.

The current findings indicated no significant differences in the percentages of the cold and hot carcasses, total edible and non-edible parts, liver and giblets as a result of the different treatments. However, the percentage of the kidneys decreased significantly ($P \leq 0.01$) in all experimental groups versus the percentage in the control animals. Additionally, the percentage of the heart decreased significantly in the group treated with the PO compared with the percentage in the control group. In accordance with the present results, Khempaka et al. (2013) indicated that the percentages of eviscerated carcasses and giblets of broilers fed dried peppermint-containing diets (0.5-2%) were similar to those in the control group. Furthermore, Abdel-Wahab et al. (2018) showed that treatment with peppermint did not influence all carcass parameters % in quails. In contrast, dietary supplementation with peppermint resulted in a decreasing trend in the carcass percentages ($P \leq 0.118$) of growing Japanese quail (Mehri et al., 2015a). The effects of BO on the carcass characteristics in the present study were consistent with the results of Abbas (2010), who reported that dietary supplementation with 3 g/kg of basil seed did not influence the organ weights and carcass characteristics in broilers. Additionally, the yields of the carcass and the fresh and relative weights of the gizzard, thigh, breast, heart and liver of broilers at 42 days of age did not affect by the dietary BO at dose of 200 ppm Riyazi et al. (2015), and El-naggar and El-Tahawy (2018) showed that

percentage of dressing and total edible parts increased with BO adding in broiler diet. Moreover, Gurbuz and Ismael (2016) found that feed additive with peppermint and basil had no significant effects on the carcass, carcass yield and abdominal fat.

The haematological parameters did not influence by the different experimental diets compared with the control group. These current findings are consistent with those of Bo and Ekwe (2012), who found that treatment with basil leaf extract (100-300 g/mL) did not affect the haematological indices of finishing broilers. However, the present results are in contrast to those of Osman et al. (2010), who indicated that supplementation with sweet basil increased the RBC and lymphocyte counts compared with those of the control group.

In the present study, the effect of different treatments on the serum lipid profile levels did not significantly differ from the levels detected for the control group. These results were consistent with those of Akbari and Torki (2014), who showed that the serum total cholesterol, HDL and LDL levels in female broiler chicks did not affect by dietary supplementation with the PO. However, the results of Ghazaghi et al. (2014) disagreed with the present results and showed that dietary peppermint supplementation resulted in a decrease in the LDL concentration in growing quail. Additionally, Mehri et al. (2015b); Abdel-Wahab et al. (2018) found that the triglyceride, total cholesterol and LDL concentrations decreased in birds that received dietary peppermint compared with those of the control group. In concerning to the effect of the BO, El-naggar and El-Tahawy (2018) disagreed with the present results and showed that dietary BO supplementation resulted in a lower of total lipids, triglycerides, cholesterol, LDL in broiler.

Supplementation with the PO, BO and EOB in the present study induced numerical improvements in IgG and IgM levels in a comparison of the control group. Similar to our results, Awaad et al. (2010), who found that the addition of 0.25 mL of a eucalyptus and PO blend/L on drinking water boosted the antibody titre against the Newcastle virus vaccine in chickens compared with the control group titre. Additionally, Emami et al. (2012) reported that feeding the PO at a dose of 400 mg/kg of diet led to a lower secondary antibody response against sheep red blood cells (SRBCs) in broilers than the response measured for the control group. Moreover, Mehri et al. (2015b) stated that growing quail fed diets supplemented with peppermint showed an increase in humoral responses against SRBCs and Newcastle disease virus compared with the control group responses. Lately, Abdel-Wahab et al. (2018) stated that GPx, IgG, IgA and IgM in quails increased significantly with peppermint supplementation.

On another side, The results of immune response in this study completely confirmed those of El-naggar and El-Tahawy (2018) that broiler supplemented with had higher IgM, IgG. Similarly, feeding experimental diets inclusive sweet basil improved the immune status in broilers, as reflected by the enzyme-linked immunosorbent assay and haemagglutination inhibition titres compared with those of the control group (Osman et al., 2010). The immunological improvement associated with EO supplementation in the present study may attributed to the active components of this oils which showed an immunostimulants activity on Swiss albino mice (Saha et al., 2012).The present findings showed that growing rabbits reared through the Egyptian summer season exhibited a significant decrease in the serum TAC and increase of MDA levels based on the results obtained for the control group. Meanwhile,

supplementation with the PO, BO and EOB significantly ($P \leq 0.01$) ameliorated the effect of the high-temperature summer season. In accordance, heat stress led to the excessive production of free radicals, which reduced the antioxidant capacity in the animal (Upton, 2003). Moreover, Newsholme et al. (2003) reported that heat stress had an effect on the sympathetic nervous system that resulted in the release of catecholamine, which caused an increase in the free radical content in the blood and body tissues. Additionally, Lin et al. (2000) indicated that free radicals gave rise to peroxidation in cells and thereby increased the lipo-peroxide concentrations in the tissues and that the increase in lipo-peroxide led to reduced glutathione peroxidase, superoxide dismutase and catalase enzyme activity. These stressful conditions of heat stress caused a depletion of serum antioxidants such as vitamins and minerals involved in the antioxidant system (Aryaeian et al., 2011).

Interestingly, the PO, BO and EOB dietary supplementation which a rich source of antioxidants ameliorated the drastic effects of heat stress in the present study. The data obtained are broadly consistent with the major trends, Khempaka et al. (2013); Abdel-Wahab et al. (2018) reported that supplementation with dried peppermint at significantly reduced the TBARS value in the serum of birds compared with the values obtained with the control group. Furthermore, El-naggar and El-Tahawy (2018) showed that TAC, GSH, GPX, SOD in broilers were higher with BO supplementation.

The important implications of these findings are that, *M. piperita* contains phenolic and flavonoid compounds Olennikov and Tankhaeva (2010). Also, PO found to contain 8-cineole, dihydrocavone, limonene, phytol, linalool, thymol, carveol, piperitenone, and eugenol (Dorman et al., 2003; Mkaddem et al., 2009; Pudpila et al., 2011). Furthermore, basil contains aromatic and phenolic compounds which attributed to antioxidant activity (Hussain et al., 2008); phenolic acids and flavonnol-glycosides are the major phenolics in basil (Kivilompolo and Hyötyläinen, 2007). Whereas, phenolics have antioxidant effect which leads to the absorption and neutralization of free radicals (Asami et al., 2003). Also, sweet basil oil contains linalool, isoanethole and eugenol, which have noticeable antioxidant activities that are comparable with those of α-tocopherol (Asami et al., 2003). Therefore, the BO can prevent hepatic damage by reducing oxidative stress (Dasgupta and De, 2007). Additionally, Politeo et al. (2007) attributed the potential antioxidant properties of basil to free volatile aglycones. These ameliorations effects of the studied EOs on antioxidant status may be attributed to the radical-scavenging and antioxidant.

CONCLUSIONS

In conclusion, the mixture of peppermint and basil essential oils has the potential for use as a feed additive for growing rabbits because it has beneficial effects on the FI, FCR and antioxidant properties without any detrimental effects on the growth performance, immunity, carcass or digestibility. Clearly, further research on the addition of different doses of peppermint and basil essential oils and their combination is needed to verify whether these EOs have beneficial effects on the growth performance, immunity, carcass and digestibility.

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Table (1): Ingredients and proximate chemical composition of the experimental basal diet

Ingredients	**Amount %**
Ground yellow corn	19.00
Wheat bran	11.00
Barley	17.20
Soybean meal (44%)	15.00
Berseem hay	33.00
Molasses	3.00
Di-calcium phosphate	1.00
Sodium chloride (salt)	0.30
Premix[1]	0.30
DL-methionine	0.10
L-lysine	0.10
Total	100.00
Chemical composition (% of DM basis)	
Dry matter	91.83
Crude protein	18.87
Ether extract	3.33
Crude fiber	13.57
Nitrogen free extract	54.89
Ash	9.34
Organic matter	90.66
DE, Kcal / Kg[2]	2502

[1]premix contained the following vitamins and minerals mixture per kg (g/kg): Vit A., 2000.000 IU, Vit E, 10 mg, Vit B1, 400 mg, Vit B2, 1200 mg, Vit B6, 400 mg, Vit B12, 10 mg, Vit D3, 180000 IU, Colin chloride, 240 mg, Pantothenic acid, 400 mg, Niacin, 1000 mg, Folic acid, 1000 mg, Biotin, 40 mg, Manganese, 1700 mg, Zinc, 1400 mg, Iron, 15 mg, Copper, 600 mg, Selenium, 20 mg, Iodine, 40 mg and Magnesium, 8000 mg.

[2]DE, Kcal / Kg: digestible energy, = 4.36-0.0491×NDF%, whereas NDF %: neutral detergent fiber, = 28.924+0.657× CF%, whereas CF%: crude fiber.

Table (2): Effect of diets supplemented with peppermint and basil essential oils and their combination on the growth performance of growing rabbits.

Items	Control	PO	BO	EOB	*P* value
Initial BW, g	705.0±66.8	702.08±68.1	705.8±67.4	706.6±69.2	0.999
Final BW, g	2100.0±46.5	2037.9±60.0	2043.8±42.5	2175.8±39.4	0.161
ADG, g/ rabbit/ day	23.42±0.94	21.58±1.13	22.08±0.79	24.58±0.95	0.130
FI, g/ rabbit/day	116.92^{a}±1.13	106.22^{b}±2.78	111.59^{ab}±3.72	103.10^{b}±2.62	0.015
FCR	4.99^{a}±0.26	4.92^{a}±0.15	5.05^{a}±0.15	4.20^{b}±0.14	0.02

PO: peppermint essential oil supplemented with 400 g/kg diet, BO: basil essential oil supplemented with 400 g/kg diet, EOB: essential oil blend supplemented with 200 g of each oil/kg diet, BW: body weight, ADG: average daily gain, FI: feed intake, FCR: feed conversion ratio.
a-b: Values in the same row with different superscripts differ significantly ($P \leq 0.05$).

Table (3): Effect of peppermint and basil essential oils and their combination on the digestion coefficients of nutrient nutritive values of growing rabbits.

Items	Control	PO	BO	EOB	*P* value
Digestion coefficients of nutrient, %					
DM	67.70±2.98	67.08±6.31	67.73±2.73	65.80±3.74	0.904
OM	78.18±3.25	79.18±2.56	78.88±1.44	81.78±1.82	0.209
CP	66.30±1.60	66.45±1.58	67.25±1.80	66.90±1.92	0.860
EE	69.78±0.97	69.50±2.50	69.85±1.76	70.00±1.83	0.984
CF	33.00±6.94	28.75±4.25	32.48±4.69	27.80±7.54	0.538
NFE	80.75^{ab}±3.44	81.50^{a}±3.55	82.63^{a}±3.97	75.50^{b}±2.93	0.059
Nutritive values, %					
TDN	64.15±2.05	65.23±1.50	66.35±2.85	62.88±5.29	0.503
DCP	12.51±0.15	12.54±0.15	12.69±0.17	12.62±0.18	0.857

PO: peppermint essential oil supplemented with 400 g/kg diet, BO: basil essential oil supplemented with 400 g/kg diet, EOB: essential oil blend supplemented with 200 g of each oil/kg diet, DM: dry matter, Om: organic matter, CP: crude protein, EE: ether extract, CF: crude fiber, NFE: nitrogen free extract, TDN: total digestible nutrient, DCP: digestible crude protein.
a-b: Values in the same row with different superscripts differ significantly ($P \leq 0.05$).

Table (4): Effect of peppermint and basil essential oils and their combination on the carcass traits of growing rabbits

Items	Control	PO	BO	EOB	*P* value
Pre-slaughter Weight, g	1943.3^{c}±148.7	2106.7^{ab}±137.8	2068.3^{bc}±49.8	2236.7^{a}±58.8	0.002
Hot carcass, %	48.39±2.62	48.24±6.08	49.18±1.79	51.26±2.46	0.473
Cold carcass, %	46.08±1.90	47.05±5.93	46.67±3.38	49.88±2.25	0.322
Liver, %	2.90±0.72	3.08±0.89	2.48±0.54	3.17±0.50	0.329
Heart, %	0.30^{ab}±0.04	0.24^{c}±0.03	0.25^{bc}±0.01	0.32^{a}±0.06	0.013
Kidneys, %	0.71^{a}±0.07	0.56^{b}±0.07	0.54^{b}±0.07	0.59^{b}±0.02	0.001
Giblets, %[1]	3.90±0.67	3.88±0.97	3.26±0.59	4.07±0.46	0.233
Total edible parts, %[2]	52.30±3.16	52.12±6.95	52.44±1.88	55.32±2.27	0.491
Non-edible Parts, % [3]	47.70±3.16	47.88±6.95	47.57±1.88	44.68±2.27	0.492

PO: peppermint essential oil supplemented with 400 g/kg diet, BO: basil essential oil supplemented with 400 g/kg diet, EOB: essential oil blend supplemented with 200 g of each oil/kg diet.
[1]Giblets % = kidney %+ heart%+liver%.
[2]Total edible parts % = hot carcass%+ kidney%+ heart%+liver%.
[3]Non-edible parts% = 100- total edible parts %.
A, b, c: Values in the same row with different superscripts differ significantly ($P \leq 0.05$).

Table (5): Effect of peppermint and basil essential oils and their combination on the hematological parameters of growing rabbits.

Items	Control	PO	BO	EOB	*P* value
Hb, mg/dl	11.10±0.82	11.38±0.25	11.10±0.55	11.05±0.73	0.881
PCV, %	46.68±3.07	46.53±4.16	46.33±0.96	44.90±5.20	0.914
RBCs,10^6/mm^3	4.93±0.36	5.27±0.41	5.43±0.17	5.20±0.40	0.290
WBCs,10^3/mm^3	4.73±0.17	4.82±1.01	5.05±1.13	6.23±1.47	0.221
Neutrophils, %	40.50±6.60	43.50±0.57	41.25±8.01	38.00±4.08	0.593
Monocytes, %	3.75±1.50	3.25±0.50	3.25±0.50	3.75±0.95	0.781
Eosinophils, %	4.75±0.95	5.00±0.81	4.75±0.95	5.50±0.57	0.566
Lymphocytes,%	51.00±4.69	48.25±1.26	50.75±6.70	52.75±4.50	0.616

PO: peppermint essential oil supplemented with 400 g/kg diet, BO: basil essential oil supplemented with 400 g/kg diet, EOB: essential oil blend supplemented with 200 g of each oil/kg diet, Hb: hemoglobin, PCV: packed cell volume, RBCs: red blood cell count, WBCs: white blood cell count.

Table (6): Effect of peppermint and basil essential oils and their combination on the serum lipid profile, serum immune response and antioxidant status of growing rabbits.

Items	Control	PO	BO	EOB	*P* value
Total lipids, mg/dl	478.00±115.10	397.50±100.67	408.00±64.46	439.50±93.03	0.473
Triglycerides, mg/dl	82.33±23.11	62.17±16.21	73.67±14.00	72.33±23.83	0.393
Cholesterol, mg/dl	72.67±10.40	66.00±6.57	72.50±15.89	71.67±7.81	0.675
HDL, mg/dl	15.88±6.56	12.62±4.37	13.60±7.17	13.95±6.16	0.828
LDL, mg/dl	10.32±9.52	10.95±5.35	14.17±9.16	14.75±10.61	0.769
VLDL, mg/dl	16.46±4.62	12.43±3.24	14.73±2.80	14.47±4.76	0.393
HDL/LDL ratio	2.41±1.70	1.36±0.63	1.29±0.92	3.29±4.74	0.499
IgG, mg/dl	221.33±45.85	226.17±29.82	259.17±47.42	253.50±46.03	0.341
IgM, mg/dl	51.56±12.57	52.89±13.03	58.65±11.08	64.18±18.75	0.412
TAC, µmol/ml	0.86^{b}±0.06	1.50^{a}±0.11	1.52^{a}±0.19	1.81^{a}±0.20	0.005
MDA, nmol/ml	5.04±0.28	4.23±0.42	4.15±0.25	4.39±0.42	0.314

PO: peppermint essential oil supplemented with 400 g/kg diet, BO: basil essential oil supplemented with 400 g/kg diet, EOB: essential oil blend supplemented with 200 g of each oil/kg diet, HDL: high density lipoprotein, LDL: low density lipoprotein, VLDL: very low-density lipoprotein IgG: immunoglobulin G, IgM: immunoglobulin M, TAC: total antioxidant capacity, MDA: malondialdehyde.
a-b: Values in the same row with different superscripts differ significantly ($P \leq 0.05$).

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الملخص العربي

أداء النمو، الاستفادة الغذائية، صفات الذبيحة، الاستجابة المناعية والحالة ضد التأكسدية للأرانب النامية المضاف لها الزيوت الطيارة النعناع والريحان

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لقد تم تقييم تأثيرات إضافة زيت النعناع و/ او زيت الريحان على الأداء الإنتاجي للأرانب. لقد تم تقسيم 48 ارنب سلالة الفرنساوي V line عمر 5 أسابيع عشوائيا الى 4 مجاميع متساوية. المجموعة الأولى (الضابطة) تم تغذيتها على العليقة الأساسية بدون أي إضافات. المجموعة الثانية والثالثة والرابعة تم تغذيتها على العليقة الأساسية مضاف لها 400 ملجم زيت النعناع، 400 ملجم زيت الريحان، 200 ملجم زيت النعناع مع 200 ملحم زيت الريحان/ كجم عليقة (خليط الزيوت الطيارة) على التوالي. انخفض المأكول مع المجموعات التي غذيت زيت النعناع وخليط الزيوت مقارنة بالمجموعة الضابطة. لقد اظهر خليط الزيوت الطيارة تأثير معنوي ($P \leq 0.01$) على معدل التحول الغذائي. بالإضافة الى ان إضافة زيت النعناع وزيت الريحان وخليط الزيوت الطيارة في العليقة الى زيادة معنوية ($P \leq 0.01$) في القدرة المضاد التأكسدية الكلية للسيرم مقارنة بالمجموعة الضابطة. على الرغم من إضافة زيت النعناع وزيت الريحان وخليط الزيوت الطيارة في العليقة لم يؤثر معنويا على وزن الجسم الحي النهائي، معدل الزيادة الوزنية اليومية، معاملات هضم العناصر الغذائية، القيم الغذائية، معظم صفات الذبيحة، قياسات الهيماتولوجية، بروتينات الامينوجلوبيولين وقياسات دهون السيرم مقارنة بالمجموعة الضابطة. ومن هنا يمكن استنتاج ان خليط الزيوت الطيارة للنعناع والريحان يمكن استخدمها كمضادات اكسدة ومنشط للمناعة للأرانب النامية.