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CARCASS CHARACTERISTICS, MEAT QUALITY AND CECAL ACTIVITY OF GROWING NEW ZELAND RABBITS FED EUCALYPTUSINCLUSION AS NON-TRADITIONAL FEED ADDITIVES

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ABSTRACT: An 8-week experiment was carried out to determine the effect of supplementing diet with dried eucalyptus globulus leaves or its aqueous extract on carcass characteristics, meat quality and cecal activity of growing New Zeland rabbits. For this, 225 weaned rabbits of 6 weeks of age were allotted to five treatments with three replicates (15 rabbits each). Treatment diets were the control diet and other four treatment diets which supplemented with 0.25; 0.5% dried eucalyptus leaves and 0.05; 0.1% aqueous extract of eucalyptus leaves, respectively.The rabbits were housed and fed in individual cages.At the end of the experiment, 15 rabbits were slaughtered (three rabbits/group) to evaluate carcass characteristics, meat quality and cecal activity.

Experimental treatments had no significant effect on carcass traits includedhot carcass, dressing and impiety intestinal weight percent except abdominal and shoulder fat % which were significantly reduced. Drip loss and cooking loose of growing rabbits meat significantly ($p<0.05\%$) improved by the experimental diets. There were no differences between experimental diets in pHu of meat and small intestine while stomach pHu was significantly reduced.Forchemical measurements of meat qualityandconcentration of total protein significantly ($P<0.01$) increased as well as cholesterol and HDL decreased, alsomalondialdehyde (MDA) concentrations were significantly improved compared to those of the control.

The cecal length was decreased ($P<0.01$) in supplemented groups, while full and impiety weight were not significantly affected. The results of cecal activity showed that inclusion of eucalyptus as dried leaves or its aqueous extract was not significantly affected the concentrations of ammonia nitrogen (NH3-N); volatile fatty acids (VFAs)and pHu of cecum. The bacterial account significantly reduced with using eucalyptus as non-traditional feed additives. The current study indicated that eucalyptus could be utilized as an effective additive to improve meat quality and to reduce caecal bacterial counts in rabbits.

Key words: eucalyptus, carcass characteristics, meat quality, cecal activity, rabbits.

INTRODUCTION

The nutritional value of rabbit meat has a high value compared with other meats (Hernández and Gondret, 2006). Also, DalleZotte, (2000) reported that rabbit meat rich in protein of high biological value. The use of antibiotic and other drugs as growth promoters have been banned by the European Union which increased digestive disorders and mortality in growing rabbits (DalleZotte ,*et al*., 2016). In recent years, natural products such as herbs, spices and their extracts attracted attention as potential alternatives to growth promoters in rabbits, due to their antimicrobial activity (Simonová, *et al*., 2012). These natural products also improved rabbit meat quality (Simonová, *et al*., 2009).

Eucalyptus globulus grows well in different parts of the world, besidesit contains hundreds of chemical substanceswhich determined its pharmaceutical activity. Barra, *et al*., (2010) found that Eucalyptus globulus contains p-cymene, 1,8-cineole, *β*-phellandrene, spathulenol, cryptone aldehydes, cuminal and uncommon ofphellandral such as α-phellandrene and β-phellandrene. Also, Eucalyptus globulus leaves have multi-functional characteristics such as anticariogenic, analgesic, antihistaminic, antioxidantive and anti-inflammatory activities (Cimanga, *et al*., 2002; Nagpal, *et al*., 2010; Vratnica, *et al*., 2011 and Ishnava, *et al.*, 2013). In addition, it contains quinones, saponins, carbohydrates, tannins, phenols and flavonoids (Kaur, *et al*., 2019) where, phenolic content of *Eucalyptus globulus* was 11.41% and the total flavonoid content was 35.88%.As reported by (Glulón, *et al*., 2019), phenolic compounds in *Eucalyptus globulus*leaf have medicinal properties as well as it is used in the pharmaceutical, health, agricultural, cosmetic and food industries. Also, Polyphenols in eucalyptus leaves have shown antioxidant activity, antitumor activity and antibacterial activity (Bokaeian, *et al.*, 2010; Chen, *et al*., 2017 and Kaur, *et al*., 2019).

Fathi, *et al*., (2019) found that supplementing rabbit diets with 0.1 and 0.2%eucalyptus leaf resulted to significantly ($P<0.02$) improve dressing % at 0.1% while 0.2% showed no improvement in comparisonwith that of the control. Some researchers discovered that feeding laying hens with diet supplemented with eucalyptus improves antioxidant status and immune response ofbroilers (Abd El-Motaal, *et al*., 2008, Farhadi, *et al*., 2017 and Chen, *et al*., 2018).

The objective of this study were to examine if dried eucalyptus globulus leaves or its aqueous extract can influence carcass characteristics, meat quality and cecal activity of New Zeland rabbit after rabbit fed diet supplemented with them.

MATERIAL AND METHODS

This study was carried out at Sakha Animal Production Research Station, Animal Production Research Institute, Agricultural Research Center, Ministry of Agriculture, Egypt.

At the room temperature green Eucalyptus leaves were dried and then ground in a blender to a particle size about 0.8-0.9 mm. Then eucalyptus globules aqueous leaves extract was prepared according to (Mittal and Aguwa, 1983). Eucalyptus globulus powdered leaves (100 gm) was infused in 500 ml hot water for 4 hours then filtered with Whattman filter paper. The extract was kept at 4°C in Deep freezer for 48 hours then dried.

Two hundred and twenty five (225), 6-weeks-old New-Zeland growing rabbits used in this study. Rabbits were divided into the control group and 4 experimental groups each group contain three replicates with 15 rabbits in replicate. The four experimental groups fed diets supplemented with 0.25; 0.5% dried eucalyptus leaves and 0.05; 0.1% aqueousextract of eucalyptus leaves, respectively. The experiment continuedfor 8 weeks and basal diet was formulated to satisfy the NRC' (1977) for growing rabbits (Table 1). Also, feed and water were offered at *ad libitum*. Rabbits were kept in standard cages under the same hygienic and environmental conditions during the experimental period.

At the end of the experiment, three rabbits (14-weeks old rabbits) of each group were overnight fasted then slaughtered to determined carcass characteristics. Hot carcass, abdominal fat and shoulder fat, liver, kidney and heart were weighted and dressing % were calculated as the sum of carcass, head, liver, kidneys, heart and head weight (g) calculated as percentage from live body weight. The weight of small intestine and stomachwere measured and the values pH measured by using pH meter (3520, UK). Front quarter and back quarter of the right side of carcass were weighted together then kept for 24 h at 4°C to evaluate meat quality of rabbits.

Growing rabbit meat samples were used to determine the physical measurements (drip loss, cooking loss and pHu).Drip loss% of meat samples were determined by Saenmahayak, *et al*., (2012). The percentages of drip loss were calculated as the difference between weights of samples before and after storage 24 h. and divided by the first samples weight. The meat samples were weighted and put in the oven in temperature between 160 – 180°C for 25minute, then let them cool down in the room temperature (25°C). The cooking loss according to Omojola and Adesehinwa, (2006) are the percentage of the different between the initial and the final weight.

$$\text{Cooking loss \%} = \frac{\text{Final meat wt.} - \text{Initial meat wt.}}{\text{Initial meat wt.}} \times 100$$

The values pHu were measured by using pH meter (3520, UK). Samples of growing rabbit meat stored on -20°C for 60 days before used to determine the chemical measurements. Samples prepared by using 10 ml of phosphate buffer pH 7.4. Colorimetric methods using analytical commercial kits produced by Biodiagnostic Company, Egypt to determine concentrations of malondialdehyde (MDA), total protein (TP), total cholesterol (TC), low density lipoprotein (LDL) and high density lipoprotein (HDL) in meat extract.

Full length, full and empty weight of the caecum were taken and individual measurements for all slaughtered rabbits; immediately after slaughtering concentrations of ammonia nitrogen (NH_3-N) and volatile fatty acids (VFAs) of caecum contents were recorded by using EIL pH meter and pH of caecum contents were recorded. Total numbers of caecum bacteria were counted by plate count data according to Allan, *et al*., (2012).

Statistical analysis:Data were statistically evaluated using General Linear Model (GLM) procedure of the statistical analysis system of SAS Institute (SAS 2001) using one way ANOVA. Duncan's Multiple Range test (Duncan's 1955) was used to separate means when separation

was relevant. Statistical significance was accepted at probability level of (P<0.05). The statistical model performed was as follow:

Yik = μ+ Ti + eik

Where, Yik = An observation, μ = Overall mean, Ti = Effect of treatments (i = 1,2….5), eik = random error**.**

RESULTS AND DISCUSSION

No significant differences were noted in the carcass and dressing percentages of growing rabbits fed experimental diets (table 2). On the other hand, the abdominal and shoulder fat % were significantly reduced with experimental diets compared with those of the control. Impiety intestinal weight (%) was not significantly affected with eucalyptus additive ssupplementation. Results are in-agreement with the conclusion of Ahmed, *et al*., (2005) who reported that carcass characteristics were not significantly affected by using eucalyptus as natural feed additives in growing rabbit diets.While,Fathi, *et al*., (2019) reported that the dressing % was significantly (P<0.02) improved in rabbits feddiet supplemented with 0.1% while rabbits fed diet contained 0.2% shows no improvement in dressing compared with the control rabbits. The reduction in the abdominal and shoulder fat%might be due to the antioxidant activity of eucalyptus (Cimanga, *et al*., 2002).

Drip loss and cooking loss were lower (P<0.05) in meat obtained from growing rabbits fed diets supplemented with 0.25; 0.5% dried eucalyptus leaves and 0.05; 0.1% aqueousextract of eucalyptus leaves compared to the control (Table 3). There were no differences in drip loss and cooking loss between experimental groups. Also, the results in table (3) shows that the pHu values of meat and small intestine were not significantly affected by experimental diets, while stomach pHu was significantly reduced. The improvement of drip loss and cooking loss may be due to the antioxidant activity of eucalyptus (Vratnica, *et al*., 2011). The antioxidant properties of eucalyptus are related to its phytochemical active ingredients including polyphenols, 1,8-cineole, and tannins which play a vital role in scavenging of the free radicals and inhibiting lipid peroxidation (Luís, *et al*., 2016).The effect of dietary treatments on some chemical measurements of meat quality of growing rabbits presented in table (4). Rabbits fed diet supplemented with either 0.25; 0.5% eucalyptus dried leaves or 0.05; 0.1% eucalyptus aqueous extract recorded significantly (P<0.01) high total protein of meat compared to the control. Cholesterol concentration in meat seems to be lower in the meat ofrabbits fed diet supplemented with eucalyptus aqueous leave extract than that ofeucalyptus dried leaves, whereas that of the control group recordedthe higher cholesterol content. No significant effects on meat LDL while HDL was significantly lower in the rabbits received diet supplemented with 0.05; 0.1% eucalyptus aqueous extract than those of the control and the rabbits received 0.25; 0.5% eucalyptus dried leaves. Malondialdehyde concentrations were significantly lower in the experimental groups by 11.13 and 13.7% for 0.25; 0.5% eucalyptus dried leaves and by 20.02 and 15.95% for 0.05; 0.1% eucalyptus aqueous extract, respectively, compared with the control.The positive effect of eucalyptus on meat quality is in agreement with Alagawany, *et al*., (2019) whoreported that using natural additives from the plants contained bioactive molecules as no-traditional feed

additives improved carcass traits and meat quality. This improvement may be due to that Kaur, *et al*., (2019) whoreported that *Eucalyptus globulus* leaves containedan antioxidant activity, which support the tissue function (Lucca, *et al*., 2009) by get ridoffree radicals that damage cells andcause some disease such as immune (Kamatou and Viljoen, 2010). Besides, eucalyptus has anti-inflammatory, antibacterial, antioxidative and antiviral properties (Patil and Sachin, 2014).

The effect of experimental diets on characteristics, activity and microbe account of ceca are presented in table (6). The length of cecalwas significantly reduced, while there were no effects on empty and full cecal weight. TVFAs and NH_3N significantly reduced with eucalyptus addition to growing rabbit diets. However, TVFAs of the caecum was not different among experimental group. PH of the caecalcontentwasnot significantly affected by Eucalyptus supplementation. Based on the above mentioned result, feeding eucalyptus inclusion had significantly lower counts of total bacteria compared with the control group. The group of eucalyptus leaves recorded the lowest bacterial counts compared with those of the eucalyptus leaves aqueous extract ones. These results agree with Mohamed, (2007) who discovered new compound in Eucalyptus globules (eucalyptone G) that has antibacterial activity.

Also, Dorman and Deans, (2000) reported that antibacterial activity of eucalyptus due to its active compounds such as terpenoids and phenylpropanoids. Fathi, *et al*., (2019) found that supplemented growing rabbit diets with eucalyptus leaves (0.1 or 0.2 %)decreasedcaecum length and consequently reduce pathogenic bacteria. This is may be due to eucalyptus contains tannins which played a role as a protective factor of the intestinal mucosa (Mancini, *et al*., 2019)

CONCLUSION

It could be concluded that supplemented rabbit diets with 0.25; 0.5% dried eucalyptus leaves or 0.05; 0.1% eucalyptus leaves aqueous extract have no adverse effect on carcass while the abdominal and shoulder fat were decreased. However, the studied additives improved meat quality and lowered total bacteria in caecum.

Table (1): Compositionand calculated chemical composition of the basal diet

Feed Ingredients, %	**calculated chemical composition (%DM basis)**		
Alfalfa hay (12%)	27	Dry Matter%	89.71
Soybean meal (44%CP)	17.65	Crude Protein%	17.14
Barley	20	Crude Fiber%	12.75
Yellow corn	11.4	Ether Extract%	2.37
Wheat bran	17.5	Calcium %	1.19
Molasses	3	Total Phosphorus %	0.8
Limestone	0.75	Lysine %	0.89
Dicalcium - phosphate	1.9	Methionine %	0.5
Sodium chloride	0.3	Met + Cys %	0.79
DL-Methionine	0.2		
Mineral-vitaminpremix*	0.3		
Total	100		

*Vit. And Min mixture: Each 3 kg contain: 6000000 IU Vit. A; 900000 IU Vit. D3; 40000 mg Vit. E; 2000 mg Vit. K3; 2000 mg Vit. B1; 4000 mg Vit. B2; 2000 mg Vit. B6; 10 mg Vit. B12; 50 mg Biotin; 10000 mg Pantothenic acid; 50000 Niacin; 3000 mg Folic acid; 250000 mg Choline; 8500 mg Mn; 50000 mg Zn; 50000 mg Fe; 200 mg I; 100 mg Se, 5000 mg Cu, and 100 mg Co.

Table (2): Effect of dietary treatments on carcass characteristics of growing rabbits

Item	**Control**	**Eucalyptus dried leaves**		**Eucalyptus aqueous extract**		**Pooled SE**	**Sig**
		0.25%	**0.5%**	**0.05%**	**0.1%**		
Hot carcass%	48.04	50.65	50.11	48.3	48.41	1.6	NS
Dressing%	52.23	54.1	53.73	52.01	52.23	2.18	NS
Abdominal fat%	0.76^{a}	0.57^{b}	0.62^{b}	0.64^{b}	0.64^{b}	0.1	**
Shoulder fat%	0.49^{a}	0.27^{b}	0.25^{b}	0.2^{b}	0.19^{b}	0.002	***
Impiety intestinal weight (%)	3.69	3.62	3.77	3.8	4.06	0.09	NS

a, b and c: Means in the same row having different superscripts differ significantly .

Table (3): Effect of dietary treatments on physical meat quality and internal organ pH of growing rabbits

Item	Control	Eucalyptus dried leaves		Eucalyptus aqueous extract		Pooled SE	Sig
		0.25%	0.5%	0.05%	0.1%		
Drip loss%	3.96^{a}	3.46a^{b}	2.7^{b}	3.14^{b}	2.77^{b}	0.17	*
Cooking loss %	21.42^{a}	12.53^{b}	12.53^{b}	13.13^{b}	13.95^{b}	0.11	*
pH							
pH of meat	6.62	6.32	6.26	6.28	6.14	0.16	NS
pH of intestine	7	6.97	7.02	6.53	6.87	0.05	NS
pH of stomach	2.86^{a}	2.28^{ab}	0.25^{ab}	1.88^{b}	1.93^{b}	0.11	*

a, b and c: Means in the same row having different superscripts differ significantly .

Table (4): Effect of dietary treatments on chemical measurements of meat quality of growing rabbits

Item	Control	Eucalyptus dried leaves		Eucalyptus aqueous extract		Pooled SE	Sig
		0.25%	0.5%	0.05%	0.1%		
Total protein(mg/100g meat)	6.46^{d}	7.17^{c}	7.66^{b}	8.1^{a}	8.37^{a}	0.05	**
Total cholesterol (mg/100g meat)	180.77^{a}	174.83^{b}	164.1^{c}	156.87^{d}	152^{d}	7.76	**
LDL (mg/100g meat)	61.4	60.9	58.96	59.43	59.08	1.23	NS
HDL (mg/100g meat)	68.39^{a}	66.62^{a}	65.86^{a}	59.34^{b}	54.01^{c}	3.13	**
Malondialdehyde (nmol/g)	9.34^{a}	8.3^{b}	8.06^{ab}	7.47^{c}	7.85^{bc}	0.16	**

a, b and c: Means in the same row having different superscripts differ significantly .

Table (5): Effect of dietary treatments on characteristics, activity and caecum microbial counts of caecal.

Item	Control	Eucalyptus dried leaves		Eucalyptus aqueous extract		Pooled SE	Sig
		0.25%	0.5%	0.05%	0.1%		
Caecal characteristics							
Length (cm)	49.2[a]	48.31[ab]	44.4[c]	46.87[b]	47.07[b]	0.61	**
Full weight (gm)	90.67	90.3	90.4	90.53	89.47	0.24	NS
Empty weight (gm)	26.93	27.63	26.8	27.37	27.1	0.41	NS
Cecal activity							
TVFAs (mEq/100gm)	6.95	7.15	7.68	7.29	7.65	0.24	NS
NH_3N(mg/100gm)	17.56	18.03	18.52	18.44	18.66	0.3	NS
PH of cecal	6.26	6.38	6.39	6.35	6.38	0.05	NS
Cecal microbe count							
Total bacteria counts CFM/ml	200[a]	162.67[b]	165[b]	154.33[b]	163.67[b]	9.6	**

a, b and c: Means in the same row having different superscripts differ significantly .

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الملخص العربي

صفات الذبيحة وجودة اللحم ونشاط الأعور في الارانب النيوزلندي النامية المغذاة علي عليقة مضاف اليها الكافور كإضافات غذائية غير تقليدية

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تم إجراء هذه التجربة لمدة ٨ أسابيع لمعرفة تأثير إضافة أوراق الكافور المجففة أو مستخلصها المائي على خصائص الذبيحة وجودة اللحم ونشاط الاعور في الأرانب النيو زيلاندى النامية. لهذا الغرض تم تقسيم ٢٢٥ أرانب مفطومة عمر ٦ أسابيع لخمس معاملات بثلاثة مكررات (١٥أرنب لكل معاملة). وكانت المعاملات معاملة مقارنة وأربعة معاملات غذائية اخري. وكانت المعاملات الغذائية مضاف اليها ٠,٢٥ و ٠,٥٪ أوراق كافور مجففة و ٠,٠٥ و ٠,١ ٪ مستخلصمائيلأوراق الكافورالمجففعلى التوالي. تم تربية الأرانب وتغذيتها في أقفاص فردية. في نهاية التجربة تم ذبح ١٥ أرنب (ثلاثة أرانب / مجموعة) لتقييم صفات الذبيحة وجودة اللحم ونشاط الاعور.

لم يكن هناك تأثير معنوي على صفات الذبيحة ، بما في ذلك الذبيحة الساخنة والاجزاء الماكولة ووزن الأمعاء الفارغة ما عدا نسبة الدهون في البطن والكتف أنخفضت بشكل معنوي. تحسنت معدل فقد السوائل والفقد في الطهي للحم الأرانب النيوزلندي النامية بصورة معنوية باستخدام المعاملات الغذائية. لم تكن هناك فروق معنوية بين المعاملات الغذائية في درجة الحموضة في اللحم والأمعاء الدقيقة في حين انخفضت درجة الحموضة في المعدة بصورة معنوية. أما القياسات الكيميائية لجودة اللحوم فأنه بأستخدام المعاملات الغذائية زادت نسبة البروتين الكلي زيادة معنوية وكذلك انخفض الكوليسترول و HDL ، كما حدث تحسن معنوي في المالونالدهيد بصورة معنوية مقارنةً بالمجموعة المقارنة.

أنخفض طول الأعور في المعاملات بصورة معنوية في حين لم يتأثر الوزن المملوء والفارغ. أظهرت نتائج نشاط الأعور أن إضافة أوراق الكافور المجففة أو مستخلصها المائي لم يؤثر بصورة معنوية علي نيتروجين الأمونيا والأحماض الدهنية الطيارة بالأعور. إنخفضت أعداد البكتيريا بصورة معنوية بإستخدام الكافور كإضافات غذائية. أشارت الدراسة الحالية إلى أن الكافور يمكن أستخدامه كإضافات غذائية غيرتقليديةفعالة لتحسين جودة اللحم وتقليل أعداد البكتيريا الموجودة في الأرانب.