THE EFFECT OF SUPPLEMENTING GROWING NEW-ZELAND WHITE RABBIT DIETS WITH LEMON GRASS OIL DURING HEAT STRESS IN EGYPT

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(Received 3/7/2024, accepted 24/7/2024)

SUMMARY

This study was aimed to evaluate the impact of supplementing growing New-Zeland rabbit diets with lemon grass oil (LGO) on growth performance, nutrient digestibility, carcass traits and meat quality during heat stress. Ninety New Zealand White (NZW) rabbits were randomly divided into three groups, each in three replicates and fed diets supplemented with 0,100 and 150 mg LGO /kg diet during summer season in Egypt. Diets and water were allowed ad-libitum to rabbits and the experiment lasted for 8 weeks. The results showed that supplemented LGO significantly improved final body weight; body weight gain and feed conversion ratio. The addition of LGO significantly improved DM, CP, CF and NFE digestible coefficients and the nutritive value (TDN and DCP) compared with control group. Supplemented growing rabbit diets with LGO significantly increased carcass, dressing, giblet, liver and heart percentages and significantly decreased abdominal fat and shoulder fat percentages compared with control group. The meat content of total protein was significantly increased, while total cholesterol and triglycerides were significantly decreased compared to control. Supplemented diet with LGO suppressed MDA concentration in rabbit meat. Both drip loss and cooking loss percentages in meat were significantly decreased. The results concluded that supplementing growing New-Zeland White rabbit diets with lemon grass oil alleviated the adverse effects of heat stress on all experimental parameters.

Keywords: *lemon grass oil, rabbit, heat stress.*

INTRODUCTION

During last years, many researchers focused on the productive performance and carcass yield of rabbit meat (Zotte, 2002). Rabbit meat considered a good source of protein because it is rich in protein and less fat than other meat. Also, it contains linoleic acid and minerals which is easy to digest for humans. Also, it is rich in polyamine, selenium and antioxidant vitamins (Zotte, and Szendroe, 2011). Rabbits are considered one the most sensitive animal to high ambient temperature (Marai, *et al.*, 2002 and Maertens and Gidenne, 2016). The genetic improvement in rabbit production makes rabbit sensitive to environmental stress such as the rise in temperature (Marai, *et al.*, 2007). The same authors reported that the rise in ambient temperature in summer lead to heat stress in rabbits which cause many adverse effects to rabbit production. There must be a balance between heat gain and heat loss, so heat stress cause disturbances thermoregulatory system in rabbits (Jimoh and Ewuola, 2016). Heat stress in rabbits causes thermal imbalance due to change in biochemical profile and physiological adjustment (Chiericato, *et al.*, 1994). Also, the rise in ambient temperature causes oxidative stress (Jimoh, *et al.*, 2017), which leads to decreases in rabbit production performance and has a bad effect on rabbit health (Lodovici, *et al.*, 2003 and Abdel-Khalek, 2013). Also, Zeferino, *et al.* (2011) found that heat stress badly impact production performance, carcass and meat quality.

Essential oils from the medicinal plants being aromatic have an anti-bacterial activities (Burt, 2004). Phenolic compounds in essential oils considered as natural antioxidants which affected oxidative

reactions (Sharma, *et al.*, 2017). Lemon grass (Cymbopogon citratus) is an aromatic perennial plant of the family Poaceae; it is used in traditional therapeutic in many countries; it contains 0.035% essential oil; lemon grass oil (LGO) is a volatile oil that could be extracted directly using steam extraction from fresh lemon grass (Malee, *et al.*, 2000; Aftab, *et al.*, 2011; Tarkang, *et al.*, 2012).

Bharti, *et al.*, (2013) reported that the essential oil of lemon grass contains citral, limonene, citronellol, α-terpineol, caffeic acid, geranial, geraniol, chlorogenic acid, kaempferol, myrcene, burneol, nerol, neral, elemicin, apigenin, luteolin, quercetin, and geranyl acetate. Furthermore, Kassahun and Gezu, (2019) discovered that lemon grass oil contains about twenty volatile components included alpha-pinen, D-limonene eucalyptol, and eucalyptol. All these compounds lead to the pharmaceutical activities of lemon grass oil such as its antioxidant (Masuda, *et al.*, 2008), antibacterial (Wannissorn, *et al.*, 2005), antifungal (Nakagawa, *et al.*, 2003), and anti-inflammatory (Abe, *et al.*, 2004) activities. The aim of this study was to investigate the effect of supplemented growing New-Zeland rabbit diets with 0, 100 and 150 mg lemon grass oil during heat stress.

MATERIALS AND METHODS

At 6 weeks of age, 90 weaned New Zealand White (NZW) rabbits were divided into 3 groups. Each group contains three replicate with 10 rabbits in each replicate. The first group was the control (without LGO supplementation), and the other two groups were fed diet supplemented with 100 and 150 mg LGO/ kg diet, respectively. Diets and drinking water were supplied ad-libitum and the experiment lasted for 8 weeks. Rabbits were individually housed in wire cages. Basal diet was formulated according to NRC (1977) as described in Table 1. All diets were iso-nitrogenous and iso-energetic. Rabbits were reared under heat stress conditions in summer season in Egypt (temperature ranged between 30 °C to 42 °C and, humidity from 45 to 70%).

Table (1): Composition and calculated analysis of the basal experimental diet of growing New-Zealand White (NZW) rabbits.

Ingredient	%	Calculated Analysis[2]	On DM bases %
Corn, ground	31.95	Dry matter	87.80
Soybean meal 44%	11.50	Crude protein	16.00
Berseem hay	39.00	Crude fibre	13.04
Wheat bran	11.50	Ether extract	7.80
Molasses	5.00	Nitrogen free-extract	54.57
NaCl	0.50	Total phosphorus	0.35
DL-Methionine	0.25	Calcium	0.59
Premix[1]	0.30	DE (Kcal/kg diet)	2669

1. Mineral and vitamin mixture supplied per kg of diet: Vitamin A 60000 IU, Vitamin D3; 900 UI, Vitamin E; 40 mg, vitamin K3; 2 mg, Vitamin B1; 2mg, Vitamin B2; 4 mg, Vitamin B6; 2 mg , Vitamin B12; 10µg, Folic acid; 10 mg, Pantothenic acid; 7 mg, Nicotinic acid; 50 mg, Biotin; 50 µg, Choline chloride; 250 mg, I; 0.2 mg, Mn; 85 mg, Cu; 5 mg, Zn; 50 mg, Fe; 50 mg, Co; 0.1 mg, , Selenium; 0.1 mg.
2. According to NRC (1977).

Growth performance of growing rabbit was measured by weekly recorded of live body weight and feed intake and calculated weight gain and feed conversion ratio. At the end of the growth experiment, samples of feed and feces were daily collected form rabbit (6 per each treatment) which individually housed in metabolic cages, for determining nutrients digestibility. Chemical analyses of diets and feces were done according to the classical methods (AOAC, 1996), while, digestibility of nutrients was measured as described by Cheeke, (1987). Thenafter, three rabbits of each treatment were slaughtered and hot carcass, liver, kidneys, heart, abdominal fat and shoulder fat were weighed and calculated as percentage from live body weight to determine carcass characteristics. After slaughtering, the L. lumborum muscles (between the 1st and 7th lumbar vertebra) were used to determine meat quality. Mixture of meat were stored on -20°C for 4 days then total protein, total cholesterol, triglycerides and malondialdehyde (MDA) contents were measured by colorimetric methods using analytical kits produced by Biodiagnostic Company, Egypt. Drip loss (DL) was determined according to Lundström and Malmfors, (1985), whereas, the cooking loss was determined according to Omojola and Adesehinwa,

(2006). Data were statistically analyzed by the general linear model (GLM) procedure of SAS User's guide (SAS, 2001) using the following fixed model:

$$Yij = \mu + Ti + e\ ij$$

Where, Y ij = The observed value of a given dependent variable,
μ = Overall adjusted mean,
Ti = Fixed effect of the treatments, i = 1, 2 ……..5,
e ij = Random error of the model.
The differences between means were analyzed by Duncan's New Multiple Range test (Duncan, 1955).

RESULTS AND DISCUSSION

The effect of supplemented growing New-Zeland rabbit diets with LGO during summer season are represented in Table2. Final live weight and total weight gain were significantly improved with LGO supplementation, while total feed intake were not significantly affected. Final live weight was increased by 8.3 and 14.36%, and total weight gain by 11.03 and 20.06% for diet supplemented with 100, 150 mg LGO, respectively, compared with control. Furthermore, values of feed conversion ratio were significantly (P≤0.01) improved by 14.66 and 19.65% for diet supplemented with 100, 150 mg LGO, respectively, compared with control group.

These results are in agreement with Al-Sagheer, *et al.*, (2017) who found that supplementing diets with LGO during heat stress improved live body weight and daily body weight gain and feed conversion ratio. Similarly, Tiwari, *et al.*, (2019) reported that supplementing broiler chickens diet with LGO improved growth performance. Although, an elevation in ambient temperature (Chiericato, *et al.*, 1993) may lead to an imbalance in rabbit body temperature (Ondruska, *et al.*, 2011) which results in disturbances in their thermoregulatory system (Jimoh and Ewuola, 2016), and caused rabbits exposed to an oxidative stress (Jimoh, *et al.*, 2017). However, adding LGO to rabbit diets alleviated heat stress effect on rabbit which improved growth performance because LGO have an antioxidant activity (Masuda, *et al.*, 2008). Also, LGO have an antibacterial (Wannissorn, *et al.*, 2005) and antimicrobial activity (Oussalah, *et al.*, 2007) which may lead to growth performance improvement.

Table (2): Effect of supplementing rabbit diets with LGO on performance during summer season.

Item	0 mg LGO	100 mg LGO	150 mg LGO	SEM	Sig
Initial live weight	648.33	656.67	646.67	0.5	NS
Final live weight	2310b	2501.67a	2641.67a	83.05	**
Total weight gain	1661.67b	1845a	1995a	75.52	**
Total feed intake	5666.7	5360	5450	15.87	NS
FCR	3.41a	2.91b	2.74b	0.02	**

a, b, c,…. Means within each row have no similar letters are significantly different (P ≤ 0.01), LGO= Lemon grass oil, SEM= standard error of means.

Table (3): Effect of supplementing rabbit diets with LGO on performance during summer season.

Item	0 mg LGO	100 mg LGO	150 mg LGO	SEM	Sig
DM	64.29^{b}	67.39^{a}	67.6^{a}	0.97	**
OM	76.94	77.66	78.4	0.47	NS
CP	71.54^{b}	74.44^{a}	74.23^{a}	0.68	**
CF	52.45^{b}	54.66^{a}	55.49^{a}	0.89	*
EE	60.29	61.34	61.13	1.14	NS
NFE	80.2^{b}	81.99^{a}	81.59^{ab}	0.52	*
Nutritive value (%DM)					
TDN	68.57^{b}	70.45^{a}	70.28^{a}	0.3	**
DCP	12.13^{b}	12.62^{a}	12.59^{a}	0.02	**

a, b, c,…. Means within each row have no similar letters are significantly different (P ≤ 0.01), LGO= Lemon grass oil, SEM= standard error of means.

The digestible coefficient of DM, CP, CF and NFE were significantly increased with LGO supplementation, while OM and EE were insignificantly affected (Table 3). On the other hand, the nutritive value (TDN and DCP) were significantly increased with LGO supplementation compared with control group. In this connection, Habeeb, *et al.*, (1992) reported that heat stressed rabbits showed decrease in digestibility of DM by 7.9%, CP by 8.1%, CF by 1.0% because heat stress decreased the production of digestive enzymes. In connection with digestible coefficient of CP and DCP, Al-Sagheer, *et al.*, (2017) reported a significantly (P≤0.05) increase by supplementing growing rabbit diets with LGO during heat stress compared with control group. The improvement in nutrients digestibility and nutritive values may be due to that LGO contains citral, a-myrcene, and cis-geraniol (Al-Sagheer, *et al.*, 2017), which have an antioxidant activity (Masuda, *et al.*, 2008).

Data of carcass characteristics are presented in Table 4. Carcass, dressing and giblet percentages were significantly higher in supplemented groups compared with control. Carcass percentages were increased by 8.82 and 16.14%, and dressing percentages by 13.46 and 15.44% for diet supplemented with 100, 150 mg LGO, respectively, compared with control. Both liver and kidney percentages increased with LGO supplementation compared with control, while heart percentages were insignificantly increased. The result showed that abdominal fat percentages were significantly decreased by 37.59 and 46.81%, and shoulder fat percentages were significantly decreased by 9.52 and 57.14% for diet supplemented with 100, 150 mg LGO, respectively, compared with control. In this respect, Zeferino, *et al.*, (2013) reported that carcass percentage decreased with an increase in ambient temperature. Al-Sagheer, *et al.*, (2017) disagree with our results, they found that dressing percentage were not significantly affected with LGO supplementation during heat stress. While, Omer, *et al.*, (2010) mentioned that dressing percentages were significantly (P<0.05) increased with supplementing New-Zealand White male rabbit diets with 0.5% lemon grass at 8 weeks of age.

Table (4): Effect of supplementing rabbit diets with LGO on carcass characteristics during summer season.

Item	0 mg LGO	100 mg LGO	150 mg LGO	SEM	Sig
Carcass%	51.71^{b}	56.27^{a}	60.2^{a}	5.17	**
Dressing %	61.85^{c}	67^{b}	71.4^{a}	4.5	**
Giblets %	3.87^{b}	4.81^{ab}	5.63^{a}	0.23	**
Liver %	3^{b}	3.74^{ab}	4.55^{a}	0.18	**
Heart %	0.33	0.36	0.4	0.002	NS
Kidney %	0.54^{b}	0.72^{a}	0.67^{a}	0.004	*
Abdominal fat %	1.41^{a}	0.88^{b}	0.75^{b}	0.07	*
Shoulder fat %	0.21^{a}	0.19^{ab}	0.09^{b}	0.003	*

a, b, c,…. Means within each row have no similar letters are significantly different (P ≤ 0.01), LGO= Lemon grass oil, SEM= standard error of means.

The effects of dietary supplementation with LGO during heat stress on meat quality of New-Zeland white growing rabbits are presented in Table 5.

Table (5): Effect of supplementing rabbit diets with LGO on carcass characteristics during summer season.

Item	0 mg	100 mg LGO	150 mg	SEM	Si
Total protein (mg/100g)	5.67^{b}	6.2^{a}	6.5^{a}	0.05	**
Total cholesterol (mg/100g)	2.07^{a}	1.87^{b}	1.79^{b}	2.9	**
Triglycerides (mg/dl)	1.14^{a}	0.09^{b}	0.09^{b}	2.4	*
Malondialdehyde (MDA)	5.1^{a}	4.77^{ab}	4.49^{b}	0.05	*
Drip loss %	23.49^{a}	19.57^{b}	18.07^{b}	2.83	*
Cooking loss %	34.74^{a}	33.03^{a}	30^{b}	1.13	**

a, b, c,…. Means within each row have no similar letters are significantly different (P ≤ 0.01), LGO= Lemon grass oil, SEM= standard error of means.

There were a significant improve in meat content of total protein by 9.46 and 14.63% for diet supplemented with 100, 150 mg LGO, respectively, compared with control. Both total cholesterol and triglycerides were significantly decreased. Moreover, malondialdehyde (MDA) concentrations were

significantly decreased by 6.47 and 11.96% for diet supplemented with 100, 150 mg LGO, respectively, compared with control. Drip loss and cooking loss percentages were significantly decreased with LGO supplementation. Similar to our findings reported herein, Al-Sagheer *et al.*, (2017) reported that MDA concentrations were significantly ($P< 0.05$) decreased in LGO supplemented diet compared with control during heat stress, and this may be due to the antioxidant activity of LGO on meat quality which can increase the shelf life of meat (Masuda, *et al.*, 2008).

CONCLUSION

In conclusion, it could be concluded that supplementing growing New-Zeland white diet with 150 mg/kg lemon grass oil during heat stress alleviated the adverse effect of heat stress and improved growth performance, nutrients digestibility, carcass characteristics and meat quality.

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تأثير إضافة زيت حشيشة الليمون لعلائق الأرانب النيوزيلندية النامية أثناء الإجهاد الحراري في مصر

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تهدف هذه الدراسة إلي تقييم تأثير اضافة زيت حشيشة الليمون لعلائق الأرانب النيوزيلندي البيضاء النامية علي الأداء الانتاجي، ومعاملات هضم العناصر الغذائية، وخصائص الذبيحة وجودة اللحم أثناء الإجهاد الحراري. إستخدم فى التجربة عدد ٩٠ أرنب نيوزيلاندى أبيض عمر ٦ أسابيع، قسمت إلى ثلاث مجموعات كل منها فى ثلاث مكررات. غذيت الأرانب على عليقة أساسية مضافا إليها زيت حشيشة الليمون بمستويات صفر، ١٠٠ و ١٥٠ ملجم زيت /كجم علف خلال موسم الصيف في مصر. إستمرت التجربة لمدة ٨ أسابيع أتيحت خلالها العلائق ومياه الشرب للأرانب طوال الوقت. أظهرت النتائج أن إضافة زيت حشيشة الليمون أدي إلى تحسن معنوي في وزن الجسم النهائي؛ زيادة وزن الجسم المكتسب ونسبة التحويل الغذائي. كما أدت إضافة زيت حشيشة الليمون إلى تحسين معاملات الهضم المادة الجافة والبروتين الخام والألياف الخام والمستخلص الخالي من النيتروجين والقيمة الغذائية (المركبات الغذائية الكلية المهضومة وكمية المهضوم من البروتين الخام) بشكل ملحوظ مقارنة مع مجموعة المقارنة. أدت إضافة زيت حشيشة الليمون للأرانب النامية إلى زيادة معنوية في نسب الذبيحة والتصافي والأحشاء والكبد والقلب وانخفاض معنوي في نسبة الدهون في البطن والكتف مقارنة مع مجموعة المقارنة. كما ارتفع معنوياً محتوى اللحوم من البروتين الكلي، بينما انخفض معنوياً مستوى الكولسترول والدهون الثلاثية. كما أدت إضافة زيت حشيشة الليمون لنقص المالونالدهيد في لحم الأرانب. انخفضت نسبة معدل فقد الماء ومعدل الفقد في الطهي بشكل كبير في المجموعات التجريبية. وقد خلصت النتائج إلى أن إضافة زيت حشيشة الليمون للأرانب النيوزيلاندى النامية خفف من الآثار الضارة للإجهاد الحراري على جميع مقاييس التجربة.