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Role of Moringa, Thyme and Licorice Leave Extracts on Productive Performance of Growing Rabbits

Lamiaa N. Alatrony[1], M. M. Abdella[1]; G. A. El- Sayaad[1]; A. S. Abd El-Hakim[2], and Sherein H. Mohamed[1*]

[1] Animal Production Department, Faculty of Agriculture, Benha University.

[2]Department of poultry Nutrition, Animal Production Research Institute, Agriculture Research Center (APRI).

***Corresponding author:** shereinabdelhadi@fagr.bu.edu.eg

Abstract

The effects of including moringa, thyme, licorice and their mixture leave extracts as phytogenic supplements for growing rabbits on productive performance, nutrients digestibility, blood parameters and carcass characteristics. A total of seventy weaned Moshtoher rabbits, at 25-30 days age and 550 ± 50 g initial live weight were used in growth trial lasted for 75 days. Rabbits were divided into five treatments of 14 animals each. The first group was fed on a basal diet without any supplementation as a control diet (G1). Other groups were supplemented with 100 mg moringa leaves extract/ kg diet (G2), 100 mg thyme leaves extract/ kg diet (G3), 100 mg licorice leaves extract/ kg diet (G4) and 100 mg mixtures from (1:1:1) moringa, thyme and licorice leaves/ kg diet (G5). Results indicated that rabbits in G2 and G5 had a remarkable ($p \leq 0.05$) enhancing effect on final weight and on body weight gain. Moreover rabbits in G2 recorded the highest digestibility coefficients ($P<0.05$) yielding the highest value, followed by G5 , then G3 and finally G4 compared to control group (G1) which showed the lowest values of the digestibility coefficients .The addition of supplements significantly ($P<0.05$) improved TDN and DCP. Dietary supplements significantly ($P<0.05$) raised some carcass characteristics. Adding supplements to growing rabbit diets boosted significantly meat CP content ($P<0.05$), while it decreased moisture and EE levels. Dietary supplement significantly reduced AST and ALT and increased TP, globulin, albumin, immunoglobulin G (IgG), and M (IgM) levels in the blood serum and decreased ($P<.05$) blood malondialdehyde, creatinine and urea. These results suggest that rabbits fed diets enriched with moringa, thyme, licorice leave extracts and their mixture at 100 mg/kg diet improved growth rate, carcass characteristics, and antioxidant status compared to the control.

Key words: moringa, thyme, licorice, productive performance, nutrient digestibility, blood parameters.

Introduction

Rabbit meat is a lean meat of high nutritive value, because it is rich in polyunsaturated fatty acids (PUFA), vitamins, minerals, essential amino acids, does not contain uric acid compared with other meats and low in cholesterol contents (**Hernández and Gondret ,2006** and **Zotte *et al.*, 2016**). The profitability of rabbit farms is partly depending on the effectiveness of weaned rabbits to grow healthy and to protect them from high mortality rates during the fattening period. Antibiotics have frequently used in the diets of growing rabbits because digestive disturbances are the main reason for morbidity and mortality in the rabbit industry (**Selim *et al*, 2021**). As a consequence of the European ban on antibiotic growth promoters and increased consumer awareness about the consumption of healthy and safer animal products, researchers and feed companies have encouraged to seek new animal feeding approaches to substitute AGPs and synthetic antioxidants (**Zotte *et al.*, 2016**). Phytogenic feed additives and/or their extracts are being progressively used in animal nutrition due to their beneficial phytochemical compounds. These active components have been shown to improve carcass yield, augment appetite, stimulate an immune response, enhance digestive enzyme secretion, and encourage antibacterial and antioxidant properties (**Abou-Elkhair *et al.*, 2018).**

Feed additives are an important component of animal feeds that help them to perform better and produce more (**Khan and Iqbal, 2016** and **Elsherif*et al.*, 2021**). In terms of feed efficiency, weight increase, and reduced mortality in poultry, natural feed additives (phytogenic) have shown promising results (**Jahan *et al.*, 2008)**. Phytogenic are supposed to boost animal performance by encouraging the release of digestive enzymes, which leads to better digestion and absorption (**Recoquillay, 2006 and Elsherif*et al.*, 2021**).

Phytochemicals or their extracts have a positive impact on animal performance, immunity, and blood parameters. Phytogenic and their extracts are effective feed additives in poultry nutrition because of their favorable effects and safety (**Hassan *et al.*, 2015 and Elsherif *et al.*, 2021**). Many studies were conducted on natural feed additives as an alternative to antibiotic to enhance performance and gut function of broiler chicks (**Schepetkin *et al.*, 2019; Oluwafemi *et al.*, 2021 and Elsherif *et al.*, 2021).**

Moringa oleifera, a native species of the Indian subcontinent, is a fast-growing drought-resistant tree belonging to the family Moringaceae (**FAO, 2016**). It is widely cultivated for the diversified use of its young seed pods and green leaves as vegetables and for medicine (**Islam *et al.,* 2021**). It is considered as a very good supplement because of its high protein value. moreover, it is known as the miracle tree because of its diversified beneficial features, *e.g.* 7 times more vitamin C than oranges, 17 times more calcium than milk, 10 times more vitamins than carrots, and 15 times more potassium than bananas (**Rockwood *et al.,* 2013**) . In addition, it helps to reduce the blood sugar level (**William *et al.,* 1993 and Wang *et al.,* 2022**), increase the blood antioxidant level (**Kushwaha *et al.,* 2014**) and sustained inflammation (**Libby *et al.,* 2002 and Luetragoon *et al.,* 2021)** The global Moringa leaf powder market demand which is expected to exceed USD 6 billion up to 2025 on account of increasing demand in the dietary supplement and food applications (**Ahuja and Mamtani, 2019**)

One of the most popular wild edible plants native to the Mediterranean region including Egypt and Arab countries is thyme (*Thymus vulgaris*). *Thymus vulgaris* commonly known as "thyme" has been used for many centuries for its culinary, flavoring and medicinal properties (**Stahl-Biskup and Venskutonis, 2012**). It is one of the most important edible plants, having many benefits. Thyme is rich in flavonoids, antioxidants, phytonutrients, minerals, B-complex vitamins, mainly vitamin B6 (pyridoxine), vitamin K, vitamin E and folic acid (**Hammoudi Halat *et al.,* 2022**). In addition, the therapeutic effects of thyme and its essential oils, especially thymol and carvacrol, against various diseases were demonstrated in several studies. This is attributed to its multi-pharmacological properties that include, but are not limited to antioxidant (**Tohidi *et al.,* 2017**), anti-inflammatory (**Lorenzo *et al,* 2019**), and antineoplastic actions (**Sampaio *et al.,* 2021**). Moreover, thyme has long been known for its antiviral (**Feriotto *et al,* 2018**), antibacterial (**He *et al.,* 2021**), antifungal (**Oliveira *et al.,* 2020**), and antiseptic activities (**Vázquez-Ucha *et al.,* 2020**).

Licorice is scientifically known as *Glycyrrhiza glabra* and belongs to the Leguminosae family. *G. glabra* is an ayurvedic herb that is frequently utilized. This medicinal plant is found throughout Asia as well as in areas of Europe (**Fiore *et al.,* 2005**). *G. glabra*, the most extensively dispersed species, is found in the most world countries. In contrast, *G. glabra* is located in Central Asia to China and Mongolia (**Hayashi *et al.,* 2019**). Licorice is one of the most commercially valuable plants globally, having a wide range of uses in cosmetics, the food industry, tobacco and pharmaceuticals **(Fenwick *et al.,* 1990**) Phytochemical and pharmaceutical analysis has been extensively explored thoroughly of licorice (**Hayashi *et al.,* 2003, Kang *et al.,* 2015: Esmaeili*et al.,* 2020**). Simple sugars, polysaccharides, mineral salts, amino acids, proteins, sterols, gums, pectin, starches and resins are all found in licorice (**Wang *et al.,* 2015),** glycyrrhizinic acid, isoliquiritin, glycyrrhizin and glycyrrhizic acid are other main chemicals in this plant with antiatherogenic, anti-cancer, anti-diabetic, anti-microbial, antispasmodic, anti-inflammatory, and anti-asthmatic properties (**Gaur *et al.,* 2014**).

Therefore, the goal of this study was to investigate the influence of the addition moringa, thyme, licorice leaves extracts **and an equal mixture of the three plant extracts** in rabbit diets on productive performance, nutrient digestibility, blood parameters and carcass characteristics.

Material and Methods

The experiment was carried out at the rabbit production unit, Research station Centre, Faculty of Agriculture, Moshtoher, Benha University, Egypt. Feed, meat and blood samples analyses were conducted at Food Analysis Lab., Faculty of Veterinary Medicine, Benha University, Egypt. The growth trial was carried out in winter during the period from 09/11/2020 to 20/01/2020.

Preparation of aqueous plant extracts.

The aqueous extracts of dried herbs were prepared according to **Al-Shawi *et al.,* (2020)** modified method. Ten g of dried materials were infused in 100 ml of (95°C) hot distilled water, left for overnight under refrigeration (4°C). After 24 h, the extracts were kept in rotary shaker at 100 rpm for 1h, the extracts were filtered with filter paper (Whatman No.1) and then frozen the extracts.

Determination of total phenolic content and antioxidant activity

The total phenolic content (TPC) and antioxidant activity (AO) of extracts were assessed as described by **Petrovic *et al.,* (2016**). The results were expressed as g of gallic acid equivalents (GAE) per 100g for TPC, and RSA%, measured by DPPH assay.

Animals and diets

A total of seventy weaned male Moshtoher rabbits, at 25-30 days age and 550 ± 50 g initial live weight were used in this study lasted for 75 days. Rabbits were divided into five treatments of 14 animals each. Rabbits were allocated individually in galvanized wire cages (40 cm high*50 cm width*50 cm length). All rabbits were kept under the same conditions in a semi-closed house with a ventilation system (the average room temperature was 25 ± 0.97°C, 62 ± 1.25% relative humidity and 14–16 h lighting).The first group of rabbits was fed on a basal diet without any supplementation and considered as a control diet (G1). Other groups were supplemented with 100 mg/ kg diet moringa leaves extract(G2), thyme leaves extract(G3) , licorice leaves extract(G4) and mixture (1:1:1) moringa, thyme and licorice leaves (G5). The offered feeds were assessed to cover the maintenance and production requirements for each animal. Feed was provided daily at 10:00 am and 10:00 pm as a pelleted feed. Chemical composition of the basal diet was prepared according to the Ministerial decree of Ministry of Agriculture and Land Reclamation (1996). The composition and chemical analysis of the experimental basal diet is presented in Table (1). Feed and fresh water were provided *ad libitum* during the whole experimental period. Individual body weights (BW), average daily weight gain (DWG) and feed consumption (FC) were determined weekly. Additionally, feed conversion ratio (FCR) was calculated as the ratio of the FC (g) to DWG (g).

Growth performance, blood sampling, and metabolites analyses

During the experimental period, all rabbits were weighed at the beginning (0 day) and the end of the trial (75 days). Feed intake of growing rabbits was recorded weekly. Accordingly, daily weight gain, daily feed intake, and feed conversion ratio (FCR) were calculated. At the end of the trial, blood samples (5 mL/rabbit) were randomly collected into tubes from the ear vein of 3 rabbits as representative sampling from each group. The blood samples were collected and then serum was prepared by centrifugation for 30 min at 3000 pm and stored at −20 ◦C until further analysis. Serum total protein, albumin, urea, creatinine, cholesterol, triglycerides, alanine aminotransferase (ALT), and aspartate aminotransferase (AST) were measured by ultraviolet spectrophotometer UV4802 (Unico Co., Dayton, OH, USA) using available kits (Biosystem S.A, Costa Brava, 30, Barcelona, Spain) according to the instructions of the manufacturer. The values of serum globulin were determined by subtracting the albumin values from the total protein values. The determination of 2-thiobarbituric acid reactive substances (TBARS) was done using a spectrophotometer, according to the method of **Esterbauer and Zollner (1989)** by detection of malondialdehyde (MDA) in blood using a commercial kit (Sigma-Aldrich St. Louis, MO, USA) following the procedures of themanufacturer. Results were expressed as nmol of MDA/mL. The activity of glutathione peroxidase in blood was also measured according to **Plaser *et al.*, (1966).**

Table 1. Composition and chemical analysis of basal diet. (on DM basis)

Ingredients	(%)
Yellow corn	18
Wheat bran	11
Soybean meal (44%CP)	25
Barley	12
Clover hay	30
Limestone	1.5
Di- Calcium phosphate	2
NaCl	0.5
Total	100
Chemical Composition as 100% DM	
OM	93.32
Ash	6.68
CP	19.25
EE	4.54
CF	14.93
NFE	54.6

CP: Crude protein%, CF: Crude fiber%, EE: Ether extract%, Ca: Calcium%, Lys.: Lysine%

Digestibility coefficient trial

At the end of the experimental period three rabbits were randomly selected from each group and housed in individual cages equipped with a system for separation of feces and urine. Rabbits were kept for 7 days for adaptation to the new conditions, followed by 4 days of collection. During the collection period, feed intake and total fecal output from each rabbit were accurately determined (**Perez *et al.*, 2010).**

Chemical composition

Dried samples of feed and feces were ground and then analyzed as dry matter according to **AOAC (2000).**

Carcass characteristics

At the end of the experiment, 3 rabbits from each group was randomly selected, overnight fasted, weighed individually and slaughtered. After complete bleeding, the weight of carcass was recorded then the carcass was eviscerated according to **Blasco and Ouhayoun (1996).** Carcass was evaluated for: carcass percentage and organs weight.

Chemical analyses of meat

The meat composition (Moisture, ash, crude protein, fiber and crude lipids (%)) of breast muscle was determined using the **AOAC (2000).**

Meat pH value, Thiobarbituric acid (TBA) and Total volatile basic nitrogen (TVBN):

The pH value was determined by homogenizing 10 g of the sample with 100 ml distilled water for 30 sec. The pH of prepared sample was measured using a pH meter model (Orion 3-star pH portable) according to **Defreitas *et al.*, (1997).** Thiobarbituric acid value was determined as described by **Harold *et al.*, (1987),** The TBA value was calculated by multiplying the absorbance by the factor (7.8) and the results were represented as mg of malonaldehyde/kg sample. Total volatile basic nitrogen was determined according to the method described by **Goulas and Kontominas (2005).** The quantity of TVBN as mg/100g of meat was calculated from the volume (v) of the added hydrochloric acid and its concentration (C) as follows: mg TVBN= (V×C×14×100)/10.

Statistical Analysis

All data were statistically analyzed using the general linear models' procedure of the statistical analysis system **SAS (2013).** Then, the comparison of means was done according to Duncan's (1955) multiple tests. Significances of differences were defined at p<0.05. All experiments as well as related analysis results were repeated three times and all obtained data are expressed as an average.

Results and discussion

Total phenolic content and radical scavenging activity of phytogenic leaves extract

The results of Table (2) showed that moringa leaves extract had the highest percentage of total phenolic content with (2102.40 mg/ 100g), followed by thyme leaves extract (1780.94 mg/ 100g) and finally licorice leaves extract (1640.80 mg/100g).Therefore, moringa, thyme and licorice leave extracts are a good source of bioactive compounds which have high antioxidative properties. The results illustrated in Table (2) showed that the radical scavenging activity of the three studied materials showed high values. It was 92.62 % for moringa leaves extract, 88.60 % for thyme leaves extract and 85.70% for licorice leaves extract .The results of total phenolic content and radical scavenging activity of three extracts were in line with those reported by **Dehshahri *et al.*, (2012), Charoensin, (2014), Nascimento *et al.*,(2017)** and **Abo El-Fadl*et al.*,(2020)** for moringa leaves extract and **Ghasemi Pirbalouti *et al.*,(2014)** for thyme leaves extract and **Frattaruolo *et al*., (2019) and AL-Bahadlyand Radhi, (2021)** for licorice leaves extract.

Table2. Total phenolic content and radical scavenging activity of phytogenic leave extracts

Material	Total phenolic content (mg/100g)	Radical scavenging activity (RSA)%
Moringa leaves extract	2102.40	92.62
Thyme leaves extract	1780.94	88.60
Licorice leaves extract	1640.80	85.70

Effects of phytogenic leave extracts on productive performance of growing rabbits.

As shown in Table (3) the control (Group 1) had the lowest growth values, whereas had the highest (p≤0.05) enhancing effect on the final weight and on body weight gain followed by G5. The highest values (P<0.05) were noted in G2 fed on basal diet with 100mg/kg aqueous moringa leaves extract, reaching higher final weight (2.46 kg) and body weight gain (1.92 kg) values followed by G5 which fed on basal diet with 100mg/kg mixed moringa , thyme and licorice leaves extract, then by G3 which fed on basal diet with 100mg/kg thyme leaves extract, followed by G4 fed on basal diet with 100mg/kg licorice leaves extract when compared with control group (final weight of 1.85 kg and body weight gain of 1.30 kg). Moringa, thyme and licorice leave extracts supplementation had a significant (P<0.05) effect on the FCR of growing rabbits during the experimental period. In comparison to the control group, inclusion of moringa, thyme and licorice leave extracts resulted in considerably (P<0.05) enhanced FCR values during the experimental period.

This improvement in growth performance with herbal extracts may be due to the high antioxidant contents in moringa (**Nascimento *et al.*, 2017** and **Abo El-Fadl *et al.*, 2020**), thyme **(Köksal *et al.*, 2017**) and licorice leaves extract (**Frattaruolo *et al.*, 2019**), which may prevent damage to body cells caused by free radicals and stimulate protein synthesis via the enzymatic system, based on the findings of this and prior investigations. Furthermore, moringa, thyme and licorice leaves extract can inhibit or limit the growth and colonization of a wide range of nonpathogenic and pathogenic microorganism in the gut, resulting in a more balanced microbial ecosystem and improved nutrient digestion and absorption, as well as improved growth performance and physiological status.

Accordingly, **El-Desoky *et al.*, (2018)**, **El-Kholy*et al.*,(2018), El-Adawy *et al.*, (2020)** and **Selim *et al*, (2021),** found that adding moringa leaves extract to the diet of rabbits promoted a significant improved (p ≤0.05) the BWG and enhanced their nutritional status compared with non-treated rabbits (control group). **Ahmed *et al.*, (2020)** , **Kucková *et***

al.,(2021) and **Elwardany *et al.*,(2022)** found that the addition of thyme leave extract to rabbit diets promoted a significant increment (p ≤ 0.05) in the BWG and enhanced the nutritional status compared with the control group. Also, **Dziewulska *et al.*,(2018) ,Alagawany *et al.*,(2019)**, **Dal Bosco *et al.*,(2019), DalleZotte *et al*.,(2020)** and **Hosny *et al.*,(2020)** found that the addition of licorice leave extract supplemented to rabbits diets enhanced (p ≤ 0.05) the BWG and enhanced the nutritional status compared with the control group.

Table 3. Effect of phytogenic leave extracts on growth performance of growing rabbits

Items	Experimental Groups					
	G1	G2	G3	G4	G5	±SE
Initial BW, kg	0.55	0.54	0.54	0.54	0.54	0.03
Final BW, kg	1.85^{d}	2.46^{a}	2.05^{b}	1.95^{c}	2.17^{b}	0.26
BW gain, g	13.0 ^{d}	19.2^{a}	15.1^{c}	14.1^{c}	16.3^{b}	0.11
DFI, g	76.40^{d}	77.60^{a}	76.90^{c}	76.60^{c}	77.10^{b}	0.01
Feed conversion ratio(FCR)	4.40^{a}	3.03^{d}	3.82^{bc}	4.07^{b}	3.54^{c}	0.10

a,b,c, mean within some rows with differing superscript are significantly differ (P<0.05).
G1: rabbits fed control diet without any supplementation.
G2: rabbits fed control diet supplemented with 100 mg moringa leaves extract/ kg diet.
G3: rabbits fed control diet supplemented with 100 mg thyme leaves extract/ kg diet.
G4: rabbits fed control diet supplemented with 100 mg licorice leaves extract/ kg diet.
G5: rabbits fed control diet supplemented with 100 mg mixture moringa, thyme and licorice leaves extract/ kg diet.

Effects of phytogenic leaves extracts on digestion coefficients and nutritive values of growing rabbits.

Influence of moringa, thyme and licorice leaves extract on digestibility coefficients and nutritive values of growing rabbits are illustrated in Table (4) Results showed that the addition of moringa, thyme and licorice leaves extract had significant affect (P<0.05) on all parameters of the digestion coefficients DM, OM, NFE, CP, CF, and EE. The addition of moringa leaves extract (G2) were substantially raised the digestibility coefficient of DM, OM, CP, CF, EE and NFE, (P<0.05), with the inclusion of 100 mg/kg moringa leaves extract yielding the highest values (66.40, 66.80,78.15,71.08, 87.78,69.80%, respectively), followed by G5 treated with 100 mg/kg mixed of moringa , thyme and licorice leaves extract with values(66.02, 66.16, 77.80, 70.24, 87.76, and 68.98 % respectively) , followed by G3 treated with 100 mg/kg thyme leaves extract with values (65.20, 65.96, 77.73, 70.10, 85.70, and 67.57 % respectively) , and finally G4 treated with 100 mg/kg licorice leaves extract with values (65. 0, 65.70, 77.39, 68.99, 85.46, and 67.58 % respectively) compared to control group (G1) which showed the lowest values of the digestibility coefficients DM, OM, NFE, CP, CF, and EE with (64.60, 65.30, 76.98, 68.05, 84.59, and 67.05 % respectively) .

The addition of moringa , thyme and licorice leaves extract significantly (P<0.05) improved total digestible nutrients (TDN) and digestible crude protein (DCP), where G2 treated with 100 mg/kg moringa leaves extract had the best total digestible nutrients (TDN) and digestible crude protein (DCP) being 71.19 and 15.20%, followed by G5 treated with 100 mg/kg mixed of moringa , thyme and licorice leaves extract being 70.87 and 15.14%, followed by G3 treated with 100 mg/kg thyme leaves extract with values 70.08 and 15.12% and finally G4 treated with 100 mg/kg licorice leaves extract with values 70.19 and 15.06% compared with the control group which showed the lowest total digestible nutrients (TDN) and digestible crude protein (DCP) with 69.23 and 14.98%.

The beneficial effects of herbal plants and their extracts in animal nutrition include stimulation of appetite, activation of the immune response, improving digestive enzyme secretion, antiviral, antibacterial and antioxidant actions that may affect the digestive tract’s physiological and chemical function (**Rahimi and Ardekani, 2013**).

Moringa, thyme and licorice leaves extract are an power antioxidant that can help the boost the secretion of pancreatic juice and gallbladder secrete bile and boost the secretion of pancreatic juice, which contain enzymes like lipase, amylase and protease that help with carbohydrate, fat, and protein digestion (**Abo El-Fadl *et al.*, 2020, Köksal *et al.*, 2017 and Frattaruolo *et al.*, 2019**). These findings are consistent with those of **Selim *et al.*,(2021), Kuckováet *al.*,(2021)** and **DalleZotte *et al.*, (2020)** who found that moringa , thyme and licorice leaves extract had the best CP and OM digestibility coefficients when compared to the control group.

Table 4. Effect of phytogenic leave extracts on coefficients of nutrient digestibility and nutritive values of growing rabbits

Item	Experimental Groups					±SE
	G1	G2	G3	G4	G5	
Digestion coefficients %						
DM	64.60^{d}	66.40^{a}	65.20^{c}	65.00^{c}	66.02^{b}	0.03
OM	65.30^{e}	66.80^{a}	65.96^{c}	65.70^{d}	66.16^{b}	0.01
CP	76.98^{a}	78.15^{a}	77.73^{a}	77.39^{a}	77.80^{a}	0.37
CF	68.05^{d}	71.08^{a}	70.10^{b}	68.99^{c}	70.24^{b}	0.55
EE	84.59^{bc}	87.78^{a}	85.70^{b}	85.46^{b}	87.76^{a}	2.04
NFE	67.05^{d}	69.80^{a}	67.57^{c}	67.58^{c}	68.98^{b}	0.09
Nutritive value %						
DCP	14.98^{b}	15.20^{a}	15.12^{a}	15.06^{a}	15.14^{a}	0.014
TDN	69.23^{d}	71.19^{a}	70.08^{c}	70.19^{c}	70.87^{b}	0.08

a,b,c, mean within some rows with differing superscript are significantly differ (P<0.05).
G1: rabbits fed control diet without any supplementation.
G2: rabbits fed control diet supplemented with 100 mg moringa leaves extract/ kg diet.
G3: rabbits fed control diet supplemented with 100 mg thyme leaves extract/ kg diet.
G4: rabbits fed control diet supplemented with 100 mg licorice leaves extract/ kg diet.
G5: rabbits fed control diet supplemented with 100 mg mixture moringa, thyme and licorice leaves extract/ kg diet.

Effect of phytogenic leave extracts on carcass characteristics of growing rabbits

Table (5) shows the effects of moringa, thyme and licorice leaves extract on carcass characteristics of growing rabbits. The experimental leaves extract had no significant effect on the liver, heart, kidney, round, lung and trachea, shoulder, rack, loin and digestive tract full weight. The effects of dietary treatments on hind up, belt weight, leg weight, live condition hot carcass weight, and final weight were significant (P<0.05) compared to the control group. The highest carcass weight values were recorded with the group supplemented with 100 mg/kg moringa leaves extract (G2), followed by the group supplemented with 100 mg/kg moringa, thyme and licorice leaves (G5) followed by the group supplemented with 100 mg/kg thyme leaves (G3) followed by the group supplemented with 100 mg/kg licorice leaves (G4) compared with control group (G1) which showed the lowest carcass weight values.
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These findings are in line with those of **El-Kholy*et al.*, (2018), Ahmed *et al.*, (2020)** and **Hosny *et al.*, (2020)**, who found that supplementation of diet with moringa, thyme and licorice leaves extracts improved carcass weight but had no effect on belly fat percentage of rabbits.

Table 5. Effect of phytogenic leave extracts on Carcass characteristics of growing rabbits

Item	Experimental Groups					±SE
	G1	G2	G3	G4	G5	
Carcass(gm)						
Kidneys weight	0.019	0.019	0.02	0.02	0.02	0.002
Liver weight	0.11	0.10	0.11	0.10	0.11	0.006
Heart weight	0.007^{b}	0.009^{a}	0.009^{a}	0.008^{ab}	0.008^{ab}	0.005
Digestive tract full weight	0.43	0.46	0.43	0.38	0.43	0.023
Hind up	0.13^{ab}	0.14^{a}	0.13^{ab}	0.13^{b}	0.13^{b}	0.003
Shoulder weight	0.21	0.24	0.23	0.22	0.21	0.009
Rack weight	0.18	0.20	0.19	0.17	0.17	0.015
Loin weight	0.34	0.32	0.28	0.29	0.28	0.021
Round weight	0.45	0.45	0.45	0.43	0.44	0.014
Hot Carcass weight	1189.33^{a}	1233.33^{ab}	1153.33^{ab}	1132.33^{b}	1110.00^{b}	0.29
Lung and Trachea weight	0.015	0.019	0.019	0.015	0.014	0.002
Leg weight	0.08^{b}	0.11^{a}	0.10^{ab}	0.09^{b}	0.10^{ab}	0.007
Belt weight	0.32^{c}	0.39^{a}	0.34^{b}	0.29^{d}	0.30^{cd}	0.008
Live condition	4.33^{ab}	5.00^{a}	4.00^{ab}	3.33^{b}	4.00^{ab}	0.42
Final weight	2413.33^{ab}	2558.00^{a}	2418.33^{ab}	2268.33^{b}	2361.67^{ab}	0.59

a,b,c, mean within some rows with differing superscript are significantly differ (P<0.05).
G1: rabbits fed control diet without any supplementation.
G2: rabbits fed control diet supplemented with 100 mg moringa leaves extract/ kg diet.
G3: rabbits fed control diet supplemented with 100 mg thyme leaves extract/ kg diet.
G4: rabbits fed control diet supplemented with 100 mg licorice leaves extract/ kg diet.
G5: rabbits fed control diet supplemented with 100 mg mixture moringa, thyme and licorice leaves extract/ kg diet.

Effect of phytogenic leave extract on meat composition and antioxidant capacity.

Table (6) shows the impact of moringa, thyme and licorice leaves extracts on rabbit meat composition and antioxidant. The addition of moringa, thyme and licorice leaves extracts to the diet of growing rabbits had a significant (P<0.05) impact on the meat moisture, protein, ash and ether extract content. Moringa, thyme and licorice leaves extracts significantly (P<0.05) boosted crude protein while decreasing moisture and fat levels in meat. With the addition of 100 mg/kg moringa leaves extract (G2), the highest value of crude protein (22.70%) was observed. While, the control group had the highest moisture and ether extract values; 73.90% and 2.53%, respectively.

Meat moisture content was reduced in response to moringa, thyme and licorice leaves extracts, implying that moringa, thyme and licorice leaves extracts may impact meat's water retaining ability. These findings are consistent with **Selim *et al.*,(2021), Ahmed *et al.*,(2020)** and **Hosny*et al.*,(2020) ,** who found that adding moringa, thyme and licorice leaves extracts to the diet significantly reduced belly fat relative and increased protein and ash content compared to the control group. Also, Table (6) the addition of moringa, thyme and licorice leaves significantly (P<0.05) enhanced GPx compared to the control group.

The inclusion of moringa, thyme and licorice leaves extract, reduced (P>0.05) MDA. The MDA exerts an adverse effect as it alters the cell membranes structure and function. The increase in the MDA level can lead to high cytotoxicity, oxidative mechanisms, and inhibitory actions. MDA acts as a tumor promoter and co-carcinogenic agent (**Nair and Nair, 2013**).The present findings tie with prior research on the antioxidant properties of moringa, thyme and licorice leaves, which were also demonstrated in this study. These findings are in line with those of other research (**Selim *et al.*,2021, Ahmed *et al.*,2020 and Hosny *et al.*,2020**), which found that moringa, thyme and licorice leaves lowered MDA levels in blood samples, indicating fewer oxidation reactions in the body.

Table 6. Effect of phytogenic leave extracts on meat composition and antioxidant capacity

Item	Experimental Groups					±SE
	G1	G2	G3	G4	G5	
Moisture	73.90^{a}	73.06^{b}	73.50^{ab}	73.9^{a}	73.1^{b}	0.19
Protein	20.10^{b}	22.70^{a}	22.07^{a}	21.63^{a}	22.43^{a}	0.34
Fat	2.53^{a}	1.77^{b}	2.10^{ab}	2.27^{ab}	1.93^{b}	0.15
Ash	1.30^{c}	2.03^{a}	1.70^{ab}	1.53^{cb}	1.83^{ab}	0.12
pH	5.71^{a}	5.55^{d}	5.62^{bc}	5.67^{ab}	5.58^{cd}	0.02
TVN	3.83^{a}	1.80^{c}	2.43^{bc}	2.83^{b}	2.13^{bc}	0.23
TBA	0.16^{a}	0.053^{c}	0.10^{cb}	0.12^{ab}	0.08^{bc}	0.01
GPx	409.3^{c}	571.3^{a}	494.0^{b}	480.0^{b}	523.0^{ab}	15.77
MDA	1.93^{a}	1.17^{c}	1.43b^{c}	1.57^{b}	1.27^{c}	0.084

a,b,c, mean within some rows with differing superscript are significantly differ (P<0.05).
G1: rabbits fed control diet without any supplementation.
G2: rabbits fed control diet supplemented with 100 mg moringa leaves extract/ kg diet.
G3: rabbits fed control diet supplemented with 100 mg thyme leaves extract/ kg diet.
G4: rabbits fed control diet supplemented with 100 mg licorice leaves extract/ kg diet.
G5: rabbits fed control diet supplemented with 100 mg mixture moringa, thyme and licorice leaves extract/ kg diet.

Effect of phytogenic leave extracts on blood constituents of growing rabbits:

The detected lipid profiles for all the investigated groups are compared and shown in Table (7) It should be noticed that the un supplemented group (control) showed higher total cholesterol and triglycerides contents (70.27, and 60.60 mg/dL, respectively) compared to treated groups. All supplemented groups with moringa, thyme and licorice leaves extracts caused a significant ($p \leq 0.05$) reduction in total cholesterol and triglycerides contents compared to control group. Among the experimental groups, Group 2 (supplemented with moringa, leaves extract), recorded the lowest total cholesterol (57.03 mg/dL) as well as significantly ($p \leq 0.05$) the lowest triglyceride content (51.03 mg/dL).

Clearly, comparing the present results, the supplemented with moringa, thyme and licorice leaves extracts resulted in a significant reduction in the total cholesterol and triglyceride levels compared to the control. It is noteworthy to state that moringa, thyme and licorice leaves extracts demonstrates remarkable hypolipidemic and hypocholesterolemic effects (**Chen *et al.*, 2020, Yalcin *et al.*, 2020 and Arafat *et al.*, 2021)**

The reported beneficial hypolipidemic effect of the moringa, thyme and licorice leaves extracts on the lipid profile may be due to phenolic compounds the natural antioxidants that are present in moringa, thyme and licorice leaves extracts (**Nascimento *et al.*, 2017, GhasemiPirbalouti *et al.*, 2014 and Frattaruolo *et al.*, 2019).** This hypolipidemic action can also be ascribed to the lipid metabolism modulation caused by phenolics such as chlorogenic acid and flavonoids such as quercetin, leading to a decrease in the total cholesterol, and triglycerides.

Concerning the liver function parameters, (as illustrated in **Table 7)** a significant increase in the AST and ALT were revealed in the untreated group (control, Group 1) compared to the treated groups (Groups 2 to 5) which caused a significant reduction in the AST and ALT and increased TP, globulin and albumin levels in the serum .On the other hand, the group treated with the moringa, leaves extract (Group 2) presented a significant the lowest AST and ALT and the highest TP , and higher globulin and albumin levels compared to the control group. This decrease in the values of aminotransferase enzymes and the restoration of some vital functions by the hepatocytes can be ascribed to the high contents of phenolic and bioactive components in moringa, thyme and licorice leaves extracts, which preserve the plasma membrane in hepatocytes and protect it from the rupture and the exit of the cytosol that is loaded with these enzymes (**Abo El-Fadl *et al.,* 2020, Köksal *et al.,* 2017 and Frattaruolo *et al.,* 2019**).

Regarding the kidney function parameters, (as shown in Table 7) a significant increase in creatinine and urea ($p \leq 0.05$) was revealed in the control group compared to the treated groups (G2 to G5) which caused a significant reduction in the creatinine and urea , This conspicuous change could be partially attributed to the bioactive components present within moringa, thyme and licorice leaves extracts, such as phenolic compounds and flavonoids (**Abo El-Fadl *et al.,* 2020, Köksal *et al.,* 2017 and Frattaruolo *et al.,* 2019),** these bioactive components act as superoxide scavengers, resulting in the suppression of reactive oxygen species; thus, in the body cells, oxidative stress and inflammation are reduced. Moreover, they can inhibit the formation of uric acid through the direct uricosuric potential or increase the glomerular filtration rate, resulting in a consequent decrease in the uric acid levels in the blood (**Lin *et al.,* 2015**).

Concerning immunoglobulin G (IgG), and M (IgM), the highest mean value was achieved in group 2 treated with moringa, leaves extract (44.53 and 65.93), whereas the lowest one was observed in the control group (37.73 and 57.93). A significant increase was revealed in the rabbits treated with moringa, thyme and licorice leaves extracts. These findings are corroborated by those of **Fathy *et al.,* (2022) , Elhofy *et al.,*(2019)** and **Reda *et al.,*(2021)** who found that supplementation with moringa, thyme and licorice leaves extracts significant increased immunoglobulin G (IgG), and M (IgM) compared to control group. Moringa, thyme and licorice leaves extracts significantly reduced cyclo-phosphamide induced immunosuppression by stimulating both cellular and humoral immunity.

Table 7. Effect of phytogenic leave extracts on blood constituents of growing rabbits

Item	Experimental Groups					±SE
	G1	G2	G3	G4	G5	
Albumin	3.80^{b}	4.37^{ab}	4.13^{ab}	4.10^{ab}	4.47^{a}	0.17
Globulin	1.87	2.27	2.13	2.07	2.0	0.12
Total protein	5.67^{C}	6.63^{a}	6.33^{ab}	6.16^{b}	6.46^{ab}	0.10
Tri glycerides	60.60^{a}	51.03^{d}	54.27^{bc}	56.43^{b}	52.87^{dc}	0.70
Cholesterol	70.27^{a}	57.03^{d}	60.50^{c}	63.23^{b}	58.77^{cd}	0.79
Urea	30.60^{a}	22.87^{d}	25.23^{bc}	26.23^{b}	24.0^{dc}	0.51
Creatinine	0.91^{a}	0.73^{d}	0.81^{bc}	0.84^{b}	0.77^{dc}	0.02
AST	37.13^{a}	28.13^{d}	30.83^{c}	32.46^{b}	29.43^{cd}	0.50
ALT	21.83^{a}	17.03^{d}	18.80^{c}	20.07^{b}	17.77^{dc}	0.34
IgG	37.73^{c}	44.53^{a}	42.80^{a}	41.0^{b}	43.87^{a}	0.56
IgM	57.93^{e}	65.93^{a}	62.77^{c}	60.87^{d}	64.23^{b}	0.46

a,b,c, mean within some rows with differing superscript are significantly differ (P<0.05).
G1: rabbits fed control diet without any supplementation.
G2: rabbits fed control diet supplemented with 100 mg moringa leaves extract/ kg diet.
G3: rabbits fed control diet supplemented with 100 mg thyme leaves extract/ kg diet.
G4: rabbits fed control diet supplemented with 100 mg licorice leaves extract/ kg diet.
G5: rabbits fed control diet supplemented with 100 mg mixture moringa, thyme and licorice leaves extract/ kg diet.

Conclusion

It could be stated that adding up to 100 mg/kg of moringa, thyme, licorice leaves extract sand the mixture to growing rabbit diets can improve growth performance, digestion coefficients and nutritive values ,blood constituents , meat composition, carcass weight, and antioxidant status without any negative effect.

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دور مستخلصات المورينجا والزعتر وأوراق عرق السوس علي الأداء الإنتاجي للأرانب النامية

لمياء ناصف الاطرونى[1], محمد محمد عبداللاه[1],جمال على الدين الصياد[1], عبدالحكيم سعد عبدالحكيم[2], شيرين حمدي محمد[1]

[1] قسم الإنتاج الحيواني ، كلية الزراعة ، جامعة بنها ، مصر

[2] قسم تغذيه الدواجن، معهد بحوث الإنتاج الحيواني، مركز البحوث الزراعية(APRI)

الملخص

تم تقييم تأثير إضافة مستخلصات نبات المورينجا والزعتر وعرق السوس و مزيجها كمكملات نباتية للأرانب النامية على الأداء الإنتاجي وهضم العناصر الغذائية ومقاييس الدم وخصائص الذبيحة. تم استخدام سبعين من الأرانب المفطومة ، في عمر 25–30 يومًا و 550 ± 50 جم وزن الحي، كانت التجربة الأولي هي تجربة النمو و التي أستمرت 75 يومًا. تم تقسيم الأرانب إلى خمسة معاملات لكل منها 14 حيوانًا. تم تغذية المجموعة الأولى من الأرانب على نظام غذائي أساسي دون أي إضافات كعليقة كنترول (G1). تم إضافة عليقة الأرانب للمجموعه الثانية بـ 100 مجم من مستخلص أوراق المورينجا / كجم علف (G2) ، 100 مجم مستخلص أوراق الزعتر / كجم علف (G3)، 100 مجم مستخلص أوراق عرق السوس / كجم علف (G4) و 100 مجم من خليط أوراق المورينجا والزعتر وعرق السوس / كجم غذاء (G5). أشارت النتائج إلى أنه كان للمجموعتان G2 و G5 تأثير ملحوظ (p≤0.05) على الوزن النهائي وعلى زيادة وزن الجسم. علاوة على ذلك ، اظهرت المجموعة G2 زيادة بشكل كبير في معاملات الهضم (P <0.05) بإعطاء أعلى قيمة ، يليها المجموعة G5 ثم المجموعة G3 ثم المجموعة G4 مقارنة بمجموعة الكنترول G1 و التي أظهرت أدنى قيم لمعاملات الهضم. أدي إضافة المستخلصات المختبرة إلى تحسن معنوي (P <0.05) في العناصر الغذائية الكلية المهضومة (TDN) والبروتين الخام المهضوم (DCP). أدت إضافة المستخلصات إلى زيادة معنوية (P <0.05) في بعض صفات الذبيحة، عززت إضافة المستخلصات المختبرة إلى علائق الأرانب النامية محتوى CP للحوم بشكل كبير (P <0.05) ، بينما قللت مستويات الرطوبة و EE. خفضت المستخلصات الغذائية المدروسة بشكل ملحوظ AST و ALT وزيادة مستويات TP ، الجلوبيولين ، البيومين ، الجلوبيولين المناعي(IgG، و IgM)في الدم وانخفضت (P <.05) مالونديالديهايد الدم والكرياتينين واليوريا. هذا و تشير النتائج إلى أن الأرانب التي تتغذى على علائق غنية بالمورينجا والزعتر وخلاصة عرق السوس ومزيجها بنسبة 100 مجم / كجم عليقة حسنت من الأداء الإنتاجي من حيث معدل النمو وخصائص الذبيحة وحالة مضادات الأكسدة مقارنة باالمجموعة الكنترول.