Effect of Adding Thyme, Rosemary and Cinnamon Powder to the Feed On Some Productive and Biochemical Characteristics in Local Lambs.

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ABSTRACT

This study was conducted at the Agricultural Research and Experimental Station (Ruminant Raheb), College of Agriculture, University of Kirkuk, from July 22, 2025, to October 20, 2025, for a period of 91 days. Using sixteen local male lambs, aged 3–4 months with an average initial body weight of 24.878 kg, were used in the experiment. The animals were randomly allocated into four experimental treatments, with four lambs per treatment, according to a Completely Randomized Design (CRD). The treatments were as follows: the first treatment served as the control (without additives); the second treatment included thyme powder at a level of 6 g/kg feed; the third treatment included rosemary powder at 6 g/kg feed; and the fourth treatment included cinnamon powder at 6 g/kg feed.

Productive traits measured included feed intake, body weight gain, feed conversion ratio, and feed efficiency. In addition, several biochemical blood parameters were evaluated, including glucose, cholesterol, total protein, triglycerides, and the liver enzymes ALT and AST. The data were statistically analyzed using a Completely Randomized Design (CRD), and the means were compared using Duncan's Multiple Range Test (1955) within the SAS statistical software package (2001).

The results indicated that the rosemary treatment showed a significant ($P \leq 0.05$) improvement in feed intake and final body weight. However, no significant differences were observed among treatments in body weight gain or feed conversion efficiency. The findings also revealed significant effects of some plant additives on biochemical blood parameters cinnamon supplementation increased blood glucose levels, thyme supplementation resulted in the highest triglyceride levels, while rosemary supplementation increased the activity of liver enzymes Alanine Aminotransferase (ALT) and Aspartate Aminotransferase (AST) within normal physiological ranges.

Key Words: Thyme powder, Rosemary powder, Cinnamon powder, local lambs, Productive Performance.

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1.1 Introduction

Sheep occupy a leading position among agricultural livestock in Iraq, and their continued production is vital for maintaining their future significance due to population growth and the escalating demand for meat particularly lamb [1]. Meat and meat product form are an important part of human diet as well as an important of a wide range of nutrient. [2]. Given the risks associated with the use of certain antibiotics and their serious side effects, the popularity of herbal feed additives in animal production is increasing. Plant extracts, essential oils, leaves, seeds, and herbal plants are characterized by antimicrobial and antioxidant properties [3]. Medicinal plants are used as natural supplements to maintain animal health and avoid diseases [4]. Among the most significant of these plants is Thyme (Thymus vulgaris), an aromatic herb belonging to the Lamiaceae family [5]. . It contains essential compounds such as thymol, flavonoids, carvacrol, phenols, volatile oils, and tannins [6]. The active ingredients in thyme such as thymol, carvacrol, and various acids endow the plant with high therapeutic potential, including the ability to resist bacteria and fungi [7]. Thyme has demonstrated excellent activity in maintaining animal health [8]. Furthermore, its use as a powder or oil in feed has shown a positive effect on weight gain and body mass improvement [9] another medicinal plant is Rosemary (Rosmarinus officinalis), an aromatic herb also belonging to the Lamiaceae family, which flourishes in diverse regions worldwide [10]. Studies have indicated that rosemary possesses antioxidant and antimicrobial properties [11] [12]. as well as anti-inflammatory effects [13]. These anti-inflammatory and antioxidant effects are attributed to compounds such as carnosol, carnosic acid, rosmarinic acid, ursolic acid, oleanolic acid, hesperidin, and micromeric acids [14] [12]. Research suggests that rosemary Performance, production traits, and certain biochemical blood parameters in

Lambs, indicating its potential to improve animal growth and overall health [15].

Additionally, Cinnamon (*Cinnamomum*) is a tropical tree belonging to the Lauraceae family, whose bark is used as a spice and remains one of the most important spices used daily worldwide [16]. It is characterized by bioactive components, most notably cinnamaldehyde, which possesses potent antimicrobial and antioxidant properties [17] [18]. The biochemical characteristics of blood constitute important tools for assessing general health status and the metabolic efficiency of the animal, as they reflect the effectiveness of metabolic processes, liver functions, and the

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body's response to various feed additives. These characteristics include measuring levels of glucose, total protein, cholesterol, and triglycerides, in addition to monitoring the activity of liver enzymes such as Alanine Aminotransferase (ALT) and Aspartate Aminotransferase (AST) which are considered vital indicators for determining metabolic efficiency and internal organ functions [19][20]. Furthermore, changes in these indicators may indicate the effect of active plant compounds in improving nutrient absorption, reducing oxidative stress, and enhancing the biological performance of the animal [21][22].

1.2 Materials and Methods.

1.2.1 Date of the experiment

This study was conducted at the ruminant Raheb of the Agricultural Research and Experimental Station in Al-Sayyada region, affiliated with the College of Agriculture, University of Kirkuk. The experiment lasted for 91 days, from July 22, 2025, to October 20, 2025.

1.2.2 Experimental Design

Sixteen local male lambs, aged between 3–4 months with an average initial body weight of 24.878 kg, were used in this experiment. The lambs were housed in a semi-open shaded facility consisting of 16 individual pens (1.65 × 1.9 m) Each pen was equipped with a water drinker, a hay feeder, and a concentrate feeder. The lambs were randomly assigned to four experimental treatments, with four lambs per treatment. Each lamb was individually separated within its group using wire mesh partitions to prevent direct contact. The experimental groups were subjected to dietary supplementation with thyme, rosemary, and cinnamon powders throughout the 91-day experimental period. The treatments were as follows:

1. **T1** (Control): Basal diet without additives.
2. **T2:** Basal diet supplemented with thyme powder at 6 g/kg feed.
3. **T3:** Basal diet supplemented with rosemary powder at 6 g/kg feed.
4. **T4:** Basal diet supplemented with cinnamon powder at 6 g/kg feed.

1.2.3 Productive Traits

1. Measurement of Lambs Weights

All lambs were weighed weekly in the morning before feeding using a rechargeable electronic scale equipped with a display, with a capacity of 300 kg and a sensitivity of ±50 g.

2. Recording Feed Intake

Feed intake for all treatments was measured weekly by subtracting the remaining feed from the total amount offered to the lambs until the end of the experiment.

ISSN 2072-3857

3. Feed Intake Rate

The feed intake rate was estimated by dividing the total feed consumed by the number of days of the experiment for each treatment.

4. Recording Weight Gain

Weight gain was calculated by subtracting the initial weight at the beginning of the week from the final weight at the end of the week.

5. Weight Gain Rate

The weight gain rate was estimated by dividing the total weight gain (final weight minus initial weight) by the number of days of the experiment for each treatment.

6. **Feed conversion ratio (FCR)**

was calculated by dividing the daily feed intake by the daily weight gain, as shown in the following equation:

Feed Conversion Ratio = Daily Feed Intake (kg) / Daily Weight Gain (kg)

7. Feed Conversion Efficiency

Feed conversion efficiency was estimated by dividing the daily weight gain by the daily feed intake for each treatment, as shown in the following equation:

Feed Conversion Efficiency = Daily Weight Gain (g) / Daily Feed Intake (g)

8. Lamb Performance Index

The lamb performance index was recorded using the following equation: Lamb Performance Index = Final Body Weight / Feed Conversion Ratio

1.2.4 Blood Collection Method

Blood samples were collected from the jugular vein on day 91 (the final day of the experiment) using disposable syringes. Approximately 3 ml of blood was drawn from each lamb and placed into tubes free of anticoagulant. The samples were left for about 20 minutes at room temperature (25°C), after which they were centrifuged using a centrifuge at 3500 rpm for approximately 15 minutes to obtain the serum.

1. Glucose

The glucose level in blood plasma was measured using several ready-to-use kits from the Swiss company AGAPPE, and the samples were read using an automatic chemical analyzer of Chinese origin from BioBase, using the enzymatic method at a wavelength of 500 nanometers.

The following equation was applied to calculate glucose concentration (mg/dl):

Glucose level = (Absorbance of sample / Absorbance of standard solution) × 100

2. Cholesterol

The level of cholesterol in blood plasma was estimated using several, ready-made kits from Spanish company (LINEAR), and the samples were read using an automatic biochemical analyzer made in China by BioBase using the enzymatic method at a wavelength of 500 nm. The following equation was applied to calculate the cholesterol level (mg/dl):

Cholesterol level = (Absorbance of sample / Absorbance of standard solution) × 200

3. Total Protein

The level of total protein in blood plasma was estimated using several ready-made estimation kits from the Swiss company (AGAPPE), and the samples were read using an automatic chemical analyzer of Chinese origin from BioBase, using the enzymatic method at a wavelength of 500 nm.

The following equation was applied to calculate total protein concentration (mg/dl):

Total protein level = (Absorbance of sample / Absorbance of standard solution) × 6

4. Triglycerides

The level of triglycerides in blood plasma was estimated using several, ready-made kits from the Spanish company (LINEAR), and the samples were read using a Chinese-made automatic chemical analyzer from BioBase by the enzymatic method at a wavelength of 500 nanometers. The following equation was applied to calculate the triglyceride level (mg/dl):

Triglyceride level = (Absorbance of sample / Absorbance of standard solution) × 200

5. Alanine Aminotransferase (ALT)

The level of alanine aminotransferase (ALT) enzyme in blood plasma was measured using ready-made kits from the French company (Blolabo), and the samples were read using an automatic chemical analyzer of Chinese origin from BioBase. The measurement principle is based on the enzyme catalyzing the transfer of an amino group between alanine and α-ketoglutarate to form pyruvate and glutamate, where the resulting pyruvate reacts in the presence of a coenzyme with the reducing agent NADH, leading to a decrease in absorbance due to the oxidation of NADH. This decrease was measured at a wavelength of 340 nm [23].

6. Aspartate Aminotransferase (AST)

The level of Aspartate Aminotransferase (AST) enzyme in blood plasma was measured using several ready-made kits from the French company Blolabo, and the samples were read using a Chinese-made automated chemistry analyzer from BioBase. The principle of the method is based on the enzyme catalyzing the transfer of the amino group between aspartate and α-ketoglutarate to form oxaloacetate and glutamate, then the resulting

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oxaloacetate reacts with a helper enzyme in the presence of the reducing agent NADH. The decrease in absorbance was measured at a wavelength of 340 nanometers [23].

1.2.5 Statistical Analysis

Data analyzed using a Completely Randomized Design (CRD) to evaluate the effects of treatments on the studied parameters. Differences among treatment means were determined using Duncan's Multiple Range Test (Duncan, 1955). Statistical analysis was performed using the Statistical Analysis System (SAS, 2001) which used to examine the statistics in accordance with the following statistical pattern [24] according to the following

Mathematical model:

$$Y_{ij}=\mu+T_i+e_{ij}$$

Where:

Y_{ij} = the observation j value for treatment i.

μ = the overall mean of the examined trait.

T_i = the impact of treatment i.

e_{ij} = the experimental error that is presumed be normally and independently distributing with a mean of zero and equivalent variance of $\sigma^2 e$.

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Table (1): Ingredient Composition and Chemical Analysis of the Diet Components (%)

Ingredient	Percentage (%)	Crude Fibe (%)	Ether Extract (%)	Crude Protein (%)	Carbohydrate (%)
Barley	63	6.50	1.42	10.72	70.35
Yellow Corn	20	2.01	4.34	9.03	71.49
Soybean Meal	8	6.19	2.44	42.48	32.11
Wheat Bran	7	10.63	4.05	15.86	54.89
Salt	1	—	—	—	—
Feed Additive	1	—	—	—	—
Total	100	—	—	—	—

The chemical composition of the diet was calculated according to [25]

1.3 Results and Discussion

1.3.1 Feed intake:

The results presented in Table (2) indicate that the inclusion of thyme, rosemary, and cinnamon powders in lamb diets had a significant effect ($P \leq 0.05$) on feed intake parameters in local lambs. Lambs in the rosemary treatment (T3) exhibited the highest total feed intake compared with the control group (T1) and the other treatments, while the second (T2) and fourth treatments (T4) recorded intermediate values. Similarly, with regard to weekly and daily feed intake, third treatment (T3) showed a clear superiority over the control (T1) and the other treatments, whereas second treatment (T2) and fourth treatment (T4) maintained intermediate levels. These effects may be attributed to the role of these plant compounds in enhancing rumen microbial activity, which in turn improves diet

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digestibility and increases voluntary feed intake. Aromatic plants such as rosemary contain phenolic compounds and essential oils that can modify the rumen environment and enhance fermentation efficiency [26] [27]. The superior performance observed in the rosemary treatment may also be related to its active constituents, such as carnosic acid and carnosol, which are known to improve ruminal fermentation processes and nutrient utilization [28].

Table (2): Effect of Thyme, Rosemary, and Cinnamon Powder on Feed Intake in Local Lambs "kg" (Mean ± SE).

Parameter	T1	T2	T3	T4
Total Feed Intake (kg)	64.43 ± 3.56 c	71.66 ± 4.39 bc	83.82 ± 3.05 a	76.53 ± 3.59 ab
Weekly Feed Intake (kg)	4.95 ± 0.27 c	5.51 ± 0.33 bc	6.44 ± 0.23 a	5.88 ± 0.27 ab
Daily Feed Intake (kg)	0.70 ± 0.03 c	0.78 ± 0.04 bc	0.92 ± 0.03 a	0.84 ± 0.03 ab

* The distinct letters inside the same row signify a marked difference among the research groups in the significance level ($P \leq 0.05$) *T1 = Control (no additives). *T2 = Thyme powder (6 g/kg feed). *T3 = Rosemary powder (6 g/kg feed). *T4 = Cinnamon powder (6 g/kg feed).

These findings are consistent with several previous studies that reported improvements in feed intake when plant additives were included in ruminant diets. For example, [29] demonstrated that thyme supplementation increased feed intake in fattening lambs, attributing this effect to enhanced rumen fermentation and improved palatability of the diet. Likewise, [30] reported that essential oils extracted from medicinal plants, including rosemary, can modify rumen fermentation patterns, thereby increasing feed intake.

In contrast, the results of the present study differ from those reported by [15], who found no significant effect of rosemary oil supplementation on feed intake. This discrepancy attributed to differences in the form of Supplementation (powder versus essential oil), inclusion level, duration of the experiment, as well as variations in the basal diet composition.

1.3.2 Productive traits:

The results presented in Table (3) indicate that the supplementation of thyme, rosemary, and cinnamon powders had a significant effect on the

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final body weight of lambs. The third treatment (T3) recorded the highest average initial body weight compared with the other treatments, and it maintained the highest average among the experimental treatments. This suggests that the observed superiority in final body weight, particularly in the third treatment (T3), cannot be attributed solely to a direct effect of plant supplementation on improving growth rate. Rather, it should be interpreted in light of the pre-existing significant differences in initial body weight among treatments, as the lack of homogeneity at the beginning of the experiment may influence the final body weight, even in the absence of a significant growth response during the experimental period. Regarding total weight gain, no significant differences were observed among the experimental treatments, as all means shared the same statistical grouping. Similarly, weekly and daily weight gain did not differ significantly among treatments, despite the presence of some numerical superiority in certain treatments, particularly rosemary followed by cinnamon.

The consistency in total, daily, and weekly weight gain among treatments indicates that the level of supplementation used in this study was not sufficient to produce a statistically significant improvement in growth performance efficiency.

Table (3) Effect of Thyme, Rosemary, and Cinnamon Powder on Productive Performance in Local Lambs (Mean ± SE).

Parameter	T1	T2	T3	T4
Initial Weight (kg)	21.63 ± 0.84 c	25.03 ± 0.16 b	28.57 ± 1.26 a	24.26 ± 0.06 b
Final Weight (kg)	35.07 ± 1.01 c	37.85 ± 0.86 bc	43.96 ± 0.73 a	39.28 ± 1.30 b
Total Weight Gain (kg)	13.43 ± 1.05 a	12.81 ± 0.81 a	15.45 ± 1.83 a	15.02 ± 1.32 a
Average Weekly Weight Gain(kg)	1.03 ± 0.08 a	0.98 ± 0.06 a	1.18 ± 0.14 a	1.15 ± 0.10 a
Average Daily Weight Gain (kg)	0.14 ± 0.01 a	0.14 ± 0.00 a	0.16 ± 0.02 a	0.16 ± 0.01 a

* The distinct letters inside the same row signify a marked difference among the research groups in the significance level ($P \leq 0.05$) *T1 = Control (no additives). *T2 = Thyme powder (6 g/kg feed). *T3 = Rosemary powder (6 g/kg feed). *T4 = Cinnamon powder (6 g/kg feed).

These findings are in agreement with the study of [31], which reported that the inclusion of cinnamon oil in lamb diets had no significant effect on growth performance, consistent with the absence of significant differences in total, daily, and weekly weight gain observed in the present study. The current results also partially agree with those of [32] on Barbarine lambs, who found that the inclusion of rosemary distillation by-products in the diet resulted in similar growth performance, with no significant differences compared with the control treatment. On the other hand, the results of the present study differ from some studies that reported improvements in growth performance when using plant mixtures or active phytogenic compounds. For instance, [33] demonstrated that a herbal mixture containing cinnamon and rosemary leaves increased dry matter intake and improved growth performance during part of the fattening period in heat-stressed lambs. This suggests that the response may be more pronounced when plant mixtures are used or under stress conditions, where the physiological effects of such additives become more evident.

1.3.3 Feed Conversion Ratio, Feed Efficiency and Lamb Performance Index of lambs:

The results presented in Table (4) indicate that the supplementation of thyme, rosemary, and cinnamon powders in lamb diets did not have a significant effect (P ≤ 0.05) on feed conversion ratio (FCR), feed conversion efficiency, or lamb performance index, as all means within each row shared the same statistical superscript, indicating the absence of significant differences among the experimental treatments in these parameters. Nevertheless, some numerical differences were observed among treatments. Third treatment (T3) recorded the highest lamb performance index (8.069), whereas the second treatment (T2) showed the lowest value. Additionally, the control treatment (T1) exhibited the best-feed conversion efficiency numerically compared with the other treatments; however, these differences did not reach the level of statistical significance.

Table (4) Effect of Thyme, Rosemary, and Cinnamon Powder on Feed Conversion Ratio, Feed Efficiency, and Lamb Performance Index in Local Lambs (Mean ± SE)

Parameter	T1	T2	T3	T4
Feed Conversion Ratio (FCR)	4.83 ± 0.22 a	5.59 ± 0.04 a	5.60 ± 0.05 a	5.17 ± 0.34 a
Feed Efficiency	0.20 ± 0.00 a	0.17 ± 0.00 a	0.18 ± 0.01 a	0.19 ± 0.01 a
Lamb Performanc Index	7.30 ± 0.38 a	6.73 ± 0.18 a	8.06 ± 0.81 a	7.70 ± 0.68 a

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* The distinct letters inside the same row signify a marked difference among the research groups in the significance level (P≤0.05) *T1 = Control (no additives). *T2 = Thyme powder (6 g/kg feed). *T3 = Rosemary powder (6 g/kg feed). *T4 = Cinnamon powder (6 g/kg feed).

The results of this study are consistent with several previous studies that reported no significant effect of plant-based additives. [15] Indicated that the inclusion of rosemary oil in lamb diets did not significantly affect feed conversion ratio, which is in agreement with the findings of the present study. Similarly, [31] found that the addition of cinnamon or essential oils derived from medicinal plants did not result in significant differences in productive performance or feed conversion ratio in lambs. These findings are also in line with [33], who suggested that the effects of medicinal plants on productive performance may be limited at certain inclusion levels.

On the other hand, the findings of the present study differ from some studies that reported improvements in feed conversion efficiency. [34] Indicated that the use of plant additives or essential oils may enhance feed conversion efficiency by improving digestion and rumen fermentation. Moreover, [27] demonstrated that bioactive plant compounds may improve feed utilization efficiency through modulation of rumen microbial activity, which positively reflects on productive performance.

1.3.4 Blood Biochemical Parameters:

The results presented in Table (5) showed significant differences among the experimental treatments in blood glucose concentration. The fourth treatment (T4) recorded the highest mean value, whereas the second treatment (T2) showed the lowest mean value. The control treatment (T1) and Third treatments (T3) exhibited intermediate values. No significant differences (P ≤ 0.05) were observed among treatments in total protein levels, and all values remained within the normal physiological range. Similarly, no

significant differences were detected in Blood cholesterol concentration among treatments, although a numerical decrease was observed in the plant-supplemented groups compared to the control. In contrast, triglyceride concentrations showed significant differences (P ≤ 0.05)

among treatments, with the second treatment (T2) recording the highest value, while the fourth treatment (T4) showed the lowest value. The results also indicated significant differences (P ≤ 0.05) in the activity of the AST enzyme among treatments. The Third (T3) and fourth (T4) treatments recorded higher Aspartate Aminotransferase (AST) activity compared to the control treatment (T1) and second treatments (T2). Likewise, significant differences ($P \leq 0.05$) were observed in ALT enzyme activity, where the Third treatment (T3) exhibited the highest value among all treatments.

Table (5): Effect of Thyme, Rosemary, and Cinnamon Powder on Some Blood Biochemical Parameters (Mean ± SE)

Parameter	T1	T2	T3	T4
Glucose (mg/dl	74.65 ± 3.66 bc	70.18 ± 2.898 c	84.45 ± 2.96 ab	87.34 ± 4.69 a
Total Protei (mg/dl)	5.52 ± 0.33 a	5.80 ± 0.050 a	5.88 ± 0.01 a	5.65 ± 0.26 a
Cholesterol (mg/dl)	65.57 ± 7.03 a	69.80 ± 5.58 a	69.37 ± 4.71 a	78.88 ± 4.72 a
Triglycerides (mg/dl)	50.52 ± 3.88 ab	58.68 ± 3.74 a	50.02 ± 5.05 ab	40.79 ± 2.46 b
AST Enzym (IU/L)	28.89 ± 2.88 b	38.21 ± 4.71 b	63.83 ± 3.62 a	52.00 ± 4.75 a
ALT Enzym (IU/L)	11.50 ± 0.11 c	12.56 ± 0.95 bc	17.98 ± 0.95 a	14.56 ± 0.84 b

* The distinct letters inside the same row signify a marked difference among the research groups in the significance level ($P \leq 0.05$) *T1 = Control (no additives). *T2 = Thyme powder (6 g/kg feed). *T3 = Rosemary powder (6 g/kg feed). *T4 = Cinnamon powder (6 g/kg feed).

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Previous studies support these findings. [35] Reported that phytogenic additives do not always affect total protein levels in blood, which is consistent with the present results. Similarly. [19] Indicated that plant-based additives can influence liver enzyme activity due to their bioactive compounds.Moreover, the findings agree with [20] who reported that rosemary supplementation led to changes in liver enzyme activity, likely due to its phenolic antioxidant compounds. Regarding glucose. [21] Suggested that plant essential oils may enhance energy utilization and influence blood glucose levels. In terms of triglycerides, the results are consistent with [22] who demonstrated that aromatic plants such as cinnamon may reduce lipid levels through their effects on lipid metabolism. Furthermore, the absence of significant differences in cholesterol levels agrees with the findings of [31] when cinnamon was included in lamb diets.

1.4 Conclusions

The results of this study showed that the supplementation of thyme, rosemary, and cinnamon powders at 6 g/kg feed produced variable effects on productive performance and some blood biochemical parameters in local lambs. Third treatment showed superiority in feed intake and final body weight; however, this advantage was partly influenced by the initial body weight. No significant differences were observed in weight gain, feed conversion ratio, and feed efficiency. The conditions of this study. Indicating that the inclusion level used was not sufficient to improve growth performance significantly. Regarding blood parameters, cinnamon increased glucose levels, thyme recorded the highest triglycerides, and rosemary increased Aspartate Aminotransferase (AST) and Alanine Aminotransferase (ALT) enzyme activities without clear adverse health effects. Overall, these plant additives can be safely used, with rosemary showing the most promising effect on improving feed intake.

1.5 References

[1]. Mustafa, K. N., Baker, I. A., & Alkass, J. E. (2022). Performance of Karadi sheep in Kurdistan region/Iraq: A review. Mesopotamia Journal of Agriculture, 50(4), 127-138.

[2]. Alsaadi, S. A. R. A., Al-perkhdri, A. S. A., & Al-Hadeedy, I. Y. H. (2020). Effects of Matricaria chamomilla flower aqueous extract on some hematological, biochemical parameters and carcass traits in Iraqi local rabbits. Plant Archives, 20(Supplement 2), 1044–1049.

[3]. Benchaar, C., Calsamiglia, S., Chaves, A. V., Fraser, G. R., Colombatto, D., McAllister, T. A., & Beauchemin, K. A. (2008). A review of plant-derived essential oils in ruminant nutrition and production. Animal feed science and technology, 145(1-4), 209-228.

ISSN 2072-3857

[4]. Al-perkhdri, A.S.A., & Muhammed, R.M. (2020). EFFECT OF USE OF DIFFERENT CONCENTRATIONS OF CINNAMOMUM CASSIA POWDER IN SOME CARCASS AND BLOOD CHEMICAL TRAITS OF BROILERS. Plant Archives, 20(Supplement 2), 2830-2832.

[5]. Mikaili, P., Nezhady, M. A. M., Shayegh, J. & Asghari, M. H. (2010). Study on of antinociceptive effect of Thymus vulgaris and Foeniculum vulgare essential oil in mouse. International Journal of Academic Research, 2 (6): 373-376.

[6]. Stahl-Biskup, E., & Venskutonis, R. P. (2012). Thyme. In Handbook of herbs and spices (pp. 499-525). Woodhead Publishing.

[7]. Rodrigues, A. C., Alencar, A. A., Medeiros, J. P., de Souza, L. D. G., de Farias, J. H. A., de Souza, J. A., & de Oliveira Filho, A. A. (2022). Aspectos botânicos, fitoquímicos e antimicrobianos de Thymus vulgaris: uma breve revisão de literatura. Diversitas Journal, 7(4).

[8]. Dauqan, E. M., & Abdullah, A. (2017). Medicinal and functional values of thyme (Thymus vulgaris L.) herb. Journal of Applied Biology & Biotechnology, 5(2), 17-22.

[9]. Cross, D. E., McDevitt, R. M., Hillman, K., & Acamovic, T. (2007). The effect of herbs and their associated essential oils on performance, dietary digestibility and gut microflora in chickens from 7 to 28 days of age. British poultry science, 48(4), 496-506.

[10]. Jardak, M., Elloumi-Mseddi, J., Aifa, S., & Mnif, S. (2017). Chemical composition, anti-biofilm activity and potential cytotoxic effect on cancer cells of Rosmarinus officinalis L. essential oil from Tunisia. Lipids in health and disease, 16(1), 190.

[11]. Al Laham, S. A., & Al Fadel, F. M. (2013). Antibacterial efficacy of variety plants against the resistant streptococcus, which cause clinical mastitis in cows. Asian Journal of Pharmaceutical Research and Health Care, 5(1), 32–41.

[12]. Nieto, G., Ros, G., & Castillo, J. (2018). Antioxidant and antimicrobial properties of rosemary (Rosmarinus officinalis, L.): A review. Medicines, 5(3), 98.

[13]. Arranz, E., Mes, J., Wichers, H. J., Jaime, L., Mendiola, J. A., Reglero, G., & Santoyo, S. (2015). Anti-inflammatory activity of the basolateral fraction of Caco-2 cells exposed to a rosemary supercritical extract. Journal of Functional Foods, 13, 384-390.

[14]. de Macedo, L. M., Santos, É. M. D., Militão, L., Tundisi, L. L., Ataide, J. A., Souto, E. B., & Mazzola, P. G. (2020). Rosemary (Rosmarinus officinalis L., syn Salvia rosmarinus Spenn.) and its topical applications: A review. Plants, 9(5), 651.

[15]. Cetin, I., Cetin, E., Karakci, D., Ercetin, E., Kirmizi, O., & Yesilbag, D. Y. (2023). The effects of rosemary essential oil supplementation on growth performance, rumen flora and

antioxidant blood parameters in growing Merino lambs. Journal of the Hellenic Veterinary Medical Society, 74(4).

[16]. Rao, P. V., & Gan, S. H. (2014). Cinnamon: a multifaceted medicinal plant. Evidence- Based Complementary and Alternative Medicine, 2014(1), 642942.

[17]. Burt, S. (2004). Essential oils: their antibacterial properties and potential applications in foods—a review. International journal of food microbiology, 94(3), 223-253. [18]. Dragland, S., Senoo, H., Wake, K., Holte, K. and Blomhoff, R. (2003) Several Culinary and Medicinal Herbs Are Important Sources of Dietary Antioxydants. The Journal of Nutrition, 133, 1286-1290.

[19]. Yesilbag, D., Eren, M., Agel, H., Kovanlikaya, A., & Balci, F. (2011). Effects of dietary rosemary, rosemary volatile oil and vitamin E on broiler performance, meat quality and serum SOD activity. British Poultry Science, 52(4), 472-482.

[20]. Güney, M., Karaca, S., Erdogan, S., Kor, A., Kale, C., Onalan, S., ... & Bingol, N. T. (2021). Effects of dietary supplementation with rosemary oil on methanogenic bacteria density, blood and rumen parameters and meat quality of fattening lambs. Italian Journal of Animal Science, 20(1), 794-805. [21]. Zaefarian, F., Abdollahi, M. R., Cowieson, A., & Ravindran, V. (2019). Avian Liver: The Forgotten Organ. Animals, 9(2), 63.

[22]. Ciftci, M., Simsek, U. G., Yuce, A., Yilmaz, O., & Dalkilic, B. (2010). Effects of dietary antibiotic and cinnamon oil supplementation on antioxidant enzyme activities, cholesterol levels and fatty acid compositions of serum and chickens. Acta Veterinaria Brno, 79(1), 3.

[23]. Burtis, C. A., & Bruns, D. E. (2014). Tietz fundamentals of clinical chemistry and molecular diagnostics-E-book: Tietz fundamentals of clinical chemistry and molecular diagnostics-E-book. Elsevier Health Sciences.

[24]. Duncan, D.B. (1955). Multiple range and multiple F-tests. Biometrics, 11, 1–42. [25]. NRC (1985). The nutrient requirement of sheep. National Academy Press, Washington, DC.

[26]. Calsamiglia, S., Busquet, M., Cardozo, P. W., Castillejos, L., & Ferret, A. (2007). Essential oils as modifiers of rumen microbial fermentation. Journal of Dairy Science, 90(6), 2580–2595.

[27]. Patra, A. K., & Saxena, J. (2009). The effect and mode of action of saponins on the microbial populations and fermentation in the rumen and ruminant production. Nutrition research reviews, 22(2), 204–219.

[28]. Borrás-Linares, I., Stojanović, Z., Quirantes-Piné, R., Arráez-Román, D., Švarc-Gajić, J., Fernández-Gutiérrez, A., & Segura-Carretero, A. (2014). Rosmarinus officinalis leaves as a natural source of bioactive compounds. International Journal of Molecular Sciences, 15(11), 20585–20606. [29]. KHAMISABADI, H., KAFILZADEH, F., & CHARAIEN, B. (2016). Effect of

thyme (Thymus vulgaris) or peppermint (Mentha piperita) on performance, digestibility and blood metabolites of fattening Sanjabi lambs. Biharean biologist, 10(2), 118-122.

[30]. Cavalheiro Junior, E. R., Serafim, C. C., Rodrigues, E. R., Guerra, G. L., do Carmo, J. P. M., dos Santos, T. F., & Prado Calixto, O. P. (2021). Effect of Supplying Rosemary (Rosmarinus officinalis L.) and Garlic (Allium sativum L.) Essential Oils to Feedlot Lambs on in vitro Ruminal Fermentation. Frontiers in Animal Science, 2, 764048.

[31]. Simitzis, P. E., Bronis, M., Charismiadou, M. A., Mountzouris, K. C., & Deligeorgis, S. G. (2014). Effect of cinnamon (Cinnamomum zeylanicum) essential oil supplementation on lamb growth performance and meat quality characteristics. Animal, 8(9), 1554–1560.

[32]. Yagoubi, Y., Hajji, H., Smeti, S., Mahouachi, M., Kamoun, M., & Atti, N. (2018). Growth performance, carcass and noncarcass traits and meat quality of Barbarine lambs fed rosemary distillation residues. Animal, 12(11), 2407-2414.

[33]. Hashemzadeh, F., Rafeie, F., Hadipour, A., & Rezadoust, M. H. (2022). Supplementing a phytogenic-rich herbal mixture to heat-stressed lambs: Growth performance, carcass yield, and muscle and liver antioxidant status. Small Ruminant Research, 206, 106596.

[34]. Kholif, A. E., & Olafadehan, O. A. (2021). Essential oils and phytogenic feed additives in ruminant diet: chemistry, ruminal microbiota and fermentation, feed utilization and productive performance. Phytochemistry Reviews, 20(6), 1087-1108.

[35]. Windisch, W., Schedle, K., Plitzner, C., & Kroismayr, A. (2008). Use of phytogenic products as feed additives for swine and poultry. Journal of Animal Science, 86(14_suppl), E140–E148.

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