*Egypt. J. Chem.* **Vol. 65**, No. 5 pp. 407 - 418 (2022)

# Egyptian Journal of Chemistry

http://ejchem.journals.ekb.eg/

## Feed Utilization and Lactational Performance of Damascus Goats Fed a Diet Supplemented with Marjoram or Basil Essential Oils

**Ahmed M. Abd EL Tawab[a]*, Abdelkader M. Kholif[a], Nasr E. El-Bordeny[b], Hamdy M. Elsayed[b], Nadia A. H. Selim[a]**

[a] *Dairy Science Department, Food Industries and Nutrition ResearchInstitute, National Research Centre, 33 Buhouth St. Dokki, Giza, Egypt.*

[b] *Animal Production Department, Faculty of Agricultural, Ain shams University, 68 Hadayek Shoubra 11241, Cairo, Egypt.*

**Abstract**

Thirty lactating Damascus goats were used to study the effect of marjoram or basil essential oils dietary supplementation on feed utilization and lactational performance. After 7 days of parturition, the goats weighing 41.0±0.8 kg were grouped into three groups 10 goats each using complete random design and fed the experimental treatments included: (1) control diet: consisting of CFM: berseem clover (*Trifolium alexandrinum*): rice straw (50:30:20 DM basis); (2) control diet plus 20 ml basil oil / kg DM; (3) control diet plus 20 ml marjoram oil / kg DM. Digestibility of DM, OM and EE were significantly increased ($P < 0.05$) with marjoram oil treatment compared to the control treatment. Inclusion of marjoram increased ($P < 0.05$) milk yield, FCM 4% yield, ECM yield and yields of TS, fat and lactose and fat percent, blood serum glucose and triglyceride, propionic, valeric and total SCFA concentration compared with control treatment. Milk efficiency as ECM/DM intake was increased ($P=0.0089$) with the marjoram EO treatment compared with the control treatment. It could be concluded that supplementation of marjoram essential oil had a positive effect of nutrients digestibility (DM and OM), ruminal fermentation parameters (SCFA), milk production and composition and milk efficiency compared to basil essential oil.

*Keywords:* Essential oils, marjoram, basil, lactating goats, digestibility, rumen and blood parameters

### 1. Introduction

Essential oils are one of phytogenic feed additives which it is widely used in animal nutrition as alternatives of synthetic chemistry [1-3]. Also, it is commonly used as feed additives to livestock production as natural ruminal modifiers as well as, improve feed efficiency and prophylactic and/or therapeutics to some metabolic disorders [4]. Generally, the active components of essential oils have been confirmed against a wide range of gram positive and negative bacteria, fungi and protozoa [5,6]. Also, it has an effect on deactivation of some microbial enzymes [7].

The essential oils of various herbal plants such as garlic, cinnamomum, coriander, rosemary, lemongrass, galangal, thyme and celery have been used on rumen fermentation modifiers by decreased ruminal bio-hydrogenation, inhibition of methanogenesis and deamination resulting in lower methane emission, ammonia, and acetate, and in higher propionate and butyrate concentrations [1,4,8,9,10,11]. Moreover, various studies found that the essential oils improved in dry matter intake, nutrients digestibility, milk yield and composition [4,11] and growth performance and meat quality [12].

Marjoram (Origanum majorana L.) essential oil contains sabinene, carvone, thymol, γ-terpinene, p-cymene and linalool depending on mainly the botanical characteristics or geographical origin of plant [13-16]. These components have strong antimicrobial activity against microorganisms [17,18].

*Corresponding author e-mail: amaeid2010@gmail.com.; (am.eid@nrc.sci.eg).
Receive Date: 01 September 2021, Revise Date: 24 October 2021, Accept Date: 31 October 2021
DOI: 10.21608/EJCHEM.2021.93871.4421

The essential oil of basil (Ocimum basilicum L.) has been recognized based on the most predominant components such as eugenol, terpineol, linalool, methyl cinnamate, chavicol, limonene and methyl eugenol [19]. The most of these components have antibacterial effect against gram-positive and gram-negative bacteria [17,20]. So, the present study aimed to evaluate the effect of using of marjoram (Origanum majorana L.) or basil (Ocimum basilicum L.) essential oils as a natural feed additive on feed utilization, digestibility, rumen fermentation, and lactational performance of Damascus goats.

## 2. Materials and methods

### 2.1. Study site

The current study was carried out at the experimental farm of Animal Production Research Institute, Ministry of Agriculture (Egypt) belonging to the Laboratory of DairyProduction, National Research Centre (Egypt). The area has a climate with winter rains and an annual average rainfall of 22 mm and means annual temperature between 14 and 28 °C. Goats were cared and handled in accordance with the Guide for the Care and Use of Agricultural Animals in Research and Teaching [21]. The field work was started in September, 2019 and lasted for 9 weeks.

### 2.2. Goats, experimental design, and diets

Thirty lactating Damascus goats weighing 41.0±0.8 kg, during the first week of lactation producing approximately 1000±50 g milk/d on average was randomly assigned to three experimental groups (10 goats per treatment) for 63 days. Goats were stratified according to parity and expected average milk yield. Kids were kept with the dam throughout the experimental period with exception of days when feed intake and nutrient digestibility were determined. The experimental design was a completely randomized design with repeated measures. Goats were cared and managed as previously reported in the study of Kholif et al. [22] and fed according to NRC [23] recommendations.

The basal diet fed to the goats contained 50:50 concentrate: roughage ratio. The concentrate feed mixture contained (CFM) of 25 % undecorticated cotton seed meal, 35 % wheat bran, 30 % corn, 3 % rice bran, 3 % molasses, 2% limestone, 1% urea and 1% salt. Ingredient and chemical compositions of the basal diet are shown in Table 1. The experimental treatments included: (1) control: the control diet, consisting of CFM: berseem clover (Trifolium alexandrinum): rice straw (50:30:20 DM basis); (2) control diet plus 20 ml basil oil / kg DM; (3) control diet plus 20 ml marjoram oil / kg DM.

Diets were offered to each goat individually at 7.00 a.m. and 7.00 p.m. in two equal portions. Daily allocations of oils were delivered in 100 g CFM to individual goats, once daily, before the morning feeding at 07:00 h to ensure the full dose was received. Feed samples of berseem clover, rice straw and CFM were taken daily, Dry matter intake was measured during the last seven days of experimental period. The fresh water was always available to animals.

**Table (1): Chemical composition of CFM, berseem clover, rice straw and basal diet (% DM basis)**

| Item | CFM | Berseem clover | Rice straw | Basal diet |
|---|---|---|---|---|
| **DM** | 90.4 | 13.2 | 95.4 | 68.23 |
| **OM** | 90.0 | 88.3 | 87.1 | 88.92 |
| **CP** | 14.1 | 14.1 | 3.4 | 11.92 |
| **EE** | 4.1 | 2.6 | 1.6 | 3.12 |
| **NFC** | 45.2 | 26.9 | 10.4 | 32.73 |
| **Ash** | 10.0 | 11.7 | 12.9 | 11.08 |
| **NDF** | 26.7 | 44.7 | 71.8 | 41.15 |
| **ADF** | 14.1 | 33.1 | 43.1 | 25.57 |

CFM; concentrate feed mixture contained 25 % undecorticated cotton seed meal, 35 % wheat bran, 30 % corn, 3 % rice bran, 3 % molasses, 2% limestone, 1% urea and 1% salt.

### 2.3. Nutrients digestibility and chemical analyses

Feed intake was recorded daily by weighing the feed and orts from the previous day. Three digestibility trials were conducted at the 30th, 45th and 60th days of the experiment, grab sample method was applied for determining the digestibility in which acid insoluble ash (AIA) was used as an internal marker according to Gallups et al. [24] and Forbes et al. [25]. Feces grab samples were collected manually from goats per treatment twice daily at 6.00 a.m. and 6.00 p.m. for three successive days at the first three days of collection periods for each experiment. Representative feces samples were sprayed by 10% sulfuric acid solution and formalin, then dried in oven at 60ºC for 24 hours. The dried feces samples for each animal were mixed well by equal weights then ground and stored in polyethylene bags for chemical analysis of DM, OM, CP, EE, NDF, ADF and ash.

The digestibility coefficient of a certain nutrient was calculated according to the following formula.

Digestion coefficient

$$= 100 - \left[100x\frac{\%\ AIA\ in\ feed}{\%\ AIA\ in\ feces}x\frac{\%\ nutrient\ in\ feces}{\%\ nutrient\ in\ feed}\right]$$

The chemical analysis of feedstuffs and feces samples were carried out to determine dry matter (DM), crude protein (CP), ether extract (EE) and ash content according to methods of A.O.A.C [26]. non-structural carbohydrates (NSC) = 100- (NDF + crude protein (CP) + ether extract (EE)+ ash). Also, organic matter (OM) was calculated by subtracting the percentage of ash from one hundred, Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined by ANKOM 200 Fiber Analyzer according to Van Soest et al. [27].

### 2.4. Sampling and analysis of rumen liquor

Rumen liquor samples were collected by stomach tube at the last day of each experimental period for each animal. Samples were taken at three hours after morning feeding. The rumen samples were filtered through 4 layers of cheesecloth. and were immediately used for determination of ruminal pH by digital pH-meter, a subsample of 5 mL was preserved in 5 mL of 0.2 M HCl for ammonia analysis, and 0.8 mL of strained ruminal fluid was mixed with 0.2 mL of a solution containing 250 g of metaphosphoric acid/L for SCFA analysis. Samples were stored at -20 °C until analyses.

pH value was determined by using Hanna digital pH meter, with glam electrode. The concentration of ammonia in the rumen fluid was determined by Konitzer and Voigt [28]. Concentration and molar proportions of individual SCFA were measured by gas-liquid chromatography (model 5890, HP, Little Falls, DE, USA). Separation process was carried out with a capillary column (30 m × 0.25 mm internal diameter, 1-m film thickness, Supelco Nukol; Sigma–Aldrich, ON, Canada), and flame ionization detection. The column temperature was adjusted to 100 °C for 1 min, and then increased by 20 °C/min to 140 °C, and then by 8 °C/ min to 200 °C, and held at this temperature for 5 min. The injector temperature was at 200 °C while the detector temperature at 250 °C. Helium was used as the carrier gas.

### 2.5. Sampling and analysis of blood

Blood samples were taken from each animal at the last day of each experimental period. The samples (10 ml of blood per animal) were taken at four hours post feeding. Each blood sample was withdrawn from the jugular vein into a clean dried tube and centrifuged at 4000 rpm. for 15 min. Blood serum was then separated into 2-mL Eppendorf tubes and frozen at -20 °C for analysis of glucose, total protein (TP), albumin, globulin, urea, aspartate aminotransferase (AST), alanine aminotransferase (ALT), triglyceride and cholesterol. Blood serum parameters were determined by Ultraviolet–Visible spectrophotometry using kits obtained from Diamond Biodiagnostic for Laboratory Services. Serum globulin was calculated by subtracting the value of albumin from the corresponding value of total protein for each sample. The A/G ratio was calculated by dividing each sample albumin value by its corresponding globulin value.

### 2.6. Milk sampling and composition

The animals were hand milked twice daily at 5.00 a.m. and 5.00 p.m. during the last three days of each experimental period. Samples of milk were collected from each animal at morning and evening milking immediately. The representative sample of each animal was a mixed sample of constant percentage of the evening and morning yield. Milk was analyzed for (Fat, total protein, lactose, total solids (TS), solids not fat (SNF), and ash content).

Fat corrected milk (4% fat) (FCM) was calculated by using the following equation according to Gaines [29].

FCM = 0.4 M + 15 F

Where: M= milk yield (g/d)

F= fat yield (an amount of fat = M x fat %).

Milk samples were analyzed for total solids, solids not fat, total protein, fat, ash, and lactose using infrared spectroscopy (Bentley 150, Infrared Milk Analyzer, Bentley Instruments, USA). Energy corrected milk (ECM) was calculated according to Sjaunja et al. [30] as:

ECM (kg/d) = milk yield (kg/day) × [38.3 × fat (g/kg) + 24.2 × protein (g/kg) + 16.54 × lactose (g/kg) + 20.7]/3140.

### 2.7. Statistical analysis

Data were analyzed as a completely randomized design using GLM procedure of Statistical Analysis System [31], version 9.2. Significant differences between means of treatments were carried out by the Tukey's test, and the significance threshold was set at

$p < 0.05$. General Modeling Procedure: $Y_{ij} = \mu + T_i + e_{ij}$. Where Yij is the parameter under analysis of the ij flask of laboratory trails or goats of farm trails, μ is the overall mean, Ti is the effect due to treatment on the parameter under analysis, eij is the experimental error for ij on the observation.

## 3. Results and discussion

### 3.1. Basil and marjoram essential oils components

Analyzing essential oils using GC-MS identified 24 and 26 componentsfor basil and marjoram essential oil, respectively (Table 2). Results showed that marjoram essential oil superior in sabinene, α-terpinene, P-Cymene, D-Limonene, γ-terpinene, Terpin-4-ol, Thymol and Linalool than basil essential oil, these active components have strong antimicrobial activity against microorganisms such as bacteria, fungi and protozoa [3,17,18]. The different effect of essential oils depends on type and concentrates the terpenoids and phenylpropanoids contents in the oils [32].

### 3.2. Dry matter intake, nutrients digestibility

No differences were recorded ($P > 0.05$) in feed intake with adding basil or marjoram essential oils to diets (Table 3). Also, no differences were observed ($P> 0.05$) with supplementing experimental diets with basil and marjoram essential oils on CP, NDF and ADF digestibility. While, Digestibility of DM ($P=0.0003$), OM ($P<0.0001$) and EE ($P=0.0018$) were significantly increased with marjoram essential oil group compared with the control group.

Inclusion of basil and marjoram essential oils in diets confirmed by Wang et al. [33] who noted that adding 250 mg/h/day of essential oil of oregano to sheep diet did not influence dry matter intake. Also, several studies found the same results, when fed different essential oils with different supplementing levels [34] [35][36][37][38].

Supplementing diets with marjoram essential oils significantly increased ($p<0.05$) dry matter digestibility (DMD), organic matter digestibility (OMD) and ether extract digestibility (EED) as compared with control. Enhanced nutrient digestibility with addition of marjoram essential oil may have confirmed the beneficial effect of their active components, and consequence improved ruminal fermentation kinetics [3,22]. These results were in agreements with Selim et al. [3] who observed that supplementation of marjoram essential oils to diets showed a significant increase in-vitro dry matter digestibility compared to basil oil. Also, Khattab et al. [39] reported that supplementing ewes' diets with thyme increased dry matter digestibility. Yang et al. [36] noted that digestibility of dry matter was higher (13%) for supplementing Holstein cows' diet with essential oil of juniper berry than the control diet. While, Malecky et al. [37] found that the digestibility of different nutrients was not affected by experimental treatment when used a monoterpene blend consisting of (45.2% linalool, 36.7% p-cymene, 16.0% α-pinene and 2.2% β-pinene) in dairy goats' diets. monoterpene blend consisting of (45.2% linalool, 36.7% p-cymene, 16.0% α-pinene and 2.2% β-pinene) in dairy goats' diets.

**Table (2): Identified active compounds of essential oils of basil or marjoram extract by GC-MS analysis (%)**

| No. | Basil | | Marjoram | |
|---|---|---|---|---|
| | **Compounds** | **%** | **Compounds** | **%** |
| **1** | α-Pinene | 0.79 | α-Pinene | 1.63 |
| **2** | Sabinene | 0.19 | Sabinene | 12.94 |
| **3** | β- Pinene | 0.63 | β- Pinene | 0.85 |
| **4** | Myrcene | 0.2 | Myrcene | 3.06 |
| **5** | P-Cymene | 0.37 | P-Cymene | 12.34 |
| **6** | D-Limonene | 1.35 | D-Limonene | 4.35 |
| **7** | Terpinolene | 0.78 | Terpinolene | 3.22 |
| **8** | α -Terpineol | 0.19 | α-Terpineol | 0.65 |
| **9** | Linalool | 4.07 | Linalool | 4.95 |
| **10** | Bornyl acetate | 0.22 | Bornyl acetate | 0.63 |
| **11** | β-Caryophyllene | 0.19 | β-Caryophyllene | 0.53 |
| **12** | Terpineol | 0.23 | Terpin-4-ol | 15.21 |
| **13** | Methyl chavicol | 63.6 | α-terpinene | 9.61 |
| **14** | Methyl Eugenol | 1.36 | γ-terpinene | 12.82 |
| **15** | 1,8-Cineole | 4.96 | α-phellandrene | 1.24 |
| **16** | Chavicol | 1.2 | β-phellandrene | 2.87 |
| **17** | β -Elemene | 3.45 | cis-sabinene hydrate | 2.26 |
| **18** | Eugenol | 0.1 | (z)-sabinene hydrate | 1.44 |
| **19** | α-Humulene | 0.55 | Thymol | 0.19 |
| **20** | β-Bisabolene | 6.05 | 2-Methyl-2-butenal | 0.9 |
| **21** | δ- Cadinene | 1 | α-thujene | 1.86 |
| **22** | Elemol | 0.33 | Comphene | 0.12 |
| **23** | Spathulenol | 4.12 | (Z)-p-Menth -2-en-1-ol | 1.08 |
| **24** | Caryophyllene oxide | 2.15 | Isobornyl acetate | 2.15 |
| **25** | | | Carvone | 0.8 |
| **26** | | | Linalyl acetate | 0.45 |

The digestibility of cell wall contents neutral detergent fiber digestibility (NDFD) and acid detergent fiber digestibility (ADFD) was not affected ($p>0.05$) by supplementing diets with either basil or marjoram essential oil to experimental diet. Castillejos et al. [40] noted that the major cellulolytic bacterial population was not affected by adding 0.005, 0.05, and 0.5 g/L of eugenol in a continuous-culture fermenter and consequently not affected NDF, and ADF digestibility. Silem et al. [3] also found no effects on NDF, and ADF digestibility when used marjoram or basil essential oils by different levels in-vitro study. Supplementation of blend of essential oils did not influence NDFD and ADFD in dairy cows' diets [41].

The digestibility of CP was not affected (p>0.05) by inclusion marjoram or basil essential oils in the diets. Furthermore, Williams and Losa [42] noted that the herbal plants extract have the ability to encourage the digestive enzymes and saliva secretions, also helpful impacts protecting the protein in the diet from microbial degradation.

The digestibility of cell wall contents neutral detergent fiber digestibility (NDFD) and acid detergent fiber digestibility (ADFD) was not affected (p>0.05) by supplementing diets with either basil or marjoram essential oil to experimental diet. Castillejos et al. [40] noted that the major cellulolytic bacterial population were not affected by adding 0.005, 0.05, and 0.5 g/L of eugenol in a continuous-culture fermenter and consequently not affected NDF, and ADF digestibility. Silem et al. [3] also found no effects on NDF, and ADF digestibility when used marjoram or basil essential oils by different levels in-vitro study. Supplementation of blend of essential oils did not influence NDFD and ADFD in dairy cows' diets [41].

The digestibility of CP was not affected (p>0.05) by inclusion marjoram or basil essential oils in the diets. Furthermore, Williams and Losa [42] noted that the herbal plants extract have the ability to encourage the digestive enzymes and saliva secretions, also helpful impacts protecting the protein in the diet from microbial degradation.

### 3.3. Ruminal fermentation

Results showed that feeding diets supplemented with basil or marjoram essential oils did not significantly affect ruminal pH (P = 0.8718), ruminal ammonia nitrogen concentration (P> 0.05), acetate (P = 0.1350), isobutyric (P = 0.3706) and isovaleric (P = 0.6143) concentrations. Inclusion of marjoram rumen simulation technique (RUSITEC). Also, Busquet et al. [55] recorded no effect for carvacrol essential oil increased propionic (P = 0.0065), valeric (P = 0.0168), and total short chain fatty acids (SCFA) (P = 0.0046). while, acetic/propionic ratio were decreased (P = 0.0090) compared with control. The butyric molar proportion was increased (P <0.0001) in basil essential oil diet than the other groups (Table 4). Ruminal pH was not influenced with feeding marjoram or basil essential oils treatments, values were within reference range for optimum microbial function (above 5.7) [43]. The pH values are play an important role in the microbial population and ruminal fermentation, that have not impacted by addition of essential oils in diets [44]. These results are affirmed by previous studies, by adding essential oil of oregano to dairy cows' diets had no influence on ruminal pH [45,46, 47][3]. While, Kouazounde et al. [48] reported that the addition of African basil (*Ocimum gratissimum*) essential oils to diets have increased the pH values in the rumen simulation technique (RUSITEC). Decrease in ruminal ammonia nitrogen concentration of marjoram essentialoil experimental group reflect the inhibition of hyper-ammonia producing (HAP) bacteria in the rumen and restrained the deamination[49]. Ammonia concentration values in the present study (26.33–28.19 g/L) are within range reported for optimal microbial growth and activity [49]. This could reduce the rate of ruminal ammonia nitrogen yield, that lead to increase the efficiency of protein utilization in the rumen [50]. Also, McEwan et al. [51], McIntosh et al. [52] and Castillejos et al. [53] noted that rumen microbial species and population were affected by addition essential oils to diets, that had deactivated the rumen HAP bacteria (*Peptostreptecoccus anaerobius* and *Clostridium sticklandii*), which had a great related to a reduction of ammonia production, while the species *Clostridium aminophilum* was less sensitive affected. These findings were synchronized with Selim et al. [3] who recorded a reduction in ammonia nitrogen concentration when tested different levels of basil or marjoramessential oils using in-vitro batch culture fermentation system. Moreover, Newbold et al. [54] suggested that the rumen ammonia concentration was decreased byadding oregano oil to diets at levels 30 and 300 mg/L. But, Kouazounde et al. [48] found that the addition of African basil (*Ocimum gratissimum*) had no effect on ammonia nitrogen concentration in the mg/L in ammonia concentration using in-vitro batch culture, and in-vivo study [35,53]. Increased in total short chain fatty acids (SCFA) concentration with addition marjoram or basil essential oils to diets may be as a result of enhanced nutrients digestibility in the rumen [10]. These results are in-agreements with Wang et al. [33] who found that total volatile fatty acids (TVFA) concentrations in the rumen increased due to addition of essential oil extract from oregano at 0.25 g/kg DM, and cinnamaldehyde at 0.2 g/kg DM [56]. Also, Sahraei et al. [57] found that the addition of rosemary essential oil at 200 mg daily in sheep diets increased ruminal SCFA concentrations. While, Benchaar et al. [35] reported the effect of essential oil on TVFA concentration may depend upon the type's diets fed to the animals. Other studies showed that total SCFA, acetate, propionic and butyric acids proportions and concentrations were not affected in cows and steers fed diets contained lemongrass [58]. Moreover, Kouazounde et al. [48] reported that the addition of African basil (*Ocimum gratissimum*) essential oils to diets have increased the acetate proportion in the rumen simulation technique (RUSITEC). A decrease in acetate to propionate ratio related to the deactivation the methanogens bacteria which associated with the methane emission in the rumen [32]. While, the acetate to propionate ratio was not changed [33,59], or increased [45,48,60,61]. The propionic acid is the primary gluconeogenic short chain fatty acid that affects glucose and lactose biosynthesis [62]. The increase in propionate concentration may be related to the positive effect of increasing propionate-producing bacteria species [50]. Basil essential oil increased the proportion of butyrate than the marjoram essential oil and the control treatments because adding basil and carvone up to 300 mg/L and anethol up to 3000 essential oil have activate ruminal gram-positive bacteria *Butyrivibrio fibrisolvens*; the major butyrate producer [63]. The superior production of SCFA, acetate, propionate and valeric concentrations with marjoram essential oil treatment than the basil essential oil treatment may be due to the presence of different and concentrate of active components between marjoram and basil essential oils.

**Table (3): Feed intake, nutrients digestibility of lactating Damascus goats fed a diet supplemented with essential oil of basil or marjoram**

| Item | Control | Basil | Marjoram | *SEM* | *P value* |
|---|---|---|---|---|---|
| **Feed intake (kg/h/d)** | 1.23 | 1.24 | 1.27 | 0.011 | 0.2242 |
| **Nutrients digestibility (%)** | | | | | |
| **DMD** | 42.40c | 49.62b | 56.30a | 1.543 | 0.0003 |
| **OMD** | 53.54b | 60.36a | 61.00a | 0.774 | <.0001 |
| **CPD** | 50.82 | 52.58 | 54.94 | 1.009 | 0.2553 |
| **EED** | 54.00b | 55.15b | 63.15a | 1.219 | 0.0018 |
| **NDFD** | 57.66 | 59.50 | 61.55 | 0.941 | 0.2433 |
| **ADFD** | 53.90 | 55.00 | 59.22 | 1.113 | 0.1210 |

Different superscripts a, b and c at the same row differ significantly ($p<0.05$).
SEM: standard error of the means

**Table (4): Rumen fermentation parameters of lactating Damascus goats fed a diet supplemented with essential oil of basil or marjoram**

| Item | Control | Basil | Marjoram | *SEM* | *P value* |
|---|---|---|---|---|---|
| **pH** | 6.67 | 6.70 | 6.57 | 0.092 | 0.8718 |
| **NH3-N g/L** | 28.19 | 28.07 | 26.33 | 0.521 | 0.2951 |
| **Acetic (mmol/100 mmol)** | 62.4 | 65.0 | 67.2 | 0.992 | 0.1350 |
| **Propionic (mmol/100 mmol)** | 20.2b | 28.6ab | 38.1a | 2.859 | 0.0065 |
| **A/P ratio** | 3.1a | 2.3ab | 1.8b | 0.220 | 0.0090 |
| **Isobutyric (mmol/100 mmol)** | 0.5 | 0.6 | 0.7 | 0.050 | 0.3706 |
| **Butyric (mmol/100 mmol)** | 18.9b | 22.9a | 18.8b | 0.694 | <.0001 |
| **Isovaleric (mmol/100 mmol)** | 1.2 | 1.3 | 1.9 | 0.282 | 0.6143 |
| **Valeric (mmol/100 mmol)** | 2.4b | 2.5b | 4.3a | 0.365 | 0.0168 |
| **Total SCFA (mmol/100 mmol)** | 105.6b | 121.0a | 131.1a | 0.054 | 0.0046 |

Different superscripts a and b at the same row differ significantly ($p<0.05$).
SEM: standard error of the means

## 3.4. Blood metabolites measurements

Inclusion of marjoram or basil essential oils in diets increased serum glucose (P = 0.0464) and triglyceride (P < 0.0001) concentration. No effects were observed (P > 0.05) with the inclusion of marjoram or basil essential oils on serum total protein, albumin, globulin, A/G ratio, urea, cholesterol, aspartate aminotransferase (AST) and alanine aminotransferase (ALT) concentrations (Table 5). All blood serum parameters in the present study were within the normal range of animals' health reported by Boyd [64]. Increases in blood serum glucose concentrations with using marjoram essential oil as feed supplement reflect the enhancement of organic matter digestibility and short chain fatty acids production. There is a positive relationship between serum glucose and milk production [65]. A significant increase in blood serum triglyceride concentration by feeding marjoram essential oil compared to the other groups may be due to the success of essential oil to cause alterations in EE digestibility. It has been reported that the adding essential oil to diets can be influence in triglyceride concentration via changes in feed intake [66]. These results are agreements with Chaves et al. [56] who found that 18-time increasing in blood serum triglyceride concentration in lambs fed 200mg cinnamaldehyde/kg DM than the control group. There is a great positive relationship between the SCFA and triglyceride production [67].

**Table (5): Blood chemistry of lactating Damascus goats fed a diet supplemented with essential oil of basil or marjoram**

| **Item** | **Control** | **Basil** | **Marjoram** | ***SEM*** | ***P value*** |
|---|---|---|---|---|---|
| **Glucose mg/dl** | 86.3b | 91.5ab | 100.8a | 2.473 | 0.0464 |
| **Total protein g/dl** | 7.4 | 7.5 | 7.4 | 0.099 | 0.9009 |
| **Albumin g/dl** | 3.4 | 3.5 | 3.5 | 0.055 | 0.8071 |
| **Urea mg/dl** | 49.6 | 40.8 | 46.1 | 1.986 | 0.1931 |
| **AST Units/ L** | 13.9 | 10.8 | 10.0 | 0.858 | 0.1479 |
| **ALT Units/ L** | 33.0 | 31.6 | 36.6 | 1.527 | 0.3969 |
| **Triglyceride mg/dl** | 89.5c | 103.4b | 114.6a | 2.590 | <0.0001 |
| **Cholesterol g/dl** | 135.8 | 145.8 | 149.4 | 4.050 | 0.3819 |

Different superscripts a, b and c at the same row differ significantly (p<0.05).
SEM: standard error of the means

### 3.5. Milk yield and composition

Data in Table 6 showed that the average body weight was insignificantly (P>0.05) impacted with feeding different essential oils. Supplementing diets with marjoram essential oil increased milk yield (P = 0.0311), FCM (P = 0.0311), ECM (P = 0.0311), TS (P = 0.0098), fat (P <0.0001), and lactose (P = 0.0405) as compared with the control. The yields of milk solids not fat (SNF), protein, and ash were not affected with feeding basil or marjoram essential oils. Greater (P = 0.0022) milk fat percent was observed for marjoram EO treatment compared with other treatments. No effect was noted (P>0.05) with feeding basil or marjoram EOs treatments in milk composition percentages of TS, SNF, protein, lactose and ash. Milk efficiency as milk yield /DM intake was not affected (P = 0.1775) by different experimental groups, while ECM/DM intake was increased (P=0.0089) with the marjoram EO treatment compared with the control treatment.

The increases of milk yield, FCM and ECM were 5.1, 7.5 and 12.4 %, and 19.7, 30.2 and 51.3 % for basil and marjoram EOs, respectively. Increased milk yield, ECM and FCM without a concomitant increase in DMI with added marjoram EOs to goats' diets resulted enhanced milk efficiency. Also, improved the nutrients digestibility and ruminal fermentation with marjoram EOs supplementation is the major reasons for higher milk yield, ECM and FCM. Rigout et al. [62] reported that the increasing in milk yield may be due to increased milk lactose content which improves milk production. the active compounds found in the marjoram EO could be enhanced ruminal fermentation processes, and increasing performance of goat production [68,69].

These results are in agreements with Kholif et al. [22] who found that feeding rosemary or lemongrass to Damascus goats increased milk yield and ECM. Also, Kung et al. [70] Chiofalo et al. [71] observed that EO increased milk yield. While, Hristov et al. [72] noted that milk production not affected by feeding different levels of *Origanum vulgare L.* leaves in lactating dairy cows with decreased in DMI and increased feed efficiency. Moreover, the milk efficiency increased by using essential oils in dairy cattle diets [73].

Milk fat content depend mainly upon mainly animals genetically, dietary feed and animal environmental factors [74]. Furthermore, the ruminal acetate/propionate ratio plays an important role in milk fat synthesis [35,61]. Feeding marjoram EO produced milk with higher lactose content. Also, the ruminal propionate plays a fundamental role in lactose synthesis as a gluconeogenesis precursor, which it affects on milk lactose content [22]. Santos et al. [75] suggested that feeding of mixture of essential oils containing coriander oil, eugenol and geranyl acetate increased milk fat yield and fat percentage, while milk yield and composition not affected.

**Table (6): Average body weight, milk yield and composition of lactating Damascus goats fed a diet supplemented with essential oil of basil or marjoram**

| Item | Control | Basil | Marjoram | *SEM* | *P value* |
|---|---|---|---|---|---|
| **Average body weight (kg)** | 40.91 | 41.80 | 42.40 | 0.378 | 0.2982 |
| **Yield (g /h/d)** | | | | | |
| **Milk** | 1099.3b | 1155.0ab | 1316.3a | 35.21 | 0.0311 |
| **FCM 4%** | 961.1b | 1033.4b | 1251.5a | 34.52 | 0.0006 |
| **TS** | 139.4b | 148.1ab | 171.2a | 4.578 | 0.0098 |
| **SNF** | 104.7 | 110.0 | 122.9 | 3.319 | 0.0706 |
| **Fat** | 34.8b | 38.1b | 48.3a | 1.457 | <0.0001 |
| **Protein** | 37.9 | 40.2 | 43.9 | 1.210 | 0.1198 |
| **Lactose** | 57.7b | 60.4ab | 68.6a | 1.833 | 0.0405 |
| **Ash** | 9.1 | 9.4 | 10.3 | 0.291 | 0.1863 |
| **Composition (%)** | | | | | |
| **TS** | 12.7 | 12.8 | 13.0 | 0.089 | 0.2753 |
| **SNF** | 9.5 | 9.5 | 9.3 | 0.061 | 0.3363 |
| **Fat** | 3.2b | 3.3b | 3.7a | 0.064 | 0.0022 |
| **Protein** | 3.5 | 3.5 | 3.3 | 0.028 | 0.0760 |
| **Lactose** | 5.2 | 5.2 | 5.2 | 0.031 | 0.8745 |
| **Ash** | 0.8 | 0.8 | 0.8 | 0.006 | 0.0817 |
| **ECM (Kg/d)** | 1.13b | 1.27ab | 1.71a | 0.076 | 0.0082 |
| **Milk efficiency** | | | | | |
| **Milk yield /DMI** | 0.90 | 0.93 | 1.03 | 0.029 | 0.1775 |
| **FCM/DMI** | 0.78b | 0.84ab | 0.98a | 0.028 | 0.0089 |

Different superscripts a and b at the same row differ significantly ($p<0.05$); SEM: standard error of the means

## 4. Conclusion

Under the condition present in-vivo study, it could be concluded that supplementation of marjoram essential oil had a positive effect of digestibility of nutrients (DM and OM), ruminal fermentation parameters (SCFA), milk production and composition and milk efficiency compared to basil essential oil, without adverse effect of goat's health.

## 5. Acknowledgements

Authors are thankful to the all-staff members of my Laboratory, Department and Centre for providing research facility and conducive environment for current research study.

## 6. Conflicts of interest

No potential conflict of interest was reported by the authors.

## 7. References

[1] Matloup O.H., Abd El Tawab A.M., Hassan A.A., Hadhoud F.I., Khattab M.S.A., Khalel M.S., Sallam S.M.A. and Kholif A.E., Performance of lactating Friesian cows fed a diet supplemented with coriander oil: Feed intake, nutrient digestibility, ruminal fermentation, blood chemistry and milk production. Anim. Feed Sci. Technol., 226: 88-97(2017).

[2] Khattab M.S.A., Azzaz H.H., Abd El Tawab A.M. and Murad H.A. Production Optimization of Fungal Cellulase and its Impact on Ruminal Degradability and Fermentation of Diet. International Journal of Dairy Science, 14: 61-68 (2019).

[3] Nadia A. H. Selim; Abd El Tawab A. M., Kholif A. M., Elsayed H.M., El-Bordeny N. E., Eman S.A. Farahat, Impact of the essential oils of marjoram or basil dietary supplementation on degradability, ruminal fermentation and total gas production in-vitro. Egyptian J. Nutrition and Feeds 24, 1,85-93 (2021).

[4] Abd El Tawab, A.M., Khattab M.S.A., Hadhoud F.I. and Shaaban M.M., Effect of mixture of herbal plants on ruminal fermentation, degradability and gas production. Acta Scientiarum. Animal Sciences, 43(1): e48549 (2021).

[5] Chao, S.C., Young D.G. and Oberg C.J., Screening for inhibitory activity of essential oils on selected bacteria, fungi and viruses. J. Essent. Oil Res., 12:639-649 (2000).

[6] Abd El Tawab A.M., Murad H.A., Khattab M.S.A. and Azzaz H.H., Optimizing Production of Tannase and in vitro Evaluation on Ruminal Fermentation, Degradability and Gas Production. International Journal of Dairy Science, 14: 53-60 (2019).

[7] El-Zaher, H.M., Eid S.Y., Shaaban M.M., Ahmed-Farid O.A., Abd El Tawab A.M. and Khattab M.S.A., Ovarian activity and antioxidant indices during estrous cycle of Barki ewes under effect of thyme, celery and salinomycin as feed additives. Zygote, 1-6 (2020).

[8] Khattab, M.S.A., Ebeid H.M., Abd El Tawab A.M., Abo El-Nor S.A.H. and Aboamer A.A., Effect of supplementing diet with herbal plants on ruminal fiber digestibility and gas production. Res. J. of Pharm., Bio. Chem. Sci., 7(6):1093-1097(2016).

[9] Khattab M.S.A., El-Zaiat H.M., Abd El Tawab A.M., Matloup O.H., Morsy A.S., Abdou M.M., Ebeid H.M., Attia M.F.A. and Sallam S.M.A., Impact of lemongrass and galangal as feed additives on performance of lactating Barki goats. Int. J. Dairy Sci., 12: 184-189 (2017).

[10] Khattab M.S.A., Abd El Tawab A.M., Hadhoud F.I. and Shaaban M.M., Utilizing of Celery and Thyme as Ruminal Fermentation and Digestibility Modifier and Reducing Gas Production. International Journal of Dairy Science, 15: 22-27 (2020a).

[11] Abd El Tawab A.M., Kholif A.E., Khattab M.S.A., Shaaban M.M., Hadhoud F.I., Mostafa M.M.M. and Olafadehan O.A., Feed utilization and lactational performance of Barki sheep fed diets containing thyme or celery. Small Ruminant Research, 192:106249 (2020).

[12] Shaaban, M.M., Kholif A.E., Abd El Tawab A.M., Radwan M.A., Hadhoud F.I., Khattab M.S.A., Saleh H.M. and Anele U.Y., Thyme and celery as potential alternatives to ionophores use in livestock production: their effects on feed utilization, growth performance and meat quality of Barki lambs. Small Ruminant Research, Volume 200, 106400, (2021).

[13] Sivropoulou A., Papanikolaou E., Nikolaou C., Kokkini S., Lanaras T. and Arsenakis M., Antimicrobial and cytotoxic activities of Origanum essential oils. J. Agric. Food Chem., 44: 1202-1205 (1996).

[14] Baser, K.H.C., The Turkish Origanum species. Pages 109–126 in Oregano: The Genera Origanum and Lippia, S. E. Kintzios, ed. Taylor and Francis, London, UK and New York, NY (2002).

[15] Figuérédo G., Cabassu P., Chalchat J., and Pasquier B., Studies of Mediterranean oregano populations. VIII—Chemical composition of essential oils of oreganos of various origins. Flavour Fragr. J. 21:134-139 (2006).

[16] Bisht, D., Chanotiya C. S., Rana M., and Semwal M., Variability in essential oil and bioactive chiral monoterpenoid compositions of Indian oregano (Origanum vulgare L.) populations from northwestern Himalaya and their chemotaxonomy. Ind. Crops Prod. 30:422-426 (2009).

[17] Walsh S.E., Maillard J.Y., Russell A.D., Catrenich C.E., Charbonneau D.L. and Bartolo R.G. Activity and mechanisms of action of selected biocidal agents on gram-positive and -negative bacteria. J. Appl. Microbiol. 94:240-427 (2003).

[18] Burt, S, Essential oils: their antimicrobial properties and potential applications in foods: a review. Int. J. Food Microbiol. 94:223-253 (1969).

[19] Grayer R.J., Kite G.C., Goldstone F.J., Bryan S.E., Paton A. and Putievsky E., Intraspecific taxonomy and essential oil chemotypes in Sweet basil, Ocimum basilicum. Phytochemistry. 43(5): 1033-1039(1996).

[20] Dorman, H.J.D. and Deans S.G., Antimicrobial agents from plants: antibacterial activity of plant volatile oils. J. Appl. Microbiol. 88, 308-316 (2000).

[21] FASS, Guide for the Care and Use of Agricultural Animals in Research and Teaching. Fed. Anim. Sci. Soc., Champaign, IL (2010).

[22] Kholif A.E., Matloup O.H., Morsy T.A., Abdo M.M., Abu Elella A.A., Anele U.Y. and Swanson K.C., Rosemary and lemongrass herbs as phytogenic feed additives to improve efficient feed utilization, manipulate rumen fermentation and elevate milk production of Damascus goats, Livestock Science, 204,39-46 (2017).

[23] NRC, Nutrient Requirements of Small Ruminants: Sheep, Goats, Cervids, and New World Camelids. National Academy Press, Washington, DC, USA (2007).

[24] Gallups W.D., Hobbs, C.S. and Briggs H.M., The use of silica as a reference substance in digestion trials with ruminants. J. Anim. Sci., 4: 68-71(1945).

[25] Forbes R.M. and Garrigus, W.P., Application of a lignin ratio technique to the determination of the nutrient intake of grazing animals. J. Anim. Sci., 7: 373-382 (1948).

[26] A.O.A.C. (1995). Official Methods of Analysis. Association of Analytical Chemists. 16th ed. Washington, D.C., USA.

[27] Van Soest P.J., Robertson J.B. and Lewis B.A., Methods for dietary fiber, neutral detergent fiber, and non-starch polysaccharides in relation to animal nutrition. J. Dairy Sci. 74, 3583-3597(1991).

[28] Konitzer K. and Voigt, S., Direct determination of ammonium in blood and tissue extracts by means of the phenol by chlorite reaction. international Journal of Clinical Chemistry, 8:5-11 (1963).

[29] Gaines W.L., The energy basis of measuring milk yields. J. Anim. Sci., 33-36(1927).

[30] Sjaunja, L.O., Baevre L., Junkkarinen L., Pedersen J. and Setala J.A., Nordic proposal for an energy corrected milk (ECM) formula. Performance recording of animals. State of the art. EAAP Publ., 50, 156-157 (1991).

[31] Statistical Analysis System SAS, SAS/STAT User's guide, Version 9.2. Cary, NC: SAS Institute Inc. (2009).

[32] Patra A.K., Effects of essential oils on rumen fermentation, microbial ecology and ruminant production. Asian Journal of Animal and Veterinary Advances, 6, 416-428 (2011).

[33] Wang, C.J., Wang S.P. and Zhou H., Influences of flavomycin, ropadiar, and saponin on nutrient digestibility, rumen fermentation and methane emission from sheep. Anim. Feed Sci. Technol., 148: 157-166 (2009).

[34] Benchaar, C., Petit H.V., Berthiaume R., Whyte T.D. and Chouinard P.Y., Effects of addition of essential oils and monensin premix on digestion, ruminal fermentation, milk production and milk composition in dairy cows. J. Dairy Sci., 89: 4352-4364 (2006).

[35] Benchaar, C., Petit H.V., Berthiaume R., Ouellet D.R., Chiquette J. and Chouinard P.V., Effects of essential oils on digestion, ruminal fermentation, rumen microbial populations, milk production and milk composition in dairy cows fed alfalfa silage or corn silage. J. Dairy Sci., 90: 886-897 (2007a).

[36] Yang, W.Z., Benchaar C., Ametaj B.N., Chaves A.V., He M.L. and McAllister T.A., Effects of garlic and juniper berry essential oils on ruminal fermentation and on the site and extent of digestion in lactating cows. J. Dairy Sci., 90: 5671-5681 (2007).

[37] Malecky, M., Broudiscou L.P. and Schmidely P., Effects of two levels of monoterpene blend on rumen fermentation, terpene and nutrient flows in the duodenum and milk production in dairy goats. Anim. Feed Sci. Technol., 154: 24-35 (2009).

[38] Smeti, S., Joy, M., Hajji, H., Alabart, J.L., Muñoz, F., Mahouachi, M. and Atti, N., Effects of Rosmarinus officinalis L. essential oils supplementation on digestion, colostrum production of dairy ewes and lamb mortality and growth. Anim. Sci. J. 86, 679-688 (2015).

[39] Khattab M.S.A., Kholif A.E., Abd El Tawab A.M., Shaaban M.M., Hadhoud F.I., El-Fouly H.A. and Olafadehan O.A., Effect of replacement of antibiotics with thyme and celery seed mixture on the feed intake and digestion, ruminal fermentation, blood chemistry, and milk lactation

of lactating Barki ewes. Food & Function, 11, 6889-6898 (2020b).

[40] Castillejos L., Calsamiglia S., Ferret A., Effect of Essential Oil Active Compounds on Rumen Microbial Fermentation and Nutrient Flow in In Vitro Systems. Journal of Dairy Science, 89, 7, 2649-2658 (2006).

[41] Kali, L., The Effects of a Blend of Essential Oils on Rumen Efficiency of Lactating Dairy Cows. Electronic Theses and Dissertations. 1230 (2017).

[42] Williams P. and Losa, R., The use of essential oils and their compounds in poultry nutrition. World's Poultry, 17, 14-15 (2001).

[43] Ørskov E.R. and Ryle R., Energy Nutrition in Ruminants. Elsevier SciencePublishers, New York (1990).

[44] Kumar, S., Dagar S.S., Sirohi S.K., Upadhyay R.C. and Puniya A.K.,Microbial profiles, in vitro gas production and dry matter digestibility based on various ratios of roughage to concentrate. Ann Microbiol. 63: 541-545 (2013).

[45] Tekippe, J.A., Hristov A.N., Heyler K.S., Cassidy T.W., Zheljazkov V.D. and Ferreira J.F., Rumen fermentation and production effects of Origanum vulgare L. leaves in lactating dairy cows. J Dairy Sci., 94: 5065–5079 (2011).

[46] Hristov A.N., Lee C., Cassidy T., Heyler K., Tekippe J.A. and Varga G.A., Effect of Origanum Vulgare L. leaves on rumen fermentation, production, and milk fatty acid composition in lactating dairy cows. J Dairy Sci. 96:1189-1202 (2013).

[47] Zhou R., Wu J., Zhang L., Liu L., Casper D.P., Jiao T., Liu T., Wang J., Lang X., Song S. and Gong X. Effects of oregano essential oil on the ruminal pH and microbial population of sheep. PLoS ONE 14(5): e0217054 (2019).

[48] Kouazounde J.B., Gbenou J.D., He M., Jardim T., Jin L., Wang Y., Beauchemin K.A. and McAllister T.A., Effects of essential oils from African basil on fermentation of Andropogon gayanus grass in the Artificial Rumen (RUSITEC). Can. J. Anim. Sci., 95: 425-431(2015).

[49] Satter L.D. and Slyter L.L., Effect of ammonia concentration on rumen microbial protein production in vitro. Br. J. Nutr. 32, 199-208 (1974).

[50] Wallace R.J., McEwan N.R., McIntosh F.M., Teferedegne B. and Newbold C.J. Natural products as manipulators of rumen fermentation. Asian-australas. J. Anim. Sci., 15:10-21 (2002).

[51] McEwan, N.R., Graham R.C., Wallace R.J., Losa R., Williams P. and Newbold C.J., Effect of essential oils on ammonia production by rumen microbes. Reprod. Nutr. Dev.42(Suppl.1): S65. (Abstr.) (2002).

[52] McIntosh, F.M., Williams P., Losa R., Wallace R.J., Beever D.A. and Newbold C.J., Effects of Essential Oils on Ruminant Microorganisms and Their Protein Metabolism. App. Environ. Microbiol. 69:5011-5014(2003).

[53] Castillejos, L., Calsamiglia S., Ferret A. and Losa R., Effects of a specific blend of essential oil compounds and the type of diet on rumen microbial fermentation and nutrient flow from a continuous culture system. Anim. Feed Sci. Technol. 119:29-41 (2005).

[54] Newbold, C.J., McIntosh F.M., Williams P., Losa R. and Wallace R.J., Effects of a specific blend of essential oil compounds on rumen fermentation. Anim. Feed Sci. Technol. 114: 105-112 (2004).

[55] Busquet, M, Calsamiglia S., Ferret A. and Kamel C., Plant extracts affect in vitro rumen microbial fermentation. J. Dairy Sci., 89(2):761-771 (2006).

[56] Chaves, A.V., Stanford K., Dugan M.E.R., Gibson L.L., McAllister T.A., van Herk F. and Benchaar C., Effects of cinnamaldehyde, garlic and juniper berry essential oils on rumen fermentation, blood metabolites, growth performance and carcass characteristics of growing lambs. Livestock Sci., 117: 215-224(2008).

[57] Sahraei M., Pirmohammadi R. and Payvastegan S., The effect of rosemary (Rosmarinus officinalis L.) essential oil on digestibility, ruminal fermentation and blood metabolites of Ghezel sheep fed barley-based diets. Sp. J. Agric. Res. 12, 448-454 (2014).

[58] Wanapat, M., Cherdthong, A., Pakdee, P. and Wanapat, S., Manipulation of rumen ecology by dietary lemongrass (Stapf.) powder supplementation. J. Anim. Sci. 86, 3497–3503 (2008).

[59] Kumar, R., Kamra D.N., Agrawal N. and Chaudhary L.C., Effect of eucalyptus (Eucalyptus globules) oil on in vitro methanogenesis and fermentation of feed with buffalo rumen liquor. Anim. Nutr. Feed Technol., 9: 237-243 (2009).

[60] Macheboeuf, D., Morgavi D.P., Papon Y., Mousset J.L. and Arturo-Schaan M., Dose-response effects of essential oils on In vitro fermentation activity of the rumen microbial population. Anim. Feed Sci. Technol., 145: 335-350 (2008).

[61] Agarwal N., Shekhar C., Kumar R., Chaudhary L.C., Kamra D.N., Effect of peppermint (Mentha piperita) oil on in vitro methanogenesis and fermentation of feed with buffalo rumen liquor. Anim. Feed Sci. Technol., 148, pp.321-327 (2009).

[62] Rigout S., Hurtaud, C., Lemosquet, S., Bach, A. and Rulquin, H., Lactational effect of propionic acid and duodenal glucose in cows. J. Dairy Sci. 86, 243–253 (2003).

[63] Russell JB and Strobel HJ., Effect of ionophores on ruminal fermentation. Appl Environ Microbiol 55:1-6 (1989).

[64] Boyd, J.W., The interpretation of serum biochemistry test results in domestic animals. 13. Veterinary Clinical Pathologypp. 7–14 (1984).

[65] Abd El Tawab, A.M., Matloup O.H., Kholif A.M., Abo El-Nor S.A.H., Murad H.A., El-Sayed H.M., and Khorshed M.M., Influence of addition of tannase enzyme to reducing tannins effects in lactating goats diets. International Journal of Dairy Science, 10(1): 24-35(2015).

[66] Yang, W.Z., Ametaj B.N., Benchaar C., He M.L. and Beauchemin K.A., Cinnamaldehyde in feedlot cattle diets: Intake, growth performance, carcass characteristics and blood metabolites. J. Anim. Sci., 88: 1082-1092 (2010).

[67] Breckenridge WC, and Kuksis A., Structure of bovine milk fat triglycerides. II. Long chain lengths. Lipids. 4(3):197–204 (1969).

[68] Bodas, R., Prieto, N., García-González, R., Andrés, S., Giráldez, F.J., and López, S., Manipulation of rumen fermentation and methane production with plant secondary metabolites. Anim. Feed Sci. Technol. 176, 78–93 (2012).

[69] Salem A.Z.M., Kholif, A.E., Olivares, M., Elghandour, M.M.Y., Mellado, M., and Arece, J., Influence of S. babylonica extract on feed intake, growth performance and diet in vitro gas production profile in young lambs. Trop. Anim. Health Prod. 46, 213-219 (2014).

[70] Kung, Jr. L., Williams P., Schmidt R.J. and Hu W., A blend of essential plant oils used as an additive to alter silage fermentation or used as a feed additive for lactating dairy cows. J. Dairy Sci., 91: 4793-4800 (2008).

[71] Chiofalo B., Riolo E.B., Fasciana G., Liotta L., Chiofalo V., Organic management of dietary rosemary extract in dairy sheep: effects on milk quality and clotting properties. Vet. Res. Commun. 34, 197–201(2010).

[72] Hristov A.N., Lee C., Cassidy T., Heyler K., Tekippe J.A., Varga G.A., Corl B., Brandt R.C., Effect of Origanum vulgare L. leaves on rumen fermentation, production, and milk fatty acid composition in lactating dairy cows. Journal of Dairy Science, 96, 2, 1189 – 1202 (2012).

[73] Tassoul, M.D. and Shaver R.D., Effect of a mixture of supplemental dietary plant essential oils on performance of periparturient and early lactation dairy cows. J. Dairy Sci., 92: 1734-1740 (2009).

[74] Kholif A.E., Morsy, T.A., Gouda, G.A., Anele, U.Y. and Galyean, M.L., Effect of feeding diets with processed Moringa oleifera meal as protein