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Improving Productivity and Health Status of Lactating Zaraibi Goats with Echinacea Purpurea or/and Chamomile Flower Supplementation

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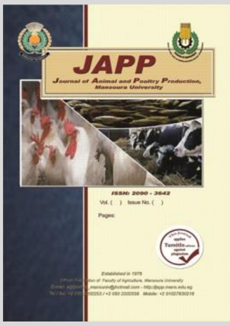

ABSTRACT

This study examined the effects of Echinacea purpurea (EP), Chamomile flowers (ChF), and their mixture on productive performance, blood profile, and physiological parameters in lactating Zaraibi goats. Twenty-eight Zaraibi goats weighing 32.38±3.35 kg were randomly divided into four equal groups after parturition. Group 1 was fed the basal diet without additives, while the other three groups were supplemented with 1.0g EP/kg diet, 1.0g ChF/kg diet, and 0.5g EP+0.5g ChF/kg diet, respectively. The results demonstrated that the supplementations had increased the feed unite intake, feeding values, and nutrient digestibility, particularly for crude protein and crude fiber, as well as increased ruminal total volatile fatty acids, with significant differences obtained ($p<0.05$) between the mixture supplementation and the control group. Hematological parameters, including hemoglobin, mean-corpuscular hemoglobin concentration, and lymphocytes, were positively affected ($p<0.05$) by the EP and the mixture supplements compared to control group. The dietary supplementations enhanced ($p<0.05$) serum total protein, globulin, aspartate amino-transferase, alanine amino-transferase, cholesterol, creatinine, and urea concentrations. The EP and mixture supplementations increased ($p<0.05$) daily milk yield, fat content, and total solids percentage, while reduced milk somatic cell count compared to control group. The supplemented groups also exhibited improved changes ($p<0.05$) in body weights and feed conversion ratios per kilogram of milk yield, with the mixture supplementation showing the most substantial improvements. Overall, improved health status and body weights align with high milk production indicate the potential benefits of incorporating the current EP and ChF combination as a dietary supplement in the management practices of lactating Zaraibi goats.

Keywords: Productive Performance, Echinacea Purpurea, Chamomile Flowers, Zaraibi Goats

INTRODUCTION

Dairy goats encounter significant challenges during the post-parturition period, which include the kids' delivery process, initiation of lactation, and metabolic imbalances. Additionally, there is a discrepancy between the energy intake and the increasing nutrient requirements, resulting in a negative energy balance. This imbalance ultimately affects the dairy goats' behavior, productivity, and reproductive performance (Zamuner *et al*., 2020; Ghavipanje *et al*., 2021; Tosto *et al*., 2021). Moreover, the goats' milk production plays a crucial role in the survival and growth of their offspring, thereby exerting a substantial impact on the goats' prolificacy. However, the severity of this imbalance varies depending on the management practices employed. Hence, it is imperative to implement effective nutritional management strategies to coordinate these challenges and enhance the adaptability of lactating goats during this critical period.

Employing natural medical herbal additives as feed additives for animals represents a promising alternative to antibiotics, promoting animal health and performance while addressing concerns related to antibiotic resistance and animal production sustainability. Supplementing animal diets with herbs, even at low concentrations in feed mixtures, has been shown to increase the activation of antioxidant enzymes in both blood and milk, which are essential for safeguarding cells against oxidative damage (Panchasara *et al*., 2019; Vizzotto *et al*., 2021; Kolling *et al*., 2022; Stobiecka *et al*., 2023). Alongside this, previous studies indicated that incorporating herbs into ruminant diets offers various benefits. These advantages include alteration of rumen microflora, enhanced feed conversion efficiency, and subsequent improvements in animal performance and health (Panchasara *et al*., 2019; Wójtowski *et al*., 2019; Chen *et al*., 2022). When herbal blends are utilized, rather than individual herbs, the production outcomes tend to be more favorable due to the synergistic effects of their active compounds (Hassan *et al*., 2021). It is worth noting that the bioactive plant compounds found in herbs are highly resistant to degradation by rumen microbes, allowing them to maintain their functionality within the digestive system (Oh *et al*., 2017).

Echinacea purpurea, a perennial herbaceous flowering plant, contains a wide range of active ingredients, including caffeic acid derivatives, polysaccharides, alkylamides, and glycoproteins (Awortwe *et al*., 2021; Ren *et al*., 2023). Alkylamides found in Echinacea purpurea play a significant role in anti-inflammatory properties, immune regulation, and macrophage regulation (Vieira *et al*., 2023). Caffeic acid derivatives, such as chicoric acid, chlorogenic acid, and caftaric acid, present in Echinacea purpurea, primarily exhibit antioxidant, anti-allergic, anti-inflammatory, anti-ulcer, and antiviral effects (Ye *et al*., 2019; de Oliveira *et al*., 2021; Ravazzolo *et al*., 2022). The polysaccharides in Echinacea purpurea contribute to various beneficial effects,

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including antioxidant, anti-tumor, antiviral, antibacterial, hypoglycemic, liver protection, immune regulation, and gastrointestinal protection (Jiang *et al*., 2021; Liu *et al*., 2020, 2022; Shi *et al*., 2021). However, numerous studies have demonstrated the immunomodulatory, antibacterial, antiviral, anti-inflammatory, and antioxidant therapeutic effects of Echinacea (Wang *et al*., 2024).

Chamomile flowers, belonging to the Asteraceae family, are often regarded as a prominent medicinal species (Ezeldien *et al*., 2023). It is widely utilized and appreciated for its extensive therapeutic potential. Chamomile is composed of various constituents, including polysaccharides, volatile oils, terpenes, sterols, terpenoids, coumarins, and flavonoids (Abd El-Hack *et al*., 2023). Due to its diverse chemical composition, chamomile exhibits a wide range of actions, encompassing anti-infective, anticancer, antioxidant, anti-inflammatory, antiallergic, neuroprotective, hypolipidemic, hypotensive, hypoglycemic, and antidepressant properties (Ubessi *et al*., 2019; Desam and Al-Rajab, 2021; Fen *et al*., 2021; Dai *et al*., 2023). Generally, Chamomile holds significant importance in traditional medicine and carries substantial economic value due to its numerous pharmacological effects and traditional uses (Dai *et al*., 2023).

While Echinacea purpurea and Chamomile flowers have been studied and used in various contexts, their use as a feed additive for dairy goats, specifically Zaraibi goats, is not well-documented or widely researched. Additionally, there is a scarcity of scientific evidence supporting the synergistic effects of their combination as animal feed additive. However, to the best of our knowledge, this study represents the first investigation into the effects of their combined mixture as feed additive, particularly in lactating Zaraibi goats. Therefore, the current study was designed to investigate the effects of Echinacea purpurea, Chamomile flowers, and their mixture on feed intake, nutrient digestibility, ruminal parameters, blood constituents, milk yield and composition, physiological parameters, and body weight changes in lactating Zaraibi goats.

MATERIALS AND METHODS

The study work was conducted in El-Serw Animal Production Research Station, belonging to the Animal Production Research Institute, Agricultural Research Center, Ministry of Agriculture, Egypt. The study was approved by the Animal Production Research Institute, Agricultural Research Center, Egypt (protocol code 132429).

Experimental Animals and Management

Twenty-eight Zaraibi goats in the lactating stage, weighing an average of 32.38 ± 3.35 kg and aged between 2 to 3 years old, were randomly assigned to four equal groups (n=7 goats/group) after giving birth. The goats in each group were given the experimental treatments as follows: the control group (G1) received a basal diet without any additives, while the other groups received the basal diet supplemented with 1.0g of Echinacea purpurea (EP)/kg of diet (G2), 1.0 g of Chamomile flowers (ChF)/kg of diet (G3), or 0.5 g of EP plus 0.5 g of ChF/kg of diet (G4). The study lasted for a period of 90 days. The basal diet was formulated to meet the goats' maintenance and production needs based on the recommendations of the NRC (2007). The basal diet consisted of 60% concentrate feed mixture, 20% berseem hay, and 20% rice straw. The concentrate feed mixture was composed of ground corn (40%), wheat bran (34%), soybean meal (4%), sunflower meal (15%), sugar cane molasses (3%), limestone (2%), and a mixture of minerals and vitamins (2%). The chemical composition of the experimental basal diet is presented in Table 1. The goats' diets and clean drinking water were divided into equal portions and offered twice daily at 07:00 am and 17:00 pm, and the remaining was recorded during the experiment. The body weight of all goats was recorded biweekly in the morning before feeding, and the feeding requirements were adjusted every two weeks based on changes in weight and milk produced.

Table 1. Chemical composition of ingredients and calculated fed ration.

	DM	Chemical composition (% on dry matter basis)*					
		OM	CP	CF	EE	NFE	Ash
Concentrate feed mixture	89.63	91.60	14.76	14.31	2.74	59.79	8.40
Berseem hay	88.81	88.13	12.31	27.42	2.44	45.96	11.87
Rice strow	87.89	83.26	2.69	35.38	1.73	43.46	16.74
Ration	89.12	89.24	11.86	21.15	2.48	53.75	10.76

***DM, dry matter; OM, organic matter; CP, crude protein; CF, crude fiber; EE, ether extract; NFE, nitrogen-free extract.**

Digestibility Coefficients and Feeding Values

At the end of the study, a random selection of four goats was made from each group. These goats were introduced to metabolic cages for a week to acclimate, during which they underwent a preliminary period, followed by a collection period lasting one week. The daily fecal collections were weighed and thoroughly mixed. Subsamples, representing 20% of each goat's daily fecal output, were taken. These subsamples were then frozen at -20°C until they were combined for the entire collection period. The fecal samples were subjected to a drying process at 65°C for two days, and then ground through a 1 mm mill screen. They were then stored for further analysis. The feed and feces samples were examined for their dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE), and ash content, following the guidelines of the AOAC (2019). The nitrogen-free extract (NFE) was calculated using the formula "NFE=(OM-(CP+EE+CF))". Digestion coefficients were calculated for feeding values and all nutrients in each experimental group. The digestible crude protein (DCP) and total digestible nutrients (TDN) were determined based on the guidelines of the NRC (2001).

Rumen Fluid Parameters

At the end of the digestibility trials, by using a stomach tube the rumen fluid samples were collected before feeding (zero time) and four hours after feeding. These samples were filtered through three layers of gauze without exerting pressure and immediately analyzed for pH value using a pH meter. The concentration of ammonia nitrogen (NH_3-N) was measured following the method outlined by Conway (1957), and the total volatile fatty acids (TVFA's) were determined using the technique described by Warner (1964).

Blood and Serum Parameters

Upon completion of the experiment, from the animals participating in the digestibility trial, two blood samples were obtained from the jugular vein. One sample was collected in heparinized tubes for hematological analysis, while the second sample was collected in un-heparinized tubes. The whole and fresh blood samples were promptly examined to determine their hematological characteristics, including hemoglobin, red blood cells, hematocrit, mean corpuscular hemoglobin concentration (MCHC), and white blood cells (hematology analyzer D-cell 60, Diagon Ltd., Hungary). The serum was separated by centrifugation for 20 minutes at 1800 rpm and stored at -20°C until analysis. The stored serum samples were later analyzed for total protein, albumin, alanine amino-transferase (ALT), aspartate amino-transferase (AST), glucose, triglycerides, cholesterol, creatinine, calcium, and phosphorus. These determinations were carried out by using commercial kits (Bio-Merieux, Craponne, France) and spectrophotometer (Jenway 6715 UV/Vis, Jenway Techne Inc., USA).

Milk Yield and Composition

Each goat daily milk yield was recorded, and biweekly milk samples (approximately 20 mL/goat) were collected using a sterile sample tube with a screw cap from the morning milking throughout the 90-day experimental period. Prior to collecting the samples, the udder and teats were cleansed using a moist cotton pad, and the initial streams of milk were discarded. The samples were promptly transferred in an icebox at 4°C to determine milk composition and somatic cell count (SCC). The pH and chemical composition of the milk samples, including total solids, fat, protein, solid-not-fat, lactose, and ash, as well as the somatic cell count, were determined using a Bentley 150 infrared milk analyzer calibrated for goat's milk (Bentley Instruments, Chaska, MN, USA). The equation that relates goat milk production to fat-corrected milk (FCM) with a fat content of 4% was FCM = Milk yield (0.411+0.147×fat %) (Mavrogenis and Papachristoforou, 1988).

Physiological Parameters

The physiological parameters of the goats were assessed at the end of the experiment on day 90 after birth. The rectal temperature was measured using a standard clinical thermometer inserted into the rectum approximately 8 cm deep for 2 minutes, with measurements recorded to the nearest 0.01°C. The skin temperature was measured using an infrared medical thermometer (Total, THIT010381). The respiratory rate was assessed by tallying the frequency of abdominal motions within a minute. The pulse rate was measured by touching the femoral arteries of the hind limb with the fingertips for a duration of one minute.

Body Weights and Feed Conversion

At the start of the experiment, the initial body weight of the goats was measured prior to their morning feeding, and this measurement was recorded twice a month. The body weight changes, average daily body weight changes, and daily feed intake were estimated. The feed conversion ratio was calculated using a ratio of the kilogram of feed intake as dry matter, total digestible nutrient, and digestible crude protein to one kilogram of milk yield.

Statistical Analysis

The data collected was subjected to analysis using the general linear model (GLM) procedure in SAS version 9.3 (SAS Institute Inc., Cary, NC, USA). The following model was employed: $Y_{ij} = \mu + T_i + E_{ij}$. In this model, Y_{ij} represents the studied traits, μ represents the overall mean, T_i represents the effect of treatments (i.e., G1, G2, G3, and G4), and E_{ij} represents the experimental error. The data was presented as mean values with standard error of the mean. Significant differences among means were determined using Duncan multiple tests (Duncan, 1955). A p-value of less than 0.05 was considered statistically significant.

RESULTS AND DISCUSSION

Feed Intake and Water Consumption

The effects of Echinacea purpurea, Chamomile flowers, and their mixture supplementation on feed intake and water consumption of lactating Zaraibi goats are shown in Table 2. The average daily feed intake varied among the experimental treatments, but the differences were not significant. The highest average daily feed unit intake (p<0.05) was observed in the G4 treatment compared to the control group G1, as total digestible nutrient and digestible crude protein increased by about 6.1% and 7.0%, respectively. The average daily water consumption and daily water consumption per dry matter intake were slightly higher with in the G4 treatment compared to the control group G1, while no significant differences were detected. However, there were no significant differences between the dietary individual supplementation of Echinacea purpurea and Chamomile flowers groups G2 and G3 compared to control group. These findings indicate that the mixture of Echinacea purpurea and Chamomile flowers had a positive effect on feed unit intake and water consumption, rather than the individual supplement.

Table 2. Effect of Echinacea purpurea, Chamomile flowers, and their mixture supplementation on feed intake and water consumption of lactating Zaraibi goats.

	Experimental treatments*				SEM
	G1	G2	G3	G4	
Av. daily feed intake as DM basis, kg					
Concentrate feed mixture	0.966	0.976	0.978	0.989	0.03
Berseem hay	0.320	0.325	0.327	0.328	0.01
Rice strow	0.324	0.326	0.325	0.332	0.01
Av. daily feed unit intake, kg					
Dry matter	1.610[b]	1.627[ab]	1.630[ab]	1.649[a]	0.03
Total digestible nutrient	1.033[b]	1.084[ab]	1.074[ab]	1.100[a]	0.03
Digestible crude protein	0.119[b]	0.125[ab]	0.122[ab]	0.128[a]	0.01
Av. daily water consumption					
Water consumption, L	4.890	5.050	5.067	5.111	0.09
Water consumption, L/kg DMI	3.037	3.104	3.109	3.099	0.13

***a, b, and c: means in the same row with different superscripts are significantly different (p<0.05). G1: control without supply, G2: 1.0g Echinacea/kg diet, G3: 1.0g Chamomile/kg diet; G4: 0.5g Echinacea+0.5g Chamomile/kg diet. DMI; dry matter intake. SEM; standard error of the mean.**

In previous studies, the effect of mixing the Echinacea purpurea and Chamomile flowers as additives in animal diet was not comprehensively studied, but the effect of each of them was studied individually.

However, the current findings are consistent with previous research. Studies by Khattab *et al.* (2018, 2021) demonstrated that incorporating Chamomile at levels of 5 or 10 g/100 kg BW/day in the diets of Frafra ewes and Frafra lambs significantly improved their daily dry matter and total digestible nutrient intake. Similarly, Ahmed *et al.* (2019) also observed a slight linear increase in daily feed intake when offering Chamomile at levels of 1, 2, and 3 g/head/day to lactating Zarabi goats. In contrast, El-Kholany *et al.* (2015, 2017) concluded that Baladi cows exhibited similar dry matter intake when their diets were supplemented with two levels of Chamomile flowers (5 or 10 g/100 kg BW/day) compared to the control ration. Furthermore, Hussein *et al.* (2018) investigated the dry matter intake of Zaraibi dairy goats and found that supplementation with 0.25% Chamomile flowers did not significantly impact their intake. Likewise, Wu *et al.* (2018) reported that lambs supplemented with 100 mg/kg BW/day of Echinacea exhibited similar average dry matter intake compared to those fed the control ration. Tantawi *et al.* (2023) conducted a study with Ossimi lambs and found that supplementation of Echinacea at levels of 4 and 8 g/head/day did not significantly affect their dry matter intake compared to the control group. Collectively, mentioned studies support the notion that incorporating Echinacea and Chamomile combination in animal diets can positively influence feed intake.

Digestibility and Feeding Values

Table 3 presented the effect of Echinacea purpurea, Chamomile flowers, and their mixture on nutrients digestibility and feeding values of lactating Zaraibi goats. The digestibility coefficients of dry matter, organic matter, ether extract, and nitrogen-free extract varied among the treatments, but the differences were not significant. However, the G4 treatment showed improved digestibility coefficients ($p<0.05$) compared to G1 in terms of crude protein and crude fiber by about 4.9% and 7.3%, respectively. Regarding the feeding values, the total digestible nutrient increased by about 3.8% and the digestible crude protein increased ($p<0.05$) by about 5.2% in the G4 treatment compared to G1. These findings indicate that the mixture of Echinacea and Chamomile supplementation had a positive effect on nutrients digestibility for crude protein and crude fiber, as well as the feeding values.

Table 3. Effect of Echinacea purpurea, Chamomile flowers, and their mixture supplementation on nutrients digestibility and feeding values of lactating Zaraibi goats.

	Experimental treatments*				SEM
	G1	G2	G3	G4	
Digestibility coefficients, %					
Dry matter	69.83	72.49	72.63	73.21	0.79
Organic matter	71.15	73.70	73.82	74.39	0.91
Crude protein	63.02[b]	66.43[a]	64.46[ab]	66.87[a]	0.48
Crude fiber	53.31[b]	55.58[ab]	55.67[ab]	57.20[a]	0.78
Ether extract	73.87	74.79	77.04	76.41	0.87
Nitrogen-free extract	77.23	79.91	78.77	79.41	0.56
Feeding values, %					
Total digestible nutrient	64.18	66.60	65.86	66.69	0.12
Digestible crude protein	7.37[b]	7.70[a]	7.47[ab]	7.75[a]	0.06

***a and b: means in the same row with different superscripts are significantly different (p<0.05). G1: control without supply, G2: 1.0g Echinacea/kg diet, G3: 1.0g Chamomile/kg diet; G4: 0.5g Echinacea+0.5g Chamomile/kg diet. SEM; standard error of the mean.**

The inclusion of herbal feed additives for ruminants has been found to promote digestive functions by aiding rumen microorganisms, as noted by Wójtowski *et al.* (2019) and Chen *et al.* (2022). These additives specifically influence the proliferation of beneficial LAB (probiotic lactic acid bacteria), which plays a crucial role in maintaining microbial balance within the gastrointestinal system (Foksowicz-Flaczyk *et al.*, 2022). These supplements have been found to promote the growth and colonization of lactic acid bacteria, which contribute to the maintenance of microbial balance and stability in the gastrointestinal tract (Foksowicz-Flaczyk *et al.*, 2022).

Research conducted on goats has demonstrated that the inclusion of herbal supplements in their diets has a beneficial impact on their digestive processes. The findings of current study align with previous research conducted by Hussein *et al.* (2018), who found that supplementing lactating Zaraibi goats with 0.25% Chamomile flowers resulted in significantly higher digestibility of nutrients and improved feeding values compared to the control group ($p<0.05$). Similarly, EL-Basiony *et al.* (2015) observed that lactating Damascus goats exhibited significantly enhanced nutrient digestibility coefficients when supplemented with 4.0 g/head/day of Echinacea purpurea ($p<0.05$). Additionally, El-Kholany *et al.* (2015, 2017) concluded that the supplementation with Chamomile at 5 and 10 g/100 kg BW/day in the diets of Baladi cows led to significant improvements in the digestibility coefficients of dry matter, crude fiber, and crude protein, as well as total digestible nutrients and digestible crude protein.

Moreover, Wu *et al.* (2018) found that lambs provided with Echinacea supplementation at a dosage of 100 mg/kg/day exhibited increased acid detergent fiber digestibility compared to the control group ($p<0.05$). Similarly, Khattab *et al.* (2018, 2021) discovered that incorporating Chamomile at levels of 5 or 10 g/100 kg BW/day in the diets of Frafra ewes and Frafra lambs significantly improved nutrient digestibility coefficients and feeding value. Furthermore, Tantawi *et al.* (2023) demonstrated that supplementing Ossimi lambs with Echinacea purpurea at levels of 4 and 8 g/head/day significantly enhanced ($p\leq0.01$) all nutrient digestibility coefficients and feeding value compared to the control group.

Ruminal Parameter

The Echinacea purpurea, Chamomile flowers, and their mixture supplementation showed lower rumen pH values at zero time and 4 h compared to control groups, but the differences were not significant (Table 4). The differences of ruminal NH3-N concentrations at zero time were not significant, while the dietary supplementation decreased ($p<0.05$) the ruminal NH3-N concentrations at 4 h of sampling time compared to control group. The total VFA's increased by approximately 7.9% in the G4 treatment at 4 h of sampling time compared to G1. However, the decreased values of pH, ammonia-N, and increased total VFA's as a result of the Echinacea purpurea and Chamomile flowers mixture dietary supplement suggesting improved ruminal acid-base balance and fermentation.

Table 4. Effect of Echinacea purpurea, Chamomile flowers, and their mixture supplementation on ruminal parameter of lactating Zaraibi goats.

	Hour	Experimental treatments*				SEM
		G1	G2	G3	G4	
pH	0	6.87	6.81	6.74	6.72	0.03
values	4	5.81	5.62	5.63	5.61	0.02
Ammonia-N,	0	16.75	16.38	16.43	16.40	0.30
mg/100ml	4	22.43[a]	21.01[b]	21.31[b]	21.07[b]	0.33
Total VFA'S,	0	9.21	9.11	9.13	9.15	0.05
meq/100ml	4	11.51[b]	12.21[ab]	12.37[ab]	12.43[a]	0.11

***a and b: means in the same row with different superscripts are significantly different (p<0.05). G1: control without supply, G2: 1.0g Echinacea/kg diet, G3: 1.0g Chamomile/kg diet; G4: 0.5g Echinacea+0.5g Chamomile/kg diet. SEM; standard error of the mean.**

Ruminal pH serves as a crucial indicator of the balanced state of the rumen environment in ruminant animals. The findings obtained in this study align remarkably well with previous experiments. Generally, earlier studies have consistently shown an increase in the concentrations of VFAs in the rumen. These VFAs are the primary byproducts of the breakdown of carbohydrates in the food consumed by ruminants and provide the majority of the energy precursors necessary for metabolic processes in these animals (Wang *et al.*, 2022).

Hussein *et al.* (2018) investigated the ruminal parameters of Zaraibi dairy goats and discovered that the addition of 0.25% Chamomile flowers significantly influenced ammonia-N levels and resulted in increased concentrations of total VFAs. Similarly, El-Basiony *et al.* (2015) demonstrated that the pH, total VFAs, and ammonia levels in lactating Damascus goats were significantly impacted (p<0.05) when they were fed a basal diet mixed with 4g of Echinacea per head per day. The results of the rumen parameters in Zaraibi bucks, who were supplemented with 5 and 10 g of Chamomile per 100 kg of body weight per day in their diets, indicated that there were no significant differences in pH value and ammonia-N levels among the groups, however, the concentrations of VFAs increased significantly at four hours after feeding (El-Kholany *et al*., 2015). Additionally, when examining the rumen parameters of Rahmani rams supplemented with 5 and 10 g of Chamomile per 100 kg of body weight per day in their diets, it was observed that the pH values remained unaffected, while the ammonia-N levels decreased, and the concentrations of total VFAs increased with the 10g Chamomile/ 100 kg BW/ day diet compared to the control group (El-Kholany *et al*., 2017). The concentration of NH3-N can provide insights into the breakdown of nitrogenous substances in the diet and the utilization of ammonia by microorganisms present in the rumen, furthermore, rumen microorganisms can synthesize some NH3-N to create microbial protein (Wang *et al*., 2022).

Blood and Serum Parameters

Echinacea purpurea, Chamomile flowers, and their mixture supplementation affected some blood and serum parameters of lactating Zaraibi goats (Tables 5 and 6).

Hemoglobin, MCHC, lymphocytes, total protein, globulin, AST, ALT, cholesterol, creatinine, and urea values varied (p<0.05) among the treatments. The groups of Echinacea purpurea G2 and its mixture with Chamomile flowers G4 showed the highest (p<0.05) values of hemoglobin, MCHC, lymphocytes, total protein, and globulin, followed by Chamomile flowers supplemented group G3. The serum values of AST, ALT, cholesterol, creatinine, and urea values decreased (p<0.05) by dietary supplementation compared to control group, while without significant differences among treated groups. Although the calcium and phosphorus concentrations increased by supplementations, no significant differences were observed.

Serum biochemical values play a crucial role in assessing the health status of animals reliably (Gabr *et al*., 2023). The enzymes ALT and AST in the serum serve as indicators of liver function, vital for maintaining metabolic homeostasis in the body (Makawana *et al*., 2022). Moreover, creatinine, a substance produced during muscle metabolism and eliminated through glomerular filtration, can serve as a marker for kidney function (Thiet *et al*., 2022). Furthermore, blood urea is regarded as an indicator of protein intake or breakdown (Pelegrin-Valls *et al*., 2020). However, El-Basiony *et al*. (2015) found that lactating Damascus goats supplemented with 4g of Echinacea/head/day exhibited slightly elevated total protein, albumin, and globulin values, along with decreased creatinine and ALT levels, conversely, the concentrations of cholesterol, triglycerides, and AST were not significantly affected. Baladi growing calves fed a diet containing 10 g of Chamomile flowers per 100 kg of body weight per day showed significant increases in hemoglobin, serum total protein, and total lipid values (El-Kholany *et al*., 2017). Khattab *et al*. (2018) reported significant increases in hemoglobin, total protein, and glucose levels when adding 5 and 10 g of chamomile/10 kg of body weight/day to ewe rations, with no significant differences between the two Chamomile levels.

Table 5. Effect of Echinacea purpurea, Chamomile flowers, and their mixture supplementation on blood hematological parameters of lactating Zaraibi goats.

	Experimental treatments				SEM
	G1	G2	G3	G4	
Hemoglobin, g/dl	11.31[b]	12.11[a]	11.71[ab]	12.19[a]	0.23
Red blood cells, x10^6/µl	11.97	12.53	12.31	12.71	0.33
MCHC, %	34.31[b]	38.17[a]	36.47[ab]	38.65[a]	0.51
Hematocrit, %	32.95	31.71	32.11	31.53	0.71
White blood cells, x10^3/µl	10.01	9.73	9.81	9.57	0.51
Lymphocytes, %	47.50[c]	52.10[a]	50.30[ab]	53.05[a]	1.53
Neutrophils, %	43.90	41.05	42.10	40.05	1.31
Monocytes, %	5.30	4.10	4.50	3.90	0.21
Eosinophils, %	2.50	1.60	1.75	1.65	0.11
Basophils, %	1.80	1.30	1.35	1.40	0.09

[*]a, b, and c: means in the same row with different superscripts are significantly different (p<0.05). G1: control without supply, G2: 1.0g Echinacea/kg diet, G3: 1.0g Chamomile/kg diet; G4: 0.5g Echinacea+0.5g Chamomile/kg diet. MCHC; mean corpuscular hemoglobin concentration. SEM; standard error of the mean.

Table 6. Effect of Echinacea purpurea, Chamomile flowers, and their mixture supplementation on serum biochemical parameters of lactating Zaraibi goats.

	Experimental treatments				SEM
	G1	G2	G3	G4	
Total protein, g/dl	6.28[c]	6.95[a]	6.61[b]	6.99[a]	0.16
Albumin, g/dl	3.50	3.60	3.54	3.64	0.05
Globulin, g/dl	2.78[c]	3.34[a]	3.07[b]	3.36[a]	0.03
ALT, IU/L	23.20[a]	21.70[b]	21.81[b]	21.53[b]	1.01
AST, IU/L	47.31[a]	43.53[b]	45.03[b]	43.37[b]	1.70
Glucose, mg/dl	74.90	77.71	75.70	77.84	3.85
Triglycerides, mg/dl	53.85	52.34	53.28	51.55	2.97
Cholesterol, mg/dl	79.53[a]	71.73[c]	75.11[b]	71.03[c]	3.01
Creatinine, mg/dl	1.48[a]	1.23[b]	1.24[b]	1.23[b]	0.07
Urea, mg/dl	49.93[a]	47.31[ab]	48.13[ab]	46.01[b]	2.01
Calcium, mg/dl	10.81	10.95	11.03	11.05	0.14
Phosphorus, mg/dl	5.61	5.70	5.77	5.81	0.07

[*]a, b, and c: means in the same row with different superscripts are significantly different (p<0.05). G1: control without supply, G2: 1.0g Echinacea/kg diet, G3: 1.0g Chamomile/kg diet; G4: 0.5g Echinacea+0.5g Chamomile/kg diet. AST; aspartate amino-transferase. ALT; alanine amino-transferase. SEM; standard error of the mean.

Furthermore, Wu *et al*. (2018) discovered that lambs fed 100 mg/kg of body weight per day of Echinacea exhibited increased alkaline phosphatase and globulin levels, as well as reduced blood urea nitrogen and albumin, compared to lambs in the control group. Khattab *et al*. (2021) observed that the addition of chamomile at 5 and 10 g/100 kg of body weight/day resulted in increased serum total protein, albumin, and globulin levels, as well as decreased creatinine and cholesterol values in Farafra lambs, although hematological parameters were not significantly affected. Tantawi *et al*. (2023) found that supplementation of Ossimi lambs' diets with 8 and 12g of Echinacea/head/ day led to increased total protein, albumin, and glucose levels, while decreased triglycerides, AST, ALP, and cholesterol values.

In contrast, El-Kholany *et al*. (2015) revealed that most blood constituents tested were not significantly affected by the diet containing 5 and 10g of Chamomile per 100 kg of body weight/day during the late pregnancy and lactation periods in Baladi cows. Similarly, the serum total protein, albumin, and globulin levels in Farafra ewes tended to insignificantly increase with supplementation of 0.5 and 1 g of Chamomile per 10 kg of body weight per day, while serum AST, ALT, creatinine, and urea concentrations did not significantly differ among groups (Saleh and Abozed, 2018). Ahmed *et al.* (2019) reported that most hematobiochemical parameters in lactating Zaraibi goats were not significantly affected by Chamomile supplementation at levels of 1, 2, and 3 g/head/day. Ganjavi *et al.* (2022) found no significant differences in blood metabolite concentrations when Holstein calves' diets were supplemented with 350, 700, and 1050 mg of Echinacea/day.

Milk Production, Composition, and Quality

The effect of Echinacea purpurea, Chamomile flowers, and their mixture supplementation on milk production, composition, and quality of lactating Zaraibi goats are presented in Table 7. The Echinacea treatment and its mixture with Chamomile resulted in significant increases ($p<0.05$) in average daily milk yield compared to control group by about 11.2% and 15.0%, respectively, and as 4% fat corrected milk yield by about 15.7% and 17.5%, respectively. The fat and total solids percentages in milk showed an improvement of approximately 9.1% and 5.2%, respectively, in the mixture supplemented group than the control group. However, without significant differences among treated groups, the dietary supplementation decreased ($p<0.05$) the somatic cell count compared to control group. However, the Echinacea purpurea and Chamomile flowers mixture supplementation increased milk yield, 4% fat corrected milk yield, milk fat and total solids percentages, as well as decreased milk somatic cell count compared to control group.

Table 7. Effect of Echinacea purpurea, Chamomile flowers, and their mixture supplementation on milk production, composition, and quality of lactating Zaraibi goats.

	Experimental treatments*				SEM
	G1	G2	G3	G4	
Av. daily milk yield, kg					
Actual milk yield	1.145[c]	1.290[a]	1.231[b]	1.317[a]	0.02
4% fat corrected milk yield	1.031[c]	1.219[a]	1.134[b]	1.251[a]	0.04
Milk composition, %					
Fat	3.31[b]	3.61[a]	3.45[ab]	3.63[a]	0.12
Protein	2.81	2.90	2.83	2.91	0.11
Lactose	4.51	4.65	4.55	4.67	0.10
Total solids	11.36[b]	11.91[a]	11.57[ab]	11.96[a]	0.15
Solids not fat	8.05	8.30	8.12	8.33	0.13
Ash	0.73	0.74	0.74	0.75	0.01
Milk quality					
pH values	6.65	6.62	6.64	6.63	0.01
Acidity, %	0.17	0.16	0.17	0.16	0.01
SCC, x10^3 cell/ml	611[a]	451[b]	505[b]	475[b]	15.8

***a and b: means in the same row with different superscripts are significantly different ($p<0.05$). G1: control without supply, G2: 1.0g Echinacea/kg diet, G3: 1.0g Chamomile/kg diet; G4: 0.5g Echinacea+0.5g Chamomile/kg diet. SCC; somatic cell count. SEM; standard error of the mean.**

The increased milk yield and milk composition of fat and total solids obtained in the current results can be attributed to the enhanced ability of the goats to digest and absorb essential nutrients, such as crude protein and crude fiber, which are facilitated by the addition of Echinacea and its mixture with Chamomile to goats' diet. However, it is important to note that the nutrients derived from the diet play a vital role in supporting milk synthesis and secretion in the mammary gland. When animals can effectively break down and absorb nutrients from their diet, it results in a more abundant supply of nutrients that support the production of various milk components. Additionally, the composition of the diet itself influences the composition of the milk produced.

According to El-Basiony *et al.* (2015), the supplementation of 4g of Echinacea/head/day resulted in increased milk yield, milk lactose, and total solids contents, as well as a decrease in somatic cell count in lactating Damascus goats. El-Kholany *et al.* (2015) found that adding 5 and 10 g of Chamomile per 100 kg of body weight/day to the diet of Baladi cows increased daily milk yield, while milk composition was not significantly affected by either of the two levels of Chamomile. Similarly, Ahmed *et al.* (2019) suggested that increasing chamomile levels in the diet of Zaraibi goats, particularly at high levels (3 g/head/day), resulted in increased daily milk production and decreased somatic cell count, while milk composition remained unaffected. However, Khattab *et al.* (2018) observed that daily milk yield increased in Farafra ewes when their diets were supplemented with 5 and 10 g of Chamomile/10 kg of body weight/day, additionally, higher level of Chamomile led to significant increases in the percentages of fat, lactose, and total solids, while reducing the milk somatic cell count. Contrarily, Hussein *et al.* (2018) reported that milk yield and composition were not significantly affected by the inclusion of 0.25% Chamomile in the diet of Zaraibi dairy goats.

Physiological Parameters

The physiological responses of dairy Zaraibi goats to the Echinacea and Chamomile supplementation presented in Table 8. The results showed that dietary supplementation of Echinacea and Chamomile did not have a significant impact on the goats' respiration rate, pulse rate, rectal temperature, and skin temperature. However, it is important to consider that various factors can influence animal physiological parameters, and nutrition plays a vital role in maintaining these parameters within normal ranges. The metabolic rate of an animal has a direct influence on its physiological parameters, and nutrition, particularly the intake of energy, plays a crucial role in determining the metabolic rate. Insufficient energy intake can lead to a decrease in body temperature, reduced activity, and changes in respiration and pulse rates. Conversely, excessive energy intake can result in increased metabolic heat production, leading to elevated body temperature and heart rate. However, generally, the current observed values in the experimental groups indicate that the goats were in good health condition, which is consistent with previous studies by Maged *et al.* (2017) and Ahmed *et al.* (2019) regarding lactating Zaraibi goats.

Table 8. Echinacea purpurea, Chamomile flowers, and their mixture supplementation on physiological parameters of lactating Zaraibi goats.

	Experimental treatments*				SEM
	G1	G2	G3	G4	
Respiratory rate, breath/min	20.30	19.53	19.05	19.71	0.63
Pulse rate, beat/min	82.51	81.70	82.05	80.90	1.51
Rectum temperature, ºC	38.75	37.85	38.31	37.95	0.81
Skin temperature, ºC	38.31	37.50	37.11	37.71	0.73

***G1: control without supply, G2: 1.0g Echinacea/kg diet, G3: 1.0g Chamomile/kg diet; G4: 0.5g Echinacea+0.5g Chamomile/kg diet. SEM; standard error of the mean.**

Body Weight and Feed Utilization

In Table 9, the effects of Echinacea purpurea (G2), Chamomile flowers (G3), and their mixture (G4) supplementation on the body weights and feed conversion of lactating Zaraibi goats were evaluated. The initial live body weights of the goats across all treatment groups were relatively similar. The final live body weights showed an increase in all groups, without significant differences.

Looking at the body weight changes and average daily body weight changes, results were significantly different ($p<0.05$) among the groups, with G4 (supplemented with the mixture) showing the highest weight gains, followed by G2, and the lowest weight gains was observed in control group G1. The G4 group demonstrated about a 34.3% improvement in both body weight changes and average daily body weight changes compared to control group G1. Feed conversion, which measures the efficiency of converting feed to 4% fat corrected milk yield, was evaluated in terms of dry matter, total digestible nutrient, and digestible crude protein (Table 9). Control group had the highest feed conversion ratio ($p<0.05$) in terms of dry matter, while G4 and G2 had the lowest feed conversion ratio followed by Chamomile supplemented group. Similar trends were observed for feed conversion based on total digestible nutrient and digestible crude protein, with the supplemented groups having lower ratio ($p<0.05$) compared to control group. The mixture supplemented group G4 showed 12.3% and 10.5% improvement in feed conversion based on total digestible nutrient and digestible crude protein, respectively compared to control group.

Table 9. Effect of Echinacea purpurea, Chamomile flowers, and their mixture supplementation on live body weights and feed conversion of lactating Zaraibi goats.

	Experimental treatments*				SEM
	G1	G2	G3	G4	
Initial body weight, kg	31.80	32.25	33.10	32.50	3.35
Final body weight, kg	32.95	33.90	34.60	34.35	4.78
Body weight changes, kg	1.15^{d}	1.65^{b}	1.50^{c}	1.75^{a}	0.08
Av. daily body weight changes, g/d	12.78^{d}	18.33^{b}	16.67^{c}	19.44^{a}	1.47
Feed conversion, kg intake/kg 4% FCM yield					
Dry matter	1.572^{a}	1.336^{c}	1.438^{b}	1.319^{c}	0.06
Total digestible nutrient	1.003^{a}	0.889^{b}	0.947^{ab}	0.880^{b}	0.05
Digestible crude protein	0.114^{a}	0.104^{b}	0.108^{b}	0.102^{b}	0.01

***a, b, and c: means in the same row with different superscripts are significantly different ($p<0.05$). G1: control without supply, G2: 1.0g Echinacea/kg diet, G3: 1.0g Chamomile/kg diet; G4: 0.5g Echinacea+0.5g Chamomile/kg diet. SEM; standard error of the mean. FCM; fat corrected milk.**

The observed increase in the changes of body weights and improved feed conversion by the dietary supplementation, particularly with the supplemented mixture, can be attributed to the obtained enhancements in the nutrient digestibility of crude protein and crude fiber, as well as the feeding values (Table 3). However, the obtained improvements in body weights align with increased milk production suggest that the mixture has greater capacity to efficiently utilize feeds compared to the control group to compensate for the nutrient requirements involved in milk production. These findings align with the results reported by Aboulthana *et al.* (2018), who noted improved growth performance possibly due to the role of polyphenolic compounds in chelating metals with prooxidant properties in the intestinal tract, resulting in a lower generation of lipid peroxides through limited intestinal absorption. However, El-Kholany *et al.* (2015) found no significant differences in live body weights when Baladi cows were fed diets supplemented with 5 and 10g of Chamomile/100 kg of body weight/day during late pregnancy and early lactation. In contrast, Hussein *et al.* (2018) demonstrated that Zaraibi goats experienced gradual increases in body weight from kidding to weaning when supplemented with 0.25% Chamomile. Similarly, supplementation of Echinacea purpurea at 4, 8, and 12g per head/day improved the final body weight, weight gain, and growth rate of Osimi lambs compared to the control group (Tantawi *et al.,* 2023).

Regarding feed conversion ratio, Ahmed *et al.* (2019) reported that lactating Zarabi goats exhibited improved feed conversion calculated based on dry matter and crude protein intake per kg of milk yield with increased levels of Chamomile supplementation at 1, 2, and 3 g/head/day compared to the control group. Hussein *et al.* (2018) also found that feed conversion, measured as kg dry matter intake per kg milk yield, improved when Zaraibi goats were supplemented with 0.25% Chamomile compared to the control group. Similarly, El-Kholany *et al.* (2015) observed improved feed conversion based on dry matter, total digestible nutrients, and digestible crude protein intake per kg milk yield when Baladi cows were supplemented with 5 and 10g of Chamomile per 100 kg of body weight/day. In contrast, increasing Echinacea levels up to 12g/head/day led to a significant decrease in feed intake and feed conversion compared to the control group, with the lowest feed conversion recorded for Osimi lambs receiving 8g Echinacea/head/day (Tantawi *et al*., 2023).

Generally, it is important to note that the effects of Echinacea and Chamomile as feed additives on animal performance, productivity, and health were varied in previous studies depending on the animal species, supplementation dosage, duration of supplementation, animals age, and production goals. However, conflicted results existed in the previously mentioned literature, highlighting the importance of current obtained results.

CONCLUSION

Overall, previous studies have shown inconsistent results regarding the effects of individual supplementation of Echinacea and Chamomile in animals' diets, and not all studied parameters responded effectively to these additives. However, the present study has demonstrated significant positive synergistic effects of the combined mixture of Echinacea and Chamomile in various aspects. These findings emphasize the importance of incorporating the current mixture of 0.5g Echinacea and 0.5g Chamomile per kg of diet to enhance lactating Zaraibi goats' performance, productivity, and health. Nevertheless, further investigations are recommended to explore alternative dosage levels of this mixture, as well as its effects on other animal species and under varying production systems and management conditions.

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تحسين الأداء الإنتاجي والحالة الصحية للماعز الزرايبي الحلابة من خلال إضافة الإشنسا بوربوريا و زهرة البابونج والخليط منهما

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الملخص

تناولت هذه الدراسة تأثير إضافة الإشنسا بوربوريا وزهور البابونج وخليطهما على الأداء الانتاجي والحالة الصحية والمؤشرات الفسيولوجية في الماعز الزرايبي الحلابة. تم تقسيم ثمانية وعشرون ماعز زرايبي بوزن ٣٢,٣٨±٣,٣٥ كجم عشوائياً إلى أربع مجموعات متساوية بعد الولادة. تم تغذية المجموعة الأولى على العليقة الأساسية بدون إضافات، في حين تمت إضافة ١,٠ جرام اشنسا/كجم علف، ١,٠ جرام بابونج/كجم علف، وخليط من ٠,٥ جرام اشنسا+ ٠,٥ جرام بابونج/كجم علف، للمجموعات الثلاث الأخرى على التوالي. أظهرت النتائج أن الاضافات الغذائية أدت إلى زيادة الوحدة المأكولة من الغذاء، وهضم العناصر الغذائية خاصة البروتين الخام والألياف الخام، وتحسن القيمة الغذائية، وكذلك أدت لزيادة إجمالي الأحماض الدهنية الطيارة في الكرش، مع ملاحظة وجود الفروق المعنوية (p<0.05) بين مجموعة الخليط والمجموعة المقارنة. تأثرت مؤشرات الدم، بما في ذلك الهيموجلوبين ومتوسط تركيز الهيموجلوبين لكرات الدم والخلايا الليمفاوية، بشكل إيجابي (p<0.05) بواسطة اضافة الإشنسا وخلطها مع البابونج مقارنة بالمجموعة المقارنة. أدت الاضافات الغذائية إلى تحسن (p<0.05) في تركيز البروتين الكلي والجلوبيولين وأنزيمات الكبد والكوليسترول والكرياتينين واليوريا. أدت إضافة الإشنسا وخلطها مع البابونج إلى زيادة (p<0.05) في إنتاج الحليب اليومي ومحتوى الدهن ونسبة المواد الصلبة الكلية، في حين أدت إلى انخفاض عدد الخلايا الجسدية في الحليب مقارنة بالمجموعة المقارنة. لم تتأثر المؤشرات الفسيولوجية للماعز بالإضافات الغذائية. أظهرت الإضافات الغذائية أيضًا تغيرات ايجابية (p<0.05) في وزن جسم الماعز ومعدل تحويل الأعلاف لكل كيلوجرام من إنتاج الحليب، حيث أظهرت مجموعة الخليط تحسينات معنوية. بشكل عام، يشير تحسن الحالة الصحية وأوزان الجسم مع ارتفاع إنتاج الحليب ومكوناته إلى أهمية دمج الخليط من الإشنسا والبابونج كإضافة غذائية في ممارسات الرعاية الغذائية للماعز الزرايبي الحلابة.