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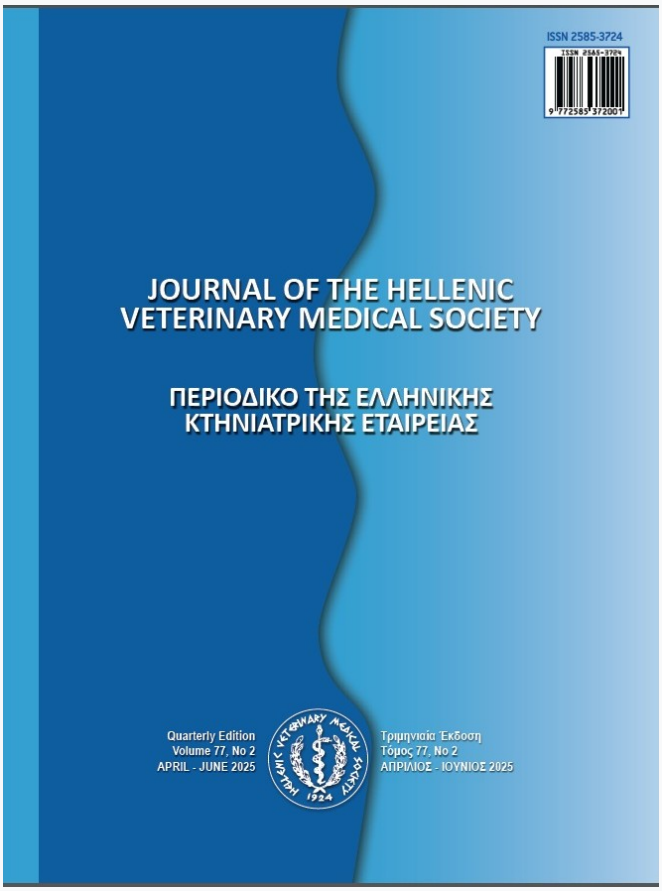

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Effects of garlic powder extract on selected fecal characteristics and health of neonatal Saanen goat kids

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ABSTRACT: Twenty-seven newborn goat kids were used to investigate the effects of garlic powder extract supplementation on selected fecal characteristics, body weight (BW), average daily weight gain (ADG), occurrence of diarrhea and hematological traits. Kids were assigned to one of the three groups (C: control group, G1: group supplemented with 50 mg/kg BW garlic product, G2: group supplemented with 100 mg/kg BW garlic product) at 3 days of age. Each group consisted of 9 kids. Each kid in G1 and G2 was supplemented with 50 or 100 mg/kg BW/day garlic powder extract from 3 days to 28 days of age, respectively, whereas the kids in C did not receive garlic product. There were no differences (P>0.05) in BW, ADG, fecal score and body temperature among the groups. There were no differences (P>0.05) in fecal pH at 3 and 21 days of age among the groups, whereas fecal pH was lower for G1 in comparison to C at 7 days of age and G2 had a higher fecal pH than C and G1 at 28 days of age (P=0.05). Fecal total coliform population results were not different (P>0.05) among the groups. The mean numbers of days with diarrhea were not statistically different among the groups (P>0.05) but were numerically decreased in G1 and G2 compared with C. No difference (P>0.05) in the incidence of diarrhea was found among the groups. The incidence of diarrhea was numerically higher for G2 in comparison to C while G1 had a lower incidence of diarrhea numerically than group C. There were no differences (P>0.05) in total white blood cell, lymphocytes, neutrophils, monocytes and eosinophils counts at 29 days of age. G1 had a lower basophils concentration (P=0.05) than C and G2. Based on the results of fecal pH, it can be reported that garlic product supplementation had no consistent effect on fecal pH. Because of both decreased mean number of days with diarrhea in G1 and a lower incidence of diarrhea in G1 compared with C, it may be stated that 50 mg/kg BW/day of garlic product helps to decrease the occurrence of diarrhea in newborn kids.

Keyword: Saanen kids; garlic; fecal characteristics.

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INTRODUCTION

Garlic (*Allium sativum*) has been used as a medicinal herb and growth promoter in animals (Ghosh et al., 2010; Shokrollahi et al., 2016; Duvvu et al., 2018; Ding et al., 2023). It has been reported that garlic has antiparasitic, antioxidant, anti-inflammatory, antibacterial, antifungal, and immune enhancer effects and these potential benefits of garlic are generally attributed to its organosulphur compounds (Tsai et al., 2012; Ding et al., 2023). The primary organosulphur compounds are ɣ-glutamyl-S-allyl-L-cysteines, which are hydrolyzed and oxidized to yield alliin during storage (Matsuura, 1997; Keyu et al., 2019). Alliin is converted to allicin, an active secondary metabolite, via enzymatic reactions when raw garlic is crushed, cut, or chewed. Allicin is considered to be responsible for most of the pharmacological activity of crushed raw garlic (Amagase, 2006; Keyu et al., 2019).

Studies in animals have shown that garlic or different garlic products can alter microbial populations of feces (Ghosh et al., 2010), fecal score (Ghosh et al., 2010; Ghosh et al., 2011) and hematological parameters (Shokrollahi et al., 2016; Afele et al., 2020; Kairalla et al., 2022) and have the potential to positively affect host health (Kewan et al., 2021; Özkaya et al., 2023) and growth performance (Ghosh et al., 2010; Ghosh et al., 2011; Shokrollahi et al., 2016).

Survival of newborn kids is an important determinant of profitability in goat farms. Mortality in preweaning kids is one of the major factors causing significant economic losses (Shokrollahi et al., 2013; Petros et al., 2014; Chauhan et al., 2019). Newborn animals are exposed to a variety of environmental and physiological stress and immunological challenges. It has been reported that the period of greater mortality risk is during the first weeks of life of the kid and the main causes of mortality are hypothermia, starvation, maternal undernutrition, bad maternal care, infections and accidents (Shokrollahi et al., 2013; Dwyer et al., 2016; Chauhan et al., 2019). During the preweaning period, especially the first month of life, diarrheal disorders are considered to be the most common causes of neonatal kid loss throughout the world (Smith and Sherman, 2009; Petros et al., 2014).

Since the use of antibiotics causes residue in foods and pathogen resistance, in recent years, more attention has been paid to the use of herbal feed additives or phytochemicals in animal nutrition for disease prevention, health and growth performance (El-Naggar and Ibrahim, 2018; Kekana et al., 2020; Ding et al., 2023). Garlic has been one of the most researched herbal remedies (Tsai et al., 2012; Özkaya et al., 2023). The effects of garlic or different garlic products on growth performance and health status have been investigated in calves (Ghosh et al., 2010; Özkaya et al., 2023), lambs (El-Naggar and Ibrahim, 2018) and kids (Shokrollahi et al., 2016) and some information is available on effects of supplementing garlic in selected species mentioned above. However, data on the efficacy of garlic are variable due to the different forms, daily dose and supplementation duration of garlic used in the studies and animal characteristics (species, age, health status) and are not yet fully conclusive. The study aimed to evaluate the effects of garlic powder extract supplementation on fecal score, fecal pH, fecal concentration of total coliform, body weight, average daily weight gain, the occurrence of diarrhea and hematological traits in Saanen kids.

MATERIALS AND METHODS

Study Area and Animals

The study was carried out at Bursa Uludag University Applied Research Center for Veterinary Faculty Unit in Bursa, Türkiye. This study was conducted under a protocol approved by the Animal Care and Use Committee of Bursa Uludag University (decision no. 2020-10/01).

Twenty-seven newborn Saanen kids (18 female and 9 male) were used in this study. The kids were sorted by parity of their dams and assigned to one of the three groups (C: control group, G1: the group supplemented with 50 mg/kg BW garlic powder extract, G2: the group supplemented with 100 mg/kg BW garlic powder extract) at 3 days of age. Each group consisted of 9 Saanen kids (6 female and 3 male).

Management and Experimental Design

The kids were housed with their dams in a paddock equipped with feeders and waterers, with straw bedding, for the first 45 days after birth. At 45 days of age, kids were separated from their dams and housed in another paddock equipped with feeders and waterers, with straw bedding, until weaning (60 days after birth). During the suckling period from day 45 to 60, kids were given 12 hours of access to the dam. The kids and their dams had free access to drinking water, pelleted concentrate (Matlı Feed Industry, Karacabey, Bursa, Türkiye), and alfalfa hay

during the suckling period. Nutrient analyses (dry matter, crude protein, ether extract, and crude ash) of pelleted concentrate and alfalfa hay were performed according to AOAC (2003). Neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) values of pelleted concentrate and alfalfa hay were analyzed as described by Van Soest et al. (1991). Nutrient compositions of pelleted concentrate and alfalfa hay were presented in Table 1. During the suckling period, kids were closely monitored to ensure sufficient sucking. Each kid in G1 was supplemented with 50 mg/kg BW/day garlic powder extract (Talya Herbal Products Co., Ltd., Kepez, Antalya, Türkiye) from 3 days to 28 days of age. Each kid in G2 was supplemented with 100 mg/kg BW/day garlic powder extract (Talya Herbal Products Co., Ltd., Kepez, Antalya, Türkiye) from 3 days to 28 days of age, whereas the kids in C did not receive garlic powder extract. The garlic powder extract used in the study was dissolved in 10-fold (weight/weight) with distilled water and was administered orally to the kids in G1 and G2 via a syringe. The daily dose of garlic powder extract was determined by body weight measurement every week. The garlic powder extract contained 4.22 % allicin according to the analysis reported by Talya Herbal Products Co., Ltd. Garlic powder extract was obtained by the transformation of a garlic juice extract into a dried powder using spray drying technique. During the study, garlic powder extract was stored in a sealed container at 4 °C. In previous studies, different doses of garlic have been used depending on the different types or forms of garlic product, intended use and animal characteristics (species, age, stage of production, health status). In some previous studies, daily dose of 250 mg/kg BW aqueous garlic extract prepared using garlic bulbs and water was effective in maintaining normal fecal score, decreasing fecal total coliform concentration and increasing ADG. In the current study, lower doses than 250 mg/kg BW were offered since there is a paucity of information on effects of garlic in suckling kids and garlic powder extract was used, unlike aqueous garlic extract in our study.

Table 1. Nutrient compositions of starter concentrate and alfalfa hay on a dry matter basis.

Item	Pelleted Starter Concentrate*	Alfalfa Hay
Dry matter (%)	89.87	90.96
CP (%)	20.57	16.22
Ether extract (%)	4.21	2.13
NDF (%)	24.13	51.91
ADF (%)	12.50	40.83
ADL (%)	3.04	9.92
NFC (%)	42.58	20.54
Ash (%)	8.51	9.20

*: Matlı Feed Industry, Karacabey, Bursa, Türkiye. Contained the main ingredients: ground corn grain, ground barley grain, wheat bran, soya bean oil, soya bean meal, corn gluten meal, sunflower meal, molasses, mineral and vitamin mixture, limestone, salt.

CP: crude protein, NDF: neutral detergent fiber, ADF: acid detergent fiber, ADL: acid detergent lignin, NFC: 100 – (NDF % + CP % + ether extract % + ash %).

Measurements and Sample Collection

Kids were weighed on birthday and 3, 7, 14, 21, 28 and 75 days of age. Average daily weight gain (ADG) was calculated for each kid. Fecal samples were collected daily from each kid by retrieval from the rectum and were scored with respect to consistency by the same researcher on all collection days according to the following system: 1 = watery, diarrhea; 2 = soft, unformed; 3 = soft, formed; 4 = hard, formed; and 5 = hard, dry pellets. At 3, 7, 21 and 28 days of age, each fecal sample was diluted immediately 10-fold with distilled water for pH measurement. The mixture of fecal sample and distilled water was homogenized and fecal pH was immediately measured using an electronic pH meter (pH 80+ DHS, XS Instruments, Italy) fitted with a glass electrode. For fecal total coliform analysis, fresh fecal samples were collected from each kid at 29 days of age (a day after the end of the experimental period) through retrieval from the rectum using sterile gloves. Following collection, fecal samples were placed in sterile sampling bags, immediately packed in ice and transferred within 30 min to the laboratory for fecal coliform enumeration. One g of fecal sample from each animal was aseptically transferred into a sterile stomacher bag and homogenized with 9 ml of saline peptone water in a Stomacher 80 Lab System (Seaward® Inc., Port Saint Lucie, FL, USA) for 2 min. Serial 10-fold dilutions were made in saline peptone water and plated onto relevant selective media. Total coliform was grown on Violet Red Bile agar (VRB, Oxoid CM0107, Basingstoke, Hampshire, UK) using the pour plate technique and the plates with 30 to 300 colonies were used for enumeration after 24 to 48 h of incubation at 37°C. All red colonies with or without halos, except pinpoint colonies, were recorded as coliform. The bacterial

counts were expressed as $\log_{10}$ colony forming units (cfu) per gram of fecal samples. Health status of the kids was monitored daily during the study. Body temperature was measured daily per rectum using a digital thermometer at 30 min after supplementation during the study. Fecal score of one was considered to be diarrhea. In addition, tail and/or hind limbs stained with feces were evaluated as a finding of diarrhea. Kids with diarrhea and kids treated for diarrhea were recorded. Blood samples were taken from the kids via jugular puncture at 2 days of age for measurement of serum total protein with an optical refractometer (Hand-held refractometer, Atago, Sur-Ne, Japan). At 29 days of age (a day after the end of the experimental period), blood samples were collected from each kid via jugular puncture in 10 ml evacuated tubes containing EDTA for total white blood cell (WBC), lymphocyte, neutrophil, monocyte, eosinophil and basophil counts. Hematological traits were measured by a hematology analyzer (VH5R, Hasvet Medical Software and Health Services Co., Ltd., Kepez, Antalya, Türkiye).

Statistical analysis

All statistical analyses were conducted by using Statistical Package for the Social Sciences software (SPSS, 2021). Data for body weight, ADG, fecal score, fecal pH, fecal total coliform concentration, the number of days with diarrhea, body temperature and hematological traits were analyzed by one way ANOVA. According to the results of Leven's test, Duncan or Games-Howell test was chosen as the post test. The incidence of diarrhea was analyzed by Chi-square test and the results were interpreted using Pearson or Fisher exact test. Differences among the groups were considered significant at $P \leq 0.05$.

RESULTS

In the current study, mean serum total protein values were 9.69, 9.59 and 9. 68 g/dl in control group (C), group 1 (G1; 50 mg/kg BW garlic powder extract) and group 2 (G2; 100 mg/kg BW garlic powder extract), respectively, at 2 days of age.

Body weight (BW) and average daily weight gain (ADG) results were presented in Table 2. There were no differences (P>0.05) in mean BW measurements at 3, 28 and 75 days of ages and all mean ADG values among the groups.

Fecal score, fecal pH, fecal total coliform population, the mean number of days with diarrhea and the incidence of diarrhea results were given in Table 3. Fecal score was not different (P>0.05) during the period from 3 days of age to 28 days of age among the groups. There were no differences (P>0.05) in fecal pH at 3 (the beginning of the study) and 21 days of age among the groups. There was a difference in fecal pH at 7 days of age (P=0.05) between C and G1. Fecal pH was lower for G1 in comparison to C at 7 days of age. Fecal pH results were similar at 28 days of age (the end of the study) between C and G1, whereas fecal pH at 28 days of age was higher for G2 in comparison to C and G1 (P=0.05). Fecal total coliform population results were not different (P>0.05) at 29 days of age (the day after the end of the experimental period) among the groups. Mean fecal concentration of total coliform (cfu log10/g fresh feces) was numerically decreased in G1 (8.06) and G2 (8.03) compared with C (8.23). The mean numbers of days with diarrhea were similar (P>0.05) for all groups during the experimental period (from 3 days of age to 28 days of age). The results of incidence of diarrhea were 66.7, 55.6 and 77.8 % in C, G1 and G2, respectively, during the experimental

Table 2. The effects of garlic powder supplementation on growth performance (mean ± SD) of kids.

Item	C[1]	G1[2]	G2[3]	P-value
BW at 3 days of age (kg)	3.73 ± 0.48	3.78 ± 0.39	3.70 ± 0.51	
BW at 28 days of age (kg)	9.67 ± 0.80	9.43 ± 1.05	9.80 ± 1.26	P>0.34
BW at 75 days of age (kg)	15.34 ± 1.72	15.29 ± 1.66	15.06 ± 0.85	
ADG (kg)				
From 3 days to 28 days of age	0.24 ± 0.03	0.23 ± 0.03	0.24 ± 0.05	
From 28 days to 75 days of age	0.12 ± 0.04	0.12 ± 0.03	0.11 ± 0.03	P>0.34
From 3 days to 75 days of age	0.16 ± 0.02	0.16 ± 0.02	0.16 ± 0.02	

[1]: control group.

[2]: the group supplemented with 50 mg/kg BW garlic powder.

[3]: the group supplemented with 100 mg/kg BW garlic powder.

Table 3. The effects of garlic powder supplementation on fecal score, fecal pH, fecal total coliform population, the mean number of days with diarrhea (mean ± SD) and the incidence of diarrhea in kids.

Item	C[1]	G1[2]	G2[3]	P-value
Fecal score	2.94 ± 0.06	2.97 ± 0.07	2.94 ± 0.07	P=0.36
Fecal pH				
3 days of age	6.47 ± 0.12	6.38 ± 0.28	6.38 ± 0.15	P>0.33
7 days of age	6.67 ± 0.32[a]	6.40 ± 0.27[b]	6.53 ± 0.23[ab]	P=0.05
21 days of age	6.77 ± 0.30	6.67 ± 0.31	6.84 ± 0.19	P>0.23
28 days of age	6.76 ± 0.20[a]	6.82 ± 0.28[a]	7.10 ± 0.26[b]	P=0.05
Fecal total coliform population[4] (cfu $\log_{10}$/g fresh feces)	8.23 ± 0.64	8.06 ± 0.86	8.03 ± 0.75	P=0.61
The mean number of days with diarrhea	2.67 ± 1.51	2.20 ± 1.30	2.14 ± 0.69	P>0.57
The incidence of diarrhea (%)	66.7	55.6	77.8	P>0.32

[1]: control group.
[2]: the group supplemented with 50 mg/kg BW garlic powder.
[3]: the group supplemented with 100 mg/kg BW garlic powder.
[4]: for fecal total coliform analysis, fresh fecal samples were collected from each kid at 29 days of age (the day after the end of the experimental period).

period (from 3 days of age to 28 days of age). No difference (P>0.05) in the incidence of diarrhea was found among the groups.

The results of body temperature and hematological traits were presented in Table 4. No differences (P>0.05) in body temperature measurements were found among the groups. There were no differences (P>0.05) in total white blood cell (WBC) count, lymphocytes, neutrophils, monocytes and eosinophils concentrations at 29 days of age (the day after the end of the experimental period). G1 had a lower basophils concentration (P=0.05) than C and G2 while basophils levels were similar for C and G2.

Table 4. The effects of garlic powder supplementation on body temperature and hematological traits (mean ± SD) of kids.

Item	C[1]	G1[2]	G2[3]	P-value
Body temperature (°C)				
3 days of age	39.14 ± 0.37	39.20 ± 0.47	39.24 ± 0.42	
From 3 days to 7 days of age	39.45 ± 0.19	39.49 ± 0.10	39.50 ± 0.14	
From 8 days to 14 days of age	39.65 ± 0.10	39.66 ± 0.11	39.59 ± 0.20	P>0.32
From 15 days to 21 days of age	39.70 ± 0.18	39.78 ± 0.13	39.79 ± 0.22	
From 22 days to 28 days of age	39.52 ± 0.28	39.54 ± 0.16	39.47 ± 0.16	
Hematological traits[4]				
Total WBC[5] (10^9/l)	10.38 ± 1.28	9.42 ± 2.20	10.02 ± 1.52	P>0.27
Lymphocytes (10^9/l)	4.80 ± 0.82	4.71 ± 1.62	4.59 ± 0.85	P>0.72
Neutrophils (10^9/l)	4.67 ± 1.57	3.96 ± 1.24	4.59 ± 1.22	P>0.31
Monocytes (10^9/l)	0.79 ± 0.15	0.68 ± 0.22	0.71 ± 0.15	P>0.21
Eosinophils (10^9/l)	0.08 ± 0.04	0.05 ± 0.02	0.09 ± 0.05	P>0.25
Basophils (10^9/l)	0.04 ± 0.02[a]	0.02 ± 0.01[b]	0.05 ± 0.03[a]	P=0.05

[1]: control group.
[2]: the group supplemented with 50 mg/kg BW garlic powder.
[3]: the group supplemented with 100 mg/kg BW garlic powder.
[4]: at 29 days of age (the day after the end of the experimental period), blood samples were collected from the kids for hematological traits.
[5]: white blood cell.

DISCUSSION

Serum total protein measurement is an economical and a practical application to determine the passive transfer status in newborn ruminants (Deelen et al., 2014; Thornhill et al., 2015; Batmaz et al., 2019). In the study conducted by Batmaz et al. (2019), the cut-off value for serum total protein in the first 3 days was calculated to be between 5.1 and 5.3 g/dL in Saanen kids. In addition, the cut-off point for serum total protein of newborn kids was found as 5.4 g/dl by O'Brien et al. (1993). Serum total protein levels at 2 days of age were adequate for all kids used in the current study.

In this study, mean BW and ADG results were similar for all groups. BW and ADG were not affected by garlic powder extract supplementation at the level of 50 or 100 mg/kg BW/day. In the study conducted by Shokrollahi et al. (2016), newborn kids were fed milk supplemented with 62.5, 125 or 250 mg/kg BW aqueous garlic extract for 42 days. Shokrollahi et al. (2016) reported that aqueous garlic extract supplementation did not affect BW in newborn kids during the experimental period. In addition, Shokrollahi et al. (2016) observed an improvement in total body weight gain when newborn kids were fed milk supplemented with 62.5, 125 or 250 mg/kg BW/day aqueous garlic extract and this increase in total body weight gain was the highest for the kids supplemented with 250 mg/kg BW garlic extract. In a previous study (Ghosh et al., 2010), supplementation of 250 mg/kg BW/day aqueous garlic extract mixed with the milk improved ADG in calves during the preweaning period up to 2 months of age. Ghosh et al. (2011) reported that 250 mg/kg BW/day aqueous garlic extract added to milk from 5 days to 2 months of age significantly increased ADG in calves. Özkaya et al. (2023) stated that BW, ADG and dry matter intake were not different among the control group and the groups supplemented with garlic when newborn calves were fed milk supplemented with 10 or 30 mg/kg BW dried garlic powder until the weaning age. The effects of garlic on BW and ADG of newborn ruminants are variable, which may be caused by the different types or forms of garlic product (liquid extract prepared using garlic bulbs and water, dried garlic powder, commercial powder product), supplementation level, the duration of supplementation, animal characteristics (species, age, stage of production, health status) and the environmental conditions. It has been reported that the positive effect of garlic supplementation on growth performance (BW, ADG and / or feed efficiency) may result from improved enteric health due to the antimicrobial effect of garlic and antioxidant effect of garlic, as well as the effect of garlic on rumen ecology (Ghosh et al., 2010; Ghosh et al., 2011; Ding et al., 2023).

Fecal scores were similar among the groups in the current study. The mean values of fecal score recorded daily during the study were within an acceptable range for all groups. The result of fecal score in our study was in agreement with the data reported by Özkaya et al. (2023), who supplemented 10 or 30 mg/kg BW dried garlic powder to calves during the sucking period. In the current study, there were no differences in fecal pH at 3 and 21 days of age among the groups, whereas fecal pH was lower for G1 in comparison to C at 7 days of age and G2 had a higher fecal pH than C and G1 at 28 days of age. Based on the results of fecal pH in our study, it can be reported that garlic supplementation had no consistent effect on fecal pH in suckling kids.

Organosulphur compounds of garlic may suppress the growth of pathogens in the intestinal flora due to the antibacterial properties (El-Naggar and Ibrahim, 2018; Ogbuewu et al., 2019). In the current study, concentrations of fecal total coliform were similar for all groups at 29 days of age (a day after the end of the experimental period). The result of fecal total coliform concentration in the study conducted by Özkaya et al. (2023) was in agreement with that of our study. However, Ghosh et al. (2010) observed that fecal concentration of total coliform was significantly lower in the group supplemented with aqueous garlic extract than control group in calves during the preweaning period. Ghosh et al. (2011) reported that the calves supplemented with aqueous garlic extract had a lower concentration of fecal coliform than control calves, although there was no significant difference in fecal coliform count between groups. Based on the results of aforementioned studies and our study, it can be reported that the effect of garlic supplementation on fecal coliform concentration is affected by the different forms of garlic (liquid extract prepared using garlic bulbs and water, dried garlic powder, commercial powder product), daily dose of garlic product and the duration of supplementation.

Excluding diarrhea, no health problems such as respiratory diseases were observed during the experimental period. In our study, no kids died up to 75 days of age. The number of kids treated for diarrhea was one in each group. Kids with diarrhea

were treated by the farm veterinarian according to protocols established by the Department of Internal Medicine, Faculty of Veterinary Medicine. In our study, the mean numbers of days with diarrhea were not statistically different among the groups. Fecal scores were recorded daily and kids were monitored daily in respect to diarrhea during the experimental period. Fecal scores of 1 and 2 were considered to be diarrhea. In addition, tail and / or hind limbs stained with feces were evaluated as a finding of diarrhea. Özkaya et al. (2023) observed that the supplementation of 10 or 30 mg/kg BW dried garlic powder significantly reduced the number of days with diarrhea in calves. In the current study, the mean number of days with diarrhea was numerically decreased in G1 (2.20) and G2 (2.14) compared with C (2.67). However, the incidence of diarrhea was numerically higher for G2 (77.8 %) in comparison to C (66.7 %) while G1 (55.6 %) had a lower incidence of diarrhea numerically than group C (66.7 %) during the experimental period. In a previous study using calves (Kekana et al., 2020), diarrhea frequency and the mean number of days with diarrhea were numerically decreased when 5 g/day dried garlic powder was added to milk during the preweaning period. Because of both decreased mean number of days with diarrhea in G1 and a lower incidence of diarrhea in G1 compared with C, it may be stated that 50 mg/kg BW/day of garlic product used for the current study helps to decrease the occurrence of diarrhea in newborn kids under the circumstances where the incidence of diarrhea is high as observed in our study.

Body temperature is evaluated as a useful indicator of describing the health status of animals (Ayışığı et al., 2005; Thayne, 2007). Normal body temperature in kids ranges from 38.8 to 40.2 °C (Jackson and Cockcroft, 2002). In our study, body temperature of all kids was measured daily to detect health status and inadequate milk sucking during the experimental period. Mean body temperature values in the different periods of the study remained within an acceptable range and were similar for all groups.

In the current study, total WBC, lymphocyte, neutrophil, monocyte and eosinophil counts were similar for all groups. Mean values of total WBC, lymphocyte, neutrophil, eosinophil and basophil were within reference ranges (Jackson and Cockcroft, 2002) in all groups. Mean monocyte counts were higher for all groups than reference range. Basophil count was significantly lower for G1 in comparison to C and G2. Afele et al. (2020) reported that basophil concentration (% of WBC) was lower for the group supplemented with garlic than control group when rams were fed the diet containing 2.5 g/kg diet dried garlic powder for 84 days. In our study, the difference in mean basophil count for G1 may not be due to the treatment effect since the results of basophil count were within reference range in all groups and were similar for C and G2. Özkaya et al. (2023) reported that total WBC counts at 28 days of age and weaning age were not different among the control group and the groups supplemented with garlic when newborn calves were fed milk supplemented with 10 or 30 mg/kg BW dried garlic powder until the weaning age. Shokrollahi et al. (2016) observed the changes in total WBC count, neutrophil and lymphocyte concentrations (% of WBC) when newborn kids were fed milk supplemented with 62.5, 125 or 250 mg/kg BW aqueous garlic extract for 42 days. Shokrollahi et al. (2016) stated that total WBC count was significantly higher in the group supplemented with 125 mg/kg BW aqueous garlic extract compared to control and other groups with garlic extract. In addition, Shokrollahi et al. (2016) reported that neutrophil concentrations were significantly lower and lymphocyte concentrations were significantly higher for all groups supplemented with garlic extract in comparison to control group. These results in the study conducted by Shokrollahi et al. (2016) were not in agreement with those of our study, which may be due to the different forms, daily dose and supplementation duration of garlic used in the studies and health status of animals. No health problems, except diarrhea, were observed during the study. Different hematological results on the effects of garlic supplementation may be obtained for kids facing an immune challenge and health problems.

CONCLUSIONS

Garlic powder extract supplemented to kids did not affect BW at 28 days of age and 75 days of age (15 days after weaning) and all mean ADG values. Based on the results of fecal pH in our study, it can be reported that supplementation of garlic product had no consistent effect on fecal pH in suckling kids. Daily doses of garlic powder extract and / or the duration of garlic product supplementation were not enough to decrease fecal concentration of total coliform. Because of both decreased mean number of days with diarrhea in G1 and a lower incidence of diarrhea in G1 compared with C, it may be stated that 50 mg/kg BW/day of garlic powder extract helps

to decrease the occurrence of diarrhea in newborn kids under the conditions of this study. The results of our study will be useful to determine the dose and duration of garlic supplementation in future studies investigating the effects of garlic on growth performance, fecal characteristics and health status in neonatal ruminants.

CONFLICT OF INTEREST

There is not conflict of interest with any person or institute and organization regarding this manuscript.

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