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Impacts of *Nigella sativa* Inclusion during Gestation and Lactation on Ovarian Follicle Development, as Well as the Blood and Metabolic Profiles of Ardi Goats in Subtropics

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Abstract: The present study aimed to alleviate the negative effects of the peripartum and postpartum periods on the timing of ovarian follicle development, milk composition, as well as blood and metabolic profiles due to *Nigella sativa* (*N. sativa*) supplementation. Twenty-seven pregnant Ardi goats were classified using a randomized complete design into three groups: a control group and two *N. sativa* groups (10.0 and 20.0 g *N. sativa* seeds per kg diet). Productive and reproductive performances, in addition to blood and metabolic profiles, were investigated and compared using Duncan's multiple test. *N. sativa* supplementation increased dry matter intake and body weight. Ruminal pH and total bacterial counts were increased versus a decreased total protozoal count due to *N. sativa* inclusion. Additionally, *N. sativa* supplementation increased the concentration of protein, lactose, solids not fat, fat, and ash in milk. Pulse rates were the lowest ($p < 0.05$) in the *N. sativa* group and the partial pressure of oxygen was the lowest in the control group. Red and white blood cells and their related parameters (hemoglobin, hematocrit, neutrophils, and lymphocytes) showed significant increases due to *N. sativa* inclusion. Total protein, albumin, globulin, glucose, and minerals (calcium, phosphorus, and magnesium) values were higher ($p < 0.05$) in the *N. sativa* group. Lower concentrations of blood urea nitrogen were found in *N. sativa* groups compared to control one. In conclusion, *N. sativa* inclusion from 4 weeks prepartum to 4 weeks postpartum of Ardi goats modified productive and reproductive performances without any adverse effects on blood and metabolic profiles.

Keywords: *Nigella sativa*; follicles; growth; blood; metabolites

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1. Introduction

The peripartum or transition period is the most critical for the productive and reproductive performances of mammalian pregnant species and their resulting offspring. It extends from 3 weeks prepartum to 3 weeks postpartum in small ruminants [1]. During this period, disruptions were observed in ovarian follicle development and the quality of the resulting oocytes and embryos, feed utilization and growth performance, milk production and composition, and blood metabolites [2–8]. The decrease in feed intake can reach 30–35%, especially during the summer season in subtropics where temperatures exceed 45.0 °C during the day. The decrease in feed intake or the lack of management resulted in severe deficiencies of productive and reproductive performances under such circumstances [2,5,6,9]. Therefore, the restoration of disruptions during the prepartum and postpartum periods might improve reproductive and productive performances of pregnant species.

Several approaches can be used to mitigate the disruptive effects of prepartum and postpartum periods in pregnant animals, such as diet composition and supplementation [2,4–7]. Because of the negative effects on animals' health and the fertility of increased protein in the diet [10,11], it is important to find beneficial and non-traditional supplements for

improving productive and reproductive performances [12]. There is an increased interest in using *N. sativa* as a diet supplement for ruminants and humans [4,13–18].

N. sativa or black seeds are obtained from an annual plant cultivated in Asia and the Middle East. The *N. sativa* seeds contain protein (20.0–27.0%), carbohydrates (23.50–33.20%), fat (34.5–38.7%), crude fiber (8.4%), and ash (4.8%), in addition to vitamins, minerals, and carotene [4]. In addition, the *N. sativa* seeds contain active materials known as thymohydroquinone, thymoquinome, and nogelleone, which are known to give antitoxic, antimicrobial, and pharmacological properties that improve the defense system [4]. The *N. sativa* seed and their purified constituents have been widely used in the treatment of different diseases. Because *N. sativa* plays an important role as a natural antioxidant and immune stimulant [4,13], it might be used for anti-stress during the elevation of ambient temperature and humidity.

Several studies have been designed using different animal species to explore the effect of *N. sativa* on growth and reproductive performance [19–21]. The supplementation of animals with black seeds or black seed oil resulted in the improvement of growth performance and milk production [22], blood profiles, plasma metabolites [20,23], and reproductive performance [21,24,25]. There is inadequate information on the effects of *N. sativa* on ovarian follicle development, growth and feed utilization, as well as the biochemical profiles of Ardi goats during the peripartum period in subtropics. Therefore, our hypothesis is that the supplementation of *N. sativa* seeds would alleviate the negative effects of the peripartum and postpartum periods through improving feed utilization, blood and metabolic profiles, ovarian follicles' development, and milk composition.

2. Materials and Methods

2.1. Animals' Diets, Management, and Experimental Management

This study was carried out in the Research and Training Station of King Faisal University and approved by the scientific research ethical committee (Ref. No. KFU-REC-2022-JAN-EA000130). Twenty-one healthy pregnant Ardi goats of 101.66 ± 0.4 kg body weight, aged 2.0–2.5 years, were allocated using complete random design to three groups: a control group and two *N. sativa* groups (10 and 20 g/kg diet). The goats were given the routine vaccination of the farm station. The goats of each group during the experimental period were kept free in pens at a stocking rate of 2.00 m^2/head, and they were fed individually. The average ambient temperature ranged between 34.0 to 45.0 °C, and the relative humidity ranged between 29.5 and 40.0%. The goats were offered daily 2.0 kg concentrate diet for the control group (Table 1) and concentrate diet supplemented with the recommended doses of 10.0 and 20.0 g *N. sativa* seeds/kg diet per head in addition to ad libitum berseem hay [4].

Table 1. Chemical composition of experimental diets on dry matter basis (%).

Parameters	Dry Matter	Organic Matter	Crude Protein	Ether Extract	Crude Fiber	Nitrogen-Free Extract	Ash
Concentrate feed mixture	90.10	90.41	14.30	3.90	8.51	63.70	9.59
Alfalfa hay	90.76	87.90	20.63	1.46	23.83	41.98	12.10

The goats were randomly assigned into three groups: two control groups and 1.0% and 2.0% *N. sativa* groups. The periods for the study included approximately 4 weeks prepartum and continued to 4 weeks postpartum with *N. sativa* supplementation. The doses of *N. sativa* seeds were mixed with the concentrate diet and given daily at 08:00 a.m. to each goat. The diet was prepared according to the guidelines from the National Research Council for goats to meet the requirements [26]. Fresh water was available ad libitum. The recorded feed intake was calculated through the difference between the daily offered diet and its respective ort. The diet and ort samples were collected daily, transformed into

composites, and stored for chemical analysis at the end of the experiment. The body weight gain (kg) of the goats was recorded 4 weeks prepartum and 4 weeks postpartum.

2.2. Collection of Ruminal Fluid

A stomach tube with sufficient diameter and length was used to collect ruminal fluid from the control and *N. sativa* (1.0 and 2.0 g/kg diet) animal groups [27]. The tube was inserted into the rumen to suck out the ruminal fluid. The tube was inserted into the mouth to the pharynx and enabled the animal to swallow the tube. The ruminal samples were aspirated 4 h after morning feeding. The ruminal samples were filtered through two layers of cheesecloth to count the protozoal [28] and bacterial numbers [29]. The filtrate portion was immediately used for pH measurement using a digital pH meter (Eacam, China) [30].

2.3. Rectal Body Temperature (RT), Heart Rate (HR), and Partial Pressure of Oxygen (SPO2)

The physiological parameters (RT, HR, and SPO2) of *N. sativa* (1.0 and 2.0 g/kg diet) and control groups were recorded biweekly. Rectal body temperature was recorded using a digital thermometer (Citizen Flex Digital Thermometer CTA303, Citizen, Stuttgart, Germany). The partial pressure of oxygen (PO2) and pulse rate were recorded using a pulse oximetry apparatus (CMS60D-VET, Contec Medical Systems Co., Ltd., Qinhuangdao (Hebei), China). The goats were kept in a pen, restrained, and the heart rate and PO2 were recorded by the proper sensor that was put on the upper lip of the goat [6].

2.4. Ovarian Follicle Development

Goats were investigated postpartum by a real-time B-mode ultrasound scanner (ContecTM B-Ultrasound Diagnostic System Model CMS 600 P2VET, Qinhuangdao (Hebei), China) with a 3.5 MHz transducer (C3.5-80R20-A16A IPX7). Ovaries of *N. sativa* and control goats were examined at days 3, 6, 9, 12, 15, and 18 postpartum to record the numbers and sizes of ovarian follicles. The ovarian follicles were categorized according to diameter into small—(diameter 2–2.9 mm), medium—(diameter 3–4.9 mm), and large-sized (diameter $\geq$ 5 mm) follicles [6].

2.5. Milk Chemical Analyses

One hundred milliliters of milk (three samples) were collected through hand milking from the control and *N. sativa* (1.0% and 2.0%) animal groups weekly (weeks 2, 3, and 4 postpartum) in flasks for the chemical analysis of protein, lactose, solids not fat, fat, and ash (MilkoScan™ Mars, Hilleroed, Denmark). Milk energy was calculated as described by Economides [31].

2.6. Blood Samples' Collection and Analysis

Blood samples were collected biweekly through jugular vein puncture from each goat of *N. sativa* (10.0 and 20 g/kg diet) and control groups in a sterile tube containing anticoagulant (EDTA K3 Australia). The collected blood samples were analyzed for hematological profiles using a hematology analyzer (Abaxis Vetscan HM5, Union City, CA, United States) and biochemistry parameters using a chemistry analyzer (Skyla VB1, Hsinchu, Taiwan). The measured hematological parameters included red blood cells, hematocrit, and hemoglobin values, in addition to white blood cells and their differentiation and platelets. The measured biochemistry plasma parameters included total protein, glucose, urea, liver functions, and mineral values.

2.7. Statistical Analysis

The statistical analysis of variances was conducted through the general linear model of the Proc Mixed SAS package version 9.2 [32]. Differences between *N. sativa* (1.0 and 2.0 g/kg diet) and control groups were tested for body weight, rumen parameters, milk traits, ovarian follicle development, as well as blood and metabolic profiles by one-way ANOVA. A comparison between the means of *N. sativa* and control groups and the level

of significance ($p < 0.05$) was set using Duncan's test [33]. The statistical model was Yij = μ + Ti + Eij, where Yij = the observation ij, μ = the overall mean, Ti = the effect due to *N. sativa* supplementation (10.0 and 20 g/kg diet), and Eij = the experimental error.

3. Results

3.1. Feed Intake, Body Weight, Ruminal Parameters, and Physiological Parameters

Feed intake, body weight, ruminal traits, and physiological parameters are shown in Table 2. Treatments with *N. sativa* (10.0 and 20 g/kg diet) resulted in higher ($p > 0.05$) dry matter intake and body weight (kg) 4 weeks postpartum. Regarding ruminal parameters, ruminal pH and total bacterial count increased, whereas the total protozoal count decreased in *N. sativa* groups compared to the control group. The highest values were recorded in the 2.0% *N. sativa* group followed by 1.0% *N. sativa* and control groups, respectively. The body temperature and partial pressure of oxygen were insignificantly increased in the 2.0% *N. sativa* when compared to 1.0% *N. sativa* and control groups. The lowest pulse rate (beats/min) was recorded in 2.0% *N. sativa* group ($p < 0.05$) compared to other groups.

Table 2. Effects of *N. sativa* (10.0 and 20 g/kg diet) on body weight, ruminal, and physiological parameters of Ardi goats in subtropics.

Parameters	Treatments			SEM	*p*-Value
	Control	*N. sativa* 1 g/kg Diet	*N. sativa* 2 g/kg Diet		
Body weight 4 weeks prepartum, kg	101.42	102.85	100.71	0.5	0.08
Body weight 4 weeks postpartum, kg	109.28 ^{c}	112.28 ^{b}	114.14 ^{a}	0.53	<0.0001
Dry matter intake (kg/d)	1.62 ^{b}	1.71 ^{a}	1.78 ^{a}	0.02	0.005
Ruminal parameters					
pH	6.30 ^{b}	6.40 ^{ab}	6.46 ^{a}	0.03	0.043
Total protozoa, $\times 10^{5}$/mL	3.16 ^{a}	3.06 ^{ab}	3.01 ^{b}	0.03	0.030
Total bacteria, $\times 10^{11}$/mL	6.20 ^{c}	6.76 ^{b}	7.10 ^{a}	0.09	<0.0001
Physiological parameters					
Body temperature, °C	37.3	37.3	37.4	0.03	0.526
Pulse rate	125.5 ^{a}	122.6 ^{a}	115.5 ^{b}	1.16	0.0005
Partial pressure of oxygen	92.5 ^{b}	94.4 ^{b}	96.8 ^{a}	0.54	0.0071

$^{a, b, c}$ Values with different superscripts between groups significantly differ at $p < 0.05$.

3.2. Ovarian Follicle Development and Milk Composition

The results of small, medium, and large ovarian follicles' development recorded 3, 6, 9, 12, 15, and 18 days postpartum indicated earlier ovarian follicle resumption in *N. sativa* groups compared to the control group (Figure 1). The numbers of small, medium, and large follicles were higher ($p < 0.05$) in the *N. sativa* groups during the postpartum periods (Figure 1A–C). *N. sativa* effects (10.0 and 20 g/kg diet) on the milk composition of Ardi goats after kidding are presented in Table 3. The *N. sativa* (10.0 and 20 g/kg diet) supplementation increased ($p < 0.05$) solids not fat, protein, lactose, and ash compared to the control group.

Table 3. Effects of *N. sativa* (10.0 and 20 g/kg diet) on milk constituents of Ardi goats in subtropics.

Parameters	Treatments			SEM	*p*-Value
	Control	*N. sativa* 1 g/kg Diet	*N. sativa* 2 g/kg Diet		
Solids not fat, %	8.83 ^{c}	9.57 ^{b}	9.84 ^{a}	0.10	<0.0001
Fat, %	3.11	3.18	3.13	0.02	0.14
Protein, %	3.11 ^{b}	3.62 ^{a}	3.69 ^{a}	0.06	<0.0001
Lactose, %	4.73 ^{b}	5.28 ^{a}	5.39 ^{a}	0.07	<0.0001
Ash, %	0.31 ^{b}	0.31 ^{b}	0.38 ^{a}	0.01	<0.0001
Density	1.026	1.029	1.030	0.00	0.052
Milk energy content, MJ/kg	3.27 ^{b}	3.31 ^{a}	3.28 ^{b}	0.01	0.0097

$^{a, b, c}$ Values with different superscripts between groups significantly differ at $p < 0.05$.

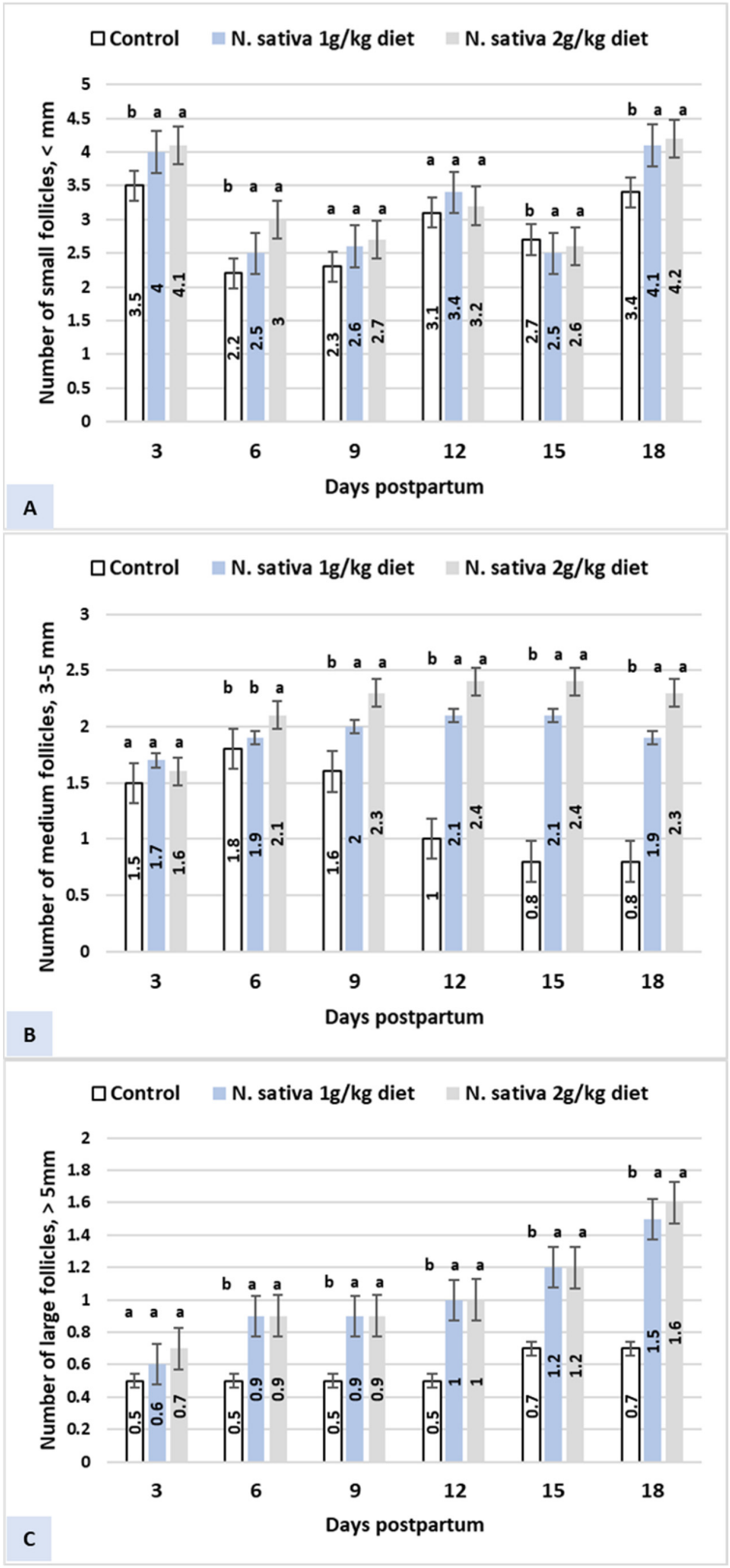

Figure 1. Effects of *N. sativa* (10.0 and 20 g/kg diet) on ovarian follicle development postpartum of Ardi goats. [a, b] Values with different superscripts between groups significantly differ at $p < 0.05$. (**A**) Number of small follicles < 3 mm; (**B**) Number of medium follicles 3–5 mm; (**C**) Number of large follicles > 5 mm.

3.3. Hematological and Biochemistry Profiles

Hematological indices are presented in Table 4. Hematological indices showed a significant increase in the values of RBCs (106/μL) and Hb (g/dL), in addition to WBCs (103/μL), lymphocytes, and neutrophils (103/μL) in *N. sativa* groups (10.0 and 20 g/kg diet), when compared to the control one. The highest values were observed in 2.0% *N. sativa* group when compared to 1.0% *N. sativa* and control groups, respectively. The blood biochemistry indices of *N. sativa* (10.0 and 20 g/kg diet) and control groups are presented in Table 5. The results indicated the highest values ($p < 0.05$) of total protein (g/dL), albumin (g/dL), globulin (g/dL), and glucose (mg/dL) recorded in the 2.0% *N. sativa* group when compared to the other groups. Urea nitrogen ($p < 0.05$) and liver enzymes ($p > 0.05$) were lowered due to 2.0% *N. sativa* supplementation when compared to 1.0% *N. sativa* and control feeding, respectively. Furthermore, the mineral concentrations (calcium, phosphorus, and magnesium) were improved ($p < 0.05$) due to *N. sativa* supplementation when compared to the control one.

Table 4. Effects of *N. sativa* (10.0 and 20 g/kg diet) on blood indices of Ardi goats in the subtropics.

Parameters	Treatments			SEM	*p*-Value
	Control	*N. sativa* 1 g/kg Diet	*N. Sativa* 2 g/kg Diet		
Red blood cells, 10^{12}/L	10.97 ^{b}	12.72 ^{a}	12.53 ^{a}	0.19	<0.0001
Hemoglobin, g/dL	12.80 ^{c}	13.40 ^{b}	15.30 ^{a}	0.28	<0.0001
Hematocrit, %	35.15 ^{b}	36.19 ^{ab}	41.22 ^{a}	0.68	<0.0001
MCV, fl or μm^3	32.00 ^{a}	28.00 ^{b}	33.00 ^{a}	0.57	0.0001
MCH, pg/cell	11.70 ^{b}	10.60 ^{c}	12.20 ^{a}	0.17	<0.0001
MCHC, g/dL or %	36.60	37.20	37.10	0.59	0.8284
RDWc, %	22.40 ^{c}	27.00 ^{a}	24.00 ^{b}	0.46	<0.0001
RDWs, fl	31.20 ^{b}	32.00 ^{ab}	32.80 ^{a}	0.25	0.0096
White blood cells, 10^{9}/L	9.36 ^{b}	11.66 ^{a}	12.0 ^{a}	0.29	<0.0001
Lymphocytes, 10^{9}/L	5.47 ^{b}	5.72 ^{b}	6.31 ^{a}	0.10	<0.0001
Monocytes, 10^{9}/L	0.05 ^{b}	0.06 ^{a}	0.06 ^{a}	0.00	<0.0001
Neutrophils, 10^{9}/L	2.39 ^{b}	4.55 ^{a}	4.47 ^{a}	0.23	<0.0001
Eosinophils, 10^{9}/L	1.27 ^{a}	1.20 ^{a}	1.05 ^{b}	0.03	0.0063
Basophils, 10^{9}/L	0.18 ^{a}	0.13 ^{b}	0.12 ^{b}	0.01	<0.0001
Platelet, 10^{9}/L	153.0 ^{b}	161.0 ^{a}	165.0 ^{a}	1.67	0.0100
Mean platelet volume, fl	6.13 ^{b}	6.50 ^{a}	6.10 ^{b}	0.06	0.0176
Platelet distribution width PDWc, %	29.50 ^{c}	27.90 ^{b}	32.30 ^{a}	0.44	<0.0001
Platelet distribution width PDWs, fl	7.00 ^{b}	6.80 ^{c}	7.30 ^{a}	0.06	<0.0001

$^{a, b, c}$ Values with different superscripts between groups significantly differ at $p < 0.05$. MCV, mean corpuscular volume; MCH, mean corpuscular hemoglobin; MCHC, mean corpuscular hemoglobin concentration; RDW, red cell distribution width.

Table 5. Effects of *N. sativa* (10.0 and 20 g/kg diet) on blood biochemistry of Ardi goats in subtropics.

Parameters	Treatments			SEM	*p*-Value
	Control	*N. sativa* 1 g/kg Diet	*N. Sativa* 2 g/kg Diet		
Total protein, g/dL	7.00 ^{b}	7.20 ^{a}	8.00 ^{a}	0.11	<0.0001
Albumin g/dL	3.20 ^{b}	3.30 ^{ab}	3.50 ^{a}	0.05	0.05
Globulin g/dL	3.80 ^{b}	3.90 ^{b}	4.50 ^{a}	0.08	0.0006
Blood urea nitrogen, mg/dL	17.20 ^{a}	15.60 ^{b}	13.50 ^{c}	0.40	0.0003
Urea, mg/dL	36.80 ^{a}	33.40 ^{b}	28.90 ^{c}	0.85	0.0003
Glucose mg/dL	60.00 ^{b}	61.00 ^{b}	75.33 ^{a}	1.88	<0.0001
Alkaline phosphatase, U/L	82.23	80.37	80.0	0.65	0.271

Table 5. *Cont.*

Parameters	Treatments			SEM	*p*-Value
	Control	*N. sativa* 1 g/kg Diet	*N. Sativa* 2 g/kg Diet		
Aspartate aminotransferase, U/L	98.13 [a]	97.27 [a]	94.27 [b]	0.56	0.008
Gamma–glutamyl transferase, U/L	40.34	39.27	38.35	0.39	0.055
Creatine Phosphokinase, U/L	114.54	115.65	112.23	0.80	0.0221
Calcium, mg/dL	08.70 [c]	09.80 [b]	10.20 [a]	0.15	<0.0001
Phosphorus, mg/dL	3.87 [c]	4.10 [b]	5.53 [a]	0.17	<0.0001
Magnesium, mg/dL	0.95 [b]	1.03 [a]	1.03 [a]	0.01	<0.0001
Sodium, mmol/L	136.61 [b]	141.31 [a]	138.17 [b]	0.56	<0.0001
Potassium, mmol/L	04.30 [b]	04.60 [a]	04.50 [a]	0.05	0.0166
Chloride, mmol/L	107.0	109.21	107.31	0.51	0.26

[a, b, c] Values with different superscripts between groups significantly differ at $p < 0.05$.

4. Discussion

The beneficial effects of feed additives, especially *N. sativa* seeds on feed utilization, metabolic conditions, and reproductive functions, have been reported in several studies [13,21,34–36]. Our present study was designed to restore the negative effects of the peripartum period on feed intake and rumen parameters, milk traits, postpartum ovarian follicle development, and the related blood and plasma metabolites of Ardi goats in the Eastern subtropical area of KSA. The significant effects of *N. sativa* seeds and extract on body health status, as well as productive and reproductive performances, were confirmed earlier in several studies [13,21,25]. In the current study, the improvement in body health, as well as productive and reproductive performances, was the highest in the *N. sativa* (20 g/kg diet) group when compared with the *N. sativa* (10.0 g/kg diet) and control groups.

4.1. Body Weight, Ruminal, and Physiological Parameters

Body weight gain was improved in *N. sativa* groups (10.0 and 20 g/kg diet) when compared to the control group, as indicated in previous studies [12,13,16,19]. This might be attributed to increased feed intake, in addition to significant changes in rumen microbes, including increased bacteria and decreased protozoa values (Table 2), which might improve digestibility coefficients. It was found that *N. sativa* inclusion (12 g/day) significantly improved the digestibility coefficients of dry matter, organic matter, crude protein, and crude fiber [12]. Collectively, earlier reports concluded that *N. sativa* seeds or their extract have positive effects on body weight gain and nutrient digestibility [12–16,19]. The stimulation of appetite and increased peristaltic action of the stomach and bowels have been recorded due to *N. sativa* actions [37,38].

Ruminal pH and total bacterial counts increased, while total protozoal counts decreased in *N. sativa* groups (10.0 and 20 g/kg diet) when compared to the control group (Table 2). The changes in the rumen environment due to the 10.0 and 20 g/kg diet *N. sativa* treatments might be favorable for bacterial species growth [12,39]. It is reported that nitrogen retention and ruminal ammonia nitrogen values were improved ($p < 0.05$) due to *N. sativa* supplementation [12]. In addition, the pulse rate decreased in *N. sativa* groups, as previously indicated [40], and this might be consequently useful in the treatment of hypertension [41]. The higher partial pressure of oxygen (PO2) in *N. sativa* groups could be attributed to the increase in RBCs in those groups compared to control one (Table 4) [42].

4.2. Ovarian Follicle Development and Milk Composition

Feed additives must be safe for the health and well-being of pregnant and lactating goats to support their ovarian structures' development, milk production, and milk quality [5–8,34]. *N. sativa* seed supplementation (10.0 and 20 g/kg diet) resulted in an increase in small, medium, and large ovarian follicles compared to the control diet. This might be attributed to the significant increase in glucose ($p < 0.05$) and the decrease in urea ($p < 0.05$)

levels in *N. sativa* groups (Table 5). The positive energy balance in the *N. sativa* group might lead to an increase in insulin concentration and glucose uptake [43] (Nielsen and Ingvartsen, 2004). This change appears to stimulate the ovary and is associated with increased folliculogenesis. This explanation could be confirmed through our supplementation of *N. sativa* oil to female mice upon ovarian transplantation. Our results indicated an increased number of aspirated oocytes and quality from ovarian follicles [21]. Furthermore, the decreased level of blood urea nitrogen is associated with increased fertility [10,11]. The other metabolic factors attributed to the beneficial effects of *N. sativa* seeds and their extracts on ovarian follicle development and reproductive performance include essential amino and fatty acids and reproductive hormone values [4,11,13,21,24,25,36,44–49]. The improvement in metabolic factors was due to the effects of *N. sativa* seeds on the digestive system, including nutrient digestibility, better absorption, and body weight gain [13,19,20,45], as indicated in this study through higher total protein and body weight gain.

The *N. sativa* inclusion in the diets (10.0 and 20 g/kg diet) significantly improved milk constituents. Earlier studies coinciding with our study indicated the significant effects of *N. sativa* on improving milk production and composition [13,16]. The main factors of *N. sativa* that are involved in milk traits' improvement are the improvement in nutrient digestibility and blood metabolic profiles [12,16,50] (Tables 3 and 4), which lead to the availability of nutrients required for milk secretion. Additionally, *N. sativa* contains several nutrients, which might be attributed to the observed increase in milk production and composition [13–15].

4.3. Hematological and Biochemistry Indices

Of note, in the current experiment, the changes in not only the blood indices were obtained by the supplementation of *N. sativa* to pregnant or lactating goats' feed, but also in the blood plasma composition. Hematological profiles (RBCs, Hb, and PCV) showed significant beneficial changes between the *N. sativa* and control groups, as previously indicated [13,21,51]. Blood profiles are indicative of the body's health status. The immune stimulation of *N. sativa* seeds recorded in earlier reports [52], in addition to antioxidant activity [53–56], plays a crucial role in the protection of the body against inflammation or infection. Therefore, the improvement in blood profiles in *N. sativa* groups (10.0 and 20 g/kg diet) compared to the control might be attributed to the increase in feed conversion and body weight gain [4].

Metabolic profiles were improved in *N. sativa* groups if compared to control one. The increased activity of hepatic function is suggested when *N. sativa* seeds were fed [16], which resulted in a higher concentration of total proteins as recorded in the present study. Furthermore, supplementation with *N. sativa* seeds enhanced glucose concentration as a result of improved nutrient digestibility and greater total volatile fatty acids production [16]. Propionate is considered as the primary gluconeogenic volatile fatty acid used for glucose biosynthesis [57]. The present data of lower blood urea nitrogen and creatinine in *N. sativa*-treated groups were the same as previous reports [13,16]. Therefore, it can be assumed that *N. sativa* supplementation might improve the protein balance in goats.

Measurements of AST, GGT, and ALP hepatic enzymes are considered reliable indicators of liver function in ruminant animals [58,59], and the liver AST enzyme values were lowered ($p < 0.05$) due to *N. sativa* inclusion in the diet of goats. Moreover, CK, which has been used as a screening diagnostic parameter for endometritis muscular damage or hypocalcemia in dairy cattle [60], was unchanged due to *N. sativa* supplementation. There were lower values ($p > 0.05$) of liver enzymes with feeding *N. sativa* seeds to calves and goats [20], indicating their probable protective roles against liver dysfunction [61–63] or renal tissue damage [64].

The calcium, phosphorus, magnesium, and potassium values were increased in *N. sativa* groups when compared to control one, as indicated in several previous studies [13]. Calcium, phosphorus, and magnesium minerals in the blood provide an indication of the animals' health, and they are important for animals' production [65]. Herein, the

aforementioned mineral values were in the normal range and reflected the adequacy of minerals of in the *N. sativa* and control diets [66]. The increase in aforementioned minerals in *N. sativa* groups could be attributed to their presence in *N. sativa* seeds [4]. Calcium, phosphorus, and magnesium minerals are essential elements for muscle contraction, skeletal building, the production of energy, and anti-viral and anti-inflammatory agents [67,68]. Collectively, *N. sativa* seed components lead to a significant improvement in the functions of the gastrointestinal tract and liver, leading to an increase in body health, body weight gain, milk production, and ovarian structures' development during gestation and lactation periods of Ardi goats in subtropics.

5. Conclusions

The supplementation of pregnant Ardi goats with *N. sativa* seeds (1.0 and 2.0 g/kg diet) during the peripartum period is an effective strategy for improving feed utilization, milk traits, and blood and metabolic profiles, in addition to higher ovarian follicle development in subtropics. Further studies may be designed to explore the effects of *N. sativa* bioactive compounds to give proof of their possible applications for treatments of metabolic dysfunctions.

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