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Effect of Dietary Supplementation with Ginger and Probiotic on Productive Performance, Nutrient Digestibility, and Blood Metabolites of Growing Karadi Lambs

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Abstract

This study investigated the effects of ginger and probiotic supplementation on the performance, nutrient digestibility, and blood metabolites of Karadi lambs. Twenty male lambs (4–5 months old; initial weight 25 ± 0.55 kg) were randomly assigned to four dietary treatments (n = 5 per group) for 84 days. The treatments were Control (basal diet only), T1 (basal diet + 3 g ginger/head/day), T2 (basal diet + 3 g probiotic/head/day), and T3 (basal diet + 3 g ginger + 3 g probiotic/head/day). All lambs received a concentrate diet (isonitrogenous and isocaloric) at 3% of body weight and had *ad libitum* access to wheat straw and water. Results showed there was not statistically significant growth performance for treatments compared to the lambs fed the control diet. However, numerically higher body weight gain, total gain, average daily gain, and total feed intake were observed, while the control group was lower. The positive effect of probiotics was significantly ($P < 0.05$) observed in dry matter, organic matter, ether extract, crude protein, nitrogen-free extract digestibility compared to the control. The overall blood plasma parameters in lambs that received different experimental diets were not statistically significant ($P > 0.05$), with the exception of albumin and creatinine levels, which were significant ($P < 0.05$). T3 had the highest value of albumin compared to other groups, while in creatinine level, T3 had the lowest value compared to other groups. The pH value in T3 shows an increase in the result, while T2 had a lower pH value compared to the control. The lambs in the T2 group showed an increased amount of total volatile fatty acids in rumen fluid compared to other groups. The results indicated that NH3-N concentrations were significantly lower in the control group than in T1. The inclusion of ginger and probiotics in Karadi male lambs improves growth performance, nutrient digestibility, and beneficial effects on rumen parameters and animal health.

Keyword: ginger, probiotic, growth performance, blood parameters, digestibility

I. INTRODUCTION

The need for high-quality, healthful animal products had increased due to the world's population growth. According to VandeHaar et al. (2016), the animal's genetic composition, its surroundings, the quality of the feed it receives, and the

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efficiency with which it is transformed into value items all affect production. Utilizing the rumen ecosystems, which are in charge of the ruminants' efficient use of feed, can result in higher animal production, better health, and higher-quality products (Santra et al., 2003). Historically, feed additives have been used in the animals' diet for this reason.

Ginger, which is widely recognized for its therapeutic benefits, helps lambs' digestion, immunity, and general health. Lamb's owners can boost their livestock's immune systems, lower the probability of digestive problems like feeling bloated and diarrhea, and possibly increase body weight by including ginger powder in the animal's meals (Nassar, 2020, and Ali et al., 2024). Important minerals including potassium, magnesium, copper, manganese, and Silicon is abundant in ginger.

In addition to protecting the heart, blood vessels, and the urinary system, potassium and manganese also help people avoid disease. According to Faniyi et al. (2016), supplementing with ginger may also aid in controlling the number of microbes in the rumen by decreasing the release of methane, minimizing degradation of proteins, and decreasing protozoa (rumen fauna). Furthermore, when added to feed, spices and flavorings like ginger have been recognized for their therapeutic advantages, which include immune-boosting, appetite-stimulating, digestion-enhancing, antimicrobial, anti-inflammatory, and antioxidant effects (Ali et al., 2024). The rhizome of Zingiber officinale, or ginger, has been used more and more by contemporary veterinarians in farm animal management in recent years. According to Ali et al. (2024), ginger has been used as a feed supplement to enhance the production, performance, and general health of a variety of agricultural animals.

Probiotics consist of live bacteria that, when given to an animal, enhance its health by inhibiting the growth of harmful bacteria and improving nutrient absorption by influencing the gut microbiota in a beneficial way. When administered to an animal, probiotics—which are living bacteria—improve nutrition absorption and prevent the formation of pathogenic bacteria by positively affecting the gut microbiota. According to Sandine (1979) and Musa et al. (2009), probiotics enhance the microbial environment. Additionally, probiotics are known to raise ruminal pH (Umberger et al., 1988), total volatile fatty acids (VFAs), and ruminal biodiversity (Newbold et al., 1996), which in turn affects microbial production of proteins, cellulolytic activity, and fiber breakdown (Yoon and Stern, 1996). Moreover, it is thought that they compete with undesirable microbes for the supply of nutrients and other development factors (Rolfe, 2000). They improve immunity by encouraging the synthesis of IgA, antibodies, and cytokines (Aattouri et al., 2002; Trebichavský and Splichal, 2006). A favorable effect of probiotic supplements on weight gain and nutritional intake and ruminant feed conversion ratio (FCR) has been numerous employees' reports (Chiofalo et al., 2004; Whitley et al., 2009; Antunović et al., 2006). The main objective of this study was to evaluate the effect of each probiotic (*Bacillus amyloliquefaciens*), ginger powder, or combination on the growth performance, nutrient digestibility, and ruminal fermentation of Karadi male lambs.

II. MATERIAL AND METHOD

A. Location of study and experimental animal

This experiment was carried out at a sheep farm at the Department of Animal Science at the College of Agricultural Sciences, University of Sulaimany, Bakrajo, Sulaimany, Kurdistan, Iraq.

The study was conducted to see the effect of adding ginger and probiotics to the diet of growing lambs on growth performance, nutrient digestibility, and blood parameters. The study lasted for 84 days; the average temperature was nearly 30-40°C.

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Twenty male Karadi lambs, each weighing 25±0.55 kg and aged 4-5 months, were used. After an adaptation period of 14 days, lambs were randomly divided into four groups; each group included 5 lambs (control, T1, T2, and T3).

Lambs were fed a concentrate diet containing 16% protein (which included 47.5% corn grain, 30.36% barley grain, 14.67% soybean meal, 3.9% wheat bran, 1.5% limestone, 1% sodium bicarbonate, 0.5% salt, and 0.5% vitamins and mineral mixture) at the level of 3% of their live body weight, and wheat straw was ad libitum throughout the period of the study. Control (receive basal diet), T1 (receive basal diet with 3 g ginger/head/day), T2 (receive basal diet with 3 g probiotic/head/day), and T3 (receive basal diet with 3 g ginger/head/day + 3 g probiotic/head/day). The probiotic includes *Bacillus amyloliquefaciens* strain H57 (10^9 CFU/kg). The chemical compositions of concentrate feed and wheat straw are shown in table 1.

Every day, before the meal was offered the next morning, the diet refusals were gathered and weighed. Always there was clean water. Weighing lambs was done once a week. The animals were housed in well-ventilated, sanitary, individual pens with cemented floors, under consistent management. The lambs were treated with enterotoxaemia and ivermectin against endo- and ectoparasites. The lambs had free intake of wheat straw and water during the experiment. Feeds offered and refused each day were written down. The daily ration for lambs was determined through weekly weighing.

TABLE (1): THE CHEMICAL COMPOSITION OF EXPERIMENTAL DIETS

Items %	Control	T1	T2	T3	Wheat straw
Dry Matter	89.4	89.2	89.7	89.5	93.2
Ether Extract	2.96	2.94	2.92	2.93	2.13
Organic Matter	94.33	94.28	94.24	94.21	89.48
Crude Protein	16.10	16.12	16.14	16.11	3.50
Nitrogen Free Extract [1]	60.37	60.1	60.57	60.31	44.76
Crude fiber	4.3	4.32	4.34	4.37	32.29
Neutral Detergent Fiber	13.5	13.46	13.52	13.54	73.57
Acid Detergent Fiber	5.50	5.51	5.54	5.56	50.87
Ash	5.67	5.72	5.76	5.79	10.52
ME (MJ/kg DM) [2]	11.51	11.5	11.53	11.5	6.7[*]

Control: basal feed; T1: basal feed + 3 g ginger powder, T2: basal feed + 3 g probiotic, T3: basal feed + ginger+ 3 g probiotic.

[1] It is calculated by this equation, NFE %=100-(Moisture%+CP%+EE%+CF%+Ash%)

[2] ME (MJ/kg DM) for concentrate = 0.012×CP+0.031×EE+0.005×CF+0.014×NFE (MAFF, 1975).

[*] ME (MJ/kg DM) for straw = Digestible energy × 0.82 (NRC, 2007).

B. Growth Performance

To evaluate performance, the lambs were weighed on the initial and final trial days following a 16-hour fasting period from a dry diet. Overall weight gained, average daily gain (ADG), and the feed conversion ratio were measured.

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C. Nutrient Digestibility and chemical analysis of feed and feces

At the seventh week of the experiment, fecal samples were collected. A digestibility analysis has been performed to find out the capacity to digest all feeds by qualitatively collecting feces over a 7-day period, during which the quantities of given and remaining feeds were recorded in detail. Feces were taken from three animals of each group using a specially designed digestion bag; the discarded feces of each lamb were gathered, properly weighed, and approximately 10% were subsampled after that, being preserved at -20°C. Following the collection time, feed and fecal samples were properly merged, and one sample of each was taken and placed in a prolonged freezer for the ensuing chemical examination (Hassan and Saeed, 2012). Straw samples taken during feeding and digestibility experiments, concentrate diet formulation samples, and concentrate diets that were presented and declined were all dried in an electric oven at 100°C until their weight remained constant, while feces were dried at 60 degrees Celsius. According to AOAC (1990), the following were identified: dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE), and crude fiber (CF). OM was measured by burning dried samples in a furnace at 550°C for four hours. CP was measured with the procedure described by the Kjeldahl method, EE was measured using the Soxhlet method of extracting hexane, and CF was analyzed by hot extraction using HCI and NaOH. The Goering and Van Soest (1970) procedure was then used to determine the acid detergent fiber (ADF) and neutral detergent fiber (NDF).

To determine the nutrient components' Nutrient Digestibility (ND), a specific equation was used:

$$ND\% = [(\text{Nutrient intake g}) - \text{Nutrient in feces(g)})/\text{Nutrient intake (g)}] \times 100$$

Where nutrient intake (g) is equal to nutrient given (g) minus nutrient in refusals (g).

D. Blood Parameters

Collections of blood taken from the lambs' jugular vein were obtained at the final stage of the research study. Blood collected from all animals Three hours after the first meal of the day, a 10-mL blood sample was collected and placed in Vacutainer tubes containing anticoagulant (EDTA). The blood plasma was extracted from the samples by centrifuging them for 15 minutes at 3500 rpm. For additional analysis, the collected plasma was transmitted to the Eppendorf tubes with labels and kept at -20°C, and samples were analyzed in the laboratory to determine biochemical parameters (total protein (TP), albumin (ALB), globulin (GLO), total bilirubin (TBIL), blood urea nitrogen (BUN), glucose (GLU), triglycerides (TG), cholesterol (CHOL), urea and creatinine (CRE), alanine aminotransferase (ALT), aspartate aminotransferase I (AST), gamma-glutamyl transferase (GGT), and alkaline phosphatase (ALP)). using the MNCHIP Celercare V machine to determine parameters at the Vet Plus Veterinary Laboratory in Sulaimany.

E. Ruminal Fluid Collection

At the end of this study, rumen fluid samples (nearly 100 ml) were collected three hours post-feeding from three animals in each group using a stomach tube. Two layers of muslin cloth were used for filtering the ruminal samples. The samples were divided into two portions: one was used to determine ruminal pH, and the other was stored at -20°C until analysis of ammonia nitrogen (NH_3-N) concentration and total volatile fatty acids (TVFAs). Ammonia nitrogen (NH_3-N) was analyzed utilizing the Markham micro-distillation equipment, while total volatile fatty acids (TVFA) were measured by the Macro Kjeldahl distillation technique.

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F. Statistical Analysis

The research findings were statistically analyzed using a one-way ANOVA in the XLSTAT program (2016). Duncan's multiple range test (1955) was employed to determine whether there were statistically significant differences among the trait means at a significance level of ($P < 0.05$). The experimental data were examined in accordance with the subsequent model:

$Yij=\mu+ti+eij$

Where: Yij represents the dependent variable, μ denotes the general mean

Ti = treatment effect (i = control, 3g ginger, 3g probiotic, and 3g ginger + 3g probiotic)

eij = standard error.

III. RESULT AND DISCUSSION

A. Growth performance

TABLE 2. Determine the growth performance of lambs during the study period. In addition to the other treatment categories, the treatments experienced a numerical rise in total weight gain, average daily gain; this could be because supplemented probiotic, ginger, or combined probiotic and ginger improved nutritional absorption. Ginger promotes the formation of saliva, which increases the release and performance of intestinal enzymes and improves absorption. Additionally, the ginger improves the ingestion of essential nutrients, which promotes animal growth (Ibrahim et al., 2022; Vyas et al., 2018). The results of T2 and T3 were lower than T1 but higher than the control group. Whereas the T2 group consumed a higher amount of daily total dry matter intake than the other groups. This result is similar to Hilal et al. (2011). Additionally, probiotic intake can positively influence the maintenance of gut microbiota, hence promoting growth and improving host resistance to illnesses (Xue et al., 2011; Du et al., 2018).

TABLE2. EFFECT OF ADDING GINGER AND PROBIOTIC TO DIET OF KARADI LAMS ON GROWTH PERFORMANCE

	Control	T1	T2	T3	*P-value*
No. animal	5	5	5	5	
Initial weight (kg)	25.64^{a} ±1.14	25.19^{a} ±0.84	25.14^{a} ±0.89	24.88^{a} ±1.69	0.975
Final weight (kg)	43.29^{a} ±4.37	44.16^{a} ±0.75	43.44^{a} ±1.94	43.89^{a} ±4.43	0.997
Total body weight gain (k	17.58^{a} ±4.57	19.05^{a} ±0.94	18.30^{a} ±1.45	19.02^{a} ±4.07	0.985
Average daily gain (g/day	209.23^{a} ±54.40	226.73^{a} ±11.15	217.82^{a} ±17.26	226.47^{a} ±48.42	0.985
DMI concentrate g/day	863.80^{a} ±54.30	878.75^{a} ±25.95	885.16^{a} ±41.75	840.46^{a} ±110.73	0.964
DMI straw (g/day)	232.19^{a} ±31.32	241.17^{a} ±21.01	247.42^{a} ±13.88	266.38^{a} ±7.62	0.692
Total DMI (g/day)	1096.96^{a} ±64.22	1118.89^{a} ±42.58	1131.01^{a} ±33.46	1108.48^{a} ±106.55	0.986
FCR	4.48^{a} ±0.24	5.04^{a} ±0.33	5.20^{a} ±0.41	4.74^{a} ±0.70	0.628

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[a] Means within row with letters and numbers are significantly different ($P< 0.05$). sig: significant effect, ns: non-significant

Control: basal feed T1: basal feed +3g ginger T2: basal feed +3g probiotic T3: basal feed +3g ginger+3g probiotic FCR: feed conversion ratio, DMI: dry matter intake.

B. Nutrient Digestibility

The effect of dietary supplemented ginger and probiotics on dry matter intake and nutrient digestibility in growing Karadi male lambs is shown in table 3. The present results indicated no significant variations in total DMI across each group of experimentation. This may be related to the acclimatization phase, which enabled the animals used in this research to ingest the given feeds without exhibiting any fluctuations in their feed intake. The enhancement was statistically insignificant for DM digestibility, OM digestibility, CP digestibility, EE digestibility, NFE digestibility, in comparison to animals receiving the control diet, which exhibited the lowest digestion values. The inclusion of *Bacillus amyloliquefaciens* in the diet of lambs fed on T2 had significantly higher dry matter digestibility (DMD), about 86.46%, compared to the lambs fed the control diet (82.54%). The DMD of T2 was not significant compared to other treatments. The higher digestibility of dry matter in lambs fed probiotics resulted from enhanced enzyme activities of microorganisms, which led to stable pH in the ruminal fluid and caused better digestion and absorption (Schofield et al., 2018; Ngo et al., 2021; Shoukry et al., 2023; Lee et al., 2024). The significantly higher ($P<0.05$) ether extract digestibility (EED) was shown in T2 (87.22%), compared to lambs fed T3, the control diet, and T1 (78.17%, 76.77%, and 75.47%), respectively. *Bacillus amyloliquefaciens* improved EED, leading to activities of lipase enzyme secretion for digestion and metabolism of the fat source in the ration (Hu et al., 2018) .The lambs fed on probiotic supplementation, ginger powder (T1), and the combination of probiotics and ginger powder (T3) had increased significantly ($P < 0.05$); organic matter digestibility (OMD) was the highest value of T2 (87.24%) compared to lambs fed on a control diet (83.48%). The addition of *Bacillus amyloliquefaciens* as a probiotic or ginger as a supplement improved the utilization of feed in lambs compared to those fed on the control diet, enhancing ruminal fermentation and increasing microbial digestive enzymes in the rumen (Schofield et al., 2018; Shoukry et al., 2023; Ali et al., 2024; Wang et al., 2024; Kang et al., 2025). The crude protein digestibility (CPD) of lambs fed probiotics (T2) was the highest value (80.36%) compared to the lowest control group (74.22%). While the ginger group (T1) had effects on CPD similar between T2, control group, and T3. The higher digestibility of CP of lambs fed on *Bacillus amyloliquefaciens* (T2) enhance protein utilization and nitrogen metabolism and efficiency. When CPD improved led to promote for growth performance in lambs and feed efficiency (Molyanova et al., 2024, Lee et al., 2024). There was no significant effect of probiotics and ginger on crude fiber (CFD), neutral detergent fiber (NDFD), or acid detergent fiber digestibility (ADFD) among treatments and lambs fed on a control diet. The significant lack of these digestibility fibers, which returned a low dosage per animal, and ginger powder, which contains phytochemical compounds (essential oils), which led to the inhibition of cellulolytic bacteria such as *Ruminococcus flavefaciens* and *Fibrobactor succinogenes*, led to lower CF degradation and lower VFA production (Altınçekiç et al., 2021; Caroprese et al., 2023). However, the CFD, NDFD, and ADFD of treatments were numerically higher than control groups, but no statistically significant effects of this nutrient digestibility appear.

The higher value ($P < 0.05$) of nitrogen-free extract digestibility (NFED) was shown in lambs fed on probiotics (T2; 92.93%), compared to lambs fed on the control diet (89.78%). This study indicates that probiotics led to better digestion of carbohydrates, which were used as energy, and better utilization of feed and efficiency. Whereas the lambs fed on ginger powder in T1 and T3, the NFED were 90.95% and 91.37%, respectively. It proposes that the ginger powder may contribute to helping digestion of carbohydrates in some amount (Schofield et al., 2018; Shoukry et al., 2023).

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TABLE 3. EFFECT OF DIETARY SUPPLEMENTED GINGER AND PROBIOTIC ON DRY MATTER INTAKE AND NUTRIENT DIGESTIBILITY IN GROWING KARADI MALE LAMBS.

Items	Control	T1	T2	T3	*P-value*
DM intake concentrate(g/day	976.35 ^{a} ± 47.42	973.31 ^{a} ±19.16	993.40 ^{a} ±49.92	984.67 ^{a} ±89.65	0.994
DM intake straw (g/day)	234.82 ^{a} ±58.09	251.37 ^{a} ±21.36	220.57 ^{a} ±26.58	239.52 a ±19.25	0.938
Total DMI(g/day)	1211.17 ^{a} ±18.83	1224.68^{a}±37.37	1213.97^{a}±37.66	1224.19 ^{a} ±70.57	0.995
DM digestibility%	82.54 ^{b} ±0.43	85.04 ^{a} ±0.37	86.46 ^{a} ±0.49	84.69 ^{a} ±0.95	0.011
Organic matter digestibility%	83.48 ^{b} ±0.35	85.53 ^{a} ±0.38	87.24 ^{a} ±0.32	85.53 ^{a} ±0.81	0.006
EE digestibility%	76.77 ^{b} ±1.99	75.47 ^{b} ±0.69	87.22 ^{a} ±2.42	78.17 ^{b} ±3.49	0.057
Protein digestibility%	74.22 ^{b} ±0.37	77.39 ^{ab} ±1.69	80.36 ^{a} ±0.66	76.13 ^{b} ±1.20	0.025
Fiber digestibility%	50.81 ^{a} ±8.36	62.48 ^{a} ±1.51	57.12 ^{a} ±3.24	60.29 ^{a} ±1.66	0.368
NFE digestibility%	89.79 ^{b} ±0.66	90.95 ^{b} ±0.19	92.94 ^{a} ±0.12	91.37 ^{ab} ±0.15	0.002
NDF digestibility%	50.60 ^{a} ±6.42	60.07 ^{a} ±1.22	61.33 ^{a} ±2.34	58.86 ^{a} ±0.42	0.201
ADF digestibility%	39.84 ^{a} ±15.56	52.43 ^{a} ±5.26	51.91 ^{a} ±6.95	52.02 ^{a} ±3.04	0.713

^{a,b} Means within rows with different letters are significantly different (P< 0.05). Control: basal feed T1: basal feed +3g ginger T2: basal feed +3g probiotic T3: basal feed +3g ginger+3g probiotic ns: no significant, sig: significant, DM: dry matter, EE: ether extract NFE: nitrogen free extract, NDF: neutral detergent fiber, ADF: acid detergent fiber.

C. **Blood parameter**

The overall findings regarding blood plasma measures in lambs that received different experimental diets showed that all treatments displayed little effect on the assessed parameters, as the variations attributable to treatment effects were not statistically significant, with the exception of albumin and creatinine levels, which were significant. The results of blood parameters are shown in TABLE 4. Fortunately, the values of the majority of blood parameters that were examined in the current study vary around the standard ranges for ruminants as documented by several researchers in previous studies (Mahmoud 1993; Nagah 2002; EL-Ashry et al., 2003; and Ragheb et al., 2003). An increase in protein synthesis by ruminal microbes may have contributed to the rise in blood albumin levels, which in turn led to greater absorption (Kholif et al., 2012). The creatinine level in the ginger group is higher than in the probiotic group. This result is similar to the result of Nasser (2020), which indicated that the ginger group had a higher creatinine level.

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TABLE 4. EFFECT OF USING GINGER POWDER AND PROBIOTIC ON SOME BLOOD PARAMETERS IN KARADI LAMBS.

Items	Control	T1	T2	T3	*P-value*
Total Protein, g/L	71.84^{a} ± 1.90	69.40^{a} ±1.08	68.97^{a} ±2.31	68.27^{a} ±1.41	0.520
Albumin, g/L	32.82^{b} ±1.65	36.46^{a} ±0.54	36.04^{a} ±0.46	37.02^{a} ±0.81	0.036
Globulin, g/L	38.93^{a} ±2.63	32.99^{ab} ±1.37	32.98^{ab} ±2.43	31.23^{b} ±1.15	0.075
Total Bilirubin, µmol/L	5.23a ±1.23	2.93^{a} ±0.26	3.88^{a} ±0.42	3.58^{a} ±0.83	0.247
Blood Urea Nitrogen, mmol/L	6.01^{a} ±0.55	6.78^{a} ±1.45	4.83^{a} ±0.25	5.81^{a} ±0.85	0.514
Glucose, mmol/L	7.57^{a} ±2.19	6.32^{a} ±0.18	6.39^{a} ±0.29	5.84^{a} ±0.37	0.739
Triglycerides, mmol/L	0.69^{a} ±0.17	0.75^{a} ±0.04	0.64^{a} ±0.05	0.71^{a} ±0.06	0.874
Cholesterol, mmol/L	2.13^{a} ±0.28	2.13^{a} ±0.10	1.97^{a} ±0.12	2.08^{a} ±0.09	0.903
Urea mg/dL	40.29^{a} ±5.03	45.01^{a} ±9.22	34.57^{a} ±2.46	39.90^{a} ±4.92	0.677
Creatinine, µmol/L	65.47^{a} ±3.36	54.80^{ab} ±7.81	50.14^{b} ±3.39	43.79^{b} ±2.88	0.037
ALT, U/L	18.51^{b} ±3.31	23.92^{ab} ±0.71	27.13^{ab} ±2.55	30.45^{a} ±5.16	0.118
AST, U/L	134.95^{b} ±12.53	161.31^{ab} ±12.50	169.13^{ab} ±6.45	196.8^{a} ±28.12	0.119
GGT, U/L	62.96^{a} ±9.87	65.18^{a} ±6.85	66.77^{a} ±7.39	64.29^{a} ±9.02	0.990
ALP, U/L	204.66^{a} ±50.95	196.03^{a} ±15.94	182.59^{a} ±8.72	231.12^{a} ±14.56	0.659

Control: basal feed, T1: basal feed + 3 g ginger, T2: basal feed + 3 g probiotic, T3: basal feed + 3 g ginger + 3 g probiotic. $^{a, b}$ Means within rows with different letters are significantly different ($P < 0.05$). ALT: Alanine aminotransferase, AST: Aspartate aminotransferase, GGT: Gamma-glutamyl transferase, ALP: Alkaline phosphatase. mmol/L: millimole per liter, g/L: gram per liter, mg/dL: milligram per deciliter, U/L: unit per liter, µmol/L: micromole per liter.

D. Ruminal fluid parameters

Feeding lambs diets supplemented with the experimental additions resulted in significantly different pH values, as shown in Table (5). The rumen pH is a crucial factor in rumen health, microbial stability, and transition, as well as an essential component for optimal microbial growth. The pH can be utilized to predict the dietary regimen provided to livestock, in addition to the fermentation rate, depending upon the extent of increase or decrease. The pH value in T3 shows an increase compared to the control, while T2 has a lower pH value compared to T3. The lambs fed on *Bacillus amyloliquefaciens* showed an increased amount of total volatile fatty acids (TVFAs) in rumen fluid compared to other groups because the TVFAs consist of organic acids, which led to a lower ruminal pH. These findings are in line with those of Sanchez et al. (2010), who found that probiotics regulate the rumen pH, raise concentrations of microbial proteins and total TVFAs, and improve overall rumen health. Soliman et al. (2016) the same to similar conclusions that the livestock receiving rations improved with prebiotics exhibited intermediate levels compared to those fed control rations or rations enhanced with probiotics, which displayed the highest levels of total volatile fatty acids (TVFAs). The data in Table 5 indicated that ruminal ammonia nitrogen concentrations were significantly lower in the control group than in the T1 (ginger powder). The reduction in ammonia (NH_3-N) content in livestock diets enriched with probiotics (direct-fed microbial) may be attributed to enhanced assimilation of ammonia into microbial protein (Abdel-hakim et al., 2024). The T1 group, which received ginger and a basal diet, shows the highest level of ammonia concentration. Ginger preserved protozoal activity and total phenolic content, which matches the results of Al-Azazi et al. (2018) and Abo Bakr (2019). The T2 group has a high level of ammonia, while the T3 group has a significantly lower value than T1 and T2.

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TABLE5. THE EFFECT OF DIETARY SUPPLEMENTED GINGER AND PROBIOTIC ON RUMINAL FLUID PARAMETERS IN GROWING KARADI MALE LAMBS.

Ite	Control	T1	T2	T3	*P-value*
Ruminal	5.69^{b} ±0.19	5.99^{ab} ±0.31	5.61^{b} ±0.08	6.42^{a} ±0.29	0.024
TVFA's ml mol/10(	8.58^{b} ±1.38	9.39^{ab} ±1.47	11.68^{a} ±0.68	8.02^{b} ±0.92	0.034
Ammonia (NH3-N) mg/10(	21.59^{b} ±2.17	32.54^{a} ±4.04	28.56^{ab} ±4.12	24.32^{ab} ±3.39	0.044

$^{a, b}$ Means within a row with different letters, they are significantly different ($P < 0.05$). Control: basal feed; T1: basal feed + 3 g ginger; T2: basal feed + 3 g probiotic; T3: basal feed + 3 g ginger + 3 g probiotic. TVFA's—total volatile fatty acids.

IV. CONCLUSION

The results indicated a numerical rise in body weight gain in treatments, feed intake, and better digestibility, which was supplemented with 3 g of each probiotic and ginger powder. The lambs fed probiotics in the basal diets had improved dry matter, organic matter, ether extract, crude protein, and nitrogen-free extract digestibility. Finally, the combination of ginger and probiotics allows growing lambs to have better feed intake, higher body weight gain, higher nutrient digestibility, and a healthy life. Further research is required to assess the effects of ginger and probiotics on various farm animals and to formulate new feed additives.

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