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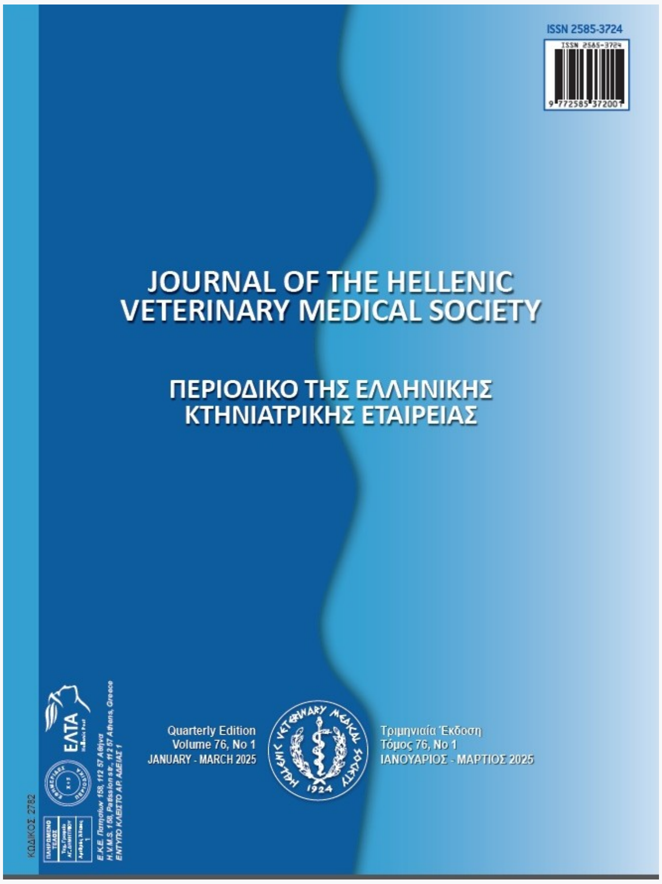

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Research article
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Effect of prebiotic, synbiotic and phytobiotic supplements on performance, digestibility and blood parameters of lambs

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ABSTRACT :This study aimed to investigate the effect of the administration of prebiotic, synbiotic, and phytobiotic supplements on growth performance, carcass traits, apparent digestibility of nutrients, and blood parameters in fattening lambs. For this purpose, 24 male lambs (Zell breed) with an average age of 5 months and a weighted mean of 25.4±0.50 were used for 90 days. The experimental treatments included 1) a control group (without supplement), 2) treatment containing 2gr prebiotic supplement (A-MAX), 3) treatment containing 3gr synbiotic supplement (Biomin IMBO), and 4) treatment containing 6 gr phytobiotic supplement (Bioherbal, Pars Imen Daroo Company, Iran) given to each head of lamb per day. The results of growth performance traits indicated a significant difference between experimental treatments in final fattening weight, dry matter intake, daily weight gain, and feed conversion ratio ($p<0.05$). According to the results of the apparent digestibility of nutrients, a significant difference existed between experimental treatments in terms of the apparent digestibility of dry matter, crude protein, the NDF, and ADF ($p<0.05$). The results of some blood serum parameters indicated a significant difference between experimental treatments in terms of glucose, cholesterol, triglyceride, and blood urea nitrogen concentration ($p<0.05$). According to the result of quantitative characteristics of the carcass, a significant difference existed between trial treatments in terms of the hot carcass weight, hot carcass percent, cold carcass weight, cold carcass percent, thigh percent, and shoulder percent ($p<0.05$). The results of this study showed that adding a 4gr dietary synbiotic supplement could improve growth performance indicators, valuable carcass parts, and apparent digestibility of nutrients in Zell fattening lambs.

Keywords: blood parameters; digestibility; lamb; growth performance; phytobiotic;prebiotic synbiotic

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INTRODUCTION

One of the most substantial goals of ruminant breeding management during different production periods especially the fattening period is to reduce breeding costs. Using useful edible additives in the diet of livestock is a method used to achieve this goal. Among various edible additives, herbal nutrients, prebiotics, and synbiotics are the most ideal and useful compounds for animal feeding since these nutrients can be consumed easily and have multidimensional effects on different parts of the gastrointestinal tract (Galvão et al., 2005). Prebiotics are indigestible food compounds that can selectively stimulate the growth of one or few bacteria in the host's gut. In 2004, Roberfroid presented another definition for prebiotics defining them as indigestible carbohydrate food sources that foster the growth and proliferation of bacteria, such as bifidobacteria and lactobacillus improving the health of the host (Manning and Gibson, 2004). These resistant and short-chain carbohydrates are known as indigestible oligosaccharides or low-digestible carbohydrates (Roberfroid, 2002). Synbiotic refers to a mixture of one probiotic (useful live microbial additive) and one prebiotic (indigestible dietary compound), which provide the effects of both compounds simultaneously. Synbiotics are indeed capable of increasing the durability and biological survival of bacteria in the upper part of the gut and enhancing the efficiency of the gastrointestinal tract (Ai et al., 2011). After the consumption of growth-stimulating antibiotics was banned by Europe in 2006, great attention was paid to herbal feed additives in recent years. Now, many commercial products are used for feeding livestock and poultry. The term phytogenic refers to herbal materials and phytobiotics defining it as the compounds derived from plants added to animals' diets to change feed's characteristics and improve performance (Windisch et al., 2008). Various studies have shown that prebiotic (Ayala-Monter et al., 2019), synbiotic (Elliethy et al., 2022), and phytobiotic (Somasiri, 2014) supplements improve the growth performance in fattening livestock. Moreover, the apparent digestibility of nutrients was improved after adding prebiotic (Zheng et al., 2018) and phytobiotic (Yang et al., 2007) supplements to the diet of ruminants. The most important properties of plant extracts (Phytobiotics) are their antibiotic properties, which can significantly reduce the use of feed antibiotics when raising animals and reduce antibiotic resistance in the human body when consuming animal products. The development of plant-based antibacterial agents and their application in animal husbandry are relevant given the high profitability of food production, which is a global trend that benefits both animals' and people's health (Ivanova et al., 2024). Regarding the numerous benefits of these supplements in feeding fattened animals, the extant study aims to investigate the effect of the administration of prebiotic, synbiotic, and phytobiotic supplements to diet on the growth performance, carcass traits, apparent digestibility of nutrients, and blood parameters in fattening lambs.

MATERIALS AND METHODS

This study was conducted in the Private Sheep Breeding Station (with a capacity of 1000 heads) located in Mazandaran Province of Juybar city, Kord Kola Village in Iran. Dr. Seyyed Makan Moosavi Kashani is the owner of this Station. The present study is taken from the Ph.D thesis approved by the Islamic Azad University of Qaemshahr. Written informed consent was taken from all participants, and the study received approval from ethics committee (Code: 10721435972006).This study was carried out from July to September 2020 in this centre. In this study, 24 male Zell lambs with an age average of 5 months and a mean weight of 25.4±0.50 were used. Lambs were transferred to individual cages to be tested for 90 days. 14 days before the study and placed in individual cages, all the lambs were given the anti-parasitic drug Albendazole (Damiyaran Arak Company, Iran) and they were also injected with enterotoxemia vaccine (Indian lmmunologicals limited) (following 14 days of repetition).Trial treatments included 1) control group (without supplement), 2) treatment containing 2gr prebiotic supplement, 3) treatment containing 3gr synbiotic supplement, and 4) treatment containing 6 gr phytobiotic supplement (Bioherbal, Pars Imen Daroo Company, Iran) given to each head of lamb per day. The prebiotic supplement was an A-MAX product made by VI-COR Company in the USA. The ingredients of the prebiotic supplement consisted of mannan and fructose oligosaccharides, and some compounds, such as Beta-Glucan. The mentioned compounds are extracted from the cellular wall of *Saccharomyces Cerevisiae* yeast. A-MAX is the natural concentrate of cell wall compounds and ingredients of Saccharomyces Cerevisiae I-1077 yeast, as well as the culture medium containing sucrose, molasses, and corn extract. The chemical analysis of A-MAX includes 10% moisture, 90% dry matter, 23% crude protein, 3% crude fat, 27% total starch, 9.40% raw fibers, and 2.90% ash. The synbiotic supplement was Biomin IMBO, which contained *Enterococcus faecium* probiotic (DSM3530 strain $10^{10}\times2.5$ colony forming units per kg), Inulin prebiotic from the Fructooligosaccharides, and seaweed extract. The phytobiotic supplement was Bio-herbal, which is a commercial product made by Pars Imen Daroo Company and contained a mixture powder of four medicinal herbs, including *Mentha piperita*, *Cuminum cyminum*, Lemon grass, and *Coriandrum sativum*. The experimental lambs' diet was adjusted by using Small Ruminant Nutrition System (SRNS) Software (Tedeschi et al., 2010). Table 1 reports the feed items and chemical composition of the diet.

After weighing the experimental lambs using a digital scale, recording their profiles, and assigning them to relevant treatments randomly, the adaptation period (14 days) was considered to get used to the individual cage (1×1.1×0.85m) and consumable diet. Lambs were fed within two meals of consumable diet (8:00 and 17:00). The amount of dry matter intake, feed conversion ratio (FCR), and average daily weight gain (ADWG) of lambs were measured during the study. A certain amount of feed was weighted as a total mixed ration for each experimental treatment then tested lambs were fed within two meals at 8:00 and 17:00. The remained feed in the manger of each experimental animal was weighed separately and then deducted from the total amount of previous meal at the end of the day to measure the dry matter intake by each lamb per day. Prebiotic, synbiotic, and phytobiotic supplements used in this research were given to each head of experimental livestock as grams per day after adding them to the diet of lambs. To measure the daily weight gain, the weighing process was done using a digital metal scale for 14 days until the end of day 90 of the study. The weighing was done in considered days and hours before feeding (imposing 12 deprivations of feed intake) to consider the same conditions for all treatments. FCR on different days of the trial was measured by dividing the average value of daily dry matter by the ADWG of lambs per treatment.

Table 1. Feed items and chemical compounds of experimental diet (dry matter%)

Feed matter	Amount in the diet (%)
Alfalfa	30.00
Corn seed	20.80
Barely grain	25.00
Wheat bran	10.50
Soybean meal	7.40
Beet pulp	4.60
Mineral-vitamin supplement[1]	0.5
Oyster powder	0.5
Sodium bicarbonate	0.4
Salt	0.3
Chemical compounds	
Metabolizable energy (Mcal/kg)	2.45
Dry matter (%)	89.45
Crude protein (%)	14.03
NDF (%)	32.50
ADF (%)	19.87
Calcium (%)	0.69
Phosphor (%)	0.43

[1]Per kg, the amount of supplement contains 500000 international units of Vitamin A, 100000 international units of Vitamin D, and 1.0gr Vitamin E. Per kg amount of supplement contains 180g calcium, 90g phosphor, 20g magnesium, 60g sodium, 2g manganese, 3g iron, 0.3g copper, 3g zinc, 1.0g cobalt, 1.0g selenium, 1.0g iodine, and 3g antioxidant.

Blood sampling by the jugular vein of experimental lambs was carried out on day 90 before feed intake by imposing 12-hour feed deprivation. Blood sampling was done in the morning using a 5ml venoject tube containing anticoagulant Ethylenediaminetetraacetic acid (EDTA). Blood samples were sent to the lab based on the cold storage principles, and then the prepared serum was tested to measure the amount of glucose, triglyceride, cholesterol, HDL, LDL, blood urea nitrogen, protein total, albumin, and IgG. The protein total of blood was measured based on the Biuret method (Thomas, 1998), and blood urea nitrogen was measured using a lab kit made by Pars Azmoon Company through a photometric technique (Thomas, 1998). The kit produced by Pars Azmoon Company of Iran was used to measure blood serum cholesterol and detect the quantity of cholesterol (CHOD-PAP) in the serum. HDL and LDL (HDL-Cholesterol, LDL-Cholesterol) were measured using a kit produced by Pars Azmoon Company of Iran through the enzymatic calorimetry technique (Friedewald et al., 1972). Glucose was measured using Pars Azmoon Kit for GOD detection in serum based on photometric technique. Albumin was measured through Bromocresol green colorimetry using Iran Pars Azmoon Kit, and a spectrophotometer device was used based on the kit's instructions. The IgG amount was measured through Nephelometry using a Nephelometry Device (Mini-neph, Binding Site Model made in the UK).

To measure carcass traits of experimental lambs on the day 90 and 24 hours after the last feed weighing, 3 lambs were selected from each treatment and then slaughtered 12 hours after feed deprivation. After the lambs were weighed and slaughtered, the intestines and internal organs were removed then the hot carcass was immediately weighed. The carcasses were kept at 4°C for 24 hours in the fridge. The carcasses were exited from the fridge after 24 hours and then weighed and recorded as cold carcass weights. Carcasses were divided longitudinally along the central axis of the body exactly from the middle point of the spine into two equal parts to measure half carcass weight. The thigh, forequarter, and neck were separated and weighed.

The apparent digestibility of dry matter, organic matter, and crude protein of feed and faeces samples of experimental lambs was measured through standard techniques (AOAC, 2003) then NDF and ADF were measured on days 85, and 90 of the experiment through Van Soest et al. technique (1991). To measure the apparent digestibility of experimental feed, insoluble ash in acid was used as an internal marker. Faeces samples were collected in considered days two times a day at 3-hour intervals. The first turn was done 4 hours after feed consumption. The collected daily faeces samples of each lamb were mixed and poured into separate plastic packages and then kept in the fridge at -20°C. To measure ash insoluble in acid, the ash of 10g feed sample and 5g dried faeces samples were collected in the furnace. To do this, the sample was kept in the furnace at 450°C for one night then the ash was poured into the Beaker, 100ml 2 normal hydrochloric acid was added, and the mixture was boiled on the heater for 5 minutes. The mixture was passed through the filter paper without ash and washed through 100-200ml hot water (90°C) to deacidify the breaker's contents. The material remaining on the filter paper was transferred to the previous-weighed crucible and its ash was again collected at 450°C for one night and then weighed after being cooled. Finally, the ash insoluble in ample acid was measured by deducting the weight of the crucible containing ash and the weight of the empty crucible divided by the weight of the dry matter of the sample. After measuring the ash insoluble in the acid of feed and faeces samples, the apparent digestibility of nutrients was calculated in percent (Van Keulen and Young, 1977).

This experiment was done by completely random design (CRD) on 24 heads of male lambs. The data were analyzed using mixed models through SAS 9.1 software considering the effect of treatment as the constant effect and the initial weight of fattening as a covariate (Equation 1). The initial weight of fattening as the effect of covariate was removed from the statistical analysis model because this variable was not significant. The observations related to consumable dry matter, ADWG, and FCR were analyzed as duplicate measurements over time (with constant effects of treatment time) (Equation 2). The mean values of treatments were compared using Duncan's multiple range test at a probability rate of 0.05 (Duncan, 1955).

Equation (1) $Y_{ij} = \mu + T_i + e_{ij}$

Equation (2) $Y_{ij} = \mu + T_i + B_j + (T\times B)_{ij} + e_{ij}$

RESULTS

Growth performance

According to the results of growth performance traits of fattening lambs, a significant difference was found between experimental treatments in terms of fattening end weight, dry matter intake, daily weight gain, and FCR ($p<0.05$). The results showed that the highest and lowest end weight of the fattening period, dry matter intake, and daily weight gain were seen in treatment containing 4g synbiotic supplement and control group, respectively. The results indicated that the highest and lowest FCR was observed in the control treatment and treatment containing a 6g phytobiotic supplement, respectively. The results showed improved growth performance of fattening lambs after using synbiotic and prebiotic supplements compared to the group without supplements (Table 2).

Apparent digestibility of nutrients

According to the results of the apparent digestibility of nutrients in experimental rations reported in Table 3, a significant difference existed between experimental treatments in the apparent digestibility of dry matter, crude protein, NDF, and ADF ($p<0.05$). The highest and lowest apparent digestibility of dry matter, NDF, and ADF were observed in the treatment containing 4g synbiotic supplement and control group, respectively. Moreover, a treatment containing a 6g phytobiotic supplement provided the highest apparent digestibility of crude protein, while the control group indicated the lowest apparent digestibility of crude protein. The results indicated improved apparent digestibility of experimental diets after adding synbiotic and phytobiotic supplements to the diet of experimental lambs in this study.

Blood parameters

According to the results of some blood serum parameters of fattening lambs reported in Table 4, a significant difference existed between treatments in glucose, cholesterol, triglyceride, and blood urea nitrogen (BUN) concentrations (p<0.05). The highest and lowest glucose concentrations were observed in treatment containing 4g synbiotic supplement and control group, respectively. The highest and lowest cholesterol concentrations were seen in the control group and treatment containing a 6g phytobiotic supplement, respectively. The highest and lowest triglyceride concentrations were observed in the control group and treatment containing 4g synbiotic supplement. Moreover, blood urea nitrogen had the highest concentration in the treatment containing 2g prebiotic supplement, while had the lowest concentration in the treatment containing 4g synbiotic supplement. The results of blood parameters indicated that synbiotic supplements could effectively reduce the concentration of blood serum fats and blood urea nitrogen of fattening lambs.

Carcass traits

According to the results of quantitative carcass traits of fattening lambs reported in Table 5, a significant difference existed between treatments in hot carcass weight, hot carcass percent, cold carcass weight, cold carcass percent, thigh percent, and shoulder percent (p<0.05). The results showed that carcass traits had higher performance in treatment containing 4g synbiotic supplement, so the highest weight of carcass traits, especially in the valuable parts of the carcass was seen in fattening lambs fed with synbiotic and prebiotic supplements compared to the control group.

Table 2. Effect of experimental treatment on the growth performance traits of fattening lambs

	Experimental treatments					
Traits	Control (without supplement)	2g prebiotic supplement	4g synbiotic supplement	6g phytobiotic supplement	SEM	p.value
Initial fattening weight (kg)	26.16	25.44	26.10	25.70	1.98	0.459
End fattening weight (kg)	44.12[b]	47.44[a]	49.24[a]	46.00[ab]	1.05	0.012
Daily intake dry matter (g)	1490[b]	1624[b]	1715[a]	1587[ab]	31.78	0.011
ADWG (g)	200.5[b]	245.0[ab]	257.1[a]	255.6[a]	3.98	0.0244
FCR	7.42[a]	6.63[b]	6.68[b]	6.21[b]	0.19	0.012

The mean values shown with different letters in each row have significant differences (P<0.05)

Table 3. Effect of experimental treatment on the apparent digestibility of nutrients in experimental diets or rations (%)

	Experimental treatments					
Variables	Control (without supplement)	2g prebiotic supplement	4g synbiotic supplement	6g phytobiotic supplement	SEM	p.value
Dry matter	66.80[b]	70.98[ab]	73.95[a]	70.30[ab]	0.79	0.017
Organic matter	70.83	71.66	73.24	72.97	0.92	0.296
Crude protein	70.75[b]	73.31[a]	73.81[a]	74.06[a]	0.85	0.035
NDF	50.15[b]	54.29[a]	55.74[a]	53.55[a]	1.09	0.018
ADF	58.70[b]	62.07[a]	63.26[b]	60.14[b]	0.94	0.001

The mean values shown with different letters in each row have significant differences (P<0.05)

Table 4. Effect of experimental treatment on some blood parameters and immune system of fattening lambs at the end of the experiment

	Experimental treatments					
Parameters	Control (without supplement)	2g prebiotic supplement	4g synbiotic supplement	6g phytobiotic supplement	SEM	p.value
Glucose (mg/dl)	59.92[b]	64.61[a]	65.55[a]	63.50[a]	0.94	0.016
Cholesterol total (mg/dl)	54.66[a]	51.59[ab]	53.30[ab]	50.99[b]	0.66	0.025
Triglyceride (mg/dl)	26.14[a]	24.19[b]	23.48[b]	24.26[b]	0.31	0.011
HDL (mg/dl)	34.69	35.75	36.12	35.25	0.56	0.670
LDL (mg/dl)	12.10	11.64	11.25	10.62	0.50	0.386
Protein total (g/dl)	5.14	6.19	5.49	6.26	0.42	0.824
Albumin (g/dl)	4.55	4.63	5.02	4.94	0.18	0.658
IgG (mg/l)	2.42	2.55	2.79	2.46	0.19	0.143
Blood urea nitrogen (mg/dl)	24.66[ab]	26.42[a]	22.78[b]	23.50[b]	0.51	0.033

The mean values shown with different letters in each row have significant differences (P<0.05)

Table 5. Effect of experimental treatment on quantitative carcass traits of fattening lambs at the end of the experiment

Traits	Experimental treatments				SEM	p.value
	Control (without supplement)	2g prebiotic supplement	4g synbiotic supplement	6g phytobiotic supplement		
Final fattening weight (kg)	44.12[b]	47.44[a]	49.24[a]	46.00[ab]	1.05	0.012
Hot carcass weight (kg)	19.91[b]	22.85[a]	24.40[a]	21.78[b]	0.75	0.011
Hot carcass yield (%)	45.11[b]	48.27[a]	49.55[a]	47.33[a]	0.88	0.024
Cold carcass weight (kg)	18.95[c]	21.66[b]	23.74[a]	20.36[b]	0.66	0.001
Cold carcass yield (%)	42.95[b]	45.64[b]	48.22[a]	44.26[b]	0.90	0.032
Shoulder percent	15.50[b]	17.21[a]	17.33[a]	16.10[b]	0.23	0.026
Thigh percent	24.75[b]	26.33[a]	27.12[a]	26.19[a]	0.42	0.022
Neck percent	6.14	6.44	6.55	6.38	0.14	0.524
Carcass length (cm)	76.45	77.16	78.33	77.44	1.05	0.239

The mean values shown with different letters in each row have significant differences (P<0.05)

DISCUSSION

Consistent with these results, various studies have reported improved growth traits in fattened lambs after adding synbiotic (Moarrab et al., 2016) and prebiotic (Ayala-Monter et al., 2019; Soliman et al., 2016) supplements to their diets. The positive effect of the synbiotic and prebiotic supplement on feed intake among fattening lambs may raise from the increased number and ratio of cellulolytic bacteria of rumen fluid and improved digestibility of raw fibres, which possibly improves the dry matter intake (Ghazanfar et al., 2015). The results obtained by Elliethy et al. (2022) showed that consumption of synbiotic or prebiotic supplements as an additive increased growth performance and improved FCR in fattening lambs. Chashnidel et al. (2020) reported that a 1.5g prebiotic supplement (Y-MOS) containing mannan oligosaccharide and beta-glucan could improve dry matter intake and increase ADWG in suckling lambs. After Ghosh and Mehla (2012) fed calves with 4g prebiotic per day, they saw body weight gain in each head of the calf and improved feed yield. Results of some studies showed that calves fed with prebiotics gained more daily weight rather than the control group (Ilgaza and Arne, 2021; Roodposhti and Dabiri, 2012). It has been revealed that some herbal additives effectively improved FCR and digestibility by improving intestine microbial flora and reducing competition between hots and microorganisms to intake nutrients (Anderson et al., 1997). The possible reasons for the improved ADWG of fattening lambs in this study may be the consumption of bio-herbal phytobiotic supplements and the role of medicinal plants and compounds derived from these plants in stimulating animal appetite and further feed consumption (Yang et al., 2010). In the present study, the improved FCR in the treatment containing bio-herbal supplements may result from improved metabolic energy of rations when feed consumption rate and animal production level are enhanced (McDonald et al., 2002). Contrary to the results of the present study, probiotic supplementation did not affect the growth performance in pre-weaned goats (Ndegwa et al., 2024). The result of a study showed that phytogenic supplementation increased overall DMI compared to control treatment in lambs. These researchers showed that the FCR was not significant (Hashemzadeh et al., 2022), which was not consistent with the results of the present study.

Consistent with the results of this study, other studies confirmed that phytobiotic supplementation could increase digestibility of dry matter and crude protein in beef cattle (Mohammed et al., 2004), digestibility of NDF in dairy cows (Benchaar et al., 2008), and digestibility of crude protein in dairy cows (Yang et al., 2007). Lin et al. (2003) concluded that the apparent digestibility of NDF and ADF was increased after adding phytobiotic supplements to the diet of dairy goats compared to the control group. The apparent digestibility of NDF was improved after adding a 10g synbiotic supplement to a diet of fattening lambs (Hossain et al., 2012). Increased number and ratio of cellulolytic bacteria in rumen fluid for better digestibility of raw fibres with synbiotic supplementation was one of the possible reasons that improved digestibility of NDF in this study (El-Katcha et al., 2016). The apparent digestibility of nutrients is affected by various factors, including nutrition level and the quality of the supplement's ration ingredients (Vanhatalo et al., 2003). According to the results of a study, synbiotic supplementation had a significant effect on the improvement of the apparent digestibility of NDF (Kazemi-Bonchenari et al., 2013). It has been shown that desired environmental conditions (in-vivo or in-vitro) for microbes living in the gastrointestinal tract improve the digestibility of nutrients, and synbiotic supplements (containing probiotic and prebiotic) provide this medium in animal host body (Gibson and Fuller, 2000). Prebiotic supplementations increased the apparent digestibility of crude protein and organic matter in calves (Kim et al., 2011). Prebiotics enhance the durability of organic matter and crude protein in the body by increasing the digestibility of these nutrients, which increases the growth of animals (Terre et al., 2013). Zheng et al. (2018) found that sheep fed with mannan oligosaccharide supplement had higher digestibility of NDF and ADF rather than the control treatment. It seems that stimulating the proliferation of intestinal epithelial cells is related to one of the action mechanisms of prebiotic and synbiotic supplements. The reason is that these supplements stimulate the proliferation of intestinal epithelial cells and improve the digestibility of nutrients by increasing the short-chain fatty acids. Along with the increased height of the villi, digestion performance, and nutrient uptake are enhanced due to increased area of uptake and nutrient transferring systems (Jin et al., 1996). In a study, probiotic supplementation did not have a significant effect on the apparent digestibility of nutrients in fattening lambs (Zamboti et al., 2023), which was not in agreement with the results of the present study.

Consistent with the results of the present study, a study showed a significant increase in the blood glucose rate of fattening lambs who received synbiotic supplements (El-Katcha et al., 2016). Moreover, a study reported that glucose concentration was significantly higher in lambs fed with prebiotic supplements rather than control treatment (Chashnidel et al., 2020). The high glucose concentration in lambs fed with Biomin Imbo synbiotic supplement may have occurred due to increased gluconeogenesis caused by higher propionate concentration or activity of bacteria living in the synbiotic supplement (*Enterococcus faecium* and *Lactobacillus plantarum*), which can convert special carbohydrates to simple substrates, such as glucose. The required energy for growth will be created if glucose concentration is kept in blood circulation (Khalid et al., 2011). On the other hand, blood glucose concentration depends on the consumable dry matter. Since the amount of consumable dry matter for fattening lambs was increased in the treatment containing synbiotic supplement compared to the control group, the blood glucose concentration was also increased. Mohammed et al. (2004) reported that blood glucose concentration was increased in the fattening calves fed with medicinal plants. In the study conducted by Nikbakht et al. (2021), blood cholesterol and triglyceride concentrations were lower in fattening lambs fed with medicinal plant powder compared to the control group, which was matched with the results of the present study. Probiotics and prebiotics can improve the performance of ruminant livestock by decreasing blood urea levels and using it optimally in the rumen to produce ammonium and create microbial protein (Fayed et al., 2005). The blood urea nitrogen of fattening lambs fed with a ration containing medicinal plant powder was significantly lower than this rate in the control group (Nikbakht et al., 2021). The decreased BUN concentration caused by phytobiotic in the extant study compared to the control group may reflect the effect of the active compound on the rumen's microorganisms, the decline in deamination, and urea production in the liver. This case can increase the feed effectiveness by reducing the energy consumed for excreting nitrogen's metabolites (Kholif et al., 2012). Polysaccharides, flavonoids, glycoproteins, polypeptides, steroids, alkaloids, and pectin available in medicinal plants can effectively decrease blood fat (Yan et al., 1996). Medicinal herbs and their essential oils play a vital role in reducing cholesterol and blood fat by producing enzymes that break the bile acids and decrease pH in the intestinal tract (Kianbakht and Jahaniani, 2003). Possible reasons for declined blood serum cholesterol concentration in fattening lambs studied in the present paper may be due to serum cholesterol-lowering effects of synbiotic supplements through their effects on the cholesterol and lipoprotein transporters' pathway. Because cholesterol is the raw material used to produce bile acids, cholesterol used for the creation of new bile acids can reduce the cholesterol concentration in blood circulation (Begley et al., 2006). Higher propionate production rather than acetate in the rumen may be a reason for the significant rise of blood glucose concentration in fattening lambs fed with phytobiotic supplements compared to the control group. The reason may be related to a decline in methane production, which reduces acetate and increases succinate production, and finally, succinate converts to propionate (McDonald et al., 2002). Researchers have reported that phytobiotics can increase bile acid production and degradation of cholesterol to faecal bile acids and natural sterols, which decrease serum cholesterol (Chithra and Leelamma, 1997). Compounds available in herbal essences would decrease cholesterol concentration and decline cholesterol-to-phospholipid conversion in the blood (Chithra and Leelamma, 1997). Results of a study showed that consumption of phytobiotic supplements containing cinnamaldehyde could reduce blood serum cholesterol concentration in fattening lambs (Chaves et al., 2008). According to two studies conducted on fattening lambs, medicinal plants could reduce triglyceride (Rahchamani et al., 2017), cholesterol, and blood urea nitrogen levels (Özdoğan et al., 2011). In a study on sheep, it was shown that blood glucose concentration was not affected by phytobiotic supplementation (Saparova and Zubova, 2019), which was not in agreement with the results of the present study. Also, Razo Ortiz et al (2020) reported that phytobiotic supplement had no significant effect on blood parameters of fattening lambs.

Ārne and Ilgaža (2016) found significantly increased cold carcass weight in the treatment containing 12g prebiotic compared to other treatments for calves. Daghash et al. (2014) reported that treatments containing 2g and 4g prebiotics could significantly increase hot carcass weight, carcass percent, and half-carcass percent of fattening lambs compared to the control group. The heavier weight of some carcass parts of fattening lambs in the extant study may occur due to more consumption of diet concentrates containing synbiotic and prebiotic supplements. Higher consumption of concentrate increases energy production for protein synthesis and growth, which may increase blood serum glucose concentration leading to higher insulin concentration that, in turn, increases the size of cells (Gardner and Kaye, 1991). Moreover, declined challenge in intestinal pathogens by synbiotic and prebiotic supplements would improve nutrient uptake and allocation finally increasing muscle volume and carcass percent (Ferket, 2004). El-Mehanna et al. (2017) reported that prebiotic, probiotic, and synbiotic supplements could significantly improve the living end weight of fattening lambs compared to control treatment. The present study showed increased daily weight gain and improved apparent digestibility of nutrients in lambs fed with synbiotic supplements, which improved carcass traits. Therefore, synbiotic supplementation may improve quantitative carcass traits, especially in valuable carcass parts (forequarter and thigh) (Quigley et al., 2002). Contrary to the results of the present study, Slavov et al. (2024) showed that probiotic and prebiotic supplementation had no significant effect on the hot carcass weight and carcass yield of fattening lambs. In a recent study, hot and cold carcass weight was not affected by probiotic and prebiotic supplementation (Estrada-Angulo et al., 2024).

The results of this study showed higher values of thigh percent and hot carcass yield in treatment containing phytobiotic supplement compared to the control group indicating improvement of these traits after being fed with phytobiotic supplement. Consistent with these results, findings of some studies on fattening livestock indicated that phytobiotic supplements containing medicinal plants could improve quantitative carcass traits (Bampidis et al., 2005; Fraser and Rowarth, 1996; Somasiri, 2014). Phytobiotic supplements can reduce the harmful microbial population of the gastrointestinal tract; hence, the protein and amino acid breakdown speed of digestive substances is reduced and a larger amount of them are absorbed and remained in the body. This case, in turn, improves the carcass percentage, reducing protein-to-fat conversion and leading to a lower amount of fat accumulated in the body (Jang et al., 2004). One of the possible reasons for improving carcass traits in the present study can be active and effective compounds available in herbal essences, which reduce low protein digestion in the rumen by inhibiting bacterial proteases using them in the intestine and being effectively used in the body of ruminant animal after being absorbed in the small intestine, which increases and improves the weight gain and carcass traits of animal (Calsamiglia et al., 2007). A study indicated the linear increase in live weight, end weight, and carcass traits of fattening lambs after adding medicinal plan powder to their feeds (Vahabzadeh et al., 2021). Hajalizadeh et al. (2020) explained that lambs fed with the diet containing fennel (*Foeniculum vulgare*) seed powder had higher end weight and hot carcass weight rather than lambs fed with the control diet. The results of the current study showed that the consumption of useful supplements (prebiotic, synbiotic and phytobiotic) in the feeding of fattening lambs could be effective on the improvement of valuable parts of the carcass, which was one of the useful economic results in the present study. In a study it was shown that lambs that received prebiotic had the highest economic feed efficiency when compared to the other groups (Shoukry et al., 2023). Several benefits have been associated with the use of prebiotics and phytobiotic in farm animals, such as improved growth and feed efficiency, reduced mortality, increasing economic efficiency and enhanced product quality (Bagno et al., 2018). The development of plant-based antibacterial agents and their application in animal husbandry are relevant given the high profitability of food production, which is a global trend that benefits both animals' and people's health (Ivanova et al., 2024).

CONCLUSION

The general results of the present study show that adding 2g prebiotic supplement and 4g synbiotic supplement to the diet improves the dry matter intake and final fattening weight. Moreover, a 6g phytobiotic supplement can significantly reduce feed conversion ratio and blood cholesterol. The apparent digestibility of dry matter and carcass yield are improved after adding a 4g synbiotic supplement to their diets. Overall, it is recommended to use dietary synbiotics and phytobiotic supplements for fattening lambs.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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