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The Effects of Diet Concentrate and Mineral Buffer Types on Fattening Lambs Performance, Nutrient Digestibility, Blood Metabolites, Rumen Fermentation and Carcass Traits

Research Article

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ABSTRACT

This study was conducted to evaluate the effects of the physical form of concentrate and mineral buffer type on lambs performance, nutrient digestibility, rumen fermentation, blood metabolites and in fattening Dalagh lambs. Twenty-eight lambs with an initial live body weight of 33 ± 2.7 kg and 6 ± 1 months of age were assigned through a completely randomized design with 2 × 2 factorial arrangement to 4 treatments and 7 replicates. Treatments contained: pelleted concentrate with sesquisodium carbonate, pelleted concentrate with sodium bicarbonate, mash concentrate with sesquisodium carbonate and mash concentrate with sodium bicarbonate. The study period was 84 days. Lambs were weighed fortnightly. In last week of the experiment, sampling and collection of feces was done to determine digestibility. Sampling from rumen fluid and blood sampling was carried out on day 80 of experiment. The results showed that in lambs fed pellet concentrate live weight, daily live weight gain, feed conversion, whole carcass, hot carcass and cool carcass were higher ($P<0.05$) in lambs fed pelleted than those fed mash concentrate. Digestibility of dry matter was higher in pellet concentrate than in mash ($P<0.05$). In blood parameters, glucose concentration in pellet concentrate was more than mash concentrate treatments ($P<0.05$). Ruminal pH showed a significant increase in the concentrations of mash and sodium bicarbonate buffer in three hours after feeding in the morning ($P<0.05$). Ammonia-N in rumen had no significant difference was observed. Among the fatty acids, concentration of TVFA, acetate and propionate in treatments of mash concentrate was higher than that of pellet ($P<0.05$). Similarly, feeding mash concentrate instead of pellet increased rumination activity ($P<0.05$). According to the results, offering pellet concentrate with either of two buffers showed higher weight gain, digestibility compared to mash concentrate. While lambs fed mash concentrate had higher rumen parameters than those fed pelleted concentrate.

KEY WORDS blood metabolite, buffer type, concentrate type, Dalagh lambs, performance, rumen fermentation.

INTRODUCTION

Meat per-capita consumption and the total amount of meat consumed are rising, driven by increasing average individual incomes and by population growth raises the relevance and importance of high quality meat supply for human consumption. Therefore, intensive ruminants fattening units require an adequate balance of ingredients for good quality meat production (Ramírez-Bribiesca *et al*. 2021). The main goal of lamb fattening is to produce large quantities and profitability of a quality product and this can be achieved by a proper nutrition (Moutik *et al*. 2021). The animals feed

mainly contains large amounts of small particles of soluble carbohydrates. The fed of these diets may led to an increase in rumen acidosis. Which is a metabolic disorder that happened by overfeeding of easily fermented concentrates such as mash in ruminants (Owens *et al*. 1998). Moreover, buffers were used in meat production systems for fattening animals fed high-concentrate diets to increase or maintain a stable ruminal pH. The role of mineral buffer compounds in reducing acid stress in the rumen have been studied and results showed that sodium containing buffers (such as sodium bicarbonate and sesquisodium carbonate) better potential (Wilkins and Jones, 2000). Rumen acid production has been associated with swelling and inflammation of the rumen wall, lameness, and purulent hepatitis, and this may be due to rapid acclimatization to high-concentrate diets (Karimizadeh *et al*. 2017). Research has shown that the use of buffer during compatibility increases production and improves health (Wenping and Murphy, 2004).

Fattening animals are fed high concentrate diets to achieve faster growth rates and to reduce the duration of the fattening period (Shahjalal *et al*. 1992). The simultaneous availability of all the nutrients needed by the animal is very important (Dus *et al*. 2004; Babker *et al*. 2009). Especially in the case of smaller particles, which usually contain effective nutrients and may settle in manger, in which case the feed eaten is not balanced and the favorable conditions in the animal's digestive tract will not be provided. To prevent such problems, food can be prepared in certain physical forms, such as pelleted (Babker *et al*. 2009; Munasik *et al*. 2013). Pelleted concentrate diet is a commonly applied for feeding animals to ensures a balanced consumption of nutrients, and minimizes the chances of feed selection, and improves animal performance by stabilizing the ruminal environment (Østergaard and Gröhn, 2000). Karimizadeh *et al*. (2017) reported that the pelleted had the higher nutrient digestibility, improved rumen fermentation, and increased performance of growing lambs compared with those fed mashed concentrate diet. Blanco *et al*. (2016) reported that offering pelleted diet increased dry matter intake and daily weight gain and reduced the fattening period in lambs. Besides, they observed an increase in digestibility of DM and a drop rumen pH t. The physical form of the concentrate in the fattening rations can influence the physical effective NDF (peNDF) contents of the diet, which has a direct impact on chewing activity, buffering capacity, and welfare of the animals (Zebeli *et al*. 2012; Blanco *et al*. 2016; Zhang *et al*. 2019). Therefore, the objectives of this study were to evaluate the effect of feeding concentrate in the forms of mash vs. pellet with sodium bicarbonate and sesquisodium carbonate buffers on performance, nutrient digestibility, carcass traits, rumen fermentation and blood parameters and in fattening Dalagh lambs.

MATERIALS AND METHODS

Location, diets, animals and experimental design

This experiment was conducted at Gorgan University of Agricultural Sciences and Natural Resources (Gorgan, Iran) from June to September of 2018 in accordance with the Care and Use of Agricultural Animals in Research and Teaching (Federation of Animal Science Societies, 2010). The rations were prepared in animal feed mill of Minoosabah (Minoodasht, Gorgan, Iran). The first step in the production of concentrate. The diet was formulated and adding additive and buffer. Then, the diet was mixed and processed into mash and pellet. Experimental treatments included: pelleted concentrate with sesquisodium carbonate, pelleted concentrate with sodium bicarbonate, mash concentrate with sesquisodium carbonate and mash concentrate with sodium bicarbonate. All diets were identical in chemical composition and differ only in the physical form and buffer. The study period was 84 days and adaptation was 14 days. The diets were formulated *add libitum* according to the NRC (2007) tables of requirements (Table 1). In this experiment, twenty-eight Dalagh male lambs (mean age=6±1 months; initial average body weight=33±2.7 kg) were selected from the University farm. Animals were assigned through a completely randomized design with 2 × 2 factorial arrangement to 4 treatments and 7 replicates. The lambs had free access to the fresh water.

Feed intake, performance, carcass and digestibility

Due to need for calculate feed intake and FCR (kg dry matter intake (DMI)/kg live mass gain) during the 84-day trial, feed intake and leftover were recorded daily and DM Intake was calculated by determination of the ration dry matter (60 ˚C, 48 h). To evaluate the growth performance including live weight (LW) changes and feed conversion ratio (FCR). The animals were weighed at the beginning of the experiment (with the starvation 8 h before the start of the experiments) and then every fortnightly. The BW changes were calculated by difference of final and initial weight. The carcasses were hung by the Achilles tendon after slaughter. Hot and cold (i.e., after 24 h chilling at 4 ˚C) carcass weights without head were recorded.

A digestion trial for 7 days (sample collection) was conducted at the end of experimental feeding, during which daily feed intake and feces excretion were collected and recorded. Samples (about 10%) of feed, leftover and feces were collected every morning and stored in a freezer at -20 ˚C. Feces were collected using a total collection method over 24 h. The feed, feces and orts samples for 7-day collection were pooled, oven dried (60 ˚C, 48 h.), ground to pass through a 1-mm screen and stored for chemical analysis.

Table 1 Feed ingredients and chemical composition of experimental diets

Item	Diets			
	Concentrate pelleted		Concentrate mash	
Ingredients, g/kg of DM	**Buffer SSC**	**Buffer SBC**	**Buffer SSC**	**Buffer SBC**
Alfalfa	250	250	250	250
Barely grain	230	230	230	230
Corn grain	260	260	260	260
Soy meal	60	60	60	60
Wheat bran	110	110	110	110
Beet pulp	60	60	60	60
Oyster shell	5	5	5	5
Salt	3	3	3	3
Dicalcium phosphate	2	2	2	2
Minerals and vitamins supplement[1]	10	10	10	10
Sodium bicarbonate	0	10	0	10
Sodiumsesquicarbonate	10	0	10	0
Nutrient and chemical composition				
Dry matter (g/kg, as-fed basis)	889	889	889	889
Crude protein	139	139	139	139
Organic matter	905	905	905	905
Neutral detergent fiber	302.8	302.8	302.8	302.8
Acid detergent fiber	194.7	194.7	194.7	194.7
Metabolizable energy (Mcal/kgDM)	2.62	2.62	2.62	2.62
Ash	101.2	101.2	101.2	101.2
Calcium	6.6	6.6	6.6	6.6
Phosphorus	4.2	4.2	4.2	4.2

[1] Premix provided the following per kilogram diet: Mn: 99.2 mg; Fe: 50.0 mg; Zn: 84.7 mg; Cu: 1.0 mg; I: 1.0 mg; Se: 0.2 mg; vitamin A: 9000 IU; vitamin D: 2000 IU; and vitamin E: 18.0 IU.
SSC: sesquisodium carbonate and SBC: sodium bicarbonate.

All samples were analyzed for DM (method 930.15), ether extract (method 920.29), acid detergent fiber (ADF, method 973.18) and N (method 984.13) of AOAC (2005) expressed inclusive of residual ash. Neutral detergent fiber (NDF) was determined without the use of sodium sulphite or α-amylase according to Van Soest *et al.* (1991).

Blood samples collection and analysis

Blood samples from jugular vein were collected in serum tubes (Damoon-E70, Iran) contain anticoagulant agent approximately 4 h after morning feeding (Coverdale *et al.* 2004) from all animals at the final week of the experiment. Collected samples were centrifuged for 3000 × g at 4 ˚C for 15 min (Hermel, Germany) and separated plasma stored in -20 ˚C until further analysis for, glucose, blood urea nitrogen, triglycerides, creatinine, total protein, albumin, globulin and cholesterol were measured using quantity detection kit (Pars azmun company, Iran) and spectrophotometer (model S Bio-Rad Libra. England), respectively.

Rumen fluid sampling and volatile fatty acid measurements

In last week of the experiment, rumen fluid samples were taken from each animal at 3 h post feeding. Approximately 100 mL of rumen liquor was collected from the rumen with a stomach tube using light suction. Rumen liquor pH was recorded immediately after collection using a digital pH meter (Metrohm model 691. Switzerland). The rumen liquor was then strained through four layers of muslin cloth. The strained samples were stored after acidifying with 0.2 mol/L HCl solution and kept in labelled polypropylene bottles at -20 °C till further analysis. The NH_3-N concentration was determined for rumen fluid samples according to Broderick and Kang (1980), and volatile fatty acids were analyzed according to Erwin *et al.* (1961).

Chewing activity

During the sampling period, the chewing activities of each animal were recorded through a visual observation method for a period of 24 h continuously (08:00 to 08:00) at 5 min intervals. The total number of minutes eating, ruminating, and resting activity were then estimated by the sum of each observation and multiplied by a factor of five (Kononof *et al.* 2002). The chewing activities were adjusted for DM, NDF and ADF intake (Beauchemin, 1991).

Statistical analysis

Data were analyzed as a completely randomized design with 2 × 2 factorial arrangements to 4 treatments and 7 replicates of treatments using GLM procedure of SAS (2004). A comparison of means by Duncan's multiple range tests was carried out at the probability of 5% level.

RESULTS AND DISCUSSION

The results of growth performance are reported in Table 2. The final live weight and daily weight gain in the group receiving pellet concentrate were greater than mash concentrate. Live weight and daily weight gain during fattening were unaffected by buffer types (P>0.05). Dry matter intake was affected by concentrate forms (P<0.05). This was greater in the pellet concentrate group. The feed conversion ratio in the first month of fattening and the whole period in the group receiving pellet concentrate was lower than the group receiving mash concentrate (P<0.05). Dry matter intake and FCR during fattening were unaffected by buffer types (P>0.05). The weight of whole carcass, hot carcass and cool carcass in the group receiving pellet concentrate were greater than mash concentrate. Live weight and daily weight gain during fattening were unaffected by buffer types. In total, no interaction was observed between the concentrate form and the type of buffer among the experimental treatments. Results of digestibility are reported in Table 3. Dry matter digestibility was affected by the diet forms (P<0.05). Dry matter digestibility was higher in the group receiving pellet concentrate than in the group receiving mash concentrate (P<0.05). But there was no significant difference in the digestibility of other nutrients (P>0.05). Also, different treatments were not affected by the type of buffer used. In total, no interaction was observed between the concentrate form and the type of buffer among the experimental treatments. The results of blood metabolites are reported in Table 4. Blood metabolites were not affected by the concentrate forms, except for Glucose, which was higher in the groups receiving pellet concentrate than mash concentrate (P<0.05). Also, blood metabolites were unaffected by the type of buffer (sodium bicarbonate and sesquisodium carbonate) used (P>0.05). The results of rumen parameters are reported in Table 5. In this study, ruminal pH was measured and recorded at 4 hours after morning feeding. The results showed that the pH of ruminal fluid at 4 hours after feeding in the treatment receiving mash concentrate was higher than the group receiving concentrate in the form of pellet (P<0.05). The use of sodium bicarbonate buffer increased the pH of ruminal fluid at 4 hours after feeding compared to sesquisodium carbonate (P<0.05). Also, no interaction was observed between the physical form of the concentrate and the type of buffer. There was no significant difference in the amount of ammonia nitrogen between the experimental treatments (P>0.05). The amount of volatile fatty acids was significantly different between the treatments receiving pellet and mash concentrate (acetate, propionate and total volatile fatty acids). The value of these parameters was greater in the groups receiving mash concentrate than in the group receiving pellet concentrate (P<0.05). But there was no significant difference in the amount of fatty acids butyrate, valerate, isovalerate and also the ratio of acetate to propionate. No interaction was observed between the physical form of the concentrate and the type of buffer. Results of feed consumption behavior are reported in Table 6. Parameters related to feed consumption behavior were affected by the concentrate forms. Eating, chewing and ruminating activities of groups receiving pellet concentrate were less than those receiving mash concentrate (P<0.05). Feed consumption behavior were unaffected by the type of buffer (sodium bicarbonate and sesquisodium carbonate) used (P>0.05). Also, no interaction was observed between the physical form of the concentrate and the type of buffer.

Processing of the feed as well as the physical form can affect its palatability, rumen fermentation, and nutrients digestibility, thereby affecting animal feed consumption and growth (Khan *et al*. 2016). The pelleting did affect the performance of lambs over the weaning transition and not just during growing or finishing periods (Li *et al*. 2021a). Porter *et al*. (2007) reported feed intake in calves fed starter in the form of mash was significantly greater than pellet. The use of initial diet in pellet and mash forms in Holstein calves showed that the total feed intake increased significantly using the initial diet of mash compared to pellet (Kertz and Loften, 2013). The use of pelleted concentrate compared to mash were improved feed consumption, weight gain and feed efficiency, which are consistent with the results of this study (Babker *et al*. 2009; Munasik *et al*. 2013). Karimizadeh *et al*. (2017) stated that daily weight gain and growth were unaffected by diet forms, while in the present study, the treatments receiving pellet concentrate had daily weight gain and growth more than the mash concentrate receiving treatment. In contrast, Kertz and Loften (2013) showed that the daily weight gain of calves fed the initial mash diet was significantly higher than pellet. Porter *et al*. (2007) also showed that the feed conversion ratio and daily weight gain using the initial mash diet were lower than pellet. Zhang *et al*. (2019) reported that feeding fattening lambs completely pelleted increased ADG and carcass yields during the experimental period, however, there is no substantial difference on FCR. The improved feed consumption and similar FCR suggested that the increased growth performance was primarily due to increased feed intake. Dry matter intake and average daily gain in animals received pellet in this study were consistent with those of the Raghuvansi *et al*. (2007). In their experiment, the lambs received pellet had significantly higher average daily gain than animals allowed grazing on a pasture and supplemented with mash concentrate.

Table 2 Effects of physical forms of concentrate and buffer types on fattening lambs performance

Item	Concentrate (C)		Buffer (B)		SEM	P- value		
	Pellet	Mash	SSC	SBC		C	B	C * B
Body weight (kg)								
Initial	33.90	33.82	33.85	33.87	0.885	0.995	0.991	0.919
28	42.11	39.92	40.96	41.07	0.931	0.109	0.914	0.731
56	51.18[a]	47.92[b]	49.55	49.75	0.967	0.025	0.991	0.672
84	58.62[a]	55.01[b]	57.00	56.62	1.029	0.021	0.792	0.336
Body weight change (kg)								
1-28	8.21[a]	6.10[b]	7.10	7.20	0.452	0.003	0.877	0.369
28-56	9.07	8.00	8.58	8.48	0.391	0.064	0.857	0.817
56-84	7.44	7.07	7.45	7.05	0.334	0.457	0.406	0.087
1-84	24.72[a]	21.17[b]	23.15	22.75	0.724	0.003	0.669	0.141
Daily weight gain (g/d)								
1-28	293.51[a]	217.92[b]	254.00	257.42	16.171	0.003	0.882	0.367
28-56	324.00	285.64	306.71	302.92	13.951	0.063	0.849	0.821
56-84	265.57	252.85	266.35	252.07	11.952	0.459	0.406	0.088
1-84	294.28[a]	252.07[b]	257.75	270.78	8.611	0.002	0.697	0.139
Dry matter intake (g/d)								
1-28	2010.07[a]	1906.07[b]	1941.42	1975.35	21.131	0.001	0.267	0.391
28-56	2226.07	2144.28	2134.07	2236.28	52.622	0.282	0.182	0.943
56-84	2406.42	2332.51	2374.28	2434.64	42.240	0.228	0.069	0.363
1-84	2214.50	2127.64	2126.57	2215.57	32.684	0.072	0.066	0.538
Feed conversion ratio								
1-28	7.11[b]	9.36[a]	8.28	8.18	0.552	0.008	0.897	0.412
28-56	6.97	6.87	7.31	7.54	0.459	0.177	0.722	0.749
56-84	9.29	9.63	9.12	9.79	0.541	0.664	0.389	0.071
1-84	7.59[b]	8.58[a]	7.90	8.27	0.281	0.021	0.368	0.117
Carcass								
Whole carcass (kg)	41.03[a]	39.21[b]	39.82	40.38	1.004	0.049	0.217	0.291
Hot carcass(kg)	30.52[a]	27.93[b]	29.38	29.15	0.878	0.013	0.162	0.743
Cool carcass (kg)	27.84[a]	25.84[b]	27.01	26.82	0.675	0.033	0.369	0.306
Whole carcass (%)	70.01	71.28	69.87	71.33	2.040	0.602	0.066	0.511
Empty carcass (%)	52.08	50.77	51.55	51.49	1.321	0.478	0.761	0.441

SSC: sesquisodium carbonate and SBC: sodium bicarbonate.
SEM: standard error of the means.

Table 3 Effects of physical forms of concentrate and buffer types on digestibility in fattening lambs

Item	Concentrate (C)		Buffer (B)		SEM	P-value		
	Pellet	Mash	SSC[1]	SBC[2]		C	B	C * B
Intake (g/day)								
Dry matter	2214.50	2127.64	2126.57	2215.57	32.684	0.072	0.066	0.538
Organic matter	2011.4	1999.7	1994.8	2013.5	27.418	0.084	0.098	0.093
Crude protein	308.4	298.7	300.3	302.8	9.174	0.248	0.278	0.267
Neutral Detergent Fiber	691.5	664.1	652.9	709.3	29.444	0.059	0.069	0.061
Acid Detergent Fiber	412.2	402.8	409.1	420.6	13.284	0.254	0.431	0.401
Ether Extract	82.7	74.8	77.4	81.9	3.142	0.087	0.487	0.741
Digestibility (g/kg)								
Dry matter	672.80[a]	651.50[b]	666.40	666.90	14.054	0.011	0.909	0.981
Organic matter	703.30	702.70	704.10	701.90	12.084	0.918	0.708	0.541
Crude protein	627.10	624.40	626.60	624.90	4.798	0.696	0.722	0.786
Neutral Detergent Fiber	552.10	564.40	551.60	549.90	7.418	0.627	0.742	0.674
Acid Detergent Fiber	527.20	522.70	526.60	524.90	11.482	0.419	0.805	0.872
Ether Extract	637.20	641.40	639.60	639.10	12.284	0.222	0.878	0.486

SSC: sesquisodium carbonate and SBC: sodium bicarbonate.
SEM: standard error of the means.

Table 4 Effects of physical forms of concentrate and buffer types on blood metabolites in fattening lambs

Blood metabolites	Concentrate (C)		Buffer (B)		SEM	P-value		
	Pellet	Mash	SSC	SBC		C	B	C * B
Glucose (mg/dL)	70.27[a]	63.90[b]	67.14	67.05	1.991	0.039	0.972	0.974
Cholesterol (mg/dL)	58.40	60.71	64.25	56.81	4.049	0.643	0.116	0.318
Triglyceride (mg/dL)	19.67	25.20	24.47	21.56	1.817	0.055	0.180	0.286
Urea (mg/dL)	35.09	34.46	35.32	34.26	1.744	0.801	0.676	0.801
Creatinine (mg/dL)	0.69	0.73	0.71	0.72	0.021	0.353	0.769	0.251
Total protein (g/dL)	6.45	6.72	6.54	6.63	0.112	0.797	0.578	0.204
Albumin (g/dL)	4.04	4.02	4.05	4.01	0.075	0.108	0.714	0.064
Globulin (g/dL)	2.41	2.70	2.49	2.62	0.148	0.606	0.303	0.191
Albumin:globulin	1.68	1.49	1.62	1.54	0.208	0.692	0.263	0.110

SSC: sesquisodium carbonate and SBC: sodium bicarbonate.
SEM: standard error of the means.

Table 5 Effects of physical forms of concentrate and buffer types on rumen parameters of fattening lambs

Rumen parameters	Concentrate (C)		Buffer (B)		SEM	P-value		
	Pellet	Mash	SSC	SBC		C	B	C *B
pH	5.31 [b]	5.74[a]	5.29[b]	5.76[a]	0.076	0.001	0.001	0.067
Ammonia-N (mg/dL)	11.23	12.61	11.30	11.54	1.663	0.321	0.901	0.887
TVFA (mmol/L)	99.65[b]	102.55[a]	101.01	101.18	0.679	0.008	0.826	0.626
Acetate (mol/100 mol)	61.05[b]	62.78[a]	61.72	62.11	0.401	0.007	0.502	0.480
Propoinate (mol/100 mol)	23.27[b]	25.11[a]	24.37	24.01	0.401	0.005	0.411	0.811
Butyrate (mol/100 mol acetate)	12.36	11.64	11.93	12.07	0.023	0.345	0.852	0.791
Iso-valerate (mol/100 mol acetate)	1.45	1.50	1.47	1.48	0.523	0.176	0.790	0.701
Valerate (mol/100 mol acetate)	1.51	1.51	1.52	1.51	0.015	0.929	0.724	0.929
Acetate:propionate	2.62	2.50	2.53	2.59	0.042	0.051	0.361	0.668

SSC: sesquisodium carbonate and SBC: sodium bicarbonate.
SEM: standard error of the means.

Table 6 Effects of physical forms of concentrate and buffer types on chewing activities of fattening lambs

Variable, min/day	Concentrate (C)		Buffer (B)		SEM	P-value		
	Pellet	Mash	SSC	SBC		C	B	C * B
Chewing	533.92 [b]	699.58 [a]	611.21	622.57	41.514	001.0	0.492	0.831
Eating	[b]289.78	[a]373.28	329.07	334.00	16.750	001.0	0.610	0.970
Ruminating	[b]244.14	[a]326.57	282.14	288.57	25.422	001.0	0.414	0.622
Chewing per kilogram DMI	241.10[b]	328.80[a]	287.41	280.99	18.698	001.0	0.407	0.981
DMI Eating per kg	130.85	175.44	154.74	150.75	11.247	0.176	0.675	0.581
Ruminating per kg DMI	110.24	153.48	132.67	130.24	10.211	0.245	0.089	0.186
Chewing per kg NDFI	772.11 [b]	1053.42[a]	936.14	877.72	49.816	001.0	0.469	0.666
Eating per kg NDFI	419.06[b]	562.08[a]	504.01	470.88	29.687	001.0	0.457	0.872
Ruminating per kg NDFI	353.05[b]	491.74[a]	432.13	406.83	24.871	001.0	0.094	0.286
Chewing per kg ADFI	1295.29[b]	1736.79[a]	1494.03	1480.19	61.255	001.0	0.471	0.181
Eating per kg ADFI	703.00[b]	926.71[a]	804.37	794.10	39.040	001.0	0.658	0.545
Ruminating per kg ADFI	592.28[b]	810.74[a]	689.66	686.09	31.459	001.0	0.740	0.186

SSC: sesquisodium carbonate and SBC: sodium bicarbonate.
SEM: standard error of the means.

Better performance in lambs fed pellet than mash diets probably was due to its higher dry matter digestibility because the nutrient digestibility has positive relationship with growth performance in all species (Wang *et al*. 2016). Pellet diet had higher rumen out flow rate which results in increase feed intake compared to mash once (Blanco *et al*. 2016). Zhong *et al*. (2018) also found that feeding pellet increased the feed consumption and growth rate of fattening lambs, which was consistent with the Coufal-Majewski *et al*. (2017) study.

They reported an increase in DLWG when lambs fed pelleted than those fed mash diets. Scales *et al*. (2000) indicated that enhanced growth rate had a positive correlation with carcass weight and yield of lambs. Zhang *et al*. (2019) reported that feeding pellet could improve the growth performance of fattening lambs by increasing carcass weight yield and proportion.

Jones *et al*. (2016) showed that the amount of dry matter consumed in the diet with high sesquisodium carbonate buffer increased compared to low sesquisodium carbonate.

But in the present study, the buffer factor could not cause a significant difference in any of the performance parameters. Adding 0.05% magnesium oxide and 0.2% sodium bicarbonate to the diet increased feed conversion ratio, daily weight gain and feed in fattening lambs (Hashemi *et al*. 2012). Although common buffers do not have a direct effect on feed intake or digestion, they can improve digestion of feed in the rumen and small intestine, if used in combination and can maintain the state of the rumen ecosystem in a way that optimizes microbial growth (Erdman, 1988). The differences in the present experiment with other experiments are probably due to different experimental diets, different climatic conditions the type of animal and management system used.

Several studies have shown that use of pelleted concentrate compared to mash improved feed consumption (Babker *et al*. 2009; Munasik *et al*. 2013; Zhong *et al*. 2018; Zhang *et al*. 2019). Consistent with the results of this experiment, pellet concentrate compared to mash increases the digestibility of dry matter in the final diet of fattening lambs (Raghuvansi *et al*. 2007; Karimizadeh *et al*. 2017). Pellet processing had no effect on the apparent digestibility of dry matter and fiber in cattle (Beauchemin *et al*. 1994). Also they about beef feedlot finishing diets reported that apparent digestibility of insoluble fiber in neutral detergent was not affected by diet processing (Beauchemin *et al*. 2001). Reducing the feed particle size of the diet reduces the ruminant time in cows and reduces the amount of digestive material floating in the ruminal fluid. Reduction of these substances leads to a decrease in saliva production and provides conditions for lowering the pH of the rumen. In contrast with the results of this study, the digestibility of chemical compounds was not affected by block, pellet and mash forms (Verma *et al*. 1996; Samanta *et al*. 2003). Digestibility of dry matter, crude protein, and acid detergent fiber were increased for calves that received pellet (Du *et al*. 2021). Li *et al*. (2021b) reported that digestibility of starch and Ether Extract increased in the lamb group that received pellet concentrate but other nutrients digestibility was not affected by diet treat means. Intense mechanical press and high temperature during the pelleting process could break the covalent bonds in biopolymers and the disrupted structures facilitate functional properties modification (Carvalho and Mitchell, 2000). In contrast with our results, Martins *et al*. (2019) observed that physical form of concentrate was not affective in dry matter digestibility. By and large, compressing feed, which includes pellet in spherical and cubic shapes, due to the use of heat during this process can affect the digestibility of feed (McDonald *et al*. 2010). The discrepancy between our results and other reports could be related to differences in dietary, nutrient composition, and particle size of feeds, or the experimental animal species and age used.

Also, a significant increase in apparent digestibility of insoluble fibers in acid detergents from 36 to 45.1% and 46.8%, respectively, was observed by adding 1% sodium bicarbonate and 0.8% magnesium oxide to the diet of dairy cows in early lactation (Erdman *et al*. 1982). Although common buffers do not have a direct effect on feed intake or digestion, they can improve digestion of feed in the rumen and small intestine, if used in combination and can maintain the state of the rumen ecosystem in a way that optimizes microbial growth (Erdman, 1988). Kawas *et al*. (2007) found that dry matter digestibility was not affected by the addition of sodium bicarbonate to lamb feed, which is in line with the findings of the current experiment.

Consistent with the results of present experiment, Du *et al*. (2021) was showed lower Glucose concentration in blood serum of calves that fed unpelleted starter than pelleted starter at day 49 and day 63 could be because pelleted starter received calves had more dry matter intake and this could to show that greater starch had been digested in the small intestine, major because of differences in physical form.

Blood urea nitrogen concentration reflects the dietary crude protein intake, the ratio of dietary crude protein to rumen fermentable organic matter, and also serves as an indicator of ruminal protein supply (Hammond, 1997; Martin *et al*. 2005).

Given that crude protein intake there was no significant difference in lambs receiving pellet concentrate and mash (Table 3). Thus, probably reason for the lack of significant differences in blood urea nitrogen concentration can be attributed to crude protein intake. On the other hand, blood urea nitrogen is highly correlated with ruminal ammonia (Burgos *et al*. 2007; Javaid *et al*. 2008), there was no significant difference in the present experiment in ruminal NH_3 concentration (Table 5). Li *et al*. (2021a) reported that the physical form pellet and mash did not affect the concentration of total protein, albumin, globulin, albumin/globulin, blood urea nitrogen (BUN), glucose, triglyceride and cholesterol blood in fattening lambs.

Karimizadeh *et al*. (2017) showed that the physical form of diet (pellet and mash) did not affect the concentration of blood glucose and blood urea nitrogen. Samanta *et al*. (2003) reported no changes in blood glucose and blood urea nitrogen between pellet and mash diet in sheep. Also Du *et al*. (2021) showed that physical form of diet Glucose concentration was not found to be different among treatments. The effects of the physical form of the feed (pelleted *vs*. conventional) on blood parameters of fattening goats were same among all groups (Malik *et al*. 2020).

Blood serum parameters are frequently measured as an indicators of the nutritional status, physiological state, and immune function of animals. Differences of these parameters in response to buffer types did not reach statistically significant levels, but agreed with the results reported in the literature. Adding bentonite in the amount of 0, 2.5 and 5% to the concentrate part increased the serum protein in goat (Mohsen and Tewfik, 2000). Sodium bentonite decreased blood plasma urea nitrogen and increased blood plasma protein in sheep (Walz *et al*. 1998). Considering that in the current study, the nutrient content of the diets was the same it was expected that there would be no significant difference in the concentration of blood parameters of fattening lambs (Li *et al*. 2021b). In addition, blood urea nitrogen is an indicator of nitrogen status in ruminant body and it is affected by the dietary intake and degradation of crude protein (Martin *et al*. 2005).

Karimizadeh *et al*. (2017) reported that rumen fluid pH, total volatile fatty acids (TVFA), acetate, propionate, butyrate, valerate and isovalerate concentrations and acetate to propionate ratio were not altered by changes in physical form of diets (mash and pellet). They showed ruminal ammonia nitrogen did not differ significantly between the treatments receiving concentrate in the forms of mash and pelleted in the diet of fattening lambs, but increased significantly in the group receiving concentrate in the form of block.

Zhang *et al*. (2019) showed that ruminal pH not altered by changes in pellet and unpelleted diets. But acetate, propionate and rumen NH_3 concentrations was significant. In line with findings of current study, Du *et al*. (2021) and Li *et al*. (2021b) reported that ammonia nitrogen in different treatment was not significant and ruminal pH was higher in unpellet concentrate. Rumen pH depends on feeding time (Hindrichsen *et al*. 2002) and the amount of volatile fatty acids produced (Synder *et al.* 2006). Also ruminal pH is largely dependent on the fermentable dietary compositions and physical forms of diets (Hussein, 2017; Kim *et al*. 2018). In the present study, similar pH values within normal physiological range were found between mash and pellet treatments, indicating that feeding pellet could maintain an appropriate acid-base status without inducing the rumen acidosis. The reason for the decrease in ruminal fluid pH in this study can be attributed to the high consumption of digestible carbohydrates and the high ratio of concentrate to forage (ratio 75 to 25) (Sutton *et al*. 2003; Calabrò *et al*. 2005; France and Dijkstra, 2005). Also, rumen out flow rate which is higher in pelleted diet than nonpelleted. It means less saliva excreted due to lower remaining time of pelleted diet (Kim *et al*. 2018).

The fermentation products in the rumen were related to the dietary compositions and rumen microbes. It is indicated that volatile fatty acid (VFA) concentrations were positively correlated with their productions (Sutton *et al*. 2003; Calabrò *et al*. 2005; France and Dijkstra, 2005). Therefore, the increase of acetate and propionate concentrations by feeding pellet was due to the increased feed intake (Table 1). As main source of rumen NH_3 arises from the degradation of dietary protein nitrogen, so do the deamination of amino acids, lysing bacteria by protozoa, and conversion endogenous non protein nitrogen compounds (Makkar, 2003). Therefore, not significant difference the rumen NH_3 concentrations in mash and pellet diet may be related to of the similar protein intake (Table 3). Desirable sodium bicarbonate and sesquisodium are among them are ruminal buffers that neutralize rumen acids provide the optimal rumen acidity (Santra *et al*. 2003). Jones *et al*. (2016) showed that ruminal pH was higher in sesquisodium and sodium bicarbonate fed to cows than in control. Similarly, it is shown that 20 g/kg DM of sodium bicarbonate in the fattening diet of merino lambs decreased ruminal acidity and increased ammonia nitrogen and volatile fatty acid composition (Bodas *et al*. 2009). Sodium Bicarbonate does not have much effect on the production of volatile fatty acids (Askar *et al*. 2011). Though, increased the ratio of acetate to propionate (Kaplan *et al*. 2010).

Bashtani *et al*. (2011) reported lower chewing and rumination in pelleted concentrate than mash concentrate was observed in Brown Swiss dairy cows. This was attributed to the increase density of forage particle and decrease bulk density through compacting the diet in pelleting process. Yang *et al*. (2001) showed that eating activity increased with increasing particle size of the diet. Karimizadeh *et al*. (2017) showed no significant difference between pelleted and mash diet in feed consumption behavior. Although, Retnani *et al*. (2009) in another study, comparing unpelleted and pelleted concentrate offered to dairy cows with forage showed that in pelleted diets cows spent more time to eat.

The differences in the results of present study with others may be due to different experimental diets, particle size of diets, different climatic conditions and the type of animal. Ghorbani *et al*. (1989) showed that Ruminant time was reduced in dairy cows receiving sesquisodium carbonate compared to low sesquisodium carbonate. However, in the present study, the buffering factor could not cause a significant difference in any of the parameters of consumption behavior.

CONCLUSION

The results of current study indicated that offering pelleted concentrate with either of two buffers increases the parameters of weight gain, carcass performance, and digestibility

in fattening lambs and offering mash concentrate in terms of rumen parameters had the best efficiency, so that increases ammonia nitrogen rumen and volatile fatty acids in rumen and reduces pH rumen. Therefore, feeding pellet and mash concentrate or selection of buffers between sesquisodium carbonate and sodium bicarbonate are a feasible strategy to raise fattening lambs in the intensive feed lot style feeding system. These findings provide new insights into the selection of the physical form of concentrate and buffers type in fattening lamb productions.

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