



Effects of adding ground or steam-flaked corn and zinc-enriched yeast to grower pellet feed on fattening performance, development of rumen papilla, and some blood parameters in lambs

Muhittin Zengin^{1*} , İhsan Kısadere² , Mustafa Usta³ , Oğuz Koray Bacaksız¹ , Ergün Demir¹ , Mehmet Ali Azman¹ 

¹ Balıkesir University, Faculty of Veterinary Medicine, Department of Animal Nutrition and Nutritional Diseases, Balıkesir, Turkey.

² Balıkesir University, Faculty of Veterinary Medicine, Department of Physiology, Balıkesir, Turkey.

³ Balıkesir University, Faculty of Veterinary Medicine, Department of Pathology, Balıkesir, Turkey.

ABSTRACT - This study aimed to evaluate the effects of ground or steam-flaked corn and zinc-enriched yeast addition to grower pellet feed on fattening performance, rumen papillae development, and some blood parameters in lambs. For this purpose, thirty-six Kivircik male lambs were selected and divided equally into six groups: basal diet containing pellet feed without different corn form and yeast (control), basal diet 80% + ground corn 20% (PGC), basal diet 80% + steam-flaked corn 20% (PFC), PGC + Zn-enriched yeast (PGCZnY), PFC + Zn-enriched yeast (PFCZnY), and control + Zn-enriched yeast (PZnY). They were fed for 56 days according to the diets mentioned above. At the conclusion of the evaluations in fattening performance, rumen papillae development, and some blood parameters, there were no significant differences in body weight gain, average daily gain, average daily feed intake, and feed efficiency among the experimental groups. In the PGCZnY group, rumen papillae length was found to be higher than the other experimental groups. At the end of the trial (day 0), leukocyte and lymphocyte counts decreased significantly only in the control group compared with the other groups in the present study. Serum blood urea nitrogen (BUN) values, analyzed at the beginning and at the end of the trial, increased significantly in all groups except in the PGCZnY group. Supplementation of Zinc-enriched yeast to ground corn can be used for increasing ruminal papilla length, however decreasing the serum BUN levels in lambs during the fattening period.

Keywords: ground corn, growth performance, lambs, steam-flaked corn, zinc-enriched yeast

*Corresponding author:
mzengin@balikesir.edu.tr

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1. Introduction

In parallel with the increasing human population, the need for red meat is increasing around the world (Juárez et al., 2021). Red meat is one of the essential nutrient sources for human health. Its physical, chemical, and biological properties indicate its nutritional quality (Holman et al., 2020). Sheep is one of the sources of red meat with its tasteful and high-quality content. Therefore, sheep breeding is of economic importance in Turkey (Yilmaz et al., 2013).

The replacement of commercial feeds, which are commonly used in animal nutrition, with different forms of corn could be a method to decrease production costs. For this reason, it is thought that

different corn types may improve feed intake in lambs (Reis et al., 2001). It has been reported that texturized starter forms containing steam-flaked grains combined with a pelleted supplement lead to better performance than a finely ground, crushed, or pelleted starter feed in previous studies (Franklin, 2003; Hill, 2012; Moeini, 2017). However, limited studies were found in which different forms of feed materials were added to pellet feed during the fattening period in lambs.

With the ban on the use of antibiotics in the European Union in 2006, the use of other feed additives as alternative growth promoters has been increased in sheep breeding (Valenzuela-Grijalva et al., 2017). Probiotics are one of the alternative feed additives that have been used in sheep breeding systems (Markowiak and Śliżewska, 2018). Abd El-Tawab et al. (2016) reported that probiotics regulate rumen pH, increase the production of volatile fatty acids (VFA), and stimulate lactic acid using protozoa, resulting in a highly efficient rumen function.

Zinc (Zn) is a trace element that plays an important role in the health and performance of animals (Suttle, 2010). The effects of Zn on fattening performance and some blood parameters were investigated in animals in previous studies (Berrie et al., 1995; Fadayifar et al., 2012). However, there are limited studies about the effects of Zn-enriched yeast on fattening performance, blood biochemical parameters, and rumen papilla development in the literature. It has been reported that Zn-enriched yeast supplementation could lessen intestinal damage and improve overall performance in lambs (NRC, 2007).

In Turkey, a combination of corn, barley, and wheat is used in standard lamb rearing feeds for fermentation in the rumen. Considering feed cost, breeders prefer to add corn and barley up to 20% to the grower feed at the last period of fattening as a general practice. In this study, the scientific basis of this application was investigated by adding also Zn-enriched yeast.

The main purpose of this study was to evaluate the effects of rate of 20% ground or steam-flaked corn and zinc-enriched yeast addition to the grower pellet feed on fattening performance, development of rumen papilla, and biochemical blood parameters in lambs.

2. Material and Methods

The experiment was undertaken in Balıkesir, Turkey (39°28'52" N and 28°2'27" E, and 340 m altitude), after approval by the local ethics committee (approval no. 6 - 1 /2021). The lambs used in the experiment were fed milk directly from their mothers for seven days after birth. In the 7-60 days period, in addition to milk, standard lamb starter diet was given *ad libitum*. Since all lambs were housed in the same conditions and fed the same way, the rumen papillae were initially considered to be homogeneous. In total, 36 Kivircik male lambs (23.76±0.05 kg body weight [BW]; two months old) were weighed and housed in a feedlot system marked with 1.25×1.80 cm individual pens. The lambs were randomly divided equally into six experimental groups (Table 1). In the study, lamb grower pellet feed (containing 18.75% crude protein), without different corn form and yeast (control), was used as a basal diet (Table 2). In addition to this basic feed, experimental groups were formed by using ground corn or steam-flaked corn, and Zn-enriched yeast: basal diet containing pellet feed basal diet 80% + ground corn 20% (PGC), basal diet 80% + steam-flaked corn 20% (PFC), PGC + Zn-enriched yeast (PGCZnY), PFC + Zn-enriched yeast (PFCZnY), and control + Zn-enriched yeast (PZnY). Lambs received 150 g of alfalfa hay and their specifically formulated experimental diets *ad libitum* in two equal parts at 07:00 and 17:00 h during 56 days. Lambs in PGCZnY, PFCZnY, and PZnY groups were fed 30 g/d Zn-enriched yeast [(Zn- Methionine Zn (1:2) 30 mg/kg, *Saccharomyces cerevisiae* (SC; NCYCR 404, 3×10⁹ cfu/kg)]. Diets were formulated according to the recommendations of NRC (2007). Lambs were weighed after an eight-hour fasting period with 14-day intervals. Dry matter (DM; method 930.15; AOAC, 2000), crude ash (method 942.05; AOAC, 2000), ether extract (method 954.02; AOAC, 2000); crude protein (N×6.25; method 990.03; AOAC, 2000) and crude fiber (method 978.10; AOAC, 2000) were analyzed according to the guidelines of AOAC (2000) (Table 3). Metabolizable energy (MJ/kg DM) was calculated according to UKASTA/ADAS/COSAC (1985). Bodyweight (BW), average daily feed intake (ADFI), average daily gain (ADG), and feed efficiency (FE) were calculated.

Table 1 - Experimental groups

Group	Treatment
Control (CON)	100% pellet feed (P)
PGC	80% P + 20% ground corn (GC)
PFC	80% P + 20% steam-flaked corn (FC)
PGCZnY	80% P + 20% GC + Zn-enriched yeast (ZnY)
PFCZnY	80% P + 20% FC + ZnY
PZnY	100% P + ZnY

Table 2 - Ingredients of pelleted feed

Ingredient	Amount g/kg
Barley	300
Wheat bran	140
Maize	280
Cottonseed meal	113
Soybean meal	110
Dicalcium phosphate	1.5
Limestone	45
Salt	8
Vit-min premix ¹	2.5

¹ Each kilogram of vitamin-mineral premix contains: 80 mg MnSO₄.H₂O, 200 mg MgO, 5 mg CuSO₄.7H₂O, 1 mg KIO₃, 5000 IU vitamin A, 1000 IU vitamin D, and 20 IU vitamin E.

Table 3 - Chemical composition of experimental diets

Ingredient	Experimental diet					
	CON	PGC	PFC	PGCZnY	PFCZnY	PZnY
Proportions of ingredients (g/kg DM)						
Pelleted feed	1000	800	800	800	800	1000
Ground corn	-	200	-	200	-	-
Flaked corn	-	-	200	-	200	-
Chemical composition						
Dry matter (%)	94.35	94.11	94.10	94.11	94.10	94.35
Crude protein (%)	18.75	16.25	16.38	16.25	16.38	18.75
Ether extract (%)	3.09	3.01	2.99	3.01	2.99	3.09
Crude ash (%)	7.4	6.22	6.14	6.22	6.14	7.4
Crude fiber (%)	5.23	4.63	4.81	4.63	4.81	5.23
ME (MJ/kg DM)	12.10	12.14	12.13	12.14	12.13	12.10

ME - metabolizable energy; DM - dry matter.

CON - control; PGC - pellet feed + ground corn; PFC - pellet feed + steam-flaked corn; PGCZnY - pellet feed + ground corn + zinc-enriched yeast; PFCZnY - pellet feed + steam-flaked corn + zinc-enriched yeast; PZnY - pellet feed + zinc-enriched yeast.

2.1. Determination of hematological and serum biochemical parameters

Hematological and biochemical parameters were examined from the blood samples of the lambs at the beginning (before the trial; day 0) and at the end of the trial (after the trial; day 56). For this purpose, blood samples were taken from the jugular vein of lambs to heparinized tubes. Erythrocyte (RBC) and leukocyte (WBC) counts; lymphocytes (LYM), monocytes (MON), and granulocytes (NEU) counts and percentages (%); hemoglobin (HGB) levels, hematocrit (HCT) values, platelet (PLT) count, mean

red blood cell volume (MCV), mean red blood cell hemoglobin (MCH), as well as mean red blood hemoglobin concentration (MCHC) were determined using an automated blood analyzer (Abacus Junior Vet-5, USA). Then, the blood samples were taken to the laboratory under the cold chain and were centrifuged at 3000 *g* for 25 min. Serum samples were taken into eppendorf tubes, and were stored in the refrigerator (−20 °C) until analysis. Values of alanine transaminase (ALT), aspartate aminotransferase (AST), gamma-glutamyl transferase (GGT), creatinine (CREAT), and blood urea nitrogen (BUN) were determined using an automated biochemistry analyzer (BS-400 PLUS Mindray, China).

2.2. Detection of rumen papillae development

At the end of the experiment, two slaughtered lambs from each group were selected for papillae lengths-widths measurements taken from rumen samples. For histopathological examination, 1-2 cm wide tissue pieces were taken from the dorsal and ventral sacs of the rumen, placed in 10% buffered neutral formaldehyde solution and fixed. Papillae samples fixed in formalin were blocked in paraffin after routine follow-up. Sections of 4 μm thickness were taken from paraffin blocks, stained with Hematoxylin-Eosin, and examined under a light microscope (Nikon, Eclipse Ni, Tokyo, Japan). The lengths and widths of the rumen papillae were photographed with a camera (Nikon, DS-Ri2, Tokyo, Japan) integrated into the light microscope, and the results were measured in the NIS-Elements BR (5.02.00, Nikon, Tokyo, Japan).

2.3. Statistical analysis

The experiment was laid out in a completely randomized design. Normality of the variables was tested with the Shapiro-Wilk test. Data were subjected to analysis of variance (Model 1) using the SPSS 20.0 program (SPSS, Inc., Chicago, IL). Means were compared ($P < 0.05$) by using Duncan's test (Duncan, 1955).

Model 1:

$$Y_{ij} = \mu + T_i + e_{ij}$$

in which Y_{ij} = observed value of the trait in animal receiving treatment i ; μ = constant inherent to all observations; T_i = effect of treatment i ($i = 1$: CON; 2: PGC; 3: PFC; 4: PGCZnY; 5: PFCZnY; and 6: PZnY); and e_{ij} = random error associated with observation Y_{ij} .

3. Results

3.1. Body weight, average daily gain, average daily feed intake, and feed efficiency

Body weight (kg), ADG (g), ADFI (g), and FE (g feed/g gain) were not significantly affected by the trials (Table 4).

Table 4 - Body weight (BW), average daily gain (ADG), average daily feed intake (ADFI), and feed efficiency (FE, g feed/g gain) in groups

Parameter	CON	PGC	PFC	PGCZnY	PFCZnY	PZnY	SEM	P
Initial BW (kg)	23.76	23.76	23.71	23.15	23.81	23.76	0.47	NS
56 BW (kg)	40.40	40.76	40.75	40.88	41.48	40.08	0.60	NS
ADG (g/day)								
0-56 days	297.02	303.57	304.16	316.66	315.47	291.37	5.66	NS
ADFI (g/day/lamb)								
0-56 days	1,297	1,340	1,363	1,308	1,298	1,248	0.01	NS
FE (ADFI/ADG)								
0-56 days	4.427	4.457	4.578	4.142	4.137	4.353	0.08	NS

SEM - standard error of the mean; NS - not significant.

CON - control; PGC - pellet feed + ground corn; PFC - pellet feed + steam-flaked corn; PGCZnY - pellet feed + ground corn + zinc-enriched yeast; PFCZnY - pellet feed + steam-flaked corn + zinc-enriched yeast; PZnY - pellet feed + zinc-enriched yeast.

3.2. Hematological and serum biochemical parameters

In this study, WBC and LYM count decreased significantly only in the CON group compared with the other groups at the end of the trial (Tables 5 and 6). At the end of the trial (day 56), MON numbers in the CON and PZnY groups decreased compared with the beginning of the trial (day 0) ($P<0.05$). On the other hand, the number of NEU and percentages of LYM, MON, and NEU were not affected by different feed applications ($P>0.05$). The RBC count increased at the end of the trial compared with beginning of the analysis in both CON and PZnY groups ($P<0.05$). The HGB and PLT values were not

Table 5 - Differential WBC counts and ratios (%) of the trial groups (mean±SE)

Group	Period	WBC ($10^9/L$)	LYM ($10^9/L$)	MON ($10^9/L$)	NEU ($10^9/L$)	LYM (%)	MON (%)	NEU (%)
CON (n = 6)	Day 0	8.67±0.73a	5.62±0.53a	0.04±0.00a	3.00±0.30	64.71±2.17	0.50±0.00	34.78±2.17
	Day 56	7.13±0.66b	4.63±0.46b	0.03±0.00b	2.45±0.25	64.71±2.16	0.50±0.00	34.78±2.16
PGC (n = 6)	Day 0	9.79±0.67	6.56±0.71	0.04±0.00	3.18±0.30	66.20±3.18	0.50±0.00	33.30±3.58
	Day 56	8.28±1.17	6.06±0.84	0.04±0.00	2.71±0.45	69.58±3.26	0.50±0.00	29.91±3.26
PFC (n = 6)	Day 0	10.19±1.21	6.06±0.98	0.05±0.00	4.08±0.63	59.41±4.24	0.50±0.00	40.10±4.23
	Day 56	8.09±1.20	5.20±0.89	0.04±0.00	2.85±0.39	63.76±2.88	0.50±0.00	35.75±2.87
PGCZnY (n = 6)	Day 0	9.29±0.86	6.39±0.65	0.04±0.00	2.86±0.34	68.61±2.43	0.50±0.00	30.90±2.42
	Day 56	7.85±0.85	5.35±0.41	0.03±0.00	2.46±0.53	70.08±4.36	0.50±0.00	29.43±4.36
PFCZnY (n = 6)	Day 0	9.59±0.96	6.32±0.65	0.04±0.00	3.23±0.50	66.18±3.06	0.50±0.00	33.33±3.05
	Day 56	7.02±0.92	4.71±0.81	0.03±0.00	2.28±0.36	66.21±4.49	0.50±0.00	33.31±4.47
PZnY (n = 6)	Day 0	11.07±1.32	6.80±0.89	0.05±0.00a	4.20±0.51	61.33±2.20	0.50±0.00	38.16±2.20
	Day 56	7.62±0.44	4.91±0.30	0.03±0.00b	4.34±1.77	64.73±3.13	0.50±0.00	34.78±3.12
Between groups A,B - $P<0.05$		NS	NS	NS	NS	NS	NS	NS
Periods of the analysis a,b - $P<0.05$		$P<0.05$	$P<0.05$	$P<0.05$	NS	NS	NS	NS

SE - standard error; NS - not significant.

CON - control; PGC - pellet feed + ground corn; PFC - pellet feed + steam-flaked corn; PGCZnY - pellet feed + ground corn + zinc-enriched yeast; PFCZnY - pellet feed + steam-flaked corn + zinc-enriched yeast; PZnY - pellet feed + zinc-enriched yeast.

a-b, A-B - Means in the same column with different letters differ significantly ($P<0.05$): A,B, between groups = $P<0.05$; a,b, periods of the analysis = $P<0.05$.

Table 6 - Some hematological parameters (mean±SE) of the trial groups

Group	Period	RBC ($10^{12}/L$)	HGB (g/dL)	HCT (%)	MCV (fL)	MCH (pg)	MCHC (g/dL)	PLT ($10^9/L$)
CON (n = 6)	Day 0	13.06±0.52b	12.81±0.26	32.30±1.15	24.83±1.13	9.85±0.27	39.98±0.92a	619.66±66.70
	Day 56	14.24±0.35a	13.13±0.34	36.65±0.85AB	25.83±0.70AB	9.25±0.18AB	35.85±0.37bAB	541.16±44.20
PGC (n = 6)	Day 0	15.82±3.13	12.00±0.53	31.43±0.88	25.33±0.76b	9.61±0.27	38.00±0.75	608.33±31.69
	Day 56	16.62±3.01	11.96±0.93	35.64±2.21AB	26.83±0.54aA	8.96±0.39AB	33.70±1.23B	577.16±88.98
PFC (n = 6)	Day 0	13.72±0.46	13.01±0.59	33.93±0.51b	25.00±0.57b	9.48±0.15	38.36±1.00a	624.66±29.63
	Day 56	14.77±0.37	13.46±0.38	38.87±1.34aA	26.50±0.50aA	9.11±0.25AB	34.81±1.38bAB	627.83±42.69
PGCZnY (n = 6)	Day 0	12.94±0.66	12.42±0.26	32.31±1.00b	25.33±0.76	9.76±0.36	38.80±1.13	703.83±60.00
	Day 56	13.99±0.46	12.73±0.34	36.03±0.46aAB	26.00±0.68AB	9.13±0.20AB	35.33±0.60AB	588.33±79.95
PFCZnY (n = 6)	Day 0	13.48±0.23	12.76±0.25	32.51±0.45	24.17±0.30	9.48±0.10	39.30±0.48	785.00±91.59
	Day 56	13.09±0.89	12.51±0.48	33.35±2.20B	25.33±0.55AB	9.81±0.64A	38.41±2.04A	482.00±65.69
PZnY (n = 6)	Day 0	13.00±0.64b	12.14±0.52	31.58±1.41b	24.17±0.30	9.43±0.32	38.88±1.49	612.50±31.23
	Day 56	14.58±0.54a	12.58±0.47	35.50±1.51aAB	24.33±0.33B	8.66±0.18B	35.61±1.07AB	657.33±46.52
Between groups A,B - $P<0.05$		NS	NS	$P<0.05$	$P<0.05$	$P<0.05$	$P<0.05$	NS
Periods of the analysis a,b - $P<0.05$		$P<0.05$	NS	$P<0.05$	$P<0.05$	NS	$P<0.05$	NS

SE - standard error; NS - not significant.

CON - control; PGC - pellet feed + ground corn; PFC - pellet feed + steam-flaked corn; PGCZnY - pellet feed + ground corn + zinc-enriched yeast; PFCZnY - pellet feed + steam-flaked corn + zinc-enriched yeast; PZnY - pellet feed + zinc-enriched yeast.

a-b, A-B - Means in the same column with different letters differ significantly ($P<0.05$): A,B, between groups = $P<0.05$; a,b, periods of the analysis = $P<0.05$.

affected by treatments. According to the HGB and PLT values, no significant difference was detected among the experimental groups before (day 0) and after (day 56) the trials ($P>0.05$). Although HCT values increased between measurements (day 0 - day 56) in all experimental groups, they showed statistical changes only in PFC, PGCZnY, and PZnY groups ($P<0.05$). In addition, the highest HCT values were found in the PFC group at the end of the trial. Analysis of the day 56, MCV values were found to be higher in the PGC and PFC groups compared with the other groups ($P<0.05$). The MHC values were not affected by the applications before and after the trials. Values of MCHC were statistically decreased between the two measurements in the CON and PFC groups ($P<0.05$).

In our study, serum BUN values increased significantly in all groups except in the PGCZnY group between the analysis of days 0 and 56 ($P<0.05$) (Table 7). The highest BUN values were determined in the PFC and PZnY groups at the end of the trial. Although serum AST values increased in all groups on day 56 ($P<0.05$), ALT values in all measurements were not affected by the treatments. In addition, the highest ALT values among the experimental groups were determined in the PGC group. Serum GGT values increased in the second analysis (day 56) compared with the first (day 0) in all groups except the PGC group ($P<0.05$). Compared with the other groups, the lowest GGT values were found in the PGC group. At the end of the trial, although serum ALB values increased in all groups, statistical differences occurred only in the CON, PFC, and PFCZnY groups ($P<0.05$). In addition, the highest ALB levels were defined in the PFC group compared with the other groups. In the CON, PGC, PFC, and PZnY groups, TP levels increased significantly on day 56 analysis due to different feed treatments ($P<0.05$). There was no significant difference between the measurements of TP levels in the PGCZnY and PFCZnY groups ($P>0.05$). On the other hand, serum CREAT levels were not affected by different feed treatments in the study ($P>0.05$). In addition, the highest CREAT levels were determined in the PFC group compared with the others in the second analysis ($P>0.05$).

Table 7 - Serum biochemical parameters (mean \pm SE) of the experimental groups

Group	Period	BUN (mg/dL)	AST (U/L)	ALT (U/L)	GGT (U/L)	CREAT (mg/L)
CON (n = 6)	Day 0	21.09 \pm 0.42b	107.67 \pm 7.65b	25.83 \pm 6.47	64.00 \pm 7.93b	1.03 \pm 0.02b
	Day 56	34.25 \pm 1.92aAB	313.66 \pm 67.74aA	20.33 \pm 1.62AB	124.33 \pm 15.09aA	1.25 \pm 0.03aAB
PGC (n = 6)	Day 0	20.37 \pm 0.58b	104.83 \pm 8.16b	24.00 \pm 6.49	65.33 \pm 7.89	1.04 \pm 0.02
	Day 56	31.09 \pm 2.99aAB	156.50 \pm 16.83aB	28.83 \pm 6.31A	75.00 \pm 9.97B	1.23 \pm 0.08AB
PFC (n = 6)	Day 0	19.89 \pm 0.69b	104.50 \pm 8.09b	18.17 \pm 1.24	65.66 \pm 7.85b	1.24 \pm 0.14
	Day 56	38.24 \pm 5.34aA	221.16 \pm 25.09aAB	25.33 \pm 2.18AB	117.33 \pm 17.65aAB	1.39 \pm 0.10A
PGCZnY (n = 6)	Day 0	20.14 \pm 0.47	105.67 \pm 7.95b	21.00 \pm 2.19	65.83 \pm 7.70b	1.06 \pm 0.02
	Day 56	24.88 \pm 2.68B	167.33 \pm 17.26aB	20.00 \pm 1.63AB	101.33 \pm 10.82aAB	1.20 \pm 0.11AB
PFCZnY (n = 6)	Day 0	20.71 \pm 0.41b	106.00 \pm 7.99b	18.50 \pm 3.18	64.16 \pm 7.91b	1.10 \pm 0.06
	Day 56	30.90 \pm 3.58aAB	152.50 \pm 12.06aB	18.50 \pm 1.94B	90.83 \pm 8.32aAB	1.01 \pm 0.08B
PZnY (n = 6)	Day 0	21.35 \pm 0.53b	105.33 \pm 8.32b	20.17 \pm 1.30	65.50 \pm 7.98b	1.07 \pm 0.03
	Day 56	38.11 \pm 5.79aA	197.66 \pm 24.66aB	20.16 \pm 1.51AB	126.66 \pm 16.67aA	1.21 \pm 0.06AB
Between groups A,B - $P<0.05$		$P<0.05$	$P<0.05$	$P<0.05$	$P<0.05$	$P<0.05$
Periods of the analysis a,b - $P<0.05$		$P<0.05$	$P<0.05$	NS	$P<0.05$	$P<0.05$

SE - standard error; NS - not significant.

CON - control; PGC - pellet feed + ground corn; PFC - pellet feed + steam-flaked corn; PGCZnY - pellet feed + ground corn + zinc-enriched yeast; PFCZnY - pellet feed + steam-flaked corn + zinc-enriched yeast; PZnY - pellet feed + zinc-enriched yeast.

a-b, A-B - Means in the same column with different letters differ significantly ($P<0.05$); A,B, between groups = $P<0.05$; a,b, periods of the analysis = $P<0.05$.

3.3. Rumen papillae development

In the histopathological examination, it was observed that the rumen papillae of lambs in CON group were parakeratotic. Black necrotic areas were observed in the extreme parts of the keratin layer. Degenerated epithelial cells with vacuoles were seen in the cytoplasm of the lamina epithelial.

Besides, focal inflammation was noted in the lamina propria foci with neutrophil leukocytes and mononuclear cell infiltration. The histopathological findings of the rumen of the animals in the PZnY group were similar to the CON group. Parakeratosis, necrosis, and hydropic degeneration were detected in the papilla ruminis of the PGC and PGCZnY groups, but no inflammation was observed. The pathological findings were not found in the PFC and PFCZnY groups. In addition, while a large amount of protozoan was observed between the papillae ruminis in the sections of the PFCZnY group, no protozoan was seen in the sections of the other groups. Papillae lengths-widths were measured (Table 8, Figures 1 and 2).

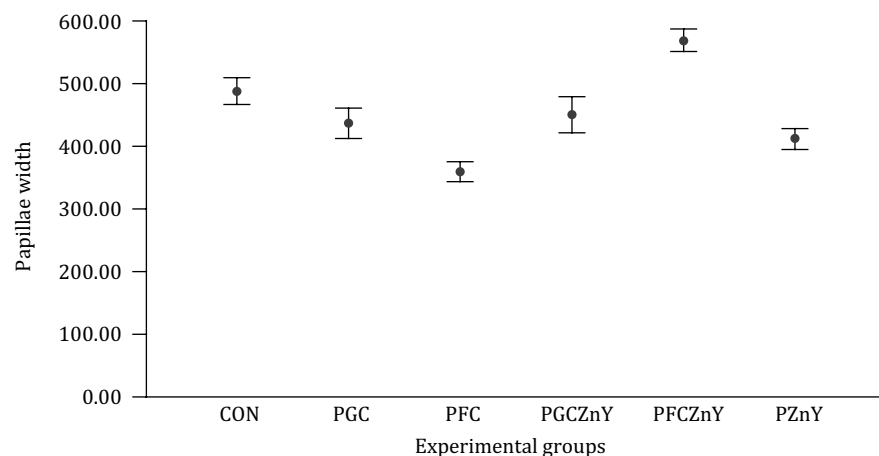
Table 8 - Rumen papilla measurement (μm)

Rumen papilla measurement	Treatment						SEM	P-value
	CON	PGC	PFC	PGCZnY	PFCZnY	PZnY		
Length	3014.83b	3002.13b	3047.01b	3616.21a	2747.28b	3115.69b	62.27	0.002
Width	487.37b	436.19cd	358.85e	449.70c	567.69a	310.90d	6.09	0.001

SEM - standard error of the mean.

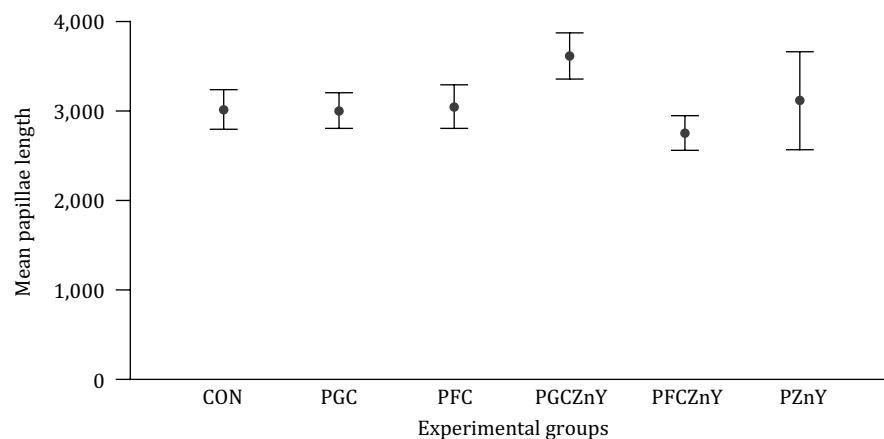
CON - control; PGC - pellet feed + ground corn; PFC - pellet feed + steam-flaked corn; PGCZnY - pellet feed + ground corn + zinc-enriched yeast; PFCZnY - pellet feed + steam-flaked corn + zinc-enriched yeast; PZnY - pellet feed + zinc-enriched yeast.

a-e - Means in the same row with different letters differ significantly ($P < 0.05$).



CON - control; PGC - pellet feed + ground corn; PFC - pellet feed + steam-flaked corn; PGCZnY - pellet feed + ground corn + zinc-enriched yeast; PFCZnY - pellet feed + steam-flaked corn + zinc-enriched yeast; PZnY - pellet feed + zinc-enriched yeast.

Figure 1 - Rumen papillae width (μm).



CON - control; PGC - pellet feed + ground corn; PFC - pellet feed + steam-flaked corn; PGCZnY - pellet feed + ground corn + zinc-enriched yeast; PFCZnY - pellet feed + steam-flaked corn + zinc-enriched yeast; PZnY - pellet feed + zinc-enriched yeast

Figure 2 - Rumen papillae length (μm).

4. Discussion

In the present study, the effects of as much as 20% ground or steam-flaked corn and zinc-enriched yeast addition to the grower pellet feed on BW, ADG, ADFI, and FE were evaluated and no significant changes among the experimental groups were found. Akin to our study, Hejazi et al. (1999) reported that corn processing might not optimize performance of feeding lambs with ground corn instead of whole shelled corn in their study. In a previous study, Ding et al. (2008) stated that the addition of yeast for 49 days to lamb rations positively affected the feed efficiency and daily live weight gain in lambs. Haddad and Goussous (2005) also found that daily supplementation of 3 g/d for 74 days of yeast culture (YC) in the rations of Awassi lambs improved the body weight gain and feed efficiency. Mikulec et al. (2010) also investigated the effects of live yeast (SC - 0.5 g/day or 1 g/day) on the growth performance of East-Friesian lambs participating in a 14.04 kg BW, and did not observe a positive effect on the growth performance similar to our results. This may be due to the differences in yeast content, animal breed, starting weight of the trial, and management conditions. In addition, the reports on the effect of the probiotic application on the growth and the fattening performance of lambs and carcass characteristics are inconsistent (Baranowski et al., 2007; Titi et al., 2008; Whitley et al., 2009). Besides, Knuth et al. (2020) indicated that the addition of Zn to ration for 63 days increased the DM intake, but did not improve the growth performance of lambs. It was also reported that there was no effect of Zn addition to the diets of lamb on growth performance (Solaiman and Min, 2019). This can be related to the type and level of probiotics and the content of the experimental diet (Khalid, 2011).

In the PGCZnY group, rumen papilla length was found to be higher than in the other experimental groups. Besides, whole rumen papilla ruminis widths were detected to be the highest in the PFCZnY group compared with the other groups in the present study. Conversely, Petrič et al. (2021) reported that supplementation of Zn to ration did not affect the weight and length of the rumen papilla ruminis in CON and Zn-added groups in lambs. However, Shahid et al. (2020) informed that the addition of Se-enriched yeast to ration improved the papillae concentration and length of the rumen papilla ruminis in the Se-added group compared with CON. On the other hand, the positive effects of Zn-enriched yeast supplementation to the ground or steam-flaked corn forms on papilla development were better observed in the PGCZnY and PFCZnY groups compared with the others in the present study. Also, parakeratosis, necrosis, and hydropic degeneration were noted in the papilla ruminis of the CON and PZnY groups, but also inflammation was observed in our study. Similarly, Steele et al. (2009) also observed parakeratosis in papilla ruminis of cows depending on easily fermentable carbohydrate rations. Focal infiltration of inflammatory cells in papillae within the epithelial layer was observed in animals fed Zn+herbs by Petrič et al. (2021).

The RBC counts were found as 13.00 ± 0.64 at the beginning of the trial and increased (14.58 ± 0.54) due to Zn-enriched yeast supplement in PZnY group in our study. On the other hand, HGB values were not affected by the different diet applications. Hematocrit (%) values increased as 38.87 ± 1.34 , 36.03 ± 0.46 , and 35.50 ± 1.51 (before and after the trial) in PFC, PGCZnY, and PZnY groups, respectively. Conversely, Petrič et al. (2021) reported that RBC, HGB, and HCT values were not significantly influenced by time (day 0, 35, and 70), treatment (Zn, Herb, Zn-Herb), or the treatment \times time interaction in lambs. However, Osita et al. (2019) found that SC (0.75 and 1.5 g/kg) supplementation to ration showed positive effects on the hematological parameters such as hemoglobin (HbC), packed-cell volume (PCV), and red blood cell (RBC) counts in weaned Najdi ram lambs. These can also be observed due to different animal types, diet applications, or management conditions. At the end of the trial (day 56), MCV (fL) values were found to be higher in the PGC (26.83 ± 0.54) and PFC (26.50 ± 0.50) groups compared with the other groups. On the other hand, MCH values were not affected by the diet administration between the analyses (day 0 and day 56), but were the highest in the PFCZnY group at the end of the trial. Petrič et al. (2021) also observed that treatment-time (organic Zn) significantly affected the MCV in lambs. Similarly, Osita et al. (2019) detected that dietary supplementation of yeast significantly increased the MCV and MCH values in lambs. In addition, MCHC values decreased as 35.85 ± 0.37 and 34.81 ± 1.38 in the CON and PFC

groups at the end of the trial compared with beginning, respectively. This finding was consistent with that of Osita et al. (2019). The differences in the results may be due to the processing method, the amount of used corn, the level, and content of yeast, differences in the animal material, age, and management conditions. The WBC and LYM counts decreased significantly only in the CON group compared with the other groups in our study. Petrič et al. (2021) also defined that treatment (Zn, Herb, and Zn-Herb supplementation) and time (day 0, 35, and 70) significantly affected NEU levels, and time (day 0, 35, 70) significantly affected the counts of LYM and eosinophil (EOS). MON counts decreased in the CON and PFZnY groups at the end of the trial (day 56) in our study. On the other hand, the number of NEU and the percentages of LYM, MON, and NEU (%) were not affected by different diet administration in the present study. Petrič et al. (2021) suggested that treatment and time (organic Zn) significantly affected NEU values and counts of LYM and EOS. Similarly, the addition of SC yeast on diet was found a factor determining an increase in the number of NEU, while receiving feed supplemented with *Yarrowia lipolytica* and/or the probiotic in piglets an increment factor for LYM count by Czech et al. (2018). In addition, Milewski (2009) reported that feeding lambs diets containing SC had a significant effect on the blood's WBC count and contributed to higher LYM percentages in the leukogram. In a previous study, a significant effect of dietary treatments (exogenous fibrinolytic enzymes cocktail and *Artemisia absinthium* Linn.) was observed for all the differential WBC except basophil count (Beigh, 2018). In addition, we did not find any significant change among the groups according to PLT values in our study. Beigh et al. (2018) also reported that feed additives supplemented alone as well as in combination did not show any significant effect on platelet indices in lambs. On the other hand, van der Peet-Schwering et al. (2007) found that the number of PLT was less in piglets fed with the CON diet compared with supplemented diets [YC and modified yeast culture (YC+cell wall product containing mannan oligosaccharides)]. It can be observed due to different animal types or digestive systems.

In the present study, serum AST values increased in all groups at the end of the trial; however, ALT values were not affected by the different diet treatments. Interestingly, the Zn-enriched yeast and ground corn diets showed the best protective effects (hepatic) on ALT and AST values in our study. Besides, serum GGT values were affected at day 56 analysis compared with the day 0 in all groups except the PGC group by the diet applications. Compared with the other groups, the lowest GGT values were found in the PGC group. Hussein (2018) informed that plasma ALT levels decreased significantly in CON and treatment groups [*L. sporogenes* (37.50×10^3), SC-47 (625.0×10^3 cfu), 1 g alpha-amylase, and 20 g sea wood powder/kg diet - concentrate feed mixture, for six months] in both sexes of lambs. On the other hand, plasma AST levels showed the opposite trend in which AST concentration increased significantly in lambs fed probiotics. El-Ashry et al. (2003) also found that supplementation of flavomycin (20 mg/h/d) and SC (5 mg/h/d) diet increased plasma ALT and AST levels in growing lambs. Abou Elenin et al. (2016) also researched the improvement of rumen fermentation and performance of the growing lambs by adding natural microbials. There were no differences in AST and ALT values between the groups to which 10 g of yeast was added per lamb daily to the basic ration for 24 weeks, the control group, and other groups with other additives to the growing lambs.

Conversely, Özsoy et al. (2013) reported that enzyme activities of AST, ALT, and GGT were not altered by yeast culture supplementation in goats. It may be due to different diet contents or application times. On the other hand, serum CREAT levels were not affected by different feed treatments except the CON group in the present study. In addition, the analysis of the day 56, the highest CREAT levels were determined in the PFC group compared with the others. Sallam et al. (2020) reported that additive mixtures (peanut hay + microbial feed additives) did not affect the concentrations of CREAT in Barki lambs similar to our results. These same results were also determined by Payandeh and Kafilzadeh (2007) and Elaref et al. (2020). In our study, serum BUN values increased significantly in all groups except the PGCZnY group between the beginning and the end of the trial. On the other hand, it was reported that the serum BUN values were not affected by different diets and additives (Özsoy et al., 2013; Sallam et al., 2020; Payandeh and Kafilzadeh, 2007). These differences may be due to the enhancement of utilization of ammonia in rumen by adding Zn-enriched yeast (Lascano and Heinrichs, 2009).

5. Conclusions

Ground corn can be added to the diet of Kivircik lambs of 56 days of age during the fattening period. Besides, the supplementation of Zinc-enriched yeast to ground corn also can be used for increasing ruminal papilla length, however decreasing the serum blood urea nitrogen levels in lambs.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Conceptualization: M. Zengin, I. Kisdere, E. Demir and M.A. Azman. Data curation: M. Zengin, I. Kisdere and M.A. Azman. Formal analysis: M. Zengin, I. Kisdere, M. Usta, O.K. Bacaksız and E. Demir. Funding acquisition: M.A. Azman. Investigation: M. Zengin, I. Kisdere, M. Usta, O.K. Bacaksız, E. Demir and M.A. Azman. Methodology: M. Zengin, I. Kisdere, E. Demir and M.A. Azman. Project administration: M. Zengin, I. Kisdere, M. Usta, O.K. Bacaksız, E. Demir and M.A. Azman. Software: M. Zengin and I. Kisdere. Supervision: E. Demir and M.A. Azman. Validation: M. Zengin, I. Kisdere, M. Usta, E. Demir and M.A. Azman. Visualization: M. Zengin and I. Kisdere. Writing – original draft: M. Zengin, I. Kisdere and E. Demir. Writing – review & editing: M. Zengin, I. Kisdere, M. Usta, E. Demir and M.A. Azman.

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