MANAGEMENT AND PRODUCTION

Growth, carcass characteristics, and meat quality of broilers fed a low-energy diet supplemented with a multienzyme preparation

E. O. S. Hussein,[*,1] G. M. Suliman,[*,†] A. N. Alowaimer,[*] S. H. Ahmed,[‡] M. E. Abd El-Hack,[§] A. E. Taha,[#] and A. A. Swelum[*,||,1]

*Department of Animal Production, College of Food and Agricultural Sciences, King Saud University, 11451 Riyadh, Saudi Arabia; †Department of Meat Production, Faculty of Animal Production, University of Khartoum, Sudan; ‡Department of Basic Sciences, College of Veterinary Medicine, Sudan University of Science and Technology, Sudan; §Department of Poultry, Faculty of Agriculture, Zagazig University, Zagazig 44511, Egypt; #Department of Animal Husbandry and Animal Wealth Development, Faculty of Veterinary Medicine, Alexandria University, Edfina 22758, Egypt; and ||Department of Theriogenology, Faculty of Veterinary Medicine, Zagazig University, Zagazig 44519, Egypt

ABSTRACT The effect of a low-ME diet with a multienzyme (Kemzyme Plus, Kemin, Des Moines, IA) blend on performance, meat quality, and carcass traits was evaluated in Hubbard broiler chicks. A total of 120 Hubbard broiler chicks were allocated to the following 4 experimental groups and every group was separated into 6 replicates, with 5 birds per replicate: control (3,180 kcal/kg of ME), control + 0.50 g/kg diet of enzyme (Cont-Enz), low-ME diet (3,080 kcal/kg), and low-ME + 0.50 g/kg diet of enzyme (low-ME-Enz). The trail lasted for 16 D (32 to 48 D of age). No significant differences in growth parameters or carcass traits were observed among treatments. However, liver weight increased with the low-ME-Enz diet ($P = 0.038$). The low-ME diet recorded the highest weight for the bursa ($P = 0.043$) and thymus ($P = 0.019$). Dietary treatments had significant impacts on the length of duodenum, ileum, and cecum, as well as the weight of duodenum. The length of duodenum, ileum, and cecum increased with enzyme supplementation. The myofibril fragmentation index was lower with the Cont-Enz, low-ME, and low-ME-Enz diets than with the control diet ($P = 0.043$). The shear force increased with the low-ME-Enz diet ($P = 0.022$) than the control diet. Dietary treatments influenced breast meat yellowness ($P = 0.019$), whereas the low-ME diet had the lowest yellowness at the slaughtering age. The dietary treatments affected the breast meat pH ($P = 0.001$), with the control diet having the highest pH value after 24 hours. Thus, there was no effect of low-ME or enzyme supplementation to the control or low-ME diet on growth performance or carcass yield. However, feeding a low-ME diet or Cont-Enz preparation influenced organ and small intestine weights and meat characteristics.

Key words: carcass, meat quality, broiler, low-energy, multienzyme

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INTRODUCTION

Maize and soybean meal (**SBM**) are the main feedstuffs used for providing energy and protein in commercial poultry diets (Zanella et al., 1999; Maisonnier-Grenier et al., 2004) because of their high digestibility. The ME level in the nutrients is dependent on the animals' requirement but can be influenced by the digestibility of nonstarch polysaccharides (**NSP**), starch, and protein. The major energy source in maize is starch and its breakdown in the digestive system tends to be incomplete because some starch can be resistant to digestion (Brown, 1996). The SBM contains some nondigestible carbohydrates, which could be available to broiler chickens with suitable enzyme addition (Cowan, 1993; Bila et al., 2017; Abd El-Hack et al., 2019). Therefore, some feeding strategies exist for improving the nutritional value of SBM and corn (Zanella et al., 1999; Maisonnier-Grenier et al., 2004). The use of a commercial enzyme (Avizyme, Finnfeeds International, Marlborough, UK) in corn and SBM nutrition of broilers improved the breakdown of nutrients and performance of broilers (Zanella et al., 1999).

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[1]Corresponding authors: shessin@ksu.edu.sa (EOSH); aswelum@ksu.edu.sa (AAS)

Moreover, adding an enzyme allowed reduction of the energy level in poultry diets (Zanella et al., 1999). On the other hand, previous studies reported that the adding of an enzyme in the corn–SBM diet has not influenced the performance of broiler chickens (Marsman et al., 1997; Kocher et al., 2002; Meng and Slominski, 2005; Alagawany et al., 2018a). In addition, the use of enzymes as feed supplements in poultry diets in improving the productivity of the birds is not a new approach but has long been existing (Attia et al., 2014; Alagawany and Attia, 2015; Abd El-Hack et al., 2017, 2018; Alagawany et al., 2017, 2018b). In this regard, Naqvi and Nadeem (2004) evaluated the bioavailability of energy through the supplementation of Kemzyme Plus (Kemin, Des Moines, IA) to broiler diets that contain 3 levels of ME (3,200, 3,000, and 2,800 kcal/kg). Kemzyme Plus is a multienzyme containing multiproteases, multiamylases, and NSP-hydrolyzing enzymes. Kemzyme Plus have been specifically developed for multisubstrate feed, such as maize–SBM and wheat–SBM–based rations for broiler chickens, to enhance the digestibility of the nutrients and to get extra amino acids and energy from these repast (Naqvi and Nadeem, 2004). Not much is known about the impact of enzyme supplementation on the characteristics and quality of the meat or digestive system, as well as the characteristics of some intestinal segments in broiler that were fed on low- or normal-ME diets. The aim of this research was to analyze the influence of corn–soybean–based diets with low- and normal-ME levels and Kemzyme Plus supplementation for broilers aged 32–48 D on growth performance, meat quality, carcass traits, and relative organ weights.

Table 1. Ingredients and composition of broiler chicken diets.

Item	Control	Low ME
Ingredient (%)		
Corn	64.81	65.81
Soybean meal, 48% CP	27.50	27.36
Palm oil	3.95	2.38
Dicalcium phosphate	1.45	1.45
Limestone	0.88	1.59
Min-vit premix[1]	0.50	0.50
Salt	0.33	0.33
DL-methionine	0.19	0.21
L-lysine HCl	0.09	0.07
Choline Cl70	0.05	0.05
Anticoccidial	0.05	0.05
Clostop	0.05	0.05
Dyno-mos	0.05	0.05
Nutrients		
DM %	89.42	89.33
ME kcal/kg	3180	3080
CP %	18.6	18.6
Arginine %	1.253	1.252
Isoleucine %	0.771	0.771
Lysine %	1.058	1.05
Methionine %	0.498	0.497
Cystine %	0.315	0.315
Methionine + cystine %	0.82	0.82
Threonine %	0.71	0.71
Tryptophan %	0.227	0.227
Valine %	0.87	0.871
Linoleic acid %	1.895	1.774
Calcium %	0.76	1.025
Total phosphorus %	0.591	0.591
Available phosphorus %	0.38	0.38
Potassium %	0.752	0.753
Chlorine %	0.256	0.254
Sodium %	0.15	0.15

Abbreviations: Min, mineral; Vit, vitamin.

[1]Min-vit. premix supplied by Agroceres Multimix (Broiler/FOCUS). The analysis guaranteed per kg of premix: vit. A, 2,000,000 IU; vit. E, 3,000 IU; vit. K3, 500 mg; vit. D3, 600,000 IU; vit. B1, 600 mg; vit. B2, 1,500 mg; vit. B6, 1,0000 mg; vit. B12, 3,500 mcg; vit B5, 3,750 mg; B3, 10 g; folic acid, 250 mg; choline, 86.6 g; iron, 12.5 g; Mn, 17.5 g; Zn, 12.5 g; Cu, 25 g; iodine, 300 mg; and Se, 50 mg.

MATERIALS AND METHODS

Animal Ethics

The experimental procedures and protocol that are applied in this study were supported by the Animal Care and Use Committee of College of Food and Agricultural Sciences, King Saud University.

Management and Treatments

A total of 120 Hubbard broiler chicks (32 D old) were randomly divided into 4 treatment groups. Each group was divided into 6 replicates, with 5 birds per replicate. The experiment was conducted in an environmentally controlled poultry unit at a temperature of 22°C–24°C. A light schedule used was 23 h of light during the entire period of the experiment, and the level of relative humidity ranged from 55 to 60%.

Broilers were raised using common floor pens (1 × 1 m) under almost even managerial and zoohygienic conditions. The birds were fed with standard finisher diets (32–48 D) based on corn SBM, with isonitrogenous contents (Table 1), in a mash form. The enzyme was supplemented in addition to the diet and was not included in the nutrient matrix. The chicks were fed with a starter feed from day 1 to 21 and, afterwards, had a growing period from day 22 to 31. After this, the birds were distributed into the following treatments: control (3,180 kcal/kg of ME), control + 0.50 g/kg of the diet enzyme (**Cont-Enz**), low-ME diet (3,080 kcal/kg), and low-ME + 0.50 g/kg of the diet enzyme (**low-ME-Enz**), respectively.

Performance and Carcass Measurements

The ADFI was determined by subtracting the amount of feed that was rejected from the birds from feed that was offered. The BW was evaluated on a 5-D basis, from which the feed conversion ratio (**FCR**) was calculated for each group.

After 48 D, 12 birds per treatment were randomly chosen and processed to evaluate the processing yields. The birds were weighed, slaughtered after 10 h of feed deprivation, bled, scalded, and defeathered in a rotary picker. The headpiece and shoulders were eliminated, and the carcasses were dissected to detach the legs and breasts. The fat amount, liver, intestines (the duodenum, jejunum, ileum, and ceca), heart, spleen, thigh, and

Table 2. Effects of dietary treatments on growth performance of broiler chickens.

Item	Treatments Control	Cont-Enz	Low-ME	Low-ME-Enz	SEM	P-value
BW (g)						
Day 32	1,805	1,803	1,786	1,795	12.82	0.962
Day 37	2,260	2,244	2,231	2,230	17.51	0.933
Day 42	2,712	2,680	2,668	2,703	17.97	0.835
Day 48	3,297	3,249	3,228	3,306	17.47	0.340
ADG (g)						
Day 32–37	91.03	88.13	88.68	87.06	1.42	0.815
Day 37–42	90.40	87.36	87.50	94.68	1.61	0.352
Day 42–48	97.60	94.85	93.38	100.53	1.23	0.178
Overall mean	93.25	90.37	90.12	94.43	1.50	0.094
ADFI (g)						
Day 32–37	153.26	151.65	152.70	149.11	2.25	0.930
Day 37–42	172.91	164.60	164.88	172.96	2.38	0.419
Day 42–48	196.18	191.81	183.20	195.67	2.66	0.302
Overall mean	175.50	170.76	167.95	173.97	1.90	0.225
FCR (g/g)						
Day 32–37	1.69	1.71	1.71	1.71	0.01	0.911
Day 37–42	1.91	1.88	1.88	1.83	0.01	0.197
Day 42–48	2.01	2.02	1.96	1.94	0.01	0.162
Overall mean	1.88	1.88	1.86	1.84	0.01	0.128

Abbreviations: Cont-Enz, control + 0.50 g/kg diet of enzyme; FCR, feed conversion ratio; Low-ME-Enz, low-ME + 0.50 g/kg diet of enzyme.

drumstick were detached and weighed. The yield percentage of every piece was computed on the basis of dressing weight.

Meat Characteristics

The breasts were sliced and weighed. The concentration of hydrogen ion was estimated using a microprocessor pH meter (Model pH 211; Hanna Instruments, Woonsocket, RI), which was set into incisions in the cranial left side of the muscle. Two measurements were recorded, and the mean pH value of the breast muscle of each carcass was calculated. The color values of CIELAB color system (1976), L^* (lightness), a^* (redness), and b^* (yellowness), were evaluated using a Chroma meter (Konica Minolta CR-400; Konica Minolta, Tokyo, Japan) in 2 different fields of the internal face of the cranial position of the postmortem. Immediately after pH and color quality evaluations, the breast muscles were iced, and kept at −20°C to be used for the evaluation of the cooking water loss (**CWL**) and shear force (**SF**). The same samples were defrosted at 4°C for 24 h and positioned in a commercial indoor counter top grill (Kalorik GR 28215; Kalorik, Miami Gardens, FL) and heated to 70°C of internal temperature. In the geometric center of the muscle, a thermocouple thermometer probe (EcoScan Temp JKT; Eutech Instruments, Singapore) was placed, to monitor the values of the internal temperature. For weighing, a semianalytical scale (Mettler MP1210; Mettler-Toledo Ltd., Leicester, UK) was used, before and after cooking, to estimate the CWL percentage, as the difference among the initial and final weights × 100/initial weight. To determine the SF or tenderness, the cooked samples for determining the CWL were also used. Then the temperature of the samples was lowered to room temperature (22°C), and afterwards, they were cut into five 2 × 1 × 1 cm parts, with the longest length parallel to the muscle fibers. It was determined that the SF was the maximum force (kg) perpendicular to the fibers, using a texture analyzer (TA-HD-Stable Micro Systems; Stable Micro Systems Ltd., Godalming, UK) equipped with a Warner-Bratzler attachment. The crosshead speed was set up at 120 mm/min.

Statistics

The data collected were subjected to ANOVA, applied by the GLM procedure (SPSS, 1997). By applying ANOVA, the differences among the means were analyzed. Afterwards, as a post hoc test, Tukey's test was used to separate the means (SPSS, 1997). To estimate the significance among means, a P-value of 0.05 was used.

RESULTS AND DISCUSSION

Growth Performance

The results presented in Table 2 revealed no significant variations in terms of growth parameters (BW, ADG, feed intake (**FI**), and FCR) among the 4 dietary treatments. Reducing ME in the diet with or without enzyme supplementation did not influence growth performance from 32 to 48 D. Chickens that were fed with a middle level (3,000 kcal/kg) of dietary energy plus Kemzyme for 6 wk achieved a higher ADG and FCR, compared with those that were fed with the same level of ME, just without enzyme addition, but had values comparable with those of chickens fed the control diet (3,200 ME kcal/kg) (Naqvi and Nadeem, 2004). In a research conducted by Perić et al. (2008), the impact of enzyme complex addition in broiler diets on growth

Table 3. Effects of dietary treatments on carcass yields and proportions of carcass parts and organs.

Item	Treatments					
	Control	Cont-Enz	Low-ME	Low-ME-Enz	SEM	*P*-value
Slaughter weight, SW, g	3,345	3,349	3,259	3,384	31.23	0.555
Carcass weight, g	2,602	2,584	2,512	2,634	28.01	0.478
Breast, g	991.10	978.41	938.50	1006.83	14.56	0.397
Thigh, g	378.01	359.83	376.75	387.66	5.30	0.319
Drumstick, g	326.50	330.08	323.58	328.50	3.83	0.944
Heart, g/kg SW	16.45	16.90	15.85	17.25	0.33	0.490
Fat, g/kg SW	51.58	48.01	44.75	45.16	2.01	0.620
Liver, g/kg SW	51.33^{b}	52.82^{b}	50.21^{b}	61.66^{a}	1.58	0.038
Gizzard, g/kg SW	70.61	77.95	68.01	70.08	1.55	0.115
Bursa, g/kg SW	$4.15^{a,b}$	3.46^{b}	4.84^{a}	$4.33^{a,b}$	1.21	0.043
Thymus, g/kg SW	9.03^{b}	$9.61^{a,b}$	11.54^{a}	$10.91^{a,b}$	0.32	0.019
Spleen, g/kg SW	2.99	3.04	3.15	3.91	0.19	0.318
Duodenum, g	13.36^{b}	15.10^{a}	12.92^{b}	15.07^{a}	0.32	0.023
Duodenum, cm	28.01^{b}	29.91^{a}	31.08^{a}	31.16^{a}	0.36	0.004
Jejunum, g	$30.03^{a,b}$	34.35^{a}	$29.19^{a,b}$	26.03^{b}	0.90	0.010
Jejunum, cm	64.25^{b}	71.16^{a}	70.91^{a}	71.41^{a}	0.95	0.015
Ileum, g	27.47	26.40	23.91	24.40	0.65	0.180
Ileum, cm	66.25^{c}	73.58^{b}	$79.33^{a,b}$	84.58^{a}	1.45	<0.001
Ceca, g	17.06	16.28	13.80	15.06	0.53	0.136
Ceca, cm	19.50^{b}	21.25^{a}	19.75^{b}	22.16^{a}	0.29	0.001

Abbreviations: Cont-Enz, control + 0.50 g/kg diet of enzyme; Low-ME-Enz, low-ME + 0.50 g/kg diet of enzyme.

[a–c]Different superscripts within the same row are significantly different ($P < 0.05$).

performance was studied for 42 D, which resulted in a positive influence on ADG and FCR. Moreover, Zhou et al. (2009) showed that the addition of a commercial multienzyme complex containing xylanase, α-amylase, and protease to broiler diets for 38 D of age enhanced the use of ME, especially in meals with low ME levels. However, some other researchers reported that the addition of an enzyme for broiler chickens had nonsignificant effects. Günal et al. (2004) showed that the supplementation of Avizyme 1300-xylanase or Avizyme 1500-amylase enzymes in diets had nonsignificant ($P > 0.05$) effect on the ADG, ADFI, FI, or FCR of chickens. Similarly, the BW, feed efficiency, FI, and endurance of chickens were not significantly influenced by the supplementation of exogenous enzyme to wheat-, barley-, and maize-based diets (Sayyazadeh et al., 2006). In a study by Sherif (2009a), he noticed a positive influence of some enzymes (Natuzyme, Bioproton Pty. Ltd., Sunnybank, Australia, and Siozyme, SICO FEEDS, Zoersel, Belgium), supplemented to broiler diets, on the final BW and ADG throughout the grower–finisher stage, whereas the FI and FCR were not affected. In another study, the same author stated that Avian Plus (Zoo Med Laboratories Inc., San Luis Obispo, CA) and Natuzyme addition increased the FCR and economic practicability of broiler chickens fed plant protein sources, whereas the FI and ADG were not affected.

Carcass Traits and Relative Organ Weights

The results presented in Table 3 indicate no significant dissimilarities among the 4 treatments for traits of carcass (carcass weight [$P = 0.478$], breast [$P = 0.397$], thigh [$P = 0.319$], drumstick [$P = 0.944$], heart [$P = 0.490$], fat [$P = 0.620$], and gizzard [$P = 0.115$], and spleen [$P = 0.318$]). However, the liver weight of birds fed the low-ME-Enz diet was higher than those of the rest of the treatments. Hu et al. (2018) reported increasing liver weight in broilers supplemented with the enzyme lipase (0 to 11,250,000 U/kg feed). The increased liver weight attributes to higher metabolic activity due to use of lipids (Al-Marzooqi and Leeson, 2000). These results are in line with the findings of Mohammadigheisar et al. (2018), where they showed that a low-energy diet in chickens with multienzyme addition (7 unit/g α-galactosidase, 22 unit/g galactomannanase, 220 unit/g β-glucanase, and 300 unit/g xylanase) had the highest relative liver weight ($P < 0.05$). Downs et al. (2006) concluded no influence of dietary energy density on the carcass characteristics of broilers. Moreover, Hidalgo et al. (2004) also noticed such effects of carcass yields to increased levels of ME in meals of straight-run broilers. In a study by Sayyazadeh et al. (2006), no significant impact of enzyme addition to diets based on wheat, corn, or barley on broilers was noticed. Similar data were also obtained by Sherif (2009b) who found that supplementing graded levels of Natuzyme and Avian Plus to plant protein diets did not affect the carcass traits of broilers. On the other hand, Bin Baraik (2010) found no effects from individual or combinations of xylanase and phytase enzymes on the carcass yield, dressing percentage, and internal organs of broilers. The latest author observed no differences in commercial meat-cut percentage. Such conclusions were also made by Aey (2013), whereas in the present study, the low-ME diet achieved the highest weights for the immune-related organs (bursa, $P = 0.043$ and thymus, $P = 0.019$). However, rare articles reported improvement of immune organ weights with diets

Table 4. Effects of dietary treatments on meat quality criteria of broiler chickens.

	Treatments					
Item	Control	Cont-Enz	Low-ME	Low-ME-Enz	SEM	*P*-value
Water-holding capacity	2.03	2.01	1.94	1.96	0.02	0.500
Myofibril fragmentation index	0.50[a]	0.43[b]	0.45[a,b]	0.43[b]	0.01	0.043
Cooking loss	36.67	37.26	35.99	35.15	0.69	0.746
Shear force	1.18[b]	1.30[b]	1.18[b]	1.78[a]	0.08	0.022
Hardness	1.25	1.23	1.21	1.31	0.03	0.832
Springiness	0.67	0.64	0.63	0.65	0.01	0.243
Cohesiveness	0.43	0.43	0.45	0.44	0.01	0.589
Chewiness	0.37	0.37	0.35	0.39	0.01	0.889

Abbreviations: Cont-Enz, control + 0.50 g/kg diet of enzyme; Low-ME-Enz, low-ME + 0.50 g/kg diet of enzyme.
[a,b]Different superscripts within the same row are significantly different ($P < 0.05$).

containing low-ME or enzyme supplementation. El-Katcha et al. (2014) reported that enzyme supplementation (Kemzyme Plus or COMBOzyme, American-Bio., Inc., Natick, MA) to both wheat grain- and corn–soybean–based diets improved the thymus gland weight ($P \geq 0.05$) and relative weight compared with those of control without providing any explanation.

Intestinal Segments

Regarding the digestive tract, dietary treatments had significant effects on the length of duodenum, ileum, and cecum, as well as the weight of duodenum. The length of duodenum, ileum, and cecum increased with enzyme supplementation (Table 3). Zhu et al. (2014) suggested that the digesta viscosity increased as a reason for no effective contact between the digesta and digestive enzymes due to presence of NSP, thus leading to significant alteration of the intestine and organ function and structure (Dworkin et al., 1976). Wang et al. (2005) stated that the secretion in the digestive system may be increased to overcome this negative effect, what could modify the size of digestive organs. Brenes et al., 1993 explain this increase in size of the gastrointestinal tract as an adaptive mechanism to a bigger demand for exogenous enzymes. On the other hand, Wang et al. (2005) noticed that the increase of enzymes in diets leads to a decrease in length and weight of the ileum, also in the length of the cecum (linearly, $P < 0.01$), at the age of 21 and 42 D (linearly, $P < 0.05$). Moreover, the same authors noticed that the weights of the liver and pancreas decreased (linearly, $P < 0.01$) at days 21 and 42 of age. In addition, Brenes et al. (1993) showed that unlike in a wheat diet, enzyme supplementation in barley-based diets reduces the lengths of the jejunum, duodenum, and ileum. Based on these facts, it can be concluded that the addition of commercial enzymes, in comparison with the control diet, modified the morphology of different parts of the gastrointestinal tract. The addition of enzymes to broiler nutrition had a positive influence on the energy digestibility (Pourreza et al., 2007). The addition of xylanase improved the nutrient usage significantly (Hosseini and Afshar, 2017). Similarly, Ramesh and Chandrasekaran (2011) stated that pure enzymes improve the apparent ME and protein and NSP digestibilities in poultry, which helps in the use of alternate feedstuffs.

Meat Quality

Except the myofibril fragmentation index and SF, the values of the meat quality were not statistically dissimilar among the low-ME, normal-ME, or enzyme diets (Table 4). The myofibril fragmentation index was lower with enzyme addition, low-ME, and low-ME-Enz diets, than with the control ($P = 0.043$). Contrarily, SF

Table 5. Effects of dietary treatments on meat color and pH of broiler chickens.

	Treatments					
Item	Control	Cont-Enz	Low-ME	Low-ME-Enz	SEM	*P*-value
pH at slaughtering	6.62	6.57	6.46	6.54	0.02	0.142
pH at 24 h	6.05[a]	5.99[a,b]	5.93[b]	5.93[b]	0.01	0.001
T°C at slaughtering	28.14[a,b]	27.78[a,b]	28.78[a]	26.62[b]	0.25	0.017
Color at slaughtering						
*L**	40.09	39.47	40.61	41.01	0.47	0.707
*a**	2.27	2.99	2.38	2.79	0.13	0.174
*b**	3.09[a]	2.71[a]	1.40[b]	1.84[a,b]	0.22	0.019
Color at 24 h						
*L**	44.21	42.48	42.77	43.93	0.55	0.640
*a**	2.47	2.90	3.28	3.43	0.14	0.074
*b**	6.08	5.38	4.92	5.63	0.21	0.276

Abbreviations: Cont-Enz, control + 0.50 g/kg diet of enzyme; Low-ME-Enz, low-ME + 0.50 g/kg diet of enzyme.
[a,b]Different superscripts within the same row are significantly different ($P < 0.05$).

increased with the low-ME-Enz diet, in comparison to other treatments ($P = 0.022$). In agreement with the current results, Habib et al. (2016) showed that there is no connection between the physical properties of broiler breast meat (pH and water holding capacity) with the addition of enzymes ($P > 0.05$). Similar results were made by Bin Baraik (2010) who claimed that commercial enzymes, such as xylanase and phytase, have no impact on meat composition or quality parameters.

This research demonstrated that the yellow color of the breast meat was influenced ($P = 0.019$) by dietary treatments, of which the low-ME diet had the lowest yellowness at the slaughtering stage. The light and red colors are not related to the dietary treatments. These results disagree with those of Cho and Kim (2013) and Mohammadigheisar et al. (2018), who claimed that feeding broilers with a low-energy diet results in a higher lightness. Meanwhile, multienzyme diets containing low energy led to a reduction in lightness. Smith et al. (2002) claimed that wheat-based diets lead to a lighter breast meat color, but the thigh meat is less affected. Besides the impact of diet, there are several factors affecting meat color such as total haem and myoglobin content, muscle pH, age, breed, and sex of birds (Wideman et al., 2016). Table 5 shows that 24 hours after slaughtering, the pH of the breast meat was influenced ($P = 0.001$) by the dietary treatments, of which the control diet had the highest pH (6.05). The slaughtering pH was not affected by the dietary treatment. These results are not in line with the data of Wang et al. (2009), which confirmed that dietary treatments had no impact on the pH of breast meat. Muscle pH has been correlated to most of meat quality parameters, such as meat color, water-holding capacity, and tenderness (Tang et al., 2007). The differences in pH values might be explained by differences in preslaughter responses to stress, storage time and temperature, slaughter weight, and the glycogen reserves at slaughter as explained by Uhlířová et al. (2018). Rosenvold et al. (2003) reported that a higher ME in poultry diets resulted in a reduction in total glycogen stores, which resulted in a higher ultimate pH value.

CONCLUSION

In conclusion, there was nonsignificant ($P > 0.05$) effect of low ME on broiler performance and no influence of a multienzyme preparation ($P > 0.05$). However, the low-ME diet recorded the highest weights of the immune organs (bursa and thymus). This suggests that a low-ME diet supplemented with enzyme might be more effective for improving the characteristics of the small intestine. From this research, it can be concluded that the supplementation of enzyme to a low-nutrient-density diet plays an important role in partially replacing the protein and energy in feedstuffs for poultry.

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