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Effect of synbiotic plus selenium or betaine on performance, intestinal health, nutrient digestibility, and carcass quality of Tegal ducks

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ABSTRACT

This study aimed to examine the effect of synbiotics and synbiotics plus Selenium or betaine on the performance, intestinal ecology, nutrient digestibility, and carcass quality of Tegal ducks. A total of 200 ducks were randomly assigned to one of four treatments in a completely randomized study. The treatment groups included control (basal feed without any additive), synbiotics (Syn; basal feed supplemented with 2% synbiotics), synbiotic plus selenium (Syn+Se; basal feed supplemented with 2% synbiotics and 10 mg/kg selenium), synbiotic plus betaine (Syn+Bet; basal feed supplemented with 2% synbiotics and 500 mg/kg betaine). The Tegal duck performance, intestinal health, nutrient digestibility, and carcass quality were determined at the end of the study. Final body weight and feed conversion ratio (FCR) were improved ($p<0.05$) in ducks given synbiotic plus selenium compared to other treatments. Betaine or selenium in combination with synbiotics lowered ($p<0.05$) the caecum's pH values. Synbiotic plus selenium or betaine enhanced ($p<0.05$) the numbers of lactic acid bacteria (LAB), but did not reduce the colonies of *Escherichia coli* in the caecum of ducks. Crude protein and crude fiber digestibility in Tegal ducks were considerably ($p<0.05$) improved by the administration of synbiotics, synbiotics plus selenium, or synbiotics plus betaine as compared to control. The Syn+Bet treatment, in contrast to the Syn and Syn+Se treatments, substantially ($p<0.05$) enhanced N and Ca retention. The Syn+Se and Syn+Bet groups had higher ($p<0.05$) carcass and thigh proportions than the control and Syn groups. The Syn+Se and Syn+Bet groups had higher ($p<0.05$) meat weights than the control and Syn groups. The treatment groups had less ($p<0.05$) abdominal fat than the control. Total cholesterol of meats was lower ($p<0.05$) in ducks treated with synbiotics or a combination of synbiotics with selenium or betaine. In conclusion, dietary administration of synbiotic plus selenium resulted in improved body weight, FCR, intestinal ecology, nutrient digestibility, carcass traits, meat weight and total cholesterol in meats of Tegal ducks.

Keywords: Betaine, Ducks, Performance, Selenium, Synbiotics

INTRODUCTION

Tegal ducks are native Indonesian ducks that are frequently reared in rural areas. Tegal ducks are mostly reared traditionally, being freed or released in the morning (the "pangon" system) and housed in the afternoon under high-stocking density of the opened-housing system. This condition is very stressful and often lead to negative impacts on health, productivity and meat quality of the ducks. Making a comfortable duck house (such as closed-house system) with normal density for ducks is one of the attempts that farmers can do. However, this requires a large investment that may not be accessible by the traditional duck producers. Study showed that dietary strategies can be carried out by the farmers to reduce the negative impact of stress caused by uncomfortable rearing conditions. In such case, feed additives may be employed by the poultry producers (Sugiharto, 2022).

Recent study has demonstrated that adding synbiotics to feed can increase broiler performance under stress conditions (Cengiz *et al.*, 2015; Kridtayopas *et al.*, 2019; Dev *et al.*, 2020). Synbiotic use in broilers also enhanced lactic acid generation, short-chain fatty acids (SCFA) production, and the number of commensal bacteria in the gut while decreasing branched-chain fatty acid production and pathogen population in the intestine (Markowiak-Kopeć and Śliżewska, 2020). With regard particularly to Tegal ducks, our previous study confirmed that synbiotics improved intestinal microbiota balance, encouraged the growth of beneficial bacteria, and improved digestibility and growth of the ducks (Mangisah *et al.*, 2020).

Selenium and betaine are two components with antioxidant capacity that can improve the physiological conditions and growth of poultry. Selenium is a cofactor component of the enzyme glutathione peroxidase (GSH-Px), which regulates extracellular and intracellular hydroperoxides. Selenium can protect animal tissues from oxidative damage and boost the immune system (Wang *et al.*, 2021). With respect to betaine, the betaine supplementation benefits the intestinal epithelium because its osmolyte function preserves villous integrity, which thereby increases nutritional digestion and absorption (Ratriyanto and Prastowo, 2019). In many cases, the combination of two or more active components can create a synergistic effect so as to further enhance the effect of each individual components on the hosts. In this present study, Tegal ducks raised in the opened-house were expected to benefit from the synergistic effects of the combination of synbiotics plus betaine or selenium. The literature search revealed that there has never been any research on this subject. Indeed, the effects of synbiotic plus Selenium or betaine on the growth performance and meat quality of ducks have not yet been documented in any publications.

The aim of the current study was to investigate the effect of dietary supplementation of synbiotics, synbiotics plus Selenium or synbiotics plus betaine on growth performance, nutrient digestibility, carcass traits and meat quality of Tegal ducks.

MATERIALS AND METHODS

Synbiotic Preparation

The synbiotic used in this study was a combination of prebiotic *Amorphophallus muelleri* tuber flour and probiotic *Lactobacillus plantarum*. The tubers of *A. muelleri* were acquired from a regional supplier in Semarang. The tubers were cleaned, sliced thinly, dried in the sun, then crushed. The Gadjah Mada University Microbiology Laboratory provided the *L. plantarum* isolate. By scraping one ose into oblique deMan Rogosa Sharpe (MRS) agar, bacterial isolates were rejuvenated before being cultured for 48 hours at 37°C. Following this, 100 mL of a 10% skim milk solution was inoculated with 10^8 cfu/mL of *L. plantarum*, and the mixture was incubated at 37°C for 24 hours. A 400 mL of 10% sterile skim milk solution was added to the incubated solution, which was then incubated once again for 24 hours at 37°C. Following the incubation, 3% *A. muelleri* tuber flour was added to

Table 1. Feed Compositions and Nutrient Contents

Ingredients	(%, except that otherwise mentioned)
Yellow corn	50.0
Soybean meal	36.0
Rice bran	7.00
Palm oil	2.30
DL-methionine	0.20
Bentonite	1.00
Limestone	1.23
Monocalcium phosphate	1.55
Premix	0.57
Chlorine chlorite	0.07
Salt	0.35
Nutrient contents	
ME (kcal/kg) *	3052
Dry matter	86.4
Crude protein	20.2
Ether extract	4.39
Crude fiber	8.22
Calcium	0.89
Phosphor	0.76

*ME (metabolizable energy) was predicted based on formulation Bolton (1967) as follow: 40.81 {0.87 [CP + 2.25 crude fat + nitrogen -free extract] + 2.5}

the bacteria. The bacteria were then incubated once more for 48 hours at 37°C, and the bacterial colony was counted using the total plate count method. The incubation products were stored and ready to be used for the *in vivo* study on Tegal ducks.

In vivo Experiment

All procedures used in this experiment were approved by the Animal Research Ethics Committee, Faculty of Animal and Agricultural Sciences, Universitas Diponegoro, Indonesia. A total of 200 Tegal male ducks were allotted to four treatment groups (each with five replications of 10 ducks) based on a completely randomized arrangement. The treatment groups included control (basal feed without any additive), synbiotics (Syn; basal feed supplemented with 2% synbiotics), synbiotic plus Selenium (Syn+Se; basal feed supplemented with 2% synbiotics and 10 mg/kg selenium), synbiotic plus betaine (Syn+Bet; basal feed supplemented with 2% synbiotics and 500 mg/kg betaine). The basal feed (Table 1) contained 3000 kcal/kg of metabolizable energy (ME) and 20% crude protein. Ducks were raised on slat floor cages for 35 days. At the age of 1 to 7 days, the ducks were raised communally using a basal feed. The treatments were applied to Tegal ducks at the age of 8-35 days. Every week, ducks' body weight and feed intake were recorded.

Data Collection

Duck performance (feed intake, body weight, and feed conversion ratio (FCR), intestinal ecology, nutrient digestibility, carcass traits and chemical meat characteristics were among the data measured. Feed consumption was calculated by subtracting the amount of feed offered from the amount of feed left over. The FCR was calculated by dividing the ducks' feed consumption by their body weight gain.

The ducks were measured for nutrient digestibility when they were 35-38 days old. One duck was taken per replicate and reared in individual battery cages. Every day, Tegal ducks were offered dietary treatments and their excreta was collected. Wet excreta was collected, weighed, and sun-dried. After the excreta had dried, it was weighed and a sample was obtained to evaluate the water content in order to quantify the excreta's dry matter. The crude protein and crude fiber content of excreta and feed samples were determined based on the AOAC (2006) methods.

The determination of lactic acid bacteria (LAB) and *Escherichia coli* counts were conducted on fluid samples from the caecum of one duck per replicate. After the duck was slaughtered, the cecal fluid was collected, placed into the sterile Eppendorf tube, and the total LAB and *E. coli* counts were enumerated based on the total plate method count method. The enumeration of LAB was conducted on MRS agar, while the *E. coli* counts was conducted on eosin methylene blue (EMB) agar according to Fardiaz (1992). The portable pH meter was used to measure the pH values of the duodenum, jejunum, ileum, and caecum of the ducks.

One duck from each replicate served as the sample for the internal organ weight measurement. The digestive and lymphoid organs were taken out of the ducks after it had been slaughtered and dissected. The weight of the digestive organs was determined by separating the duodenum, jejunum, ileum, and cecum. The bursa of Fabricius, spleen, and thymus were the lymphoid organs that were weighed. To get relative organ weights, the organ weight was divided by the live body weight. Following this, the carcass proportion of the ducks were determined.

Breast and thigh meats were used to determine the cholesterol content of the meats. The cholesterol levels in meats were assessed using the cholesterol oxidase-p-aminophenazone (CHOD-PAP) kits according to the manufacturer protocol (Diasys, Germany). Meat samples were examined for their protein and fat content using the AOAC (2006) method.

Data Analysis

The SPSS version 22 was used to statistically analyze the data collected during the study.

RESULTS AND DISCUSSION

Performance of Ducks Fed Synbiotic Plus Selenium or Betaine

Data on daily feed intake and final body weight of Tegal ducks are shown in Table 2. During the rearing period, the final body weight and FCR were better ($p<0.05$) in ducks given synbiotic plus Selenium compared to other treatments. In this study, the final body weight did not differ ($p>0.05$) between control ducks compared to ducks given synbiotic. Also, there was no significant difference between ducks given a combination of synbiotic and betaine and control ducks. This finding was inconsistent with a number of studies showing the growth-promoting effect of synbiotic supplementation on broiler chickens (Sunu *et al.*, 2019; Mangisah *et al.*, 2021; Song *et al.*, 2022). Perhaps, different types and levels of synbiotics, types of poultry, feed compositions, and environmental conditions during the study are responsible for the different impacts of synbiotics on the growth performance of poultry. The absent effect of synbiotics and betaine on the final body weight of Tegal ducks in the current study may confirm that the increase in the final body weight of the ducks in the Syn+Se group was very likely due to the impact of Selenium. This inference was supported by Baltić *et al.* (2016) reporting that dietary administration of selenium-yeast (organic selenium) improved the growth performance of ducks. In this case, Selenium may protect animal tissues from oxidative disruptions due to stress and improve the immune system of the animals (Wang *et al.*, 2021). Such improvement may thereby lead to the better growth performance and feed efficiency of the ducks.

Intestinal Ecology of Ducks Fed Synbiotic Plus Selenium or Betaine

Table 3 displays the selected microbial population in the caecum and gut pH of Tegal ducks given synbiotic plus Selenium or betaine. According to the current findings, betaine or Selenium in combination to synbiotics lowered ($p<0.05$) the caecum's pH values. On the pH of

Table 2. Performance of Ducks Fed Synbiotic Plus Selenium or Betaine

Variables	Treatments				SEM	p value
	Control	Syn	Syn+Se	Syn+Bet		
Feed consumption (g)	3193	3175	3242	3186	36.1	0.19
Final body weight (g)	938[b]	951[b]	1036[a]	948[b]	12.7	0.04
Feed conversion ratio (FCR)	3.96[a]	3.87[a]	3.58[b]	3.90[a]	0.25	0.01

[a,b]Means within similar row with divergent superscripts differ considerably (p<0.05).
Control: basal feed without any additive, Syn: basal feed supplemented with 2% synbiotics, Syn+Se: basal feed supplemented with 2% synbiotics and 10 mg/kg Selenium, Syn+Bet: basal feed supplemented with 2% synbiotics and 500 mg/kg betaine, SEM: standard error of the means

Table 3. Intestinal Ecology of Ducks Fed Synbiotic Plus Selenium or Betaine

Variables	Treatments				SEM	p value
	Control	Syn	Syn+Se	Syn+Bet		
Bacterial population in caecum						
E. coli (log cfu/g)	6.84	6.54	6.60	7.56	0.07	0.82
LAB (log cfu/g)	10.3[b]	10.8[ab]	11.3[a]	11.4[a]	0.12	0.03
pH values of intestine						
Duodenum	5.94	5.98	5.86	5.97	0.46	0.94
Jejunum	5.92	5.69	5.94	5.98	0.54	0.47
Ileum	5.93	5.74	5.88	6.1	0.09	0.22
Caecum	6.38[a]	6.23[ab]	6.05[b]	6.12[b]	0.04	0.04

[a,b]Means within similar row with divergent superscripts differ considerably (p<0.05)
Control: basal feed without any additive, Syn: basal feed supplemented with 2% synbiotics, Syn+Se: basal feed supplemented with 2% synbiotics and 10 mg/kg Selenium, Syn+Bet: basal feed supplemented with 2% synbiotics and 500 mg/kg betaine, SEM: standard error of the means

Table 4. Internal Organ Relative Weight of Ducks Fed Synbiotic Plus Selenium or Betaine

Relative weight of organs (% BW)	Treatments				SEM	p value
	Control	Syn	Syn+Se	Syn+Bet		
Bursa of *Fabricius*	0.10	0.11	0.12	0.10	<0.01	0.46
Thymus	0.47	0.49	0.50	0.51	0.01	0.49
Spleen	0.13	0.14	0.11	0.12	0.01	0.92
Duodenum	0.50	0.51	0.55	0.53	0.02	0.35
Jejunum	1.17	1.07	1.16	1.02	0.06	0.41
Ileum	1.03	0.90	1.14	1.07	0.04	0.32

Control: basal feed without any additive, Syn: basal feed supplemented with 2% synbiotics, Syn+Se: basal feed supplemented with 2% synbiotics and 10 mg/kg Selenium, Syn+Bet: basal feed supplemented with 2% synbiotics and 500 mg/kg betaine, BW: body weight, SEM: standard error of the means the duodenum, jejunum, and ileum, the treatments had no appreciable (p>0.05) impact. Synbiotic plus Selenium or betaine enhanced (p<0.05) the numbers of LAB, but did not reduce the colonies of *E. coli* in the caecum of ducks. The administration of synbiotic alone did not affect (p>0.05) the bacterial population in caecum and pH values of the intestine of Tegal ducks.

Although there was a numerical change, the effect of synbiotics supplementation on the LAB colonies or the pH level in the caecum of Tegal ducks was not observed significantly in this investigation. However, when Selenium was added to the synbiotic, the combined additives considerably enhanced (p<0.05) the LAB population and decreased the pH values in the caecum of Tegal ducks. Based on the aforementioned circumstances, it was quite likely that synbiotics and Selenium had a synergistic effect on the LAB population and pH in the caecum of Tegal ducks. In many circumstances, it is believed that *L. plantarum* has the capacity to bind, absorb, and convert inorganic Selenium and offers advantages over Selenium or individual probiotics. According to Khan *et al.* (2017), *Lactobacillus* bacteria was highly capable of binding, absorbing, and converting inorganic Selenium (sodium selenite) into organic Selenium (Se-methionine and Se-cystine), which has positive effects on health. It was further confirmed that poultry given individual Selenium or probiotics did not significantly improve the antioxidant system as evidenced by the concentration of Selenium, glutathione (GSH), GSH-Px, superoxide dismutase (SOD), and malondialdehyde (MDA) (Khan *et al.*, 2017). After receiving Syn+Se, there was an increase in LAB, which had an effect on the production of lactic acid and SCFA. As a result, the pH in the caecum was much lower than the control.

Synbiotic plus betaine administration resulted in a substantial rise (p<0.05) in LAB colonies compared to control. The use of betaine enhanced the production of acetic acid, propionic acid, and total SCFA in ducks, according to a study by Park and Kim (2017). The increased production of SCFA leads to an improvement in gut ecology, which hence encourages the development of LAB. The latter investigators further suggested that betaine plays a part in protecting the beneficial bacteria from osmotic pressure, which can potentially be harmful, particularly under stressful conditions. It was very likely that the increased counts of LAB along with the increased production of lactic acid and SCFA, which thereby led to a drop in the caecum's pH values.

Internal Organs of Ducks Fed Synbiotic Plus Selenium or Betaine

The relative weights of the bursa of *Fabricius*, thymus, and spleen in Tegal ducks were unaffected (p>0.05) by the treatments of synbiotic plus Selenium or betaine in feeds (Table 4). Similar to the lymphoid organs, the relative weights of duodenum, jejunum and ileum of Tegal ducks were not affected (p>0.05) by the dietary treatments (Table 4). Typically, the weight of the lymphoid organs and intestinal segments are attributed to the immune status and digestive functions of poultry, respectively. Indeed, although there was no difference in the relative weights of lymphoid organs and intestinal segments across the treatment groups, the weight of such vital organs was within the normal range (Sugiharto *et al.*, 2018).

Nutrient Digestibility of Ducks Fed Synbiotic Plus Selenium or Betaine

Crude protein and crude fiber digestibility in Tegal ducks were considerably (p<0.05) improved by the administration of synbiotics, synbiotics plus Selenium, or synbiotics plus betaine as compared to control (Table 5). The improvement in crude protein and crude fiber digestibility in the Syn, Syn+Se, and Syn+Bet indicated that the rise in LAB counts (due to synbiotics) resulted in an improvement in intestinal health and intestinal functions (digestive and absorption functions). Through the mechanism of competitive exclusion, synbiotic may suppress the proliferation of pathogenic bacteria, leading to a more conducive environment for the growth of favora-

Table 5. Nutrient Digestibility and Passage Rate of Ducks Fed Synbiotic Plus Selenium or Betaine

Variables	Treatments				SEM	p value
	Control	Syn	Syn+Se	Syn+Bet		
CP digestibility (%)	76.3^{b}	86.8^{a}	87.9^{a}	86.8^{a}	0.70	<0.01
CF digestibility (%)	15.8^{b}	25.8^{a}	30.4^{a}	27.9^{a}	0.82	0.00
N retention (g/bird)	1.76^{b}	2.07^{ab}	2.11^{ab}	2.35^{a}	0.30	0.01
Ca retention (g/bird)	0.48^{b}	0.55^{ab}	0.56^{ab}	0.64^{a}	0.08	0.02
Passage rate (minutes)	166	217	194	195	8.06	0.23

^{a,b}Means within similar row with divergent superscripts differ considerably ($p<0.05$)

Control: basal feed without any additive, Syn: basal feed supplemented with 2% synbiotics, Syn+Se: basal feed supplemented with 2% synbiotics and 10 mg/kg Selenium, Syn+Bet: basal feed supplemented with 2% synbiotics and 500 mg/kg betaine, CP: crude protein, CF: crude fiber, N: nitrogen, Ca: calcium, SEM: standard error of the means

Table 6. Carcass Traits of Ducks Fed Synbiotic Plus Selenium or Betaine

Variables	Treatments				SEM	p valu
	Control	Syn	Syn+Se	Syn+Bet		
Carcass (% live BW)	64.9^{b}	65.6^{b}	67.4^{a}	67.7^{a}	0.34	0.1
Carcass (g)	617^{b}	618^{b}	632^{a}	641^{a}	8.08	0.0
Breast (% carcass)	13.7	15.3	14.3	14.7	0.47	0.6
Back (% carcass)	36.8	36.2	35.9	35.5	0.36	0.2
Wings (% carcass)	15.7	14.6	13.9	15.2	0.28	0.1
Thigh (% carcass)	17.6^{b}	17.8^{b}	20.0^{a}	20.6^{a}	0.29	0.0
Drumstick (% carcass)	16.2	17.0	17.2	16.7	0.63	0.9
Abdominal fat (% carcass)	0.44^{a}	0.22^{b}	0.26^{b}	0.30^{b}	0.02	0.0
Meat: bone ratio	1.11	1.10	1.19	1.18	0.10	0.1
Meat weight (g)	198^{b}	204^{b}	212^{a}	213^{a}	12.7	0.3
Bone weight (g)	178	185	178	180	9.87	0.2

^{a,b}Means within similar row with divergent superscripts differ considerably ($p<0.05$)

Control: basal feed without any additive, Syn: basal feed supplemented with 2% synbiotics, Syn+Se: basal feed supplemented with 2% synbiotics and 10 mg/kg Selenium, Syn+Bet: basal feed supplemented with 2% synbiotics and 500 mg/kg betaine, BW: body weight, SEM: standard error of the means

Table 7. Meat Quality of Ducks Fed Synbiotic Plus Selenium or Betaine

Variables	Treatments				SEM	p value
	Control	Syn	Syn+Se	Syn+Bet		
Crude protein (g/100 g)	21.1	21.0	21.0	20.1	0.27	0.54
Total fat (g/100 g)	1.38	1.61	1.34	1.63	0.06	0.23
Total cholesterol (mg/100 g)	120^{a}	96.0^{b}	110^{b}	103^{b}	2.43	0.03

^{a,b}Means within similar row with divergent superscripts differ considerably ($p<0.05$)

Control: basal feed without any additive, Syn: basal feed supplemented with 2% synbiotics, Syn+Se: basal feed supplemented with 2% synbiotics and 10 mg/kg Selenium, Syn+Bet: basal feed supplemented with 2% synbiotics and 500 mg/kg betaine, SEM: standard error of the means

ble microorganisms, nutrient-sparing effect, and improved nutrient utilization (Dev *et al.*, 2020; Sugiharto, 2022). In mammals, Selenium is a crucial part of the glutathione peroxidase (GPH-Px) and thioredoxin reductase (TrxR), which function as antioxidants and support immunity (Li *et al.*, 2021). Owing to this, Selenium may protect the intestines of Tegal ducks from inflammation as well as against an overgrowth of harmful bacteria that could affect normal intestinal function. Overall, the favorable synbiotic and Selenium interactions led to the enhanced crude protein and crude fiber digestibility in Tegal ducks.

Similar to synbiotics and their combination with Selenium, administration of synbiotic plus betaine improved the crude protein and crude fiber digestibility in Tegal ducks. The Syn+Bet treatment, in contrast to the Syn and Syn+Se treatments, considerably ($p<0.05$) enhanced N and Ca retention in Tegal ducks. In this case, the ability of betaine to maintain intestinal cellular water and osmotic pressure was particularly advantageous for the growth and survival of the intestinal cells as well as to increase cell activity, which may have a beneficial effect on nutritional digestibility and retention (Sun *et al.*, 2019). Furthermore, Wang *et al.* (2018) noted that betaine supplementation improved the activity of amylase, lipase, trypsin, and chymotrypsin in the small intestine, which had a favorable effect on nutrient digestibility and retention. Consistent with the aforementioned study, Liu *et al.* (2019) found that betaine improved N retention in heat-stressed broilers by preserving cell integrity.

Carcass Traits and Meat Quality of Ducks Fed Synbiotic Plus Selenium or Betaine

Table 6 presents data on the carcass characteristics of ducks fed synbiotics along with Selenium or betaine. The Syn+Se and Syn+Bet groups had higher ($p<0.05$) carcass weights and thigh portion than the control and Syn groups. The Syn+Se and Syn+Bet groups had higher ($p<0.05$) meat weights than the control and Syn groups. In this study, the treatment group had less ($p<0.05$) abdominal fat content than the control group. The increase in carcass weight of Tegal ducks in the treatment group was very likely due to improved nutrient digestibility, especially crude protein digestibility and physiological conditions in the Syn+Se and Syn+Bet groups. These improvements resulted in increased protein deposition in the form of meat so that the Tegal duck carcasses became greater. In this case, the influence of Selenium and betaine seemed to be more dominant than that of synbiotics as there was no difference of carcass weight, thigh proportion and meat weight between Syn and control ducks.

Synbiotic supplementation, synbiotic plus Selenium or synbiotic plus betaine resulted in lower abdominal fat content of Tegal ducks. The earlier study by Chen *et al.* (2018) reported that synbiotic (combination of xylooligosaccharide, *Clostridium butyricum*, and *Bacillus subtilis*) supplementation decreased abdominal fat pad in Cherry Valley ducks, and this may be owing to the lipid-lowering function of the synbiotics. With regard to Selenium, the study by Pardechi *et al.* (2020) reported that Selenium administration reduced abdominal fat in broiler chickens. The latter authors confirmed that Selenium administration was capable of reducing lipogenesis activity in the liver thereby reducing fat deposition in the abdomen. In accordance with finding in this current study, Shuzhen *et al.* (2021) showed a decrease in abdominal fat content due to betaine administration in ducks. Betaine involved in the synthesis of choline methylated compounds such as carnitine and reduced the need for other methyl donors such as creatine. As a result, betaine was used as a carcass modifier to increase muscle percent and decrease fat percentage.

Table 7 shows data on meat quality of Tegal ducks fed synbiotic plus Selenium or betaine. In this study, the crude protein and total fat content in Tegal duck meat did not differ ($p>0.05$) among treatment groups. On the other hand, total cholesterol of meats was lower ($p<0.05$) in ducks treated with synbiotics or a combination of synbiotics with Selenium or betaine. The reduction in the total cholesterol in the meat of the treated Tegal ducks was thought to be the result of either the conversion of cholesterol to coprostanol in the intestine by the presence of probiotic bacteria or bile acid deconjugation, which occurs as a result of an increase in LAB. Such bile acid deconjugation stimulates the production of new bile acids by more cholesterol, which then lowers serum cholesterol. Moreover, prebiotics (in synbiotics) can thicken the mucous layer in the intestine, which reduces cholesterol absorption and, as a result, increases cholesterol catabolism in the liver, which aids in the hypocholesterolemic effect. Prebiotics have also been shown to enhance the production of SCFA, which limit the liver's ability to synthesize triglycerides or cholesterol (Dev *et al.*, 2020). Adding synbiotics to Selenium and betaine also has an effect on increasing antioxidant capacity, which lowers postprandial lipids linked to oxidative damage and may eventually limit cholesterol synthesis, lowering cholesterol accumulated in meats.

CONCLUSION

Dietary administration of synbiotic plus Selenium resulted in improved body weight, FCR, intestinal ecology, nutrient digestibility, carcass traits, meat weight and total cholesterol in meats of Tegal ducks.

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