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Article

Bamboo vinegar liquid probiotics for replacing antibiotic on the performance and meat quality of broiler chicken

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Abstract: A study was conducted to investigate the effects of bamboo vinegar liquid with beneficial microbes (probiotics), BVLP on growth performance, meat composition, and thiobarbituric acid (TBA) value. A total of 175 one day old Ross broiler chicks were distributed to 5 treatments having 5 replications with 7 chicks in each, following a completely randomized design. The treatments were: control (basal), antibiotic (basal+30 ppm Oxytetracycline), bamboo vinegar liquid probiotics (basal+0.2%, basal+0.4% and basal+0.8%). Significantly lowest feed intake was recorded in 0.4% BVLP compared to 0.8% BVLP group although highest weight gain was observed in 0.2% BVLP among the BVLP groups($P<0.05$). Significantly highest protein percentage in broiler meat fed BVLP (0.2 and 0.4%) were recorded compared to 0.8% and antibiotic fed diet ($P<0.05$). Crude fat significantly reduced in 0.2% BVLP group than control and antibiotic group. Statistically similar values in fresh meat TBA were observed in 0.2 to 0.4% BVLP fed broilers with antibiotic group except 0.8% BVLP diet ($P<0.05$). After 3 weeks preservation no statistical differences were observed among the treatments, that indicates no detrimental effects observed after addition of BVLP. Significantly lowest abdominal fat was found in 0.2% BVLP compared to antibiotic group ($P<0.05$). Significantly highest length of large intestine was recorded in 0.8% BVLP compared to control and 0.4% BVLP groups ($P<0.05$). Considering the findings, bamboo vinegar liquid probiotics can be replaced instead of antibiotic and BVLP 0.2 to 0.4% may be the suitable level for broiler production.

Keywords: bamboo vinegar liquid; probiotics; antibiotic alternative; meat quality; fatty acids; broiler meat

1. Introduction

A European has culture to eat broiler breast meat for cooking willingly, but an Asian likes broiler leg meat for roasting because, the taste of breast meat is plain due to little fat (Ruttannavut *et al*., 2009). High concentrations of free radicals are dangerous to living organisms because of their abilities to react with varies organic substrates, which are ultimately lead to cell damage (Swindle and Metcalfe, 2007). Chemical compounds capable of generating potential toxic oxygen species can be termed as pro-oxidant (Lee *et al.*, 2008). Normal cell possess an appropriate pro-oxidant/antioxidant balance. When the balance is shifted towards the pro-oxidant, such a state is called "oxidative stress" (Somogyi *et al.*, 2007). Antibiotics have been used as feed additives to improve growth performance and control disease in animals. However, antibiotic use tends to produce antibiotic resistance and residues in animal products (Chen *et al.*, 2009). So throughout the world researchers are trying to find out alternative natural substances that can be substituted antibiotic and use for

animal as safe feed additives. There are various active substances present in medicinal plants like natural antibiotics. Among many medicinal plants bamboo as well as bamboo vinegar is very effective due to its natural active substances. Bamboo vinegar is a by-product of bamboo carbonization and is derived from the smoke of carbonized bamboo, has a special tart flavor and smoky smell. It contains over 200 ingredients (80 - 90% of which is water); all are of a natural composition, and safe for use on human and animal. The acetic acid contained in bamboo vinegar will soften the skin cuticle and has a wonderful effect for skin care relieving dermatitis, itch, athlete's foot etc. The functional and medicinal properties of bamboo such as antioxidant, antimicrobial, antimutagenic activities have been studied for decades (Li *et al*., 2008), recently bamboo vinegar has drawn the attention of medical researchers. Suga *et al*. (2003) isolated an antioxidative phyllostadimier from *Phyllostachys edulis*, a common bamboo species.

There are limited information on the use of fermented feeds in chickens (Chen *et al*., 2009). Therefore, this study investigated the beneficial effects on combined 2 stage fermentation feed inoculated *Lactobacillus* spp. (2 strains) with high proteolytic capacity *Bacillus subtillis* in the first stage, and high acidic capacity *Saccharomyces cerevisiae* in the second stage fermentation. Substantial progress has been made in the development of probiotics, prebiotics, and synbiotics, which are effective in increasing and maintaining the population of lactic acid bacteria in the intestine (Klein *et al*., 1998). The major probiotic strains include *Lactobacillus*, *Saccharomyces*, *Bacillus*, *Streptococcus*, and *Aspergillus* (Tannock, 2001). Presently *Bacillus* (Jin *et al*., 1996), *Lactobacillus* (Jin *et al*., 1998; Yeo and Kim, 1997), and *Saccharomyces* (Zhang *et al*., 2005) are the major strains applied in broilers. Diet supplemented with *Bacillus subtilis*, which secrete protease, amylase, and lipase can improve growth performance (Santoso *et al*., 2001). Diets supplemented with 0.5% dried *B. subtilis* fermented product or probiotic powder improved weight gain and feed efficiency (Santoso *et al*., 1995, 2001; Jin *et al*., 1996). *Saccharomyces* with protein digestion and high acidic capacity could prevent antimicrobial-associated diarrhea (Surawicz *et al*., 1989; Bleichner *et al*., 1997). Diets supplemented with yeast (*Saccharomyces cerevisiae*) cell components can improve growth performance in chickens (Karaoglu and Durag, 2005; Zhang *et al*., 2005).

The ultimate goal of antibiotics alternatives is a complete substitution of antibiotics. However, practically it is very difficult to complete substitution of antibiotic by one substance. Considering these reasons, studies on synergistic effects using two alternative substances with different mechanism are newly emerging. Therefore, the objective of this study was to evaluate the effects on production performance and body composition with meat quality of broilers when fed bamboo vinegar liquid with beneficial microbes (mixed probiotics).

2. Materials and Methods

2.1. Animals and experimental design

One hundred seventy five "Ross" one day old broiler chicks were housed in a closed, ventilated caged-broiler house. From 1 to 14 days of age, supplemental heat was provided by electric heater which was placed inside the chicken house, thereafter the room temperature was kept at 22±2℃ by providing through a supplemental heating system. The birds were assigned to 5 dietary treatments each of 5 replications having 7 chicks each in a completely randomized design (CRD). The feed additives groups were control, antibiotics (basal+30 ppm oxytetracycline), and bamboo vinegar liquid probiotics, BVLP (basal+ 0.2%, 4% and 8%). The feed and drinking water were provided ad libitum to the broiler chicks.

2.2. Diets and feeding

Experimental diets were formulated to meet or exceed nutrient requirement of broiler suggested by NRC (1994). The diets used for this study were starter diet containing ME 12.97 MJ/kg and 22% CP, and a finisher diet containing ME 13.18 MJ/kg and 19% CP. The broiler chicks were housed individually in 3-tiered cages and they were provided starter diet from first day to 3 weeks and then finisher diet up to 5 weeks. The BVLP is a kind of mixed probiotics with liquid bamboo vinegar that was prepared by mixing defatted rice bran, 99.5% and bamboo vinegar liquid (BVL), 0.5% with beneficial bacteria. The chemical composition of bamboo vinegar liquid after fermentation with multi probiotics are given in Table 1.

The fermentation product, BVLP was produced as follows: Lactic acid bacteria (*Lactobacillus acidophilus*, KCTC 3111 and *Lactobacillus plantarum*, KCTC 3104) and yeast (*Saccharomyces cerevisiae*, KCTC 7915) were formulated into media containing 95.5% defatted rice bran and 0.5% BVL. It was, then, fermented at 40°C for 5 hours in anaerobic conditions and 3 hours in aerobic conditions and subsequently continued for 48 hours. After that, there was a second inoculation with bacteria (*Bacillus subtilis*, KCTC 3239) and, then dried for 72 hours. This is composed of 17.73% crude protein, 2.90 % crude fat, 9.71% crude fiber and 10.37% crude ash in the bamboo vinegar liquid probiotics (BVLP). The number of multi-probiotics used in BVLP were 4.2×10^{7}

cfu/g of *Lactobacillus acidophilus*, 5.8×10^6 cfu/g of *Lactobacillus plantarum*, 2.6×10^7 cfu/g of *Bacillus subtilis* and 6.2×10^9 cfu/g of *Saccharomyces cerevisiae*.

2.3. Record keeping and analysis

Body weights of broilers were measured by a digital balance on weekly basis from initial day to the final day of the experiment. Feed intake was determined by measuring feed residue on weekly basis upto 5 weeks since the beginning of the experiment. Feed conversion ratio was obtained from a ratio of the feed intake to body weight gain. At the end of the experiment, 20 chickens were slaughtered and meat samples were collected from breast and thigh muscle. The chemical composition of the carcass was determined according to AOAC (1990) and meat minerals (Ca, Mg & Fe) content were determined by using the atomic absorption spectrophotometer, AA 6200 (Shimadzu Corporation, Analytical & Measuring Instruments Division, Tokyo, Japan). The internal organs were removed and fat tissues were collected from gizzard, intestine, cloaca and around abdominal muscle to measure fat pad. The liver, kidney, small intestine, large intestine, gizzard, pancreas, cecum, heart and crop were weighed to calculate a percentage of each organ to carcass weight.

For the determination of carcass rancidity of broiler meat the method described by Witte *et al.* (1970) was used with little modifications. For this analysis, 10 g of thigh and breast meat mixture was blended at full speed for 1.5 min in chilled stainless watering blender cup with 25 ml of extracting solution containing 20% trichloroacetic acid (TCA) in 2M phosphoric acid. The resulting sediment was transferred quantitatively to 50ml volumetric flask with 20ml distilled water and diluted by shaking and homogenized. A 25ml portion was filtrated through Whatman No.6 filter paper. Then 5ml filtrate was transferred to a test tube and 5ml of 2-thiobarbituric acid (0.005 M in DW) was added. The solution was shaken in a water bath at 80℃ for 30 min. After cooling, the color development was measured at 530 nm in a spectrophotometer, biochrom, Libra S22 (Biochrom Ltd., Cambridge, England). Thiobarbituric acid (TBA) reactive substance values were expressed as micromole of malondialdehyde (MDA) per hundred gram of meat.

2.4. Statistical analysis

The data (mean±standard error) obtained by analyzed using general linear models (GLM) of SAS Package Program (1990) to estimate variance components for a completely randomized design. The differences were statistically assessed at $P<0.05$.

3. Results and Discussion

3.1. Growth performance

The effects of feeding bamboo vinegar liquid probiotics on growth performance are shown in Table 2. The results revealed that difference in body weight gain and feed conversion ratios of broiler chicks were not significant among the treatment groups. Significantly reduced feed intake was recorded in 0.4% BVLP compared to other two levels of BVLP (0.2 and 0.8%) and with control and antibiotic groups *(P*<0.05*)*.

The synergistic effects of two different feed additives (medicinal plants and probiotics) on weight gain and feed conversion of broiler has showed neither any adverse effect nor significant variation compared to control. These findings in our current study similar with the findings of Oh *et al*. (2007). They reported no positive effects on body weight gain and feed conversion ratio of broilers fed diets containing 0.5 and 1.0% of probiotics made up with medicinal plants, Dandelion. As probiotics they used *Lactobacillus plantarum* (1.2 x 1010cfu/g) and *Bacillus subtillis* (8.8 x 109 cfu/g). In their study, no statistical difference were observed in feed intake after feeding probiotics with medicinal plants which is not in agreement with our observation. Kook et al. (2005) reported a significantly higher feed conversion body weight gain in finishing pigs after using bamboo vinegar liquids in the diet which is not similar with our findings. The reasons might me our trial was on broiler, bamboo vinegar liquid was mixed with probiotics, and also the addition of BVLP levels was less compared to them. Major chemical components of bamboo culms are cellulose, hemicellulose, and lignin, and minor components are resins, tannins, waxes, and inorganic salts (Ju *et al*., 2005), those could be a possible reason for the proper utilization of feed in 2% BVLP group. Kim *et al.* (2002) reported that it was possible to improve weight gain and feed conversion when 0.1 to 0.5% probiotics with *Lactobacillus* spp., *Bacillus* spp. and yeast were fed to broilers.

3.2. Meat composition

The effects of BVLP on the body composition of broilers are shown in Table 3. The moisture content of broiler meat was significantly lower in all the feed additives (3 levels of BVLP and antibiotic) compared to control group. The crude protein content of broiler meat were increased significantly in 0.2-0.4% BVLP group as

compared to 0.8% BVLP and antibiotic treatments (P<0.05) although statistically similar with control. The crude fat content of meat was reduced significantly in 0.2% BVLP addition diet than control and antibiotics groups, but there were no significant differences among the levels of BVLP (P>0.05). The crude ash content of broiler meat was increased significantly in broilers fed diets containing BVLP groups as compared to the control and antibiotics groups (P<0.05). Mineral in meat (Fe and Mg) showed positive effect in 0.4% BVLP than other groups in broiler meat (Table 4).

According to Oh *et al*. (2007), feeding broilers with 1.0% dandelion and 0.5 and 1.0% dandelion fermented probiotics did not affect crude protein and crude fat content of broiler meat which is not in agreement with the result of this study. In this study, crude protein content of broiler meat were increased significantly in 0.2-0.4% BVLP group as compared to 0.8% BVLP and antibiotic treatments (P<0.05) although statistically similar with control. The improvement of crude protein might be for the supplemental yeast as probiotic that is rich source of protein, although the exact mode of action is not clear. Santoso *et al*. (1995, 2001) also found that supplementation of *Bacillus subtilis* in broiler diets significantly (P<0.05) reduced carcass fat deposition in carcass, and suggested that *B. subtilis* could significantly decrease the activity of acetyl-Co A carboxylase which catalyses the rate-limiting step in fatty acid biosynthesis. In our study the reducing trend of fat in broiler meat especially at 0.2% BVLP showed a significant reduction of fat content compared to control might be a reason, hence this finding agrees with our study. In Table 5, mineral content in broiler meat (Fe and Mg) showed positive effect (improvement) in 0.4% BVLP than control and other groups. The reason might be *Saccharomyces cerevisiae* has beneficial effect as it is a naturally rich source of protein, minerals and B-complex vitamins (Davis, 1976). For substituting antibiotics, a possible solution seems to be supplied an appropriate nutrition that involves the use of the supplements based on organic minerals and probiotics (Sara and Odagiu, 2008).

3.3. Meat oxidation determination

Table 5 shows that thiobarbituric acid (TBA) value of fresh broiler meat was significantly highest in 0.8% fermented BVLP supplement group (2.65 µmol/100g)compared to antibiotic (2.06 µmol/100g) but no statistical difference with control at fresh state (P<0.05). In case of 1-3 weeks of storage, TBA values of broiler meat were not affected by addition of BVLP (P>0.05). Although there is no statistical difference in the average meat TBA value among the groups found but there is a lowering trend observed after addition of feed additives (Figure 1).

Wang *et al*. (2008) reported that lipid oxidation in carcass causes loss of nutritional and sensory values as well as the formation of potentially toxic compounds that compromise meat quality and reduce its shelf life. The anti-oxidative property of both kind of additives (bamboo vinegar liquid and probiotics) were much popular according to many literatures (Li *et al*., 2008; Akakabe *et al*., 2006). Biological significances of bamboo may arise from the presence of phytochemicals and their antioxidant capacities. Recent *in vitro* works have identified phytochemicals with antioxidative activities using the leaves (Zhang *et al*., 2005) and culms (Suga *et al*., 2003). In our current study although there was a reducing trend observed in meat oxidation after addition of bamboo vinegar liquid probiotics but significant differences among the values were not observed. In our previous study the same 4 probiotics strains were used for fermentation of medicinal plant (green tea) and used in broiler diet. It was observed that addition of mixed probiotics with medicinal plants (green tea) can reduce the rancidity i.e. oxidation of broiler meat after preservation upto 3 weeks (Sarker *et al*., 2009).

3.4. Relative internal organs development

The effects of feeding bamboo vinegar liquid probiotics supplemented diets on the development of relative internal organs weight of broiler chicks are shown in Table 6. The results showed that the kidney weight was decreased significantly in broilers fed diets containing 0.2% bamboo vinegar liquid probiotics supplement compared to control (P<0.05). There were lowering trend observed in small intestine both in weight and length (Table 7 and Figure 2) after addition of BVLP but no statistical significant difference observed (P>0.05) among the treatments.

The abdominal fat weights were reduced significantly in broilers fed diets containing different feed BVLP supplement (0.2 and 0.8%) compared to control (P<0.05). There were no statistical difference observed in crop wt., heart wt., liver wt., gizzard wt., pancreas wt., caecum wt., large intestine and proventriculus wt. among the dietary feed additives group with control (P>0.05). Figure 3 shows that a significantly highest (P<0.05) length of large intestine was recorded in 0.8% BVLP compared to control and 0.4% BVLP groups. BVLP (0.2%) group broilers showed statistically similar values in the length of large intestine with antibiotic group (P>0.05).

The intestine seems to be the most fundamental organ for improving animal products. Activation of intestinal function of broiler might increase meat products in response to an increasing demand for animal protein

(Ruttanavut *et al*., 2009). Supplemental broilers with microbial cultures provide beneficial bacteria to aid in nutrient absorption and enhance the microbial balance in the avian digestive tract (Shareef and Al-Dabbagh, 2009). The main component of bamboo vinegar compound liquid is acetic acid. It is one of the main short chain fatty acids produced by intestinal microbes, which can affect intestinal functions and metabolism (Bergman, 1990; Kishi *et al.*, 1999; Lutz and Scharrer, 1991). The lowering trend in small intestine both in weight and length of broiler in this study agreed with other researchers. Kim *et al.* (2006) reported that the reason of the reduced small intestine weight is because the burden on the small intestine due the improvement of digestive function by feeding the animal with antibiotics or functional additives. Yustizal (2003) stated mannan Oligosaccharide, a prebiotic, naturally derived from the cell wall of *Saccharomyces cerevisiae*, has the potentiality to reduce the abdominal fat. In 0.2% BVLP group broilers showed statistically reduced abdominal fat (1.71%) compared to control (1.84%). No negative effects were observed in all other internal organs after addition of BVLP compared with control.

Table 1. The name, strain and number of microflora used in fermentation of bamboo vinegar liquid with chemical composition.

Items	Contents
Number of microflora in BVLP [1)]	4.2×10^7 cfu/g
Lactobacillus acidophilus, KCTC 3111	5.8×10^6 cfu/g
Lactobacillus plantarum, KCTC 3104	2.6×10^7 cfu/g
Bacillus subtilis, KCTC 3239	6.2×10^9 cfu/g
Saccharomycetes cerevisiae, KCTC 7915	
Chemical composition(g/100g) [2)]	
Moisture	8.98
Crude Protein	17.73
Crude Fat	2.90
Crude Fiber	9.71
Crude ash	10.37

[1)] BVLP=Bamboo vinegar liquid probiotics
[2)] Calculated chemical composition

Table 2. The effects of bamboo vinegar liquid probiotics on growth performance and feed intake of broiler.

Treatments	Control	Antibiotics	BVLP[1)]		
			0.2%	0.4%	0.8%
Initial weight (g)	44.82±0.15	44.86±0.23	44.86±0.10	44.79 ±0.27	44.61±0.27
Final weight (g)	2079.29±52	2073.57±58	2055.71±49	1922.86±59	2054.29±11
Weight gain (g)	2034.46±52	2028.71±58	2010.86±49	1878.07±59	2009.68±11
Feed intake (g)	3453.99^{a} ±72	3423.43^{a} ±59	3416.86^{a} ±42	3221.38^{b}±49	3430.39^{a}±70
FCR[2)](Feed/Gain)	1.70 ±0.02	1.69 ±0.02	1.70 ±0.04	1.72 ±0.04	1.71 ±0.03

[1)] Bamboo vinegar liquid probiotics, Data: Mean ± SE
[2)] FCR = Feed Conversion Ratio

Table 3. The effect of the bamboo vinegar liquid probiotics on proximate composition of broiler meat (g/100g).

Treatments	Control	Antibiotics	BVLP[1)]		
			0.2%	0.4%	0.8%
Moisture	74.92^{a} ±0.55	73.74^{b} ±0.13	73.27^{b}±0.10	73.01^{b}±0.41	73.48^{b}±0.13
Crude protein	23.61^{ab}±0.30	22.11^{b} ±0.69	24.76^{a} ±0.27	24.96^{a}±0.42	22.32^{b}±0.95
Crude fat	0.71^{ab}±0.08	0.85^{a}±0.07	0.22^{c}±0.10	0.43^{bc}±0.03	0.43^{bc}±0.18
Crude ash	1.10^{b}±0.01	1.10^{b}±0.03	1.15^{a}±0.02	1.18^{a}±0.02	1.20^{a}±0.01

[a,b,c] Mean with different superscripts within the same raw are significantly different (P<0.05),
Data: Mean± SE, [1)] Bamboo vinegar liquid probiotics

Table 4. Effect of dietary bamboo vinegar liquid probiotics on mineral content in broiler meat.

Treatment (mg/100g)	Control	Antibiotics	BVLP (%)		
			0.2%	0.4%	0.8%
Ca	10.85^{a}±0.30	7.93^{bc}±0.42	7.14^{bc}±0.33	8.24^{b}±0.21	6.83^{c}±0.30
Mg	0.90^{b}±0.03	0.93^{b}±0.06	1.06^{ab}±0.03	1.40^{a}±0.14	1.40^{a}±0.06
Fe	8.74^{ab}±0.67	7.77^{b}±0.37	7.75^{b}±0.80	9.44^{a}±0.47	8.51^{ab}±0.29

^{a,b,c} Mean with different superscripts within the same raw are significantly different (P<0.05)

Table 5. The effects of feeding bamboo vinegar liquid probiotics on the TBA value of broiler meat (µmol/100g) in different weeks.

Treatments	Control	Antibiotics	BVLP[1)]		
			0.2%	0.4%	0.8%
Fresh	2.31^{ab}±0.09	2.06^{b}±0.22	2.28^{ab}±0.11	2.37^{ab}±0.08	2.65^{a}±0.24
1st week	4.52±0.05	2.77±0.46	2.89±0.29	4.46±1.65	2.37±0.15
2nd week	7.28±0.74	6.55±0.45	6.83±0.43	6.74±0.49	6.55±0.37
3rd week	15.02±2.14	14.62±3.26	14.12±1.07	13.66±1.01	13.05±1.25

^{a,b,c} Mean with different superscripts within the same raw are significantly different (P<0.05), Data: Mean ± SE, [1)] Bamboo vinegar liquid probiotics

Table 6. The effect of bamboo vinegar liquid probiotics on internal organ developments in broiler.

Internal Organs (g/100g BW[1)])	Control	Antibiotics	BVLP[2)]		
			0.2%	0.4%	0.8%
Crop wt.	0.29±0.05	0.30±0.03	0.24±0.04	0.20±0.03	0.25±0.04
Heart wt.	0.60±0.04	0.60±0.04	0.64±0.03	0.63±0.06	0.63±0.04
Liver wt.	1.87±0.16	1.86±0.20	1.78±0.12	2.02±0.28	1.79±0.13
Gizzard wt.	0.89±0.05	1.01±0.06	0.97±0.08	0.87±0.04	0.91±0.03
Pancreas wt.	0.16±0.01	0.17±0.03	0.15±0.02	0.19±0.01	0.18±0.01
Caecum wt.	0.49±0.04	0.55±0.08	0.38±0.12	0.43±0.10	0.43±0.08
Kidney wt.	0.75^{a}±0.03	0.70^{ab}±0.05	0.52^{b}±0.13	0.71^{ab}±0.11	0.75^{ab}±0.01
SI wt.	2.59^{a}±0.26	2.33^{ab}±0.10	2.25^{ab}±0.10	2.56^{a}±0.29	2.39^{ab}±0.04
LI wt.	0.16±0.02	0.18±0.02	0.17±0.03	0.16±0.02	0.17±0.02
Abdominal fat wt.	1.84^{a}±0.27	1.91^{ab}±0.17	1.71^{b}±0.17	1.93^{ab}±0.30	1.77^{b}±0.27
Proventriculus wt.	0.38±0.06	0.40±0.07	0.38±0.06	0.37±0.05	0.35±0.01

^{a,b} Mean with different superscripts within the same raw are significantly different (P<0.05). Data: Mean ± SE, [1)] Body weight, [2)] Bamboo vinegar liquid probiotics. SI: Small intestine, LI: Large intestine

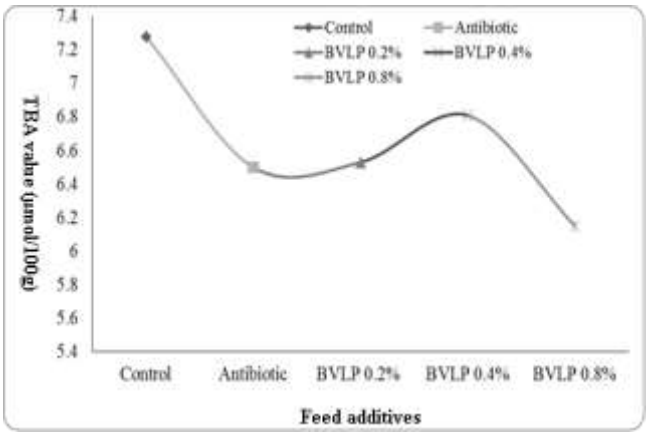

Figure 1. Effect of bamboo vinegar liquid probiotics on average TBA (thiobarbituric acid) value in the broiler meat at 21 days after preservation (P<0.05).

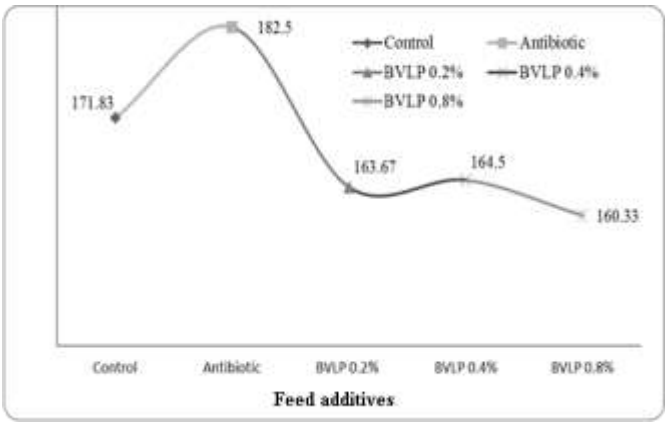

Figure 2. Effect of bamboo vinegar liquid probiotics on the length of small intestine (cm) of broilers (P<0.05).

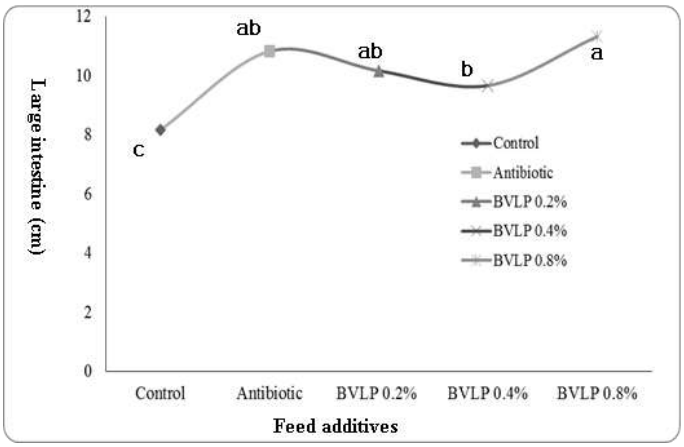

Figure 3. Effect of bamboo vinegar liquid probiotics on the length of large intestine (cm) of broilers (P>0.05).

4. Conclusions

Actually there might be so many reasons for screening the actual synergistic effect of combined feed additives for replacing antibiotic in broiler production. In this study it was tried to summarize the findings of bamboo vinegar liquid probiotics in broiler performance and meat quality traits. Considering the parameters addition of 0.2 to 0.4% bamboo vinegar liquid probiotics in the diet can be replaceable instead of antibiotic for improving growth performance and meat quality of broilers.

Conflict of interest

None to declare.

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