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CARCASS, MEAT AND BONE QUALITY OF BROILER CHICKENS FED WITH POSTBIOTIC AND PREBIOTIC COMBINATIONS

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ABSTRACT: *The study assessed the effects of different types of postbiotics that mixed with different levels of prebiotic (inulin) on carcass, meat and bone quality. A total of 280 male Cobb broiler chickens were randomly assigned to 8 treatment groups. The treatments included basal diet (-ve control), basal diet+neomycin and oxytetracycline (+ve control), (T1) basal diet+0.3% postbiotic RI11 (T2) basal diet+0.3% postbiotic RG14 (T3) basal diet+0.3% postbiotic RI11+0.8% inulin, (T4) basal diet+0.3% postbiotic RI11+1.0% inulin, (T5) basal diet+0.3% postbiotic RG14+0.8% inulin, and (T6) basal diet+0.3% postbiotic RG14+1.0% inulin. The birds were fed the diets for 6 weeks and slaughtered. Meat quality assessment was conducted on the breast muscle while bone quality traits were assessed on tibia of right leg. Birds fed postbiotics and inulin had lower ($p< 0.05$) drip loss and improved ($p< 0.05$) lightness of breast muscle as compared to the control birds. No changes were observed in cooking loss, shear force and most carcass attributes among the treatments. Carcass attributes, bone breaking strength, tibiotarsal index and robusticity index were not significantly different ($p>0.05$) among the treatments. Postbiotic and inulin had beneficial effect on meat quality as compared to antibiotics.*

KEY WORDS: Bone quality, Carcass, Inulin, Meat quality, Postbiotics, Probiotics

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INTRODUCTION

There is an ongoing trend for reducing the use of antibiotics in animal feed as a result of the contamination of meat products with antibiotic residues. Furthermore, there are other problems caused by the use of antibiotics in animals such as microbial resistance (Shazali et al., 2014), genotoxicity and allergies (Markovicv, 2005). On the other hand, human health can be affected directly through residues of antibiotic in relation to food (Boerlin and Reid-Smith, 2008). At the same time, due to the improved standard of living in recent years (Kleter and Marvin, 2009); there has been a considerable increase in demand for safer chicken meat. Thus, natural feed additives are advocated to substitute in–feed antibiotic in order to reduce food borne illnesses. The most common additives are prebiotics, probiotics, synbiotics and postbiotics (metabolic products by probiotic) (Hajati and Rezaei, 2010; Thanh et al., 2010). These biotic additives are nutritionally feasible replacements for growth promoters in animal feeding (Loh et al., 2014). Moreover, the use of additives contributed to improvements in the meat quality (Aristides et al., 2012). Liu et al. (2012), reported that *Bacillus licheniformis* can serve as a means of promoting growth and enhancing the quality of meat in broiler chicken. Probiotics are beneficial microbes, which stimulate immune system and increase its defensive activity against pathogenic bacteria. In spite of beneficial effects of probiotics, the major problem with their application is that some probiotics have antibiotic resistance genes, especially those encoded by plasmids which can be transferred between organisms (Marteau and Shahanan, 2003). The metabolite products synthesized from probiotic

are known as postbiotics. It is believed that postbiotics have the probiotic effects without living cells, whereas prebiotics are health promoting material that cannot be digested by the animal's digestive enzymes. It can affect the host beneficially by selectively stimulating the growth of naturally present or introduced bacterial species in the intestine (Young, 1998). The connection and association between prebiotics and probiotics is technically indicated, and some profitable products are already available (Takahashi et al., 2005). This is due to the fact that, these biotics inhibit proliferation of pathogenic bacteria by competitive exclusion and the production of bactericidal substances. They are also able to provide substrates for the improvement of health-promoting microorganisms (Menten, 2002; Kareem et al., 2014). Apart from enhancing immunity and performance of animals, reports have shown that various feed additives influence carcass traits and meat quality (Falaki et al., 2011; Shabani et al., 2012; Liu, et al., 2012).

In addition, administration of alternative growth promoters may have a beneficial effect on bone quality and ileal digestibility of nutrients in broiler chicken (Ortiz *et al.* 2009; Ziaie et al., 2011). There is limited information on the effect of postbiotic and inulin on carcass, meat quality and bone quality of broilers. Thus, this experiment was conducted to investigate the effects of postbiotic and inulin on carcass meat quality and bone quality in broiler chickens.

MATERIALS AND METHODS

Postbiotics and Inulin: The stock culture of *Lactobacillus plantarum* RG14 and *Lactobacillus. plantarum* RI11 were

TABLE 1. Composition and nutrient content of starter diets. * -ve C: (negative control), +ve C: (positive control), T1: (0.3% RI11), T2: (0.3% RG14), T3: (0.3% RI11+0.8% Inulin), T4: (0.3% RI11+1.0% Inulin), T5: (0.3% RG14+0.8% Inulin), T6: (0.3% RG14+ 1.0%Inulin). §Mineral mix contains Fe 100 mg, Mn 110 mg, Cu 20 mg, Zn 100 mg, I 2 mg, Se 0.2 mg, Co 0.6 mg. ¶Vitamin premix contains retinol 2 mg, cholicalciferol 0.03 mg, α-tocopherol 0.02mg, menadione 1.33 mg, cobalamin 0.03 mg, thiamine 0.83 mg, riboflavin 2 mg, folic acid 0.33 mg, biotin 0.03 mg, panthothenic acid 3.75 mg, niacin 23.3 mg, pyridoxine 1.33 mg. †Antioxidant contains butylated hydroxyanisole (BHA). ‡Toxin binder contains natural hydrated sodium calcium aluminium silicates (HSCAS).

Ingredients	Dietary treatment*							
	-ve C	+ve C	T1	T2	T3	T4	T5	T6
Corn	50	50	50.18	50.18	50.2	50.2	50.2	50.2
Soybean	29.38	29.375	30.94	30.94	29.995	30	29.995	30
Wheat pollard	6.895	6.895	4.645	4.645	4.82	4.49	4.82	4.49
CPO	3.4	3.4	3.68	3.68	3.59	3.665	3.59	3.665
Fish meal (55%)	7.58	7.575	6.825	6.825	7.55	7.6	7.55	7.6
L-Lysine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
DL-Methionine	0.2	0.2	0.15	0.15	0.2	0.2	0.2	0.2
Monodicalcium phosphate21	1	1	1.1	1.1	1	1	1	1
Calcium carbonate	0.68	0.68	1	1	0.68	0.68	0.68	0.68
Choline chloride	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Salt	0.25	0.25	0.3	0.3	0.25	0.25	0.25	0.25
Mineral premix§	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Vitamin premix¶	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Antioxidant†	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Toxin binder‡	0.135	0.135	0.4	0.4	0.135	0.135	0.135	0.135
Antibiotic		0.01						
probiotic RI11			0.3		0.3	0.3		
probiotic RG14				0.3			0.3	0.3
Inulin					0.8	1	0.8	1
Total	100	100	100	100	100	100	100	100
Calculated analysis								
Crude protein (%)	22.05	22.04	22	22	22.04	22.03	22.04	22.03
Metabolizable energy (MJ/Kg)	12.96	12.96	12.96	12.96	12.95	12.95	12.95	12.95

TABLE 2. Composition and nutrient content of finisher diets. * -ve C: (negative control), +ve C: (positive control), T1: (0.3% RI11), T2: (0.3% RG14), T3: (0.3% RI11+0.8% Inulin), T4: (0.3% RI11+1.0% Inulin), T5: (0.3% RG14+0.8%Inulin), T6: (0.3% RG14+ 1.0% Inulin). §Mineral mix contains Fe 100 mg, Mn 110 mg, Cu 20 mg, Zn 100 mg, I 2 mg, Se 0.2 mg, Co 0.6 mg. ¶Vitamin premix contains retinol 2 mg, cholicalciferol 0.03 mg, α-tocopherol 0.02mg, menadione 1.33 mg, cobalamin 0.03 mg, thiamine 0.83 mg, riboflavin 2 mg, folic acid 0.33 mg, biotin 0.03 mg, panthothenic acid 3.75 mg, niacin 23.3 mg, pyridoxine 1.33 mg. †Antioxidant contains butylated hydroxyanisole (BHA). ‡Toxin binder contains natural hydrated sodium calcium aluminium silicates (HSCAS).

Ingredients	Dietary treatment*							
	-ve C	+ve C	T1	T2	T3	T4	T5	T6
Corn	54.7	54.7	54.89	54.89	54.8	54.69	54.8	54.69
Soybean	29.1	29.1	27.04	27.04	29.3	29.31	29.3	29.31
Wheat pollard	5.36	5.35	5.9	5.9	3.41	3.16	3.41	3.16
CPO	3.46	3.46	3.4	3.4	3.74	3.815	3.74	3.815
Fish meal (55%)	3.6	3.6	5.04	5.04	3.87	3.945	3.87	3.945
L-Lysine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
DL-Methionine	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Monodicalcium phosphate21	1.4	1.4	1.35	1.35	1.4	1.4	1.4	1.4
Calcium carbonate	1.3	1.3	1	1	1.3	1.3	1.3	1.3
Choline chloride	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Mineral premix§	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Vitamin premix¶	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Antioxidant†	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Toxin binder‡	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Antibiotic		0.01						
probiotic RI11			0.3		0.3	0.3		
probiotic RG14				0.3			0.3	0.3
Inulin					0.8	1	0.8	1
Total	100	100	100	100	100	100	100	100
Calculated analysis								
Crude protein (%)	19.91	19.91	19.91	19.91	19.9	19.91	19.9	19.91
Metabolizable energy (MJ/Kg)	13	13	13	13	13	13	13	13

prepared at the Laboratory of Prebiotic and Probiotic Technology II of Institute Bioscience, Universiti Putra Malaysia. The stock cultures were revived by using de-Mann Rogosa Sharpe (MRS) broth and incubated at 30°C for 48 and 24 hr subsequently at static condition, followed by spread plate and incubation was carried out for 48 hr at 30°C. A single colony was then picked and inoculated into 10 mL MRS broth and incubated for 24 hr, followed by subculturing into 10 mL MRS broth and incubated for 24 hr at 30°C. The culture was then ready to be used as an inoculum. An inoculum size of 1% (v/v) was inoculated into the respective reconstituted media and incubated at static condition at 30°C for 24 hr. After separating the bacterial cell by centrifugation at 10,000 ×g for 15 min, the postbiotic was collected and kept at 4°C (Foo et al., 2003) prior to feeding trials. The inulin (Frutafit IQ) was provided by Connell Bros. Company (Malaysia) Sdn. Bhd.

Animal And Experimental Design: A total of two hundred and eighty-eight, one day old chicks were purchased from a local hatchery. The broiler chicks were allocated into eight treatment groups. Each group consists of six replicates while each replicate had six birds. The treatment groups included basal diet feed (negative control), basal diet feed + neomycin and oxytetracycline (positive control), Basal diet + 0.3% postbiotic RI11, Basal diet + 0.3% postbiotic RG14, Basal diet + 0.3% postbiotic RI11 + 0.8% inulin, Basal diet + 0.3% postbiotic RI11 + 1.0% inulin, Basal diet + 0.3% postbiotic RG14 + 0.8% inulin, Basal diet + 0.3% and postbiotic RG14 + 1.0% inulin. Water and feed were offered *ad libitum* to the birds until 42 days of age. Starter and finisher diets (Tables 1 and 2) were offered from days 0 to 21 and days 22 until 42 of age respectively. The experimental animals received humane care as outlined and approved by Institutional

Animal Care and Use Committee for the Care and Use of Animals for Scientific Purposes (Research Policy, Universiti Putra Malaysia).

Carcass Yield: At 42 days of age, the birds were randomly chosen, weighed and slaughtered in order to evaluate carcass yield and cuts yield. Carcasses were weighed without feet, head and neck. Cuts were performed, and yields were calculated for the relative weight, breast and legs %. Viscera organs were also sampled (liver, gizzard, spleen) and weighed.

Drip Loss: Fresh samples from the breast muscle at day 0 were individually weighed (approximately 30 g) and recorded as the initial weight (W1). The samples were later on placed in sealed polyethylene plastic bags; vacuum packaged, placed within a container and were stored in a chiller at 4°C. The samples were immediately removed from the bags, gently blotted dry, weighed and recorded as W2 (final weight) and this was done after 7 d of storage, The percentage of drip loss was calculated and expressed as the percentage of differences of sample initial weight. After 7 d of storage the sample weight was divided by sample initial weight (Honikel, 1998), using the following equation:

$$\text{Drip loss (\%)} = [(W1 - W2) \div W1] \times 100$$

Cooking Loss and Shear Force: Breast muscle samples from each treatment were individually weighed and recorded as the initial weight (W1). The samples were then placed in plastic bags and cooked in a pre-heated water bath at 80 C° for 20 minutes. Samples were cooled in ice slurry for about 20 min and then reweighed and recorded as W2. Cooking loss was calculated as follow:

$$\text{Cooking loss (\%)} = [(W1 - W2) \div W1] \times 100$$

Shear force was determined from the breast muscle samples that were previously used for cooking loss. Sub-samples of 1cm high × 1cm width × 2 cm length dimension were sheared by the Volodkevitch bite jaw which was already attached to a texture analyzer (TA.HD plusR, Stable Micro System, Surrey, UK) and perpendicular to the longitudinal direction of the fibers (Sazili et al., 2005). In order to conduct textural analysis, the cooked samples were cut into sub-samples after overnight storage at 4°C, Shear force values were recorded as the average of all sub-samples value and the results were expressed as gram force (g f) to shear.

Muscle pH Measurement: The pH of breast muscles was determined using a portable pH meter (Mettler Toledo, AG 8603, Switzerland). Prior to each measurement, the pH meter was calibrated with standard buffers at pH 4.0 and pH 7.0. Approximately 0.5 g of muscle sample was crushed and homogenized (Wiggen HauserR D-500, Germany) for 20 sec in 10 ml ice cold distilled water. The electrode attached to a pH meter was used to measure the pH of homogenates. Each sample was measured in triplicate and the average pH was calculated.

Colour Measurement: Samples were removed from the -80 °C freezer and subjected to overnight thawing at 4 °C. They were removed from the packaging and the meat colour was allowed to bloom in the air for 20 min before the colour measurement was taken place. Meat colour measurement was conducted using a Colour Flex spectrophotometer (Hunter Lab Reston, VA, USA). The calibration of the device against black and white reference tiles took place prior to use. The colours of L* (lightness), a* (redness) and b* (yellowness) were measured in triplicate on each sample at 1 day post-mortem.

Biomechanical parameters of tibia bone: Tibia from the right leg was collected and cleaned of adhering tissues. Bone breaking force was measured by following the method of Świątkiewicz et al. (2011). The tibiotarsal and the robusticity indexes are determined using the following formula:

Tibiotarsal index = diaphysis diameter - medullary canal diameter/ diaphysis diameter X 100
(Barnet and Nordin, 1960)

Robusticity index = bone length/cube root of bone weight
(Reisenfeld, 1972)

Statistical Analysis: Statistical analysis was conducted by SAS package Version 9.4 software using a completely randomized design procedure. Data obtained for the carcass yield, drip loss, cooking loss, shear force, color, pH, breast, legs, liver, gizzard, spleen, bone breaking strength, tibiotarsal index and robusticity index were subjected to generalised linear model of SAS. The significant difference of means was compared using Duncan multiple range test.

RESULTS AND DISCUSSION

The results of carcass, cut yields and viscera are shown in Table 3. No significant differences ($p<0.05$) were observed in carcass, breast, liver, gizzard, and spleen yields between control and treated groups. The results of the present study agreed with the finding of Aristides et al., (2012) who observed that the addition of various probiotic, antibiotic, prebiotic and symbiotic had no effect on the carcass yield. In contrast to the present finding, Falaki et al., (2011) reported that chickens fed probiotic and prebiotic diet presented higher yields of carcass and breast muscle. However, +ve control and 0.3% RI11+0.8% inulin had higher leg yield ($p<0.05$), similar to the report of Pelicano et al. (2003). On the other hand, Loddi et al. (2000) observed no differences in leg yield between control birds and those receiving additives.

TABLE 3. The effect of treatment on carcass weight and carcass yield of broiler receiving diet supplemented with probiotic and prebiotic. [abc]means within a column for each parameter with different superscripts are significantly different ($p<0.05$). *–ve control: basal diet feed, +ve control: basal diet feed+ neomycin and oxytetracycline, T1: (0.3% RI11), T2: (0.3% RG14), T3: (0.3% RI11+0.8% inulin), T4: (0.3% RI11+1.0% inulin), T5: (0.3% RG14+0.8% inulin), T6: (0.3% RG14+1.0% inulin).

Treatments*	Carcass weight(g)	Carcass yield (%)	Breast (%)	Legs (%)	Liver (%)	Spleen (%)	Gizzard (%)
-ve control	1684.0 [a]	75.69 [a]	33.20 [a]	26.86 [bc]	2.81 [a]	0.13 [a]	3.45 [a]
+ve control	1733.0 [a]	76.57 [a]	33.83 [a]	29.95 [a]	2.98 [a]	0.13 [a]	3.28 [a]
T1	1730.50 [a]	73.83 [a]	33.78 [a]	29.79 [ab]	3.11 [a]	0.13 [a]	3.69 [a]
T2	1733.25 [a]	75.08 [a]	33.73 [a]	27.88 [abc]	3.15 [a]	0.16 [a]	3.74 [a]
T3	1732.25 [a]	75.78 [a]	33.33 [a]	30.81 [a]	2.77 [a]	0.13 [a]	3.68 [a]
T4	1726.75 [a]	75.57 [a]	33.09 [a]	29.82 [ab]	3.07 [a]	0.14 [a]	3.50 [a]
T5	1636.25 [a]	74.45 [a]	32.08 [a]	26.58 [c]	3.06 [a]	0.14 [a]	3.42 [a]
T6	1737.25 [a]	76.12 [a]	33.89 [a]	28.94 [abc]	2.97 [a]	0.09 [a]	3.68 [a]
SEM	17.94	0.32	0.34	0.38	0.07	0.01	0.08

TABLE 4. Drip loss, cooking loss and shear force of breast meat in broiler chickens fed with probiotics and prebiotic. [abc] means within a column for each parameter with different superscripts are significantly different ($p<0.05$). *–ve control: basal diet feed, +ve control: basal diet feed+ neomycin and oxytetracycline, T1: (0.3% RI11), T2: (0.3% RG14), T3: (0.3% RI11+0.8% inulin), T4: (0.3% RI11+1.0% inulin), T5: (0.3% RG14+0.8% inulin), T6: (0.3% RG14+1.0% inulin).

Treatments*	Drip loss (%)	Cooking loss (%)	Shear force (g)
-ve control	4.38 [a]	19.09 [a]	925.91 [a]
+ve control	4.19 [b]	18.90 [a]	924.80 [a]
T1	3.90 [c]	18.48 [a]	915.01 [a]
T2	3.89 [c]	18.44 [a]	917.51 [a]
T3	3.98 [c]	18.51 [a]	919.42 [a]
T4	3.88 [c]	18.47 [a]	920.26 [a]
T5	3.90 [c]	18.57 [a]	920.90 [a]
T6	3.86 [c]	18.40 [a]	910.38 [a]
SEM	0.05	0.20	11.55

The effect of postbiotic and inulin supplementation on drip loss, cooking loss and shear force in chicken breast meat are shown in Table 4. As for "postbiotic and inulin" additive groups, a significant difference ($P < 0.05$) was observed in drip loss compared with that of control groups. However, drip loss was not significantly different among the "postbiotic and inulin" treated groups. The lower drip loss observed in birds fed "postbiotic and inulin" additives supported the findings of Zhou et al., (2010) who reported reduction in drip loss in breast muscle of chicken fed with probiotic. No significant differences ($P>0.05$) were recorded for cooking loss and shear force of breast meat among all treatment groups. Drip and cooking losses serve as useful indicators for the water holding capacity of meat. Decreased water holding capacity will cause a greater amount of purge within the package which consumers find unacceptable (Barbut, 1993; Denbow, 2003). Cooking loss is an imperative characteristic for the processing industry as water retention is the main point of profit (Van Laack et al., 2000). Furthermore, tenderness has been noted as the most important quality attribute in determining consumer's ultimate satisfaction for the whole cut of poultry muscle (Fletcher, 2002).

The findings of this study indicated that cooking loss in breast meat was not influenced by dietary treatments. Similar findings were reported by Khalafalla et al., (2011) who found that probiotic and prebiotic had no effect on cooking loss of broiler breast meat. In contrast, Ali (2010) reported that birds fed probiotics had lower cooking loss than the control birds. The similarity in tenderness observed among the treatments is in agreement with those of Ali

(2010), who reported no significant difference in shear force in breast muscle of broilers among treatments with or without probiotics. Conversely, it has been found in a previous study that broiler chickens fed with *Bacillus subtilis* had increased tenderness (Khalafalla et al., 2011). Zhou et al., (2010) also reported that basal diet supplemented with probiotic, *Bacillus coagulans* ZJU0616, had beneficial effects on shear force of chicken.

TABLE 5. pH values and color of breast meat in broiler chickens fed with probiotics and prebiotic. [abc]means within a column for each parameter with different superscripts are significantly different ($p<0.05$). *–ve control: basal diet feed, +ve control: basal diet feed+ neomycin and oxytetracycline, T1: (0.3% RI11), T2: (0.3% RG14), T3: (0.3% RI11+0.8% inulin), T4: (0.3% RI11+1.0% inulin), T5: (0.3% RG14+0.8% inulin), T6: (0.3% RG14+1.0% inulin).

		Color		
Treatment*	pH	L*	a*	b*
-ve control	6.24 [a]	53.88 [b]	6.21 [ab]	18.23 [a]
+ve control	6.20 [ab]	54.92 [a]	5.61 [bc]	17.10 [b]
T1	6.03 [c]	54.39 [ab]	6.08 [ab]	18.18 [a]
T2	6.00 [c]	54.85 [a]	5.98 [abc]	18.04 [a]
T3	6.15 [ab]	53.71 [b]	5.97 [abc]	17.05 [b]
T4	6.10 [bc]	53.65 [b]	6.33 [a]	18.47 [a]
T5	6.09 [bc]	54.09 [ab]	5.84 [abc]	17.01 [b]
T6	6.02 [c]	54.88 [a]	5.42 [c]	17.17 [b]
SEM	0.02	0.12	0.07	0.10

TABLE 6. The effects of probiotic and inulin on indexes parameters and bone strength measurements of tibia bone at 6 week of age. [a] means within a column for each parameter with different superscripts are significantly different ($p<0.05$). *–ve control: basal diet feed, +ve control: basal diet feed+ neomycin and oxytetracycline, T1: (0.3% RI11), T2: (0.3% RG14), T3: (0.3% RI11+0.8% inulin), T4: (0.3% RI11+1.0% inulin), T5: (0.3% RG14+0.8% inulin), T6: (0.3% RG14+1.0% inulin).

Treatment*	Robusticity index	Tibiotarsal index	Bone breaking force (N)
-ve control	4.47 [a]	36.75 [a]	289.94 [a]
+ve control	4.48 [a]	40.68 [a]	286.25 [a]
T1	4.41 [a]	39.78 [a]	285.73 [a]
T2	4.38 [a]	39.57 [a]	295.39 [a]
T3	4.45 [a]	41.84 [a]	302.23 [a]
T4	4.41 [a]	41.89 [a]	296.74 [a]
T5	4.42 [a]	39.95 [a]	287.94 [a]
T6	4.39 [a]	42.06 [a]	318.57 [a]
SEM	0.02	0.67	5.99

The results of the pH and color values are shown in Table 5. The pH value at day 0 was significantly decreased with all "postbiotic and inulin" additives as compared to control groups except T3. The muscle pH is an important indicator of various quality traits in meat. The pH of breast meat of approximately 6.0 is considered to be good quality (Fernandez *et al.*, 1994; Alvarado *et al.*, 2007). The pH values observed for all additives in this study were around pH 6.0. Th2 low pH values observed for "postbiotic and inulin" corroborates the findings of Khalafalla et al. (2011) who found that probiotic influenced pH decline in broiler meat particularly on day 0. On the contrary, Pelicano et al. (2003) did not observed significant differences in muscle pH between control birds and those fed probiotics.

Birds fed positive control, T6 and T2 diet had higher ($p<0.05$) lightness compared to those fed with negative control diet. However, there was no significant difference ($p>0.05$) in lightness among T3, T4, T5, T1 and the negative control. Normal breast meat has an L* of approximately 55 and those that appear to be pale have L* values greater than 60 (Van Laack et al., 2000; Schilling et al., 2008). A low pH reduces adhering tissues. Bone breaking force was measured by following the method of myoglobin in selectively absorbing green light, resulting in meat that appeared lesser red and more yellow (Castellini et al., 2002). Thus, the higher lightness in all additive treatments could be due to lower pH value of the muscle. As pH increased the L* value decreased, i.e. while darkness of meat increased the lightness declined. Moreover, it can be influenced by increasing a* and b* values. When a* and b* values increased, L* value declined and the color gradually darkened (Karaoğlu et al., 2006). The T6 samples indicated lower redness (a*) and this was significantly different ($p<0.05$) from negative control of T1 and T4. A significant decrease in b* (yellowness) ($P<0.05$) was found in the positive control, T3, T5 and T6 as compared with negative control. Similar findings were reported by Karaoğlu et al., (2006) and Ali, (2010), who showed that dietary supplementation of probiotics positively influenced color attributes in chicken breast meat. On the contrary, Aristides et al., (2012) reported no difference in the color of breast meat between the control group and probiotic, prebiotic and symbiotic additive treatments.

Breaking bone strength, tibiotarsal index and robusticity parameters were not affected by the postbiotic and inulin diet (Table 6). This observation corroborates the findings of Swiatkiewicz et al., (2011) who reported that 0.7% inulin and 7% oligofructose did not improve bone quality of broilers. Similarly Vahdatpour et al. (2014) observed that consumption of probiotic, prebiotic and symbiotic in quails did not show positive effects on bone indexes and strength. In contrast, Ziaie et al. (2011) reported that supplementing broiler diet

with antibiotic and its alternative such as prebiotic, probiotic, commercial herbal blend and organic acid could improve bone characteristic. Mutush et al., (2006) also reported that the probiotic diet resulted in a greater ($p<0.05$) tibiotarsal index than the birds fed the control diet. In conclusion, the results of this study revealed that using postbiotics and inulin as replacement for antibiotics had beneficial effects on drip loss, pH and meat color and did not have adverse effect on carcass traits and bone quality. It can be concluded that postbiotics and inulin have remarkable potential in improving meat quality of broiler chickens compared with antibiotics.

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REFERENCES

Ali, F.H. (2010). Probiotics Feed Supplement to Improve Quality of Broiler Chicken Carcasses. *World Journal of Dairy & Food Sciences* **5,** 93-99.

Alvarado, C. Z., Richards, M. P., O'Keefe, S. F. and Wang, H. (2007). The effect of blood removal on oxidation and shelf life of broiler breast meat. *Poultry Science* **86,** 156-161.

Aristides, L.G., Paião, F.G., Murate, L.S., Oba, A. and Shimokomaki, M. (2012). The Effects of Biotic Additives on Growth Performance and Meat Qualities in Broiler Chickens. *International Journal of Poultry Science* **11,** 599-604.

Barbut, S. (1993). Color measurement for evaluating the pale soft exudative (PSE) occurrence in turkey meat. *Food Research International* **26,** 39-43.

Barnet, E. and Nordin, B. (1960). The radiological diagnosis of osteoporosis: A new approach. *Clinical Radiology* **11,** 166–169.

Boerlin, P. and Reid-Smith, R.J. (2008). Antimicrobial resistance: Its emergence and transmission. *Animal Health Research Reviews* **9,** 115–126.

Castellini, C., Mugnai, C. and Dal Bosco, A. (2002). Effect of organic production system on broiler carcass and meat quality. *Meat Science* **60,** 219-225.

Denbow, M.D. (2003). Factors Affecting Meat Quality. URL(http://www.poultryscience.org/pba/1952-2003/2000/2000%20Denbow.pdf. Accessed on February 7th, 2010.

Falaki, M., shams shargh, M., dastar, B. and zerehadaran, S. (2011). Effects of different levels of probiotic prebiotic on performance and carcass characteristics of broiler chickens. *Journal of animal veterinary advances* **10,** 378-384.

Fernandez, X., Forslid, A. and Tornberg, E. (1994). The effect of high postmortem temperature on the development of pale, soft, and exudative pork: Interaction with ultimate pH. *Meat Science* **37,** 133-147.

Fletcher, D.L. (2002). Poultry meat quality. *World's Poultry Science Journal* **58,** 131–145.

Foo, H.L., Loh, T.C., Law, F.L., Lim, Y.S., Kuflin, C.N. and Rusul, G. (2003). Effect of feeding *L. plantarum* I-UL4 isolated from Malaysian Tempeh on growth performance, fecla flora and lactic acid bacteria and plasma cholesterol concentrations in post weaning rats. *Journal Food Science Biotechnology* **12,** 403–408.

Hajati, H. and Rezaei, M. (2010). The Application of Prebiotics in Poultry Production. *Int. J. Poultry Science* **9,** 298-304.

Honikel, K.O.(1998). Reference methods for the assessment of physical characteristics of meat. *Meat Science* **49,** 447-457.

Karaoğlu, M., Aksu, M., Esenbuga, N., Macit, M. and Durdağ, H. (2006). pH and colour characteristics of carcasses of broilers fed with dietary probiotics and slaughtered at different ages. *Asian-Australasian Journal of Animal Science* **19,** 605-610.

Kareem, K.Y., Foo, H.L., Loh, T.C., Ooi, M.F. and Samsudin, A.A. (2014). Inhibitory activity of probiotic produced by strains of Lactobacillus plantarum using reconstituted media supplemented with inulin. *Gut Pathogens* **6,** 23. doi:10.1186/1757-4749-6-23

Khalafalla, F.A., Fatma, H.M., Ali, D., Zahran, A. and Mosa, A.M. (2011). Influence of Feed Additives in Quality of Broiler Carcasses. *Journal World's Poultry Research* **2,** 40-47.

Kleter, G.A. and Marvin, H.J. (2009). Indicators of emerging hazards and risks to food safety. *Food Chemestry Toxicology* **47,** 1022–1039.

Liu, X., Yan, H., Lv, L., Xu, Q., Yin, C., Zhang, K., Wang, W. and Hu, J. (2012). Growth performance and meat quality of broiler chickens supplemented with Bacillus licheniformis in drinking water. *Asian-Australasian Journal of Animal Science* **25,** 682 - 689.

Loddi, M.M., Gonzales, E., Takita, T.S., Mendes, A.A.M. and Roça, R.O. (2000) Uso de probiótico e antibiótico sobre o desempenho, rendimento equalidade de carcaça de frangos de corte. *Revista Brasileira de Zootecnia* **29,** 1124-1131.

Loh, T.C., Choe, D.W., Foo, H.L., Sazili, A.Q. and Hair Bejo, M. (2014). Effects of feeding different probiotic metabolite combinations produced by *Lactobacillus plantarum* strains on egg quality and production performance, faecal parameters and

plasma cholesterol in laying hens. *BMC Veterinary Research* **10,** 149 doi:10.1186/1746-6148-10-149.

Markovicv, R. (2005). The effect of different growth promoters in broiler nutrition on performance and health status. *In Master Thesis. Faculty of Veterinary Medicine. Belgrade, Serbia: University of Belgrade*

Marteau, P. and Shanahan, F. (2003). Basic aspects and pharmacology of probiotics: An overview of pharmacokinetics, mechanisms of action and side effects. *Best Practice and Research in Clinical Gastroenterology* **17,** 725-740.

Menten, J.F. (2002). Probióticos, prebióticos e aditivos fitogênicos na nutrição de aves. In: 2° Simpósio sobre Ingredientes na Alimentação Animal;*Uberlândia, Minas Gerais, Brasil,*251-276.

Mutus, M., Kocabagli, N., Alp, M., Acar, N., Eren, M. and Gezen, S. S. (2006). The effect of dietary probiotic supplementation on tibial bone characteristics and strength in broilers. *Journal of Poultry Science* **85,** 1621-1625.

Ortiz, L.T., Rodriguez, M.L., Alzueta, C., Rebole, A. and Trevino, J. (2009). Effect of inulin on growth performance, intestinal tract sizes, mineral retention and tibial bone mineralisation in broiler chickens. *British Poultry Science* **50,** 325-332.

Pelicano, E.R.L., De Souza, P., De Souza, H., Oba, A., Norkus, E., Kodawara, L. and De Lima, T. (2003). Effect of different probiotics on broiler carcass and meat quality. *Revista Brasileira de Ciência Avícola* **5,** 207-214.

Reisenfeld, A. (1972). Metatarsal robusticity in bipedal rats. *American Journal of Physical Anthropology* **40,** 229–234.

Sazili, A., Parr, T., Sensky, P., Jones, S., Bardsley, R. and Buttery, P. (2005). The relationship between slow and fast myosin heavy chain content, calpastatin and meat tenderness in different ovine skeletal muscles. *Meat Science* **69,** 17-25.

Schilling, M.W., Radhakrishnan, V., Thaxton, Y.V., Christensen, K., Thaxton, J.P. and Jackson, M.V. (2008). The effects of broiler catching method on breast meat quality. *Meat Science* **79,** 163-171.

Shabani, R., Nosrati, M., Javandel, F. and Kioumarsi, H. (2012). The effect of probiotics on carcass and internal organs of broilers. *Annals of Biological Research* **3,** 5475-5477.

Shazali, N., Foo, H.L., Loh, T.C., Choe, D.W. and Abdul Rahim, R. (2014). Prevalence of antibiotic resistance in lactic acid bacteria isolated from the faeces of broiler chicken in Malaysia. *Gut Pathogens* **6:** (1). doi:10.1186/1757-4749-6-1.

Swiatkiewicz, S., Koreleski, J. and Arczewska-Włoek, A. (2011). Effect of inulin and oligofructose on performance and bone characteristics of broiler chickens fed on diets with different concentrations of calcium and phosphorus. *British Poultry science* **52,** 483-91.

Takahashi, S.E., Mendes, A.A., Saldanha, E.S., Pizzolante, C.C., Pelícia, K., Quinteiro, R.R., Komiyama, C.M., Garcia, R.G., Almeida, and Paz, I. (2005). Efficiency of Prebiotics and Probiotics on the Performance, Yield, Meat Quality and Presence of Salmonella spp in Carcasses of Free-Range Broiler Chickens. *Rev. Bras. Cienc. Avic.* **7,** 151-157.

Thanh, N.T., Loh, T.C., Foo, H.L., HAIR-BEJO, M. and Azhar, B.K. (2010). Inhibitory activity of metabolites produced by *Lactobacillus plantarum* isolated from Malaysian fermented food. *Int J Probiotics Prebiotics* **5,** 37–44.

Vahdatpour, T., Ebrahimnezhad, Y. and Vahdatpour, S. (2014). Effects of dietary functional additives on characteristics and minerals of tibia bone and blood parameters of Japanese quails (coturnix coturnix japonica). *International journal of plant, animal and environmental sciences* **4,** 690-695.

Van Laack, R.L.J.M., Liu, C.H., Smith, M.O. and Loveday, H.D. (2000). Characteristics of Pale, Soft, Exudative Broiler Breast Meat. *Poultry Sci*ence **79,** 1057-1067.

Young, J. (1998). European market developments in prebiotic and probiotic containing foodstuffs. *British Journal Nutrition* **80,** 231-233.

Zhou, X., Wang, Y., Gu, Q. and Li, W. (2010). Effect of dietary probiotic, *Bacillus coagulans*, on growth performance, chemical composition, and meat quality of Guangxi Yellow chicken. *Poultry science* **89,** 588-593.

Ziaie, H., Bashtani, M., Torshizi, M. K., Naeeimipour, H., Farhangfar, H. and Zeinali, A. (2011). Effect of antibiotic and its alternatives on morphometric characteristics, mineral content and bone strength of tibia in Ross broiler chickens. *Global Veterinary* **7,** 315-322.