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Effects of Banana Peel Meal on the Feed Conversion Ratio and Blood Lipid Profile of Broiler Chickens

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Abstract: The aim of this research was to study the effect of banana peel meal on the feed conversion ratio (FCR) and blood lipid profile, including total cholesterol, triglycerides, high density lipoprotein (HDL and low density lipoprotein (LDL levels, in the blood serum of broiler chickens. This study used 50-day-old strains of Charoen Phokphand 707 chickens of varied sex and standard body weight. The chickens were randomly divided into five groups: control chickens were fed 100% BR-1 commercial broiler feed; treatment group 1 (P-1) was fed 90% BR-1+10% banana peel meal; P-2 was fed 80% BR-1+20% banana peel meal; P-3 was fed 70% BR-1+30% banana peel meal; P-4 was fed 60% BR-1+40% banana peel meal. After a 35-d rearing period, body weight, FCR, total cholesterol, triglyceride, HDL and LDL levels in sera were quantified and analyzed by ANOVA. The results showed that FCR, total cholesterol and LDL levels were not significantly different ($p>0.05$) after administration of banana peel meal, while HDL and triglyceride levels were significantly different ($p<0.05$) among the treatment groups. These results indicate banana peel meal can be used as an alternative nutrient material in commercial broiler chicken feed to reduce the cost of production.

Key words: Banana peel meal, feed conversion ratio (FCR), blood lipid profile, broiler chickens

INTRODUCTION

Bananas are tropical plants that can grow almost anywhere in Indonesia, from the coast to the highlands. All parts of the banana plant, including the stems, leaves, fruit and banana peel, can be used for various purposes. Their high nutrient content, delicious fruit flavor, market availability and low price are all reasons why bananas are a very popular fruit. Banana is classified into the family *Musaceae*, genus *Musa* and species *Musa paradise* (Anonymous, 2011).

The banana peel is a waste product of the banana production industry. Typically, the peels are not used properly, they just left as organic waste (Nuramah *et al*., 2011). However, banana peels are reportedly high in protein and carbohydrates (Shah *et al*., 2012), containing 59.09% carbohydrates, 0.90% protein and 31.7% crude fiber (Anhwange *et al*., 2009). They also contain several minerals, such as sodium, calcium, magnesium, phosphorus, zinc and manganese (Emaga *et al*., 2006). Furthermore, compared to banana fruit flesh, the peel has higher antioxidant content, namely flavonoids and saponins (Someya *et al*., 2002).

In the poultry industry, the high cost of feed is a constraint which affects the cost of production. High feed costs directly reflect the cost of importing the raw materials used to make it, such as corn, soybean meal, meat meal, fish meal and supplementary nutrition. This also explains why feed prices tend to increase over time and why availability is limited, resulting in even higher production costs. In the broiler farm industry, feed costs are the largest production cost, making up about 60-70% of total production costs (Mulyantini, 2010). Therefore, alternative feed ingredients that have good nutritional value, high abundance, ready availability and low manufacturing cost are necessary. Broiler feed ingredients derived from banana peel waste can be used as alternative feed or feed supplement because it is inexpensive, nutritious and easy to produce and add to broiler feed mixtures (Mulyantini, 2010).

Broiler chickens grow rapidly and are very efficient at converting feed into meat due to genetic factors. With a good maintenance system, broilers will gain between 1.3-1.6 kg within 5-6 weeks (Koni *et al*., 2013). External factors greatly affect the optimal growth of broiler chickens, such as intensive maintenance and feed quality (Abun, 2005). The need for dietary protein and energy in the broiler diet is higher than that of other domestic chickens; broiler chicken growth will be less than optimal if they are only fed an energy content less than 2400 kcal and protein content less than 20 g/head/d (Suprijatna *et al*., 2005).

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The rapid growth of broiler chickens is always offset by an increased level of fat in the meat. A high amount of fat in the meat is a primary concern for consumers of animal-sourced foodstuffs as certain fats, such as cholesterol, can lead to degenerative diseases, such as heart disease (Meliandasari *et al*., 2015). Coronary heart disease is characterized by hardening of the arteries and high fat levels in the blood (hyperlipidemia), especially cholesterol [hypercholesterolemia] (Murray *et al*., 2009). Therefore, we investigated banana peels as an alternative nutrient source for broiler feed mixtures. The purpose of the current research was to study the effect of banana peel meal on the feed conversion ratio (FCR) and blood lipid profile triglycerides, total cholesterol, HDL and levels in broiler chickens.

MATERIALS AND METHODS

Chicken preparation: This study used 50-day-old Charoen Phokphand 707 chicken strains of varied sex standard body weight. Chickens were kept for 35-d in cages which used an open house system where litters were placed in five smaller cages. The size of each smaller cage was 2 x 1 m, rice husks were used as litter and each cage contained one food and drink apparatus. During the 35-d nursing period, chickens were fed BR-1 commercial broiler feed (Japfa Comfeed Indonesia Co.) *ad libitum* and were vaccinated against Newcastle Disease and Infectious Bronchitis according to standard broiler vaccination protocols and schedules recommended by the vaccine manufacturer.

Preparation of banana peel meal: Banana peels were collected from traditional market traders then washed with fresh water and cut into small pieces to expedite drying. The banana peel pieces were dried indoors and not exposed to direct sunlight to prevent nutrient loss. The dried pieces were then sorted and ground using a grinding machine; the pieces were milled at least twice to produce a soft and smooth powdery texture. The banana peel powder was then dry stored until use.

Broiler rearing: Fifty-day-old chickens were reared for 3 weeks with BR-1 and fresh drinking water *ad libitum*. After they reached 3 weeks of age, the broilers allocated to treatment groups were given a specified amount of banana peel meal, as described below, together with BR-1, whereas those in the control group were continuously fed only BR-1. Cages were cleaned daily. Feed portions were adapted to weight gain and broiler age.

Study design: Broiler chickens were fed treatment diets for 2 weeks. Before beginning dietary treatments, each broiler was weighed and randomly divided into five trial groups. Dietary treatments were as follows:

a: Control (C) chickens were given commercial BR-1 feed
b: Treatment group 1 (P-1) was fed 90% BR-1 mixed with 10% banana peel meal
c: Treatment group 2 (P-2) was fed 80% BR-1 mixed with 20% banana peel meal
d: Treatment group 3 (P-3) was fed 70% BR-1 mixed with 30% banana peel meal
e: Treatment group 4 (P-4) was fed 60% BR-1 mixed with 40% banana peel meal

Chickens were fed twice daily (morning and evening) along with fresh drinking water *ad libitum*; each feed amount was weighed and recorded. Any residual feed was also weighed and recorded as consideration for quantifying food requirements on following day. All broilers were weighed once a week at the end of the week. In the fifth week, three broilers from each group were randomly selected and 2 mL of blood was taken from the brachialis vein to determine total cholesterol, HDL, LDL and triglyceride levels; a total of 15 broilers were analyzed. The experimental design which used in this study was completely randomized design (CRD).

Blood collection: In the fifth week, 3 mL of blood was taken from the brachial vein of chickens using a Terumo syringe. Blood samples were collected in a vacutainer tube then centrifuged at 6000 rpm for 10 min. Serum was separated from the blood and blood lipid profiles were quantified (total cholesterol, HDL, LDL and triglyceride levels).

Blood lipid profiles: The quantification of total blood cholesterol was carried out using the cholesterol oxidase-phenol aminophenazone photometric method. First, the blank tube was prepared by mixing 10 μL of distilled water with 990 μL of cholesterol reagent. The standard tube was prepared by mixing 10 μL of cholesterol (200 mg/dL) with 990 μL of cholesterol reagent. The sample tubes contained a homogenous mixture of 10 μL of broiler serum and 990 μL of cholesterol reagent. Tubes were incubated at room temperature (24-30°C) for 20 min. Measurements were performed using a MicroLab 300 spectrophotometer at 546 nm in end-point mode. Total cholesterol was measured spectrophotometer automatically and the levels were quantified using the following formula:

$$\text{Cholesterol level} = \left[\frac{\text{Sample absorbance}}{\text{Standard absorbance}}\right] \times \left[\text{Standard conc. (200 mg/dL)}\right]$$

In principle, quantification of HDL and LDL levels in broiler serum is similar to that of total cholesterol, except

that HDL and LDL quantification used a precipitation process. To quantify LDL levels, 50 µL of broiler serum was mixed and precipitated with 500 µL of a precipitation solution, while HDL quantification used 100 µL of serum and 250 µL of precipitation solution. After being mixed well, tubes were incubated at room temperature for 15 min before being centrifuged at 12,000 rpm for 2 min. Supernatants were removed by micropipette and the levels of HDL and LDL were quantified using standard and blank solutions. HDL and LDL levels were measured using a MicroLab 300 photometer at 546 nm in end-point mode. HDL and LDL levels were quantified using the following formulae:

$$\text{HDL precipitate level} = \left[\frac{\text{Sample absorbance}}{\text{Standard absorbance}}\right] \times \left[\text{Standard conc. (200 mg/dL)}\right]$$

$$\text{LDL precipitate level} = \left[\frac{\text{Sample absorbance}}{\text{Standard absorbance}}\right] \times \left[\text{Standard conc. (200 mg/dL)}\right]$$

$$\text{LDL level} = \left[\text{Total Cholesterol}\right] \times \left[\text{Cholesterol in supernatant (precipitate)}\right]$$

Triglyceride quantification was done with a glycerol-3-phosphate oxidase photometric reaction. The blank tube was filled with 10 µL of distilled water and 990 µL of reagent solution. The standard and sample tubes were prepared by mixing 10 µL of triglyceride solution (200 mg/dL) or broiler serum, respectively, with 990 µL of reagent solution until homogeneous. Then, each tube was incubated at room temperature (24-30°C) for 30 min. Measurement of triglyceride levels was performed with a MicroLab 300 photometer at 546 nm in end-point mode. Triglyceride levels were quantified using the following formula:

$$\text{Triglyceride level} = \left[\frac{\text{Sample absorbance}}{\text{Standard absorbance}}\right] \times \left[\text{Standard conc. (200 mg/dL)}\right]$$

Data analysis: The parameters measured were FCR, total cholesterol, HDL, LDL and triglyceride levels. The results were statistically analyzed using analysis of Variance (ANOVA) by SPSS version 17 software (Satria, 2013). The mean of each parameter for each group are reported.

RESULTS AND DISCUSSION

FCR: FCR is the ratio between the amount of feed consumed and meat produced by a broiler. In other words, FCR represents the amount of feed consumed to produce 1 kg of meat. FCR was determined after calculating the total amount of feed consumed by each group divided by the last broiler body weight taken before harvesting the chickens (Rasyaf, 2008). In broilers, the FCR value is influenced by several factors, such as age, breed, feed nutrient content, temperature and chicken condition (Anggorodi, 1994). Mean FCR results for all groups are shown in Table 1. The lowest mean FCR was found in the P-1 group (1.48±0.22), while the highest was in P-4 (1.72±0.33). These data indicate 90% BR-1 mixed with 10% banana peel meal had the highest level of fed efficient relative to all other groups because a smaller FCR value means the chicken were able to utilize their feed efficient for growth (Campbell and Lasley, 1984). This finding is similar to that reported by Udjianto *et al.* (2005) who showed higher FCR values (1.69-2.23) with increased consumption of fermented banana peels in chicken feed. Furthermore, the mean FCR was not significantly different between C and treatment groups, meaning that mixing banana peel meal with commercial feed did not significantly affect the FCR ($p>0.05$).

Interestingly, the P-1 group showed the lowest FCR compared to all other groups, including the C. This result suggests that mixing 10% banana peel meal with 90% BR-1 feed provides an optimal FCR and desired weight gain. It is thought that lower FCR values are likely influenced by the high protein content of banana peels. However, Koni *et al.* (2013) showed a lower FCR corresponded with an increase in banana peel content but decreased amino acid content in broiler feed. This is likely due to the increasingly poor quality of forages in the P-2 to P-4 groups, which inhibits broiler weight gain. Thus, the main factors affecting feed conversion are the feed quality and chicken strain (Koni *et al.*, 2013).

Triglycerides: Triglycerides are a form of fat that efficiently store energy essential to biochemical processes in the cell. Triglycerides are not hydrated; when oxidized, they only produce 4 kcal/g, while carbohydrates and protein produce 9 kcal/g (Linder, 2006). Triglycerides can be found as grains of fat in liver and muscle cells and can be directly used as an energy source. According to Basmacioglu and Ergul (2005), normal triglyceride levels in the body of broilers are less than 150 mg/dL.

Triglyceride levels measured in the current study are shown in Table 2. The smallest mean amount of blood triglycerides was found in C chickens (61.23±6.9 mg/dL) and increased with supplementation of banana peel meal, with P-4 broilers having the highest levels (193.33±22.3 mg/dL). These results indicate banana peel meal elevates triglyceride levels more than commercial feed alone. The difference between mean triglyceride levels in the blood of C and treatment chickens was further analyzed by multiple comparisons

test to determine which the difference was greatest. The multiple comparisons test showed the greatest difference between the C and P-4 groups, further indicating the significant effect of banana peel meal ($p<0.05$) on blood triglyceride levels.

Figure 2 graphically shows the increase in mean triglyceride levels in the blood of broilers with increasing amounts of banana peel meal, with P-4 chickens having the highest levels. An increase in triglyceride levels may be associated with abnormalities in liver function caused by damage to liver cells. Toxic substances in banana peels could damage cell membranes preventing lipoprotein lipase hydrolysis of triglycerides to release fatty acids (Situmorang and Martha, 2014). Membrane damage can also be caused by mitochondrial dysfunction resulting from mitochondrial fatty acid oxidation. The purpose of triglyceride hydrolysis by lipoprotein lipase in the cell membrane and fatty acid oxidation in mitochondria is to reshape triglycerides. If the process of fatty acid oxidation decreases due to mitochondrial dysfunction, fatty acids can be used to fuel metabolism and are reconverted back into triglycerides (Begriche *et al*., 2011).

Our results concerning triglyceride levels in broiler serum are in direct contrast to those of Farida *et al.* (2009) who reported that banana peel flavonoids can enhance the activity and levels of lipoprotein lipase and thereby lower triglyceride levels. This would also cause hydrolysis of very low LDLs that transport triglycerides into fatty acids and glycerol. These liberated fatty acids are then absorbed by the muscles and other tissues and oxidized to release energy and/or is stored by adipose tissues (Marks *et al*., 2000). Furthermore, flavonoids have been shown to inhibit fatty acid synthase, which is an important enzyme in the metabolism of fat. Inhibition of fatty acid synthase function will directly reduce formation of fatty acids (Tian *et al*., 2011). Thus, a decrease in fatty acids can cause a decrease in the formation of triglycerides (Farida *et al*., 2009).

Total cholesterol: Broilers are in great demand by the public because their meat is fine textured, soft and tender. However, fat easily accumulates among coarse fibers in meat (Sutrihadi *et al*., 2013). The cholesterol content in broiler chickens is typically high at about 200 mg, which is higher than that in other chickens (100-120 mg). The high cholesterol level in broiler blood results in accumulation of cholesterol in the meat and potentially the body of those that consume it. The normal level of total blood cholesterol in broiler chickens is about 52-148 mg/dL according to Manoppo *et al.* (2007). Normal HDL levels in the blood of broilers according to Manoppo *et al.* (2007) are 40-60 mg/dL, whereas normal blood LDL levels are 95-125 mg/dL. Basmacioglu and Ergul (2005) previously stated that safe and healthy LDL and HDL levels in livestock are $\leq$130 and $\geq$22 mg/dL, respectively. Importantly, a lower LDL level in broiler meat is better because it relates to the amount of fat deposited; high LDL levels lead to the deposition of cholesterol in meat.

Total cholesterol, HDL and LDL levels are shown in Table 3. The mean total cholesterol, HDL and LDL measured in broiler blood indicates that all groups were still within the normal range, with the lowest mean total cholesterol in P-1 (102.03±26.05 mg/dL) and highest in P-2 chickens (125.63±10.99 mg/dL). Mean HDL and LDL levels in P-1 broilers were also the lowest (HDL, 13.47±9.5 mg/dL; LDL, 78.87±19.9 mg/dL), while C chickens had the highest mean HDL (34.73±6.7 mg/dL) and P-4 the highest mean LDL (94.9±33.4 mg/dL). These findings demonstrate that administration of 10%

Table 1: Broiler feed conversion ratio (FCR) after the 35-d rearing period

Sample	Mean amount of feed consumed (gram)	Mean body weight (gram)	Mean FCR
C	2881.8	1823.0	1.58±0.14
P-1	2878.0	1966.7	1.48±0.22
P-2	2924.5	1777.7	1.65±0.15
P-3	3142.7	1850.0	1.69±0.05
P-4	3130.8	1866.7	1.72±0.33

C, control group = 100% BR-1commercial feed
P-1, treatment group 1 = 90% BR-1+10% banana peel meal
P-2, treatment group 2 = 80% BR-1+20% banana peel meal
P-3, treatment group 3 = 70% BR-1+30% banana peel meal
P-4, treatment group 4 = 60% BR-1+40% banana peel meal

Table 2: Mean triglyceride levels in broiler serum

Sample	Mean triglyceride (mg/dL)
C	61.23±6.90
P-1	105.73±0.86
P-2	113.67±9.01
P-3	136.63±4.94
P-4	193.33±22.3

C, control group = 100% BR-1 commercial feed
P-1, treatment group 1 = 90% BR-1+10% banana peel meal
P-2, treatment group 2 = 80% BR-1+20% banana peel meal
P-3, treatment group 3 = 70% BR-1+30% banana peel meal
P-4, treatment group 4 = 60% BR-1+40% banana peel meal

Table 3: Mean of total cholesterol, HDL and LDL levels in broiler blood serum after treated with banana peel meal

Group	Mean total cholesterol (mg/dL)	Mean HDL (mg/dL)	Mean LDL (mg/dL)
C	123.73±20.01	34.73±6.7	87.57±22.7
P-1	102.03±26.05	13.47±9.5	78.87±19.9
P-2	125.63±10.99	21.63±8.7	84.13±15.1
P-3	108.07±5.12	31.40±7.9	81.40±9.1
P-4	124.67±11.34	25.87±6.4	94.90±13.4

C, control group = 100% BR-1 commercial feed
P-1, treatment group 1 = 90% BR-1+10% banana peel meal
P-2, treatment group 2 = 80% BR-1+20% banana peel meal
P-3, treatment group 3 = 70% BR-1+30% banana peel meal
P-4, treatment group 4 = 60% BR-1+40% banana peel meal

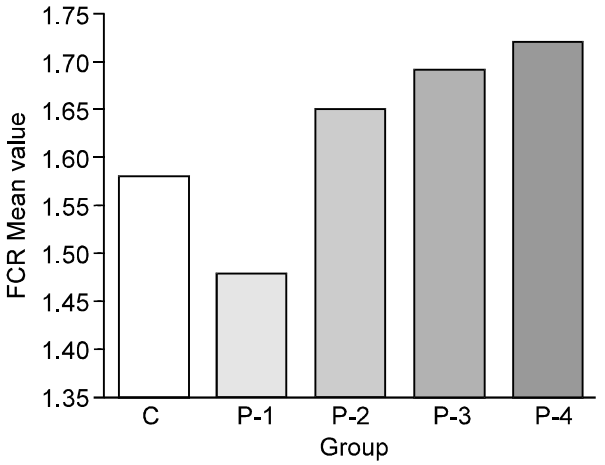

Fig. 1: Mean feed conversion ratio (FCR) of control (C) and treatment groups (P-1, P-2, P-3 and P-4)

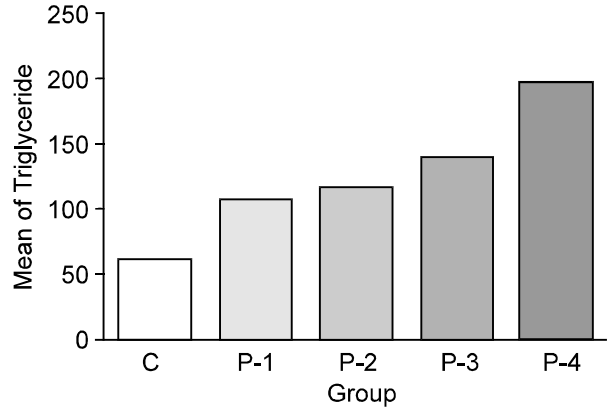

Fig. 2: Mean triglyceride levels in serum of control (C) and treatment groups (P-1, P-2, P-3 and P-4)

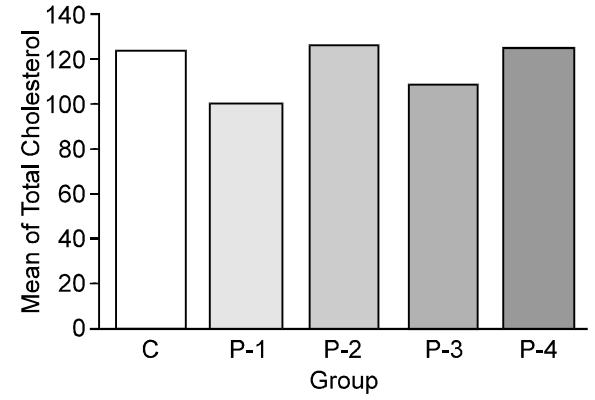

Fig. 3: Mean total cholesterol in serum of control (C) and treatment groups (P-1, P-2, P-3 and P-4)

banana peel meal lowers total cholesterol, HDL and LDL in the blood to optimal levels. Furthermore, ANOVA of mean total cholesterol levels showed no intergroup treatment difference, indicating that provision of banana peel meal had no significant impact on total cholesterol levels in blood of broilers ($p>0.05$).

Figure 3 shows that P-1 chickens fed 10% banana peel meal exhibited the greatest reduction in total blood cholesterol levels compared to C chickens. It is believed that the decrease in total blood cholesterol was influenced by the high amount of crude fiber found in banana peel meal [31.70%, Anhwange *et al.* (2009)]. According to Sutrihadi *et al.* (2013), blood cholesterol levels can be affected by dietary crude fiber. High fiber quickens the digestive process, moving digested food relatively faster through the intestines. However, a high level of dietary crude fiber will also reduce the rate of nutrient and cholesterol absorption in the intestines.

Saponins in banana peels can induce hyperlipidemia through reduced cholesterol synthesis by inhibiting the activity of 3-hydroxy-3-methylglutaryl-CoA (HMG-CoA) reductase and increasing excretion of bile acids via conversion of cholesterol into bile acids. Saponins are also able to inhibit the absorption of cholesterol and bile acids by interrupting the formation of micelles. Saponins also play a role in increasing turnover or exfoliation of intestinal cells through their membranolytic action, thereby augmenting loss of cholesterol in cell membranes into cells that exfoliate (Afrose *et al.*, 2010).

ANOVA of mean LDL levels showed no intergroup treatment difference, indicating provision of banana peel meal had no significant impact on LDL levels in blood of broilers ($p>0.05$). ANOVA of mean HDL levels, on the other hand, did show some intergroup treatment differences, which were further analyzed by multiple comparisons test. The multiple comparisons test also showed HDL differences between C and P-1 groups, further suggesting banana peel meal significantly impacted blood HDL levels in broiler chickens ($p<0.05$).

Figure 4 shows that P-1 broilers fed 10% banana peel meal exhibited the greatest reduction in blood HDL and LDL levels compared to C chickens. Decreases in blood HDL levels are thought to be influenced by flavonoids, which are quite high in banana peel meal as reported by Nuramah *et al.* (2011). Secondary metabolites contained in banana peels include flavonoids, terpenoids, saponins and tannins. The drying technique used in the current study does not change the content or type of secondary metabolites found in banana peels; the content of secondary metabolites in banana peels left after drying was 97.85%.

The decreased HDL levels in the blood of broiler chickens fed banana peel meal in the current study is in direct contrast to results by Guilaume *et al.* (2006) who reported that flavonoids can increase HDL levels by increasing the production of apolipoprotein A1 (Apo A1), which serves as a cofactor for lecithin cholesterol acyltransferase and as a ligand for lipoprotein receptors

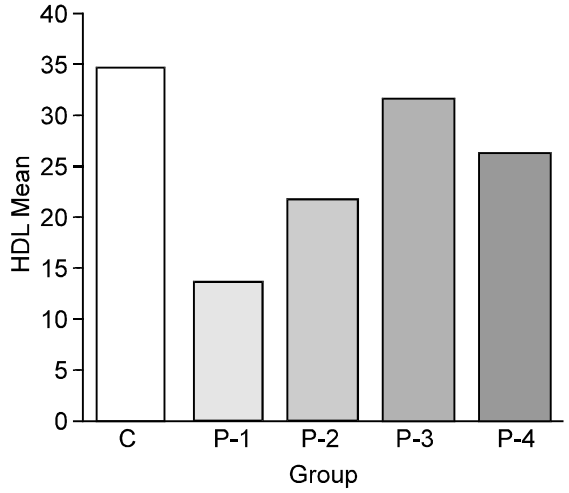

Fig. 4: Mean high density lipoprotein (HDL) levels between control (C) and treatment groups (P-1, P-2, P-3 and P-4)

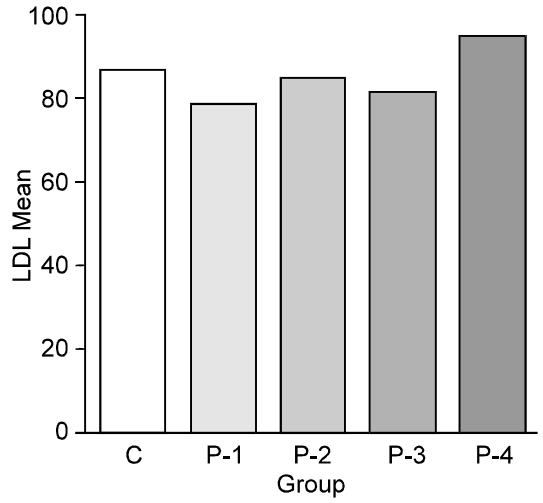

Fig. 5: Mean low density lipoprotein (LDL) levels between control (C) and treatment groups (P-1, P-2, P-3 and P-4)

in tissues. Thus, an increase in Apo A1 is expected to increase HDL levels. Apo A1 containing HDL protect against atherosclerosis (Murray *et al*., 2009). This is in line with research conducted by Baba *et al*. (2007) where banana peel flavonoids were shown to increase HDL levels by increasing production of Apo A1 HDL.

Figure 5 shows that P-1 broilers had the greatest reduction in blood LDL levels compared to C chickens. The decrease in LDL levels found in the present study is thought to be caused by flavonoids contained within banana peels, according Nijveldt *et al*. (2001). Flavonoids are antioxidants that capture free radicals by freeing hydrogen atoms of hydroxyl groups. It is also thought that flavonoids can inhibit LDL oxidation reactions in the body. Damage to the endothelium caused by hyperlipidemia, which triggers oxidation, can be inhibited by preparations of antioxidants, such as flavonoids. In small doses, flavonoids are able to dilate blood vessels, as well as lower the level of LDL oxidation (Setyaningrum *et al*., 2014). Furthermore, flavonoids have been shown to increase LDL receptors by five times the normal levels (Wilcox *et al*., 2001).

Banana peel meal also contains tannins. Tannins can inhibit HMG-CoA reductase, which acts to synthesize cholesterol and acetyl coenzyme A acetyltransferase, which is responsible for the esterification of cholesterol. Inhibition of HMG-CoA reductase decreases the cholesterol synthesis in the liver, thereby reducing Apo B-100 synthesis. Therefore, LDL in blood will be drawn to the liver and will reduce the level of HDL and very low density lipoprotein (VLDL) (Do *et al*., 2011).

Conclusion: The FCR, total cholesterol and LDL levels were not significantly changed ($p>0.05$) after administration of banana peel meal in broiler feed, while HDL and triglyceride levels were significantly different between the treatment groups ($p<0.05$). These results indicate banana peel meal can be used as an alternative nutrient source with commercial chicken feed to reduce the cost of broiler production.

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