# Performance of Broiler Chickens Fed Diets with Different Levels of Mangosteen (*Garcinia mangostana* Linn.) Rind Powder

**Julius Jerome G. Ele[1], Josephine R. Migalbin, Elma G. Sepelagio, and Peter Greame F. Lacia**

Department of Animal Science, College of Agriculture, University of Southern Mindanao, Kabacan, Cotabato, Philippines 9407
[1]jeromeele@yahoo.com

***Keywords:***

mangosteen rind powder, broiler chickens, growth performance, anatomical, and metabolic effects

**ABSTRACT**

Mangosteen is a tropical fruit known to have therapeutic and medicinal properties. The beneficial effects of mangosteen include antioxidant, anti-inflammatory, antihistamine, antibacterial, antifungal, anticancer, antiviral, antidiabetic, nerve, blood, digestive and cardiovascular functions. The general objective of the study is to determine the performance of broiler chickens fed diets with different levels of mangosteen rind powder. The study was conducted in a Completely Randomized Design. A total of 100 birds for study 1 and 80 day old chicks for study 2 were randomly distributed into five different treatments namely, T1 – basal diet (corn-soya based) control, T2 – basal diet + commercial antioxidant, T3 – basal diet + 33g mangosteen rind powder/kg of feed, T4 – basal diet + 66g of mangosteen rind powder/kg of feed and T5 - 100g of mangosteen rind powder/kg of feed.

There were no significant differences observed in the final weight, total feed intake, total weight gain, feed conversion efficiency, dressing percentage, livability, production number and index of broilers fed with five treatment diets.

No significant differences were noted in the broiler's cholesterol, High Density Lipoprotein (HDL) and Low Density Lipoprotein (LDL) levels at day 14 fed diets with different levels of mangosteen rind powder. Meanwhile, triglycerides level at day 14 and day 28, cholesterol, HDL and LDL levels at day 28 showed significant differences among treatment means.

Weight of internal organs (heart, liver, and gizzard) relative to body weight showed no significant differences among treatment means for day 14 and day 28.

For the cost and return analysis, highest return of investment was obtained by the birds fed with commercial antioxidant at 49.89%. This was followed by the control group at 47.34%. Treatment with 66g of MRP followed with 45.82%, then by treatment with 100g of MRP at 43.90%. Lastly, the 33g of MRP group had 40.06%.

Feeding broilers with diets with different levels of mangosteen rind powder have shown similar growth performance results of mangosteen rind powder and those fed with commercial antioxidants. Moreover, the results have shown that the 66g of mangosteen rind powder and 100g of mangosteen rind powder are capable of decreasing the amounts of triglycerides, increasing the amounts of HDL and reducing the levels of LDL.

## INTRODUCTION

The search for finding new feed additives is one of the most active sections of animal nutrition. The utilization of growth promoters of natural origin became an interest in recent years (Iji *et al*., 2001). With the use of antibiotics facing serious criticism (Iji *et al.*, 2001). The overuse and unnecessary use of antibiotics has been linked to adverse drug events (ADEs), including allergic reactions, end-organ toxic effects, subsequent infection with antibiotic-resistant organisms and Clostridium difficile infections (Tamma *et al.*, 2017). Hence, there is a need to find alternative growth and health enhancers which are of natural origin. Plant based sources or herbal supplements are seen as promising alternatives with its demonstrated positive effects on production performance and carcass quality (Schleicher *et al.*, 1998).

Nutritional content of an animal feed is influenced by several factors including feed forms, digestibility, presence of toxic and anti-nutritional factors and effect on intestinal health to name a few. A typical diet of livestock and poultry in the Philippines is composed of a corn – soy-based diet formulation. Feed additives are also added as a supplement to the usual diet to complement the other needed nutritional content such as vitamins or minerals.

Feed additives are products used in animal nutrition for purposes of improving the feed quality, its products and animals' performance and heath. A feed additive may be categorized as acidifier, antibiotic, antimalarial, antimold, coccidiostat, dewormer, enzyme, flavoring, pellet binder, pigmenter, toxin binder, hormones, probiotic and antioxidants (Philippine Society of Animal Nutritionist Handbook, 2003).

Antioxidants are capable of stabilizing, or deactivating, free radicals before they attack cells. They are critical to maintain optimal cellular and systemic health and well-being (Percival, 1996). These involve different endogenous and exogenous component (nutrient-derived antioxidants, antioxidant enzymes, metal binding proteins and phytonutrients or phytochemicals) which interact together to neutralize free radicals (Jacob, 1995).

Phytonutrients or phytochemicals are plant nutrients with specific biological activities that support human health (Gupta & Prakash, 2014). Moreover, they have beneficial effects in human health such as anti-microbial, anti-oxidants, anti-inflammatory, antiallergic, anti-spasmodic, anti-cancer, anti-aging, hepatoprotective, hypolipidemic, neuroprotective, hypotensive, diabetes, osteoporosis, CNS stimulant, analgesic, protection from UVB-induced carcinogenesis, immuno-modulator, and carminative. Furthermore, the phenolics are largest category of phytochemicals and the most widely found in the plant kingdom (Saxena *et al.*, 2013). It was further stated that examples of major phenolic compounds are simple phenols, benzoquinones, phenolic acids, acetophenones, tyrosine derivatives, hydroxycinnamic acid, coumarins, naphthoquinones, xanthones, stilbenes, flavonoids, lignans, bioflavonoids and condensed tannins.

Phenolic compounds found in plants, spices, vegetables, fruits, grains and other seeds are important group of natural antioxidants with possible beneficial effects on human health. These can participate in protection against the harmful action of reactive oxygen species, mainly oxygen free radicals. Free radicals are produced in higher amounts in a lot of pathological conditions and are involved in the development of the most common chronic degenerative diseases, such as cardiovascular disease and cancer (Qazi & Molvi, 2018).

Phenolic compounds such as flavonoids are ubiquitous within the plant kingdom. There are approximately 3,000 flavonoid substances described (Briviba & Sies, 1994). These findings suggest that the

antioxidant activity of several vitamins and minerals present in fruits and vegetables play a protective role against cell damage or mutation caused by free radicals but what may also be beneficial are the multitude of non-nutrient compounds (phytochemicals) that are present in plant foods (Wattenberg, 1985).

Mangosteen (*Garcinia mangostana* L.) is a tropical fruit cultivated in the tropical rainforest of some Southeast Asian nations like Indonesia, Malaysia, Sri Lanka, Philippines and Thailand (Pedraza-Chaverri *et al.*, 2008; Zarena & Sankar, 2009). Research showed that xanthone, a phytochemical, is present in mangosteen.

Xanthones and other bioactive substances is known to possess antioxidant, antitumoral, antiallergic, anti-inflammatory, antibacterial, antifungal and antiviral properties (Pedraza-Chaverri *et al.*, 2008).

Most of the antioxidants in mangosteen can be found in the pericap. The pericarp or rind of mangosteen is the source of xanthones and other bioactive substances. The most studied xanthones are alpha-, beta-, and gamma-mangostins, garcinone E, 8-deoxygartanin and gartanin (Pedraza-Chaverri *et al.*, 2008).

Several researches have been done to see the efficiency and effectiveness of mangosteen for disease prevention and treatment and immune enhancement properties (Foiklang *et al.*, 2016; Hidanah *et al.*, 2017; Kusmayadi *et al.*, 2019). However, there is a need to establish the level of MRP that will enhance performance parameters and of animals and improve its resistance from diseases and eventually allow farmers to have access to natural antioxidants and immunostimulants.

With the emergence of antibiotic resistance that poses a threat to food safety and human health, there is a global trend to shift to natural feed additives which will allow animal raisers to reduce the use of costly antibiotic.

This research will pave the way in promoting the use of plants and herbs for disease prevention and enhancement of immune system of food producing animals to reduce production cost. This will also promote the utilization of the rind of mangosteen which is commonly neglected and thrown as a waste. Poultry and livestock farmers, animal nutritionists, researchers and veterinarians will benefit from this study.

With the different citations mentioned from the previous readings, this present study was therefore proposed to evaluate MRP in its potential as an immune response booster, disease prevention and production performance enhancer in broiler chickens.

The general objective of the study is to determine the performance of broiler chickens fed diets with different levels of mangosteen rind powder (MRP). Specifically, it aimed (1) to determine the production performance of broiler chickens; and (2) assess the anatomical and metabolic effects of different levels of MRP on broilers.

## MATERIALS AND METHODS

### Study 1. Production Performance of Broiler Chickens fed diets with Different Levels of MRP

The study was conducted in a Completely Randomized Design (CRD). One-hundred-day old chicks were randomly distributed into five different treatments with four replications at five chicks per replication. The treatments were as follows:

Levels of MRP

| | |
|---|---|
| Treatment 1 | Basal diet (No MRP or antioxidant) |
| Treatment 2 | Basal diet + commercial antioxidant |
| Treatment 3 | Basal diet + 33g of MRP/kg of feed |
| Treatment 4 | Basal diet + 67g of MRP/kg of feed |
| Treatment 5 | Basal diet + 100g of MRP/kg of feed |

Fresh and clean drinking water was provided to the birds at all times. Fresh water was placed every morning from the beginning until the whole duration of the study.

Vaccination of the birds against New Castle's Disease and Infectious Bursal Disease (6th and 12th day) were given.

The data that were gathered for the study were final weight, weight gain, feed intake, feed conversion efficiency, percent livability, production number (Euribrid, 1994), production index (Singh *et al.*, 1987), dressing percentage and cost and return analysis. The cost of feed, vaccines, birds, housing, labor, electricity and the total cost of producing a kilogram of bird and the return of investment (ROI) were determined after the study.

Data gathered were analyzed using the CRD. The treatments were subjected to Duncan's Multiple Range Test (DMRT) if there were any significant differences.

**Study 2. Anatomical and Metabolic Effects of MRP on Broiler Chickens**

The second study was conducted in a CRD. Eighty-day-old chicks were randomly distributed into the different treatments with four replications at four birds per replication. The same management activities were done similar to study 1.

The internal organs at day 14 and day 28, specifically the heart, liver and gizzard, were collected and weighed. Four birds per treatment were randomly selected at the day of data collection. The abdominal or the adipose tissues found near the abdomen were weighed at the 28th day of data collection. Four per birds per treatment were randomly selected.

Blood via the jugular vein was collected from the chickens at day 14 and day 28. Four birds per treatment were selected at the day of data collection. The blood samples were evaluated for cholesterol level (total cholesterol, HDL, LDL, and triglycerides). The blood samples were analyzed using the Screen Master Semi-Automated blood chemistry analyzer. It was assured that the standard procedures (Lumeij, 1987) were followed at the course and whole duration of the experiment.

Data gathered were analyzed using CRD. The treatments were subjected to DMRT if there were any significant differences.

*Preparation of MRP*

Following the methodology of Zarena and Sankar (2009), the fresh pericarp or rind of mangosteen was oven dried at 70°C. When the mangosteen rind was dry, it was ground to powder form using a hammer mill. The samples were kept in airtight containers and stored in a cool and dry place. The MRP were analyzed for phenolic compounds (Table 6) present through a Spectro 23 Spectro Photometer, LaboMed, Inc.

*Preparation of Diets with Different Levels of MRP*

Diets were prepared according to the level of MRP stated in the treatments. The experimental diets were formulated using a corn-soy based basal diet and MRP as feed additive was incorporated to the formulated diet. Feeds were fed to the birds in an *ad libitum*. The nutrient requirements for the formulated broiler diets were based on Philippine Society of Animal Nutritionist Handbook (2003). Fresh and clean drinking water was provided to the birds at all times.

## RESULTS AND DISCUSSIONS

**Study 1. Production Performance of Broiler Chickens fed diets with Different Levels of MRP**

*Liveweights of Broiler Chickens*

The summary of live weight (g/bird) of broiler chickens fed diets with varying levels of MRP in their diet is presented in Table 1. The data shows that there is no significant difference observed in the initial and final weight of the birds assigned to the various treatments of the study. The final

weight of the birds ranged from 1422.05g to 1539.16g.

The results of the study agreed with Toghyani *et al.* (2010) wherein no significant difference was observed among the control treatment and the treatments with dietary thyme in terms of the live weight of the birds. Similar to results of this study, Suchitra and Wanapat (2008) stated that feeding mangosteen peelings had no significant difference to the control group in terms of live weight gain. However, the results are in contrast with the findings of Al-Sultan (2003) where birds fed with diets inlcuding plant origin-based additives are showed to improve live weight of birds compared to the control group.

*Total Feed Intake of Broiler Chickens*

Total feed intake (g/bird) of broiler chickens fed diets with varying levels of MRP in their diet is presented in Table 1. There were no significant differences in the total feed intake of the birds fed diets with different levels of MRP. The total feed intake of the birds ranged from 2826.25g to 2906.10g. Results were similar to Demir *et al.* (2005) stating no differences in feed intake of broilers fed diets supplemented with antibiotic growth promoter and five herbal natural feed additives from day 0 to 42.

Moreover, results were also similar to results of Denli *et al.* (2004) wherein the feed intake of birds fed with herbs essential oils had no significant difference in terms of feed intake. Similarly, Hidanah *et al.* (2017) stated that feeding broilers with diets including mangosteen peel did not significantly increase feed consumption. However, when mangosteen peel was combined with ginger rhizome the feed consumption of broilers significantly increased.

*Total Weight Gain of Broiler Chickens*

The summary of total weight gain (g/bird) of broiler chickens fed with varying levels of MRP in their diet is presented in Table 1.

There were no significant differences in the total weight gain of the birds fed diets with different levels of mangosteen rind powder. The total weight gain of the birds ranged from 1375.15g to 1492.31g.

The findings on live weight of broilers

**Table 1. Summary of production parameters from 0-35 days of broiler chickens fed diets with different levels of MRP**

| Treatment | Production Parameters | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Initial Weight (g/bird) | Final Weight (g/bird) | Feed Intake (g/bird) | Weight Gain (g/bird) | Feed Conversion | Dressing Percentage (%) | Livability (%) | Production Number | Production Index |
| Control | 46.85 | 1489.45 | 2826.25 | 1442.60 | 1.96 | 68.71 | 100.00 | 210.82 | 51.10 |
| Commercial Antioxidant | 46.85 | 1539.16 | 2884.10 | 1492.31 | 1.94 | 69.85 | 95.00 | 211.19 | 51.76 |
| 33g of MRP | 46.90 | 1422.05 | 2827.75 | 1375.15 | 2.06 | 71.05 | 100.00 | 191.48 | 48.65 |
| 66g of MRP | 46.75 | 1511.70 | 2906.10 | 1464.90 | 1.99 | 69.46 | 100.00 | 211.90 | 50.39 |
| 100g of MRP | 46.90 | 1486.20 | 2864.10 | 1439.30 | 2.00 | 69.59 | 100.00 | 207.71 | 50.21 |
| Significance | ns | ns | ns | ns | ns | ns | ns | ns | ns |
| CV (%) | 2.99 | 6.05 | 2.65 | 6.20 | 5.78 | 1.98 | 4.52 | 13.64 | 5.80 |

*W2ns = not significant*

in this research disclosed similar results to Hidanah *et al.* (2017), wherein inclusion of mangosteen peel in broilers showed no significant difference from the control group. However, Kusmayadi *et al.* (2019) stated that ducks given with mangosteen peel had significant improvement on bodyweights compared to birds fed with only basal diet and no feed additive incorporated. The results were similar to results of Sarica *et al.* (2005) and Hernandez *et al.* (2004) where results revealed no significant differences in body weight gain of broilers when thyme powder and a blend of extracts of sage, thyme and rosemary were added to their basal diets. Demir *et al.* (2005) also disclosed that there are no differences in weight gain of broilers fed diets supplemented with antibiotic growth promoter and five herbal natural feed additives from day 0 to 42.

*Feed Conversion Efficiency of Broiler Chickens*

The summary of feed conversion efficiency of broiler chickens fed diets with varying levels of MRP in their diet is presented in Table 1. There were no significant differences in the feed conversion efficiency (FCE) of the birds fed diets with different levels of MRP. The feed conversion efficiency of the birds ranged from 1.94 to 2.06. Results were similar to Toghyani (2010) showing that FCE of birds fed diets with inclusion of plant additive thyme and increasing its levels in the diet had the same results with control diets. Moreover, Kusmayadi *et al.* (2019) fed mangosteen peel flour as feed additive in ducks disclosed the same results. Starcevic, *et al.* (2015) revealed that phenolic compounds have negative effects on body weight gain and feed conversion ratio when included in the diet of broilers. This might be the reason for the low FCE of all the diets with MRP although the results were not significantly different.

*Dressing Percentage of Broiler Chickens*

Dressing percentage of broiler chickens fed diets with varying levels of MRP in their diet is presented in Table 1. There were no significant differences in the dressing percentage of the birds fed diets with different levels of MRP. The dressing percentage of the birds ranged from 68.71% to 71.05%. These results were similar to Fuentes (2009) wherein birds fed with different herbal extracts and control group had no significant differences in terms of dressing percentage results. Moreover, results were similar to Toghyani (2010) showing that carcass yield of birds fed with inclusion of plant additive thyme and increasing its levels in the diet had the same results with control diets. Furthermore, carcass evaluation results of broilers of including mangosteen peel and ginger rhizome in their diets were not significantly different from the control birds (Hidanah *et al.*, 2017).

*Livability (%) of Broiler Chickens*

Livability of broiler chickens fed with varying levels of MRP in their diet is shown in Table 1. There were no significant differences in the livability of the birds fed diets with different levels of mangosteen rind powder. The livability of the birds ranged 95% to 100%. Results were similar to Rahimi *et al.* (2011) wherein there were no significant differences among treatments fed with different herbal extracts and control groups in terms of percent livability.

*Production Number of Broiler Chickens*

Production number of broiler chickens fed diets with varying levels of MRP in their diet is presented in Table 1. There were no significant differences in the production number of the birds fed diets with different levels of mangosteen rind powder. The production number of the birds ranged 191.48 to 211.19. The production number result of the study is within the range of results of Pourali *et al.* (2010) ranging from 156.69 to 221.32.

*Production Index of Broiler Chickens*

The summary of production index of broiler chickens fed diets with varying

levels of MRP in their diet is presented in Table 2. There were no significant differences in the production index of the birds fed diets with different levels of mangosteen rind powder. The production index of the birds ranged 48.65 to 51.76. The production index result of the study is within the range results of Pourali *et al.* (2010) ranging from 49.75 to 56.57.

*Cost and Return Analysis*

The cost and return analysis of the production performance broilers fed diets with varying levels of MRP in their diet is shown in Table 3. The result revealed that highest total cost spent per head was seen T4 (basal diet + 66g of MRP) at PhP 103.67, followed by T5 (basal diet + 100g of MRP) at 103.28, T2 (basal diet + commercial antioxidant) at PhP 102.69, T3 (basal diet + 33g of MRP) at PhP 101.53 and T1 (basal diet) at PhP 101.09. The highest ROI was obtained by the birds in T2 group at 49.89%.

## Study 2. Anatomical and Metabolic Effects of MRP on Broiler Chickens

*Blood Plasma Lipid Parameters*

The blood plasma lipid parameters of broiler chickens fed with varying levels of MRP in their diets is presented in Table 4.

**Table 2. Summary of production parameters per stage of broiler chickens fed diets with different levels of MRP**

| Treatment | Production Parameters | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Brooding (0-7 days) | | | | | Starter (8-28 days) | | | | Finisher (29-35 days) | | | |
| | Initial Weight (g) | Body Weight (g) | Weight Gain (g) | Feed Intake (g) | FCE | Body Weight (g) | Weight Gain (g) | Feed Intake (g) | FCE | Body Weight (g) | Weight Gain (g) | Feed Intake (g) | FCE |
| Control | 46.85 | 134.70 | 87.85 | 141.10 | 1.62 | 1085.25 | 950.55 | 1867.15 | 1.97 | 1489.45 | 404.20 | 818.00 | 2.03 |
| Commercial Antioxidant | 46.85 | 133.05 | 86.20 | 140.00 | 1.63 | 1109.84 | 976.79 | 1877.09 | 1.93 | 1539.16 | 429.33 | 867.01 | 2.04 |
| 33g of MRP | 46.90 | 131.20 | 84.30 | 143.00 | 1.71 | 1095.00 | 913.65 | 1842.40 | 2.02 | 1422.05 | 377.20 | 842.35 | 2.24 |
| 66g of MRP | 46.75 | 131.60 | 84.80 | 139.80 | 1.66 | 1077.50 | 945.80 | 1873.80 | 1.98 | 1511.70 | 434.20 | 892.50 | 2.11 |
| 100g of MRP | 46.90 | 131.60 | 84.70 | 140.20 | 1.66 | 1083.15 | 951.55 | 1852.75 | 1.96 | 1486.20 | 403.05 | 871.15 | 2.21 |
| Significance | ns | ns | ns | ns | ns | ns | ns | ns | ns | ns | ns | ns | ns |
| CV (%) | 2.99 | 5.63 | 8.92 | 2.85 | 8.02 | 7.01 | 5.90 | 1.94 | 5.19 | 6.05 | 13.21 | 6.20 | 14.05 |

*ns = not significant*

*Cholesterol at Day 14*

The summary of blood cholesterol at day 14 of broiler chickens fed diets with different levels of mangosteen rind powder is presented in Table 4. Cholesterol levels at day 14 ranged from 2.72 mmol/L to 3.33 mmol/L. The findings of the present study revealed no significant differences among treatment means. The same results were revealed in ducks (Kusmayadi *et al.*, 2019) wherein inclusion of mangosteen peel in their diets did not have a significant difference from the control group. However, inclusion of mangosteen peel and combination with turmeric flour obtained lower values of total cholesterol. Results were also similar to Toghyani *et al.* (2010) where no significant differences were found among treatment fed with increasing levels of thyme in the diet. Furthermore, this is in contrast to findings

**Table 3. Cost and return analysis of the production performance of broiler chickens fed diets with different levels of MRP**

| | Treatments | | | | |
|---|---|---|---|---|---|
| **Particulars (PhP)** | **Control** | **Commercial Antioxidant** | **33g of MRP** | **66g of MRP** | **100g of MRP** |
| Cost Chicks | 17.50 | 17.50 | 17.50 | 17.50 | 17.50 |
| Feeder/Waterer | 8.75 | 8.75 | 8.75 | 8.75 | 8.75 |
| Housing | 6.66 | 6.66 | 6.66 | 6.66 | 6.66 |
| Labor | 0.88 | 0.88 | 0.88 | 0.88 | 0.88 |
| Electricity | 1.60 | 1.60 | 1.60 | 1.60 | 1.60 |
| Water | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| Vaccines/Medicines | 2.52 | 2.52 | 2.52 | 2.52 | 2.52 |
| Vitamin Supplement | 3.86 | 3.86 | 3.86 | 3.86 | 3.86 |
| Feeds | 59.22 | 60.82 | 59.66 | 61.80 | 61.41 |
| Total (Cost per Head) | 101.09 | 102.69 | 101.53 | 103.67 | 103.28 |
| **Benefit ( Php/head)** | | | | | |
| Liveweight (g) | 1489.45 | 1539.16 | 1422.05 | 1511.70 | 1486.2 |
| Price (Php/head) | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| Total Benefit | 148.95 | 153.92 | 142.20 | 151.17 | 148.62 |
| Income (Php/head) | 47.86 | 51.23 | 40.67 | 47.50 | 45.34 |
| Benefit- Cost Ratio | 1.47 | 1.49 | 1.40 | 1.46 | 1.44 |
| ROI (%) | 47.34 | 49.89 | 40.06 | 45.82 | 43.90 |

of Starcevic *et al.* (2014) who disclosed that phenolic compounds have potential hypocholesterolaemic effect of in the liver.

*Triglyceride Levels at Day 14*

The summary of triglyceride levels at day 14 of broiler chickens fed with varying levels of MRP in their diet is presented in Table 4.

Triglycerides level at day 14 at T5 was significantly different from T1, T2, T3 and T4.

The reduction of triglycerides in the blood for T3 and T4 are comparable to T1 and T2. While it has been said that phenolic compounds can reduce plasma lipids (Auger *et al.*, 2002), T5 was unable to reduce triglycerides in the blood. The findings are similar to findings of Kusmayadi *et al.* (2019) wherein addition of mangosteen peel in the diet of ducks did not reduce the plasma triglycerides in blood. Another probable reason could be due to the tannins. Tannins, found in mangosteen, are known to complex with protein, inhibit lipase and lipoxygenase action and inhibit iron absorption (Naczk *et al.*, 1998; Moosophin *et al.*, 2010).

*HDL Levels at Day 14*

HDL levels at day 14 of broiler chickens fed diets with varying levels of MRP in their diet is presented in Table 4. HDL levels at day 14 ranged from 2.78 mmol/L to 3.63 mmol/L. The results revealed no significant

differences among treatment means.

The reason for determining HDL or High-Density Lipoprotein is due to its functions that may contribute to its cardiovascular protective effects, including promotion of macrophage cholesterol efflux, RCT, anti-inflammatory and anti-oxidative effects (Eren *et al.*, 2012).

The result of this study is similar to Kusmayadi *et al.* (2019) which disclosed that HDL results were not significantly different from the control when only mangosteen peel was added in the diet. The best HDL results were found with the combination of mangosteen peel and turmeric in the diet of the ducks. It is also interesting to note from the study, although not statistically significant the HDL levels of T4 and T5 are lower compared to T2 which was given commercial antioxidant. Moreover, the present study also had similar findings to Abuzaid *et al.* (2017) wherein rats were given with mangosteen pericarp extract had similar HDL results with that of the control. They also disclosed that mangosteen pericarp extract was unable to increase the HDL levels in the experimental rats.

*LDL Levels at Day 14*

The LDL levels at day 14 ranged from 1.28 mmol/L to 1.68 mmol/L. The results revealed no significant differences among treatment means. The results of the present study are similar to the findings of Abuzaid *et al.* (2017) wherein addition of mangosteen pericarp extract was not significantly different to the control group in week 4 in Wistar rats. Furthermore, LDL results of the present study is similar to the findings of Kusmayadi *et al.* (2019) in ducks wherein addition of mangosteen peel in the diet had no significant difference to that of the control. However, result of the research is in contrast from the findings of Rahimi *et al.* (2011) which revealed that LDL levels significantly reduced by the different herbal extracts. Although not statistically significant the levels of those with MRP group had significantly lower LDL compared to the control and those fed with commercial antioxidant.

*Cholesterol Levels at Day 28*

Cholesterol levels at day 28 of broiler chickens fed diets with varying levels of MRP in their diet is presented in Table 4.

Cholesterol levels at day 28 revealed highly significant differences among treatment means. The lowest cholesterol level was found in the control group which was significantly lower from MRP fed groups T3 and T5. However, T2 was not significantly different from the control. The possible reason for this may be due to the metabolic down-regulation of LDL-receptor synthesis could be a common cause of moderate hypercholesterolemia (Grundy & Vega, 1990). They further elaborated that by reducing the synthesis of LDL receptors, such an abnormality should delay the clearance of LDL from plasma. In addition, Hummel *et al.* (2003) stated that low levels of expression and sluggish sterol-mediated regulation have been likely reasons for the failure to molecularly characterize a bona fide LDL receptor (LDLR) in egg-laying species (such as chickens).

*Triglyceride Levels at Day 28*

The triglyceride levels at day 28 of broiler chickens fed with varying levels of MRP in their diet is presented in Table 4.

The triglyceride levels showed significant differences among different treatments. T4 was significantly lower to T1 and T3 but not significantly different from T2 and T5. T4 have shown to reduce the triglyceride levels in the blood. Mangosteen peel is proven to have phenolic compounds present (Table 6). This agrees to the statements that phenolic compounds are said to reduce plasma lipids (Auger *et al.*, 2002).

Moreover, Adriania *et al.* (2018) disclosed that triglycerides in Sentul chickens were decreased when the birds were given

with mangosteen peel extract. In addition, Taher *et al.* (2016) stated that mangosteen ethanolic extract reduced the triglyceride levels of STZ (streptozotocin) rats.

*HDL Levels at Day 28*

HDL levels at day 28 of broiler chickens fed with varying levels of MRP in their diet is presented in Table 4. The HDL levels at day 28 disclosed significant differences among treatment means. The levels of HDL for T3, T4 and T5 were significantly higher than the control group. However, T2 was not significantly different from the MRP treated diets. The results were similar to the findings of Boontiam & Kumari (2019) wherein quails given with mangosteen pericarp crude extract increased their levels of HDL. Furthermore, the present study also agrees with the findings of Adiputro *et al.* (2013) wherein rats given with mangosteen pericarp ethanolic extract increased their HDL levels.

*LDL Levels at Day 28*

The LDL levels at day 28 of broiler chickens fed with varying levels of MRP in their diet is presented in Table 4. LDL levels have highly significant differences among treatment means. The LDL values of T1, T4 and T5 are not significantly different from each other. T1 and T4 are significantly different from T2 and T3.

Findings of this study is in contrast to Kusmayadi *et al.* (2017) wherein mangosteen peel in the diets of the ducks was not significantly different from the control. However, addition of turmeric flour and mangosteen peel decreased the levels of LDL. Furthermore, similar findings were also illustrated by Boontiam and Kumari (2019) wherein LDL results of quails given with mangosteen pericarp crude extract were not significantly different from the control.

In all the blood plasma lipid parameters for this study, whether significant or not, clearly shows that positive results would be abruptly reduced once it has reached the 100g of MRP. All the results for the 66g of MRP are significantly higher or numerically higher than that of the 100g of MRP and of equal or better significance to the control and the antioxidant group.

The concentration of the phenolic compounds could be the contributory factor as stated in the above results. Better results have been shown by the 66g of MRP group than those with the 33g of MRP and 100g of MRP groups.

*Weight of Internal Organs Relative to Body Weight (BW)*

Weight of internal organs at day 28 of broiler chickens fed diets with varying levels of MRP in their diet is presented in Table 5.

*Internal Organs at 14 Days*

Heart, liver and gizzard weight on day 14 fed with varying levels of MRP is presented in Table 5. Results showed no significant differences among treatment means. Values ranged from 0.75-0.88g (heart), 2.69-3.29g (liver) and 3.73-4.61g (gizzard).

*Internal Organs at 28 Days*

Heart, liver and gizzard weight on day 28 fed with varying levels of MRP is presented in Table 5. Results showed no significant differences among treatment means. Values ranged from 0.44-0.52g (heart), 2.12-2.82g (liver) and 2.30-2.65g (gizzard).

It is interesting to note although not significantly different, the results for the heart, liver and gizzard weights of birds fed with MRP at 33g, 66g and 100g were numerically higher compared to control at day 14 and becomes numerically smaller compared to control group at day 28

**Table 4. Summary of blood plasma lipid parameters of broiler chickens fed diets with different levels of MRP**

| Treatment | Day 14 | | | | Day 28 | | | |
|---|---|---|---|---|---|---|---|---|
| | Blood Plasma Lipid Parameters 1/ | | | | | | | |
| | Cholesterol | Triglycerides | HDL | LDL | Cholesterol | Triglycerides | HDL | LDL |
| Control | 3.23 | 0.18a | 2.98 | 1.68 | 1.84a | 0.29b | 1.98b | 0.63a |
| Commercial Antioxidant | 3.16 | 0.13a | 3.11 | 1.59 | 2.50ab | 0.20ab | 2.50ab | 2.50b |
| 33g of MRP | 3.33 | 0.17a | 3.63 | 1.49 | 3.16b | 0.29b | 2.91a | 2.15b |
| 66g of MRP | 2.72 | 0.16a | 2.78 | 1.28 | 2.65ab | 0.16a | 2.78a | 1.21a |
| 100g of MRP | 3.09 | 0.24b | 3.05 | 1.45 | 2.84b | 0.20ab | 2.60a | 1.44ab |
| Significance | ns | * | ns | ns | ** | ** | * | ** |
| CV (%) | 10.40 | 20.58 | 14.47 | 13.83 | 13.90 | 22.72 | 15.55 | 32.01 |

*1/ Means with different letter superscripts differ significantly by DMRT*
*ns = not significant*
*HDL = High Density Lipoprotein*
*LDL = Low Density Lipoprotein*

except for the gizzard weight (Table 5). Weights of different organs of birds are commonly evaluated to be used as models in predicting performance and nutritional requirements (Plavnik & Hurwitz, 1982). Organs such as the liver are noted to be predisposing factors for sudden death syndrome (Bowes & Julian, 1988) and heavier value of liver maybe caused by tannins in the feed which might cause inflammation and friable liver (Ibitoye *et al.*, 2012) in broilers. While higher gizzard weight in Hubbard Flex broilers is an indicative of better muscle development (Kokoszyński *et al.*, 2017). Furthermore, anatomical parameters of heart and lungs are known to be involved in the process of ascites incidence (Hassanzadeh *et al.*, 2005).

*Abdominal Fat Weight at 28 Days*

Abdominal fat weight at day 28 of broiler chickens fed with varying levels of MRP is presented in Table 5. The results ranged from 0.59 to 0.91. The findings of this study on abdominal fat are similar to the results of Kusmayadi *et al.* (2019) wherein the ducks given with mangosteen peel was not significantly different from the control. However, combining the mangosteen peel with turmeric flour showed reduced weight of abdominal fat in ducks. Furthermore, although not statistically significant abdominal fat weight values are lower in the MRP diets compared to the control and the commercial antioxidant diet. Moreover, Adnyana *et al.* (2016) disclosed that mangosteen pericarp extract have phytochemical bioactive content that contains anti-obesity potential through pancreatic lipase and α-amylase inhibitory activity.

## CONCLUSION

The results of feeding diets with different levels of mangosteen rind powder on the growth performance of broiler chickens have the similar results to those given with commercial antioxidant.

Moreover, the results of the study have shown that the 66g and 100g MRP are capable of decreasing the amounts of triglycerides, increasing the amounts of HDL and reducing the levels of LDL.

The similar weights of the liver, heart and gizzard of the control, the commercial antioxidant and the different treatments of MRP in the diet of broiler chickens shows that the similar anatomical and metabolic results have no harmful effects, safe and not toxic, therefore can be used as a natural feed additive to broiler chickens.

## RECOMMENDATIONS

It is recommended that further research be done for the MRP for swine and ruminants. Digestibility trials should be done for other species determine if MRP affects absorption of nutrients. Microbiological tests should also be conducted to evaluate the antimicrobial capacity of MRP and enhance beneficial microorganisms. Other potential plant or fruit sources can be investigated to evaluate their medicinal, immune

**Table 5. Summary of weight of internal organs and abdominal fat relative to body weight of broiler chickens fed diets with different levels of MRP**

| Treatment | Day 14 | | | Day 28 | | | |
|---|---|---|---|---|---|---|---|
| MRP per kg of feed | Blood Plasma Lipid Parameters 1/ | | | | | | |
| | Heart | Liver | Gizzard | Heart | Liver | Gizzard | Abdominal Fat |
| Control | 0.75 | 2.69 | 3.73 | 0.52 | 2.82 | 2.53 | 0.91 |
| Commercial Antioxidant | 0.88 | 3.12 | 4.61 | 0.52 | 2.36 | 2.30 | 0.76 |
| 33g of MRP | 0.79 | 3.29 | 4.39 | 0.50 | 2.48 | 2.30 | 0.59 |
| 66g of MRP | 0.79 | 2.96 | 4.08 | 0.44 | 2.12 | 2.49 | 0.65 |
| 100g of MRP | 0.75 | 2.78 | 4.09 | 0.48 | 2.35 | 2.65 | 0.63 |
| Significance | ns | ns | ns | ns | ns | ns | ns |
| CV (%) | 19.93 | 9.42 | 14.37 | 15.33 | 9.42 | 16.96 | 24.23 |

*ns = not significant*

**Table 6. Concentration of phenolic compounds of MRP**

| MRP (g) | Concentration (moles/liter) |
|---|---|
| 33 | 1.58 |
| 66 | 3.51 |
| 100 | 2.65 |

enhancing properties and health benefits.

The Department of Agriculture – Bureau of Animal Industry could consider the results of this study to determine the amount or level of MRP that could be used for broiler chicken production. Moreover, the Department of Health - Bureau Food and Drug Administration could also cite this result and develop low cost phytonutrient, phytochemical, nutraceutical or alternative medicine.

## LITERATURE CITED


Abuzaid, A. S., Sukandar, E. Y., Kurniati, N. F. & Adnyana, I. K. (2017). Antihyperlidemic effects of mangosteen (*Garcinia mangostana* L.) pericarp ethanolic extract in high-carbohydrate wistar rats. *Journal of Natural Remedies*, *17*(4), 166-173.

Adiputro, D. L., Widodo, M. A., Romdoni, R. & Sargowo, D. (2013). Extract of mangosteen increases high density lipoprotein levels in rats fed high lipid. *Univ Med*, *32*(1), 37-43.

Adriania, L., Widjastutia, T., Nurdiantib, R.R. & Wiradimadjaa, R. (2018). Effects of mangosteen peel extract (*Garcinia mangostana* L.) on blood lipid of Sentul chicken growth phase. Proceeding of the 3rd International Conference of Integrated Intellectual Community, 1-5.

Al-Sultan, S.I. (2003). The effect of *Cucurma longa* (Turmeric) on over-all performance of broiler chickens. *International Journal of Poultry Science*, *2*(5), 351-353.

Adnyana, K., Abuzaid, A. S., Iskandar, E. Y. & Kurniati, N. F. (2016). Pancreatic lipase and α-amylase inhibitory potential of mangosteen (*Garcinia mangostana* Linn.) pericarp extract. *Int J Med Res Health Sci*, (1), 23-28.

Auger, C., Caporiccio, B., Landrault, N., Teissedre, P. L., Laurent, C., Cros, G. & Rouanet, J. M. (2002). Red wine phenolic compounds reduce plasma lipids and apolipoprotein B and prevent early aortic atherosclerosis in hypercholesterolemic golden Syrian hamsters (*Mesocricetus auratus*). *J Nutr*, *132*(6), 1207-13.

Boontiam, W. & Kumari, P. (2019). Effect of mangosteen (*Garcinia mangostana*) pericarp extract in reducing the heat stress of laying quails. *Advances in Animal and Veterinary Sciences*, *7*(6), 452-460.

Bowes, V. A. & Julian, R. J. (1988). Organ weights of normal broiler chickens and those dying of sudden death syndrome. *Can Vet J*, *29*, 153-156.

Briviba, K. & Sies, H. (1994). Nonenzymatic antioxidant defense systems, Chapter 4, pp. 107-128. In: Natural antioxidants in human health and disease. ed. Frei, B. Academic Press: San Diego.

Demir, E., Sarica, S., Özcan, M. A., & Suiçmez, M. (2005). The use of natural feed additives as alternative to an antibiotic growth promoter in broiler diets. Arch. Fur Geflugelkunde, *69* (3), 110-116.

Denli, M., Okan, F. & Uluocak, A. N. (2004). Effect of dietary supplementation of herb essential oils on the growth performance, carcass and intestinal characteristics of quail. South Africa. *J Anim Sci*, *34*(3), 174-179.

Eren, E., Yilmaz, N. & Aydin, O. (2012). High density lipoprotein and its

dysfunction. *The Open Biochemistry Journal*, *6*, 78-93.

Euribrid, B. V. (1994). Technical information for hybro broilers, p. 22. Boxmeer, The Netherlands, Euribrid Poultry Breeding Farm.

Foiklang, S., Wanapat, M. & Norrapoke, T. (2016). Effect of grape pomace powder, mangosteen peel powder and monensin on nutrient digestibility, rumen fermentation, nitrogen balance and microbial protein synthesis in dairy steers. Asian Australas. *J. Anim. Sci*, *29*(10), 1416-1423.

Fuentes, A. E. (2009). Herbal plants as potential feed additive in broiler diets. Graduate School, University of Southern Mindanao, Kabacan, Cotabato. Ph.D. Dissertation, 177.

Grundy, S. M. & Vega, G. L. (1990). Causes of high blood cholesterol. *Circulation*, *81*(2), 412-427.

Gupta, C. & Prakash, D. (2014). Phytonutrients as therapeutic agents. *J Complement Integr Med*, *11*(3), 151–169.

Hassanzadeh, M., Gilanpour, H., Charkhkar, H., Buyse, J. & Decuypere, E. (2005). Anatomical parameters of cardiopulmonary system in three different lines of chickens: further evidence for involvement in ascites syndrome. *Avian Pathology*, *34*(3), 188-193.

Hernandez, F., Madrid, J., Garcıa, V., Orengo, J. & Megias, M. D. (2004). Influence of two plant extracts on broilers performance, digestibility, and digestive organ size. *Poult Sci*, *83*, 169-174.

Hidanah, S., Hadi Warsito, S., Nurhajati, T., Lokapirnasari, W. P. & Malik, A. (2017). Effects of mangosteen peel (*Garcinia mangostana*) and Ginger Rhizome (*Curcuma xanthorrhiza*) on the performance and cholesterol levels of heat-stressed broiler chickens. *Pak. J Nutr*, *16*(1), 28-32.

Hummel, S., Lynn, E. G., Osanger, A., Hirayama, S., Nimpf, J. & Schneider, W. J. (2003). Molecular characterization of the first avian LDL receptor: role in sterol metabolism of ovarian follicular cells. *Journal of Lipid Research*, *44*, 1633-1642.

Ibitoye E. B., Olorede B. R., Jimoh A. A. & Abubakar, H. (2012). Comparative performance and organ relative weight of broiler chickens fed three sources of energy diet. *J Anim Prod Adv*, *2*(5), 233-238.

Iji, P. A., Saki, A. & Tivey, D. R. (2001). Body and intestinal growth of broiler chicks on a commercial starter diet. 1. Intestinal weight and mucosal development. *British Poultry Science*, *42*, 505-513.

Jacob, R. A. (1995). The integrated antioxidant system. *Nutr Res*, *15* (5), 755-766.

Kokoszyński, D. I., Bernacki, Z. I., Saleh, M., Stęczny, K. & Binkowska, M. (2017). Body conformation and internal organs characteristics of different commercial broiler lines. *Brazilian Journal of Poultry Science*, *19*(1), 47-52.

Kusmayadi, A., Bachtiar, K. R. & Prayitno, C. H. (2019). The effects of mangosteen peel (*Garcinia mangostana* L.) and Turmeric (*Curcuma domestica* Val) flour dietary supplementation on the growth performance, lipid profile, and abdominal fat content in Cihateup ducks. *Veterinary World*, *12*(3), 402-408.

Lumeij, J.T. (1987). Avian clinical pathology. General considerations. Veterinary Quarterly, *9*(3), 249-254.

Moosophin, K., Wetthaisong, T., Seeratchakot, L., & Kokluecha, W. (2010). Tannin extraction from mangosteen peel for protein precipitation in wine. *KKU Res J*, *15*(5).

Naczk, M., Amarowicz, R., Sullivan, A. & Shahidi, F. (1998). Current research developments on polyphenolics of rapeseed/canola: A review. *Food Chem*, *4*, 489-502.

Pedraza-Chaverri, J., Cárdenas-Rodríguez, N., Orozco-Ibarra, M. & Pérez-Rojas, J. M. (2008). Medicinal properties of mangosteen (*Garcinia mangostana*). *Food Chem*. Toxicol, *46*, 3227- 3239.

Percival, M. (1996). Antioxidants. *Nut. Rev. Clinical Nutrition Insights*.

Philippine Society of Animal Nutritionist Handbook (2003). Feed Reference Standards (3rd Ed), 441.

Plavnik, I. & Hurwitz, S. (1982). Organ weights and body composition in chickens as related to the energy and amino acid requirements: Effects of strain, sex, and age poultry science, *62*, 152-163.

Pourali, M., Mirghelenj, K. & Kermanshahi, H. (2010). Effects of garlic powder on productive performance and immune response of broiler chickens challenged with Newcastle disease virus. *Global Veterinaria*, *4*(6), 616-621.

Qazi, M.A. & Molvi, K.I. (2018). Free radicals and their management. *Am. J. Pharm Health Res*, *6*(4), 2-10.

Rahimi, S., Teymouri, Z., Zadeh, M. A., Torshizi, K., Omidbaigi, R. & Rokni, H. (2011). Effect of the three herbal extracts on growth performance, immune system, blood factors and intestinal selected bacterial population in broiler chickens. *J. Agr Sci Tech*, *13*, 527-539.

Sarica, S., Ciftci, A., Demir, E., Kilinc, K., & Yildirim, Y. (2005). Use of an antibiotic growth promoter and two herbal natural feed additives with and without exogenous enzymes in wheat-based broiler diets. South Africa. *J Anim Sci*, *35*(1), 61-72.

Saxena, M., Saxena, J., Nema, R., Singh, D. & Gupta, A. (2013). Phytochemistry of medicinal plants. *Journal of Pharmacognosy and Phytochemistry*, *1*(6), 168-182.

Schleicher, A., Z. Fritz & Kinal, S. (1998). Zastosowanie wybranych ziół w mieszankach tre ciwych dla kurcz_t rze_nych (The use of some herbs in concentrates for broiler chickens). *Rocz Nauk Zootech*, *25*, 213-244.

Singh, C. V., R. V. Singh & Singh, Y. P. (1987). Effect of some non-genetic factors on economic traits in Nili-Ravi buffaloes. Ind. *J Anim Sci*, *57*(8), 152.

Starcevic, K., Krstulovic, L., Brozic, D., Mauric, M., Stojevic, Z., Mikulec, Z., Bajic, M. & T. Mašekc, T. (2015). Production performance, meat composition and oxidative susceptibility in broiler chicken fed with different phenolic compounds. *J Sci Food Agric*, *95*, 1172–1178.

Suchitra, K. & Wanapat, M. (2008). Effects of mangosteen (*Garcinia mangostana*) peel and sunflower and coconut oil supplementation on rumen fermentation, milk yield and milk composition in lactating dairy

cows. *Livestock Research and Rural Development*, 1-5.

Taher, M., Syafiq, M. F., Zakaria, T., Susanti, D. & Zakaria Z. A. (2016). *BMC Complementary and Alternative Medicine*, *16*, 135.

Tamma, P. D., Avdic, E., Li, D. X., Dzintars, K. & Cosgrove, S. (2017). Association of adverse Events with antibiotic use in hospitalized patients. *JAMA Internal Medicine*, *177*(9), 1308-1315.

Toghyani, M., Tohidi, M., Ali Gheisari, A. & Ali Tabeidian, K. (2010). Performance, immunity, serum biochemical and hematological parameters in broiler chicks fed dietary thyme as alternative for an antibiotic growth promoter. *African Journal of Biotechnology*, *9*(40), 6819-6825.

Wattenberg, L. W. (1985). Chemoprevention of cancer. *Cancer Res*, *45*, 1-8.

Zarena, A. S. & Sankar, K.U. (2009). Screening of xanthone from mangosteen (*Garcinia mangostana* L.) peels and their effect on cytochrome c reductase and phosphomolybdenum activity. *J Nat Prod*, *2*, 23-30.