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

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Abstract – *The general objective of the study is to determine the immune response of feeding diets with different levels of mangosteen rind powder to broiler chickens. Specifically, it aimed (1) to determine the immune responses of broiler chickens on the total white blood cell count, heterophil count and lymphocyte count, including the presence of basophils, eosinophils and monocytes and (2) to determine the immune effects of the different levels of mangosteen rind powder on the bursa of Fabricius and spleen through histological examination. The study was conducted in a Completely Randomzed Design. A total of eighty (80) day old chicks were randomly distributed into five (5) different treatments. The five (5) treatments used include the control wherein no mangosteen rind powder or no commercial antioxidant is incorporated in the diet, commercial antioxidant incorporated in the diet, 33 g of mangosteen rind powder/ kg of feed, 66 g of mangosteen rind powder/ kg of feed and 100 g of mangosteen rind powder/ kg of feed. For study 1 and 2, formulated diets of corn-soya based was used incorporated with different levels of mangosteen rind powder were used. The inclusion of 66 g and 100 g of mangosteen rind powder per kg of feed in the diet of broiler chickens increased the total white blood cell count, heterophil count, lymphocyte concentration in the bursa of Fabricius and the spleen lymphatic node formation. Results show that mangosteen rind powder at 66 g/kg of feed and 100 g/ kg of feed enhances the immune system of broiler chickens.*

Keywords – Mangosteen rind powder, Broiler Chickens, Immune Response

INTRODUCTION

The poultry industry in the Philippines is one of the progressive animal industry sector with its continues improvement in nutrition, breeding and management. The acceptance of chicken is widely known throughout the world. The onset of development in the poultry industry has helped in the development of three general type of chicken enterprises which are the broiler production, egg production and raising replacement pullets [1].

The broiler chickens are fast growing and have meaty conformation. Broiler chicken strains produced in the Philippines generally have white feathers and yellow shanks. The comb, wattle and earlobes are red. Broilers are highly efficient converters of feedstuff to high quality animal protein [2]. The broiler chickens are marketable nowadays in a period of 30 days or less.

The meat of chicken is becoming popular because of the notation that white meat is healthier compared to red meat. However, the raising of broilers and other livestock became a concern these days because of the misuse of feed additives particularly of antibiotics. Since the wrong utilization of antibiotics arises to antibiotic resistance.

Antibiotics are used for improvement of growth rate, feed conversion efficiency and to minimize the incidence of diseases in livestock and poultry. The use of antibiotics in feeds at sub-therapeutic levels may give rise to populations of bacteria which are resistant to penicillin, the tetracycline and other antibiotics, the resistance might interfere with subsequent treatment of sick livestock and this resistance might be transferred to bacteria in humans leading to the possibility of untreatable diseases in humans [3].

The threat of antibiotic resistance has prompted countries to produce animals with minimal use of synthetic antibiotics. This has given rise increased awareness and promotion of organic and natural production of livestock and poultry. The different organizations both private and public have been initiating ways to mediate and take action on the threat of antibiotic resistance.

The improvement of immune response in veterinary and animal science could be done by the enhancement of resistance to infection and the treatment of immunosuppressive conditions [4]. The lymphatic system of chickens does not contain lymph nodes. The bird's immune system mainly consists of lymphatic vessels and lymphoid tissue. Primary tissues are the thymus, located in the neck along the jugular vein, and the bursa of Fabricius, located adjacent to the cloaca. Secondary lymphatic organs and tissues would be the spleen, cecal tonsils, Meckel's diverticulum, bone marrow, Harderian gland and diffuse lymphoid tissue [5].

The search for finding new feed additives and solutions to minimize and eliminate antibiotic resistance is the utilization of growth and health promoters of natural origin has become an interest in recent years [6]. Plant based sources or herbal supplements are promising alternatives. 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 and may also be beneficial are the multitude of non-nutrient compounds called phytochemicals that are present in plant foods [7].

One of the fruits noted for its phytochemical is mangosteen. Mangosteen (*Garcinia mangostana* Linn.) is a tropical fruit available in Southeast Asia [8]. In addition, it is cultivated in the tropical rainforest of some Southeast Asian nations like Indonesia, Malaysia, Sri Lanka, Philippines and Thailand [9]. Most of the antioxidants in mangosteen can be found in the rind or pericarp. Few antioxidants are contained in the whole fruit, trunk, leaves and branches. The pericarp of mangosteen is a source of xanthones and other bioactive substances.

Xanthones have been the subject of alternative medicine and health. It was also determined that the physiological availability of xanthones and vitamins found in a xanthone-rich product and their effects on the degree of antioxidant potency in the human body [10]. Extracts of root bark, stem bark and the latex collected from the green fruits of mangosteen gave alpha-mangostin, beta-mangostin, gamma-mangostin, garcinone-E, methoxy-beta-mangostin and a new geranylated biphenyl derivative 3-hydroxy-4- geranyl-5-methoxybiphenyl which are highly bioactive compounds in large quantities should be the causative factor for mangosteen's medicinal value in indigenous medicine [11].

Experimental studies have demonstrated that extracts of mangosteen have antioxidant, antitumoral, antiallergic, anti-inflammatory, antibacterial, and antiviral activities. This illustrates that mangosteen has disease preventing characteristics [12].

Folklore uses its pericarp to treat abdominal pain and diarrhea and used as an external astringent, decoction of roots used for dysmenorrheal, genitourinary ailments, febrifuge and thrush, bark and young seeds used to treat dysentery and gastrointestinal problems and as a wash for stomatitis [13].

A number of researches have been done to see the effectiveness of mangosteen for disease prevention and treatment and immune enhancement properties. Establishing the level of mangosteen rind powder that will promote productivity and health benefits to broilers will greatly allow farmers to have access to natural antioxidants and immunostimulants. In connection, this will allow animal raisers to minimize the use of antibiotics and lessen the incidence of antibiotic resistance which have side effects to humans. Moreover, it also provides alternative medicinal and health benefits in the country and eventually throughout the region greatly reducing needs for imported and costly animal drugs.

Mangosteen rind powder has immune enhancing properties and disease preventing properties which is easy to prepare and is of natural origin, residue free and has no effect on human and animals. The mangosteen rind powder is rich in antioxidants which is needed by animals for better growth and development and for the prevention of diseases and ultimately for better production. Mangosteen is found and is available in the country particularly in Mindanao.

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

OBJECTIVES OF THE STUDY

The general objective of the study is to determine the immune responses of feeding diets with different levels of mangosteen rind powder to broiler chickens. Specifically, it aimed (1) to determine the immune responses of broiler chickens on the total white blood

cell count, heterophil count and lymphocyte count, including the presence of basophils, eosinophils and monocytes and (2) to determine the immune effects of the different levels of mangosteen rind powder on the Bursa of fabricius and spleen through histological examination.

MATERIALS AND METHODS

The study was conducted in a Completely Randomized Design. Eighty day-old chicks were randomly distributed into the different treatments with four replications at four birds per replication.

The treatments were absence of mangosteen rind powder or commercial antioxidant in the diet, commercial antioxidant incorporated in the diet, 33 g of mangosteen rind powder/ kg of feed, 67 g of mangosteen rind powder/ kg of feed, 100 g of mangosteen rind powder/ kg of feed.

Day-old chicks were randomly assigned to the dietary treatment groups following the computed ration formulation and stated amounts of mangosteen rind powder levels. Vaccination of the birds against Newcastle Disease (NCD) was done. Moreover, Infectious Bursal Disease (IBD) vaccine was given on the 6^{th} and 12^{th} day.

For study 1, blood of the birds fed with the different levels of mangosteen rind were collected at day 7 and day 14. Four birds per treatment were randomly selected at the day of data collection. The blood samples were collected through the jugular vein. The blood of the birds were evaluated. The total white blood cells including the heterophils and lymphocytes were counted through the differential counting method of Campbell [14]. The data on the white blood cells were recorded and statistically analyzed using the Analysis of Variance (ANOVA) techniques of Completely Randomized Design. The treatments were subjected to Duncan's Multiple Range Test if there were any significant differences.

The basophils, eosinophils and monocytes were detected if present or not in the blood samples through subjective scoring with a (+) if present and (-) sign if absent. It was assured that the standard procedures were followed at the course and whole duration of the experiment.

In this study 2, the organs related to immune system, specifically, the bursa of Fabricius and spleen were collected at day 7 and day 14. Four birds per treatment were randomly selected at the day of data collection.

The bursa of Fabricius and spleen were collected and fixed in 10% phosphate buffered saline solution. The tissues were routinely processed, paraffin embedded and cut (4um thick). Tissue sections were stained with Hematoxylin and Eosin (H&E) and mounted with Eukitt. A subjective scoring system was used for microscopic evaluation of the organs. For the bursa of Fabricius, tissue sections were examined based on lymphocyte concentration in the cortex and medulla region of follicles. The spleen was evaluated on the basis of lymphatic nodule formation in white pulp. In both organs, scores (+) few; (++) moderate; (+++) many were arbitrarily assigned. Laboratory results were recorded for analysis and interpretation.

Preparation of Mangosteen Rind Powder

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 preparation was similar to the methods by Zarena and Sankar [15].

Preparation of Diets with Different Levels of Mangosteen Rind Powder

Diets were prepared according to the level of mangosteen rind powder stated in the treatments. The experimental diets were formulated using a corn-soy based basal diet. The level of mangosteen rind powder used 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 PHILSAN [16].

RESULTS AND DISCUSSION

Total White Blood Cells at Day 7

Total white blood cells at day 7 of broiler chickens fed with different levels of mangosteen rind powder is shown in Table 1-1. Result of total white blood cells revealed significant differences among treatment means. The total white blood cell levels of 66 g of mangsoteen rind powder and 100 g of mangosteen rind powder were significantly higher compared to control and those with commercial antioxidant group. However, 33 g of mangsoteen rind powder was not significantly different from the 66 g of mangsoteen rind powder and 100 g mangosteen rind powder and control and commercial antioxidant group.

Table 1-1 White blood cell count at day 7 of broiler chickens fed diets with different levels of mangosteen rind powder.

Treatment Level of Mangosteen Rind Powder (MRP)	**DAY 7 White Blood Cell Counts[1/]**		
	Total WBC (no.of cells/µL)	**Heterophils ($x10^9$/L)**	**Lymphocytes ($x10^9$/L)**
Control	4900.00 [a]	40.75	55.75
Commercial Antioxidant	5302.50[a]	41.00	54.75
33g of MRP	5775.00[ab]	42.00	55.75
66g of MRP	6475.00[b]	43.25	54.75
100g of MRP	6275.00[b]	44.00	53.50
Significance	**	ns	ns
CV (%)	8.98	4.64	3.52

1/ Means with different letter superscripts differ significantly using Duncan's Multiple Range Test
ns = not significant

Results of this study were similar to Tollba [17] wherein increased plant extracts in diets of chickens revealed significantly increased levels total white blood cells. The results show that mangosteen has disease preventing characteristics.

Heterophils at Day 7

Heterophils at day 7 of broiler chickens fed with different levels of mangosteen rind powder revealed no significant differences among treatment means. The heterophils ranged from 40.75 to 44.00 ($x10^9$/L). It is interesting to note although not statistically different that the mangosteen rind powder groups had numerically higher counts of heterophils compared to their control group and commercial antioxidant counterparts as seen in Table 1-1.

Lymphocytes at Day 7

Lymphocytes at day 7 of broiler chickens fed with different levels of mangosteen rind powder is shown in Table 1-1. Results of lymphocytes revealed no significant differences among treatment means. The lymphocytes ranged from ranged from 53.50 to 55.75 ($x10^9$/L). Results were similar to Toghyani [18] wherein addition of plant extract did not increase the white blood cell count.

Total White Blood Cells at Day 14

At day 14, the total white blood cell count of broiler chickens fed with different levels of mangosteen rind powder is shown in Table 1-2. Result of total white blood cells at day 14 revealed highly significant differences among treatment means. The results showed that total white blood cells of of 66 g of mangosteen rind powder and 100 g of mangosteen rind powder were significantly higher compared to control and the commercial antioxidant group. However, 33 g of mangosteen rind powder was not significantly different from the treatments in the study.

Table 1-2. White blood cell counts at day 14 of broiler chickens fed diets with different levels of mangosteen rind powder.

TREATMENT Level of Mangosteen Rind Powder (MRP)	**DAY 14 WHITE BLOOD CELL COUNTS[1/]**		
	Total WBC (no.of cells/µL)	Heterophils ($x10^9$/L)	Lymphocytes ($x10^9$/L)
Control	5000.00[a]	39.00[a]	59.25
Commercial Antioxidant	5675.50[a]	39.25[a]	59.00
33g of MRP	6150.00[ab]	39.00[a]	59.25
66g of MRP	6825.00[b]	43.25[b]	56.50
100g of MRP	6600.00[b]	43.75[b]	54.50
Significance	**	*	ns
CV (%)	8.21	6.27	4.51

1/ Means with different letter superscripts differ significantly using Duncan's Multiple Range Test
ns = not significant

Table 1-3. Presence of basophil at day 7 and day 14 of broiler chickens fed diets with different levels of mangosteen rind powder.

TREATMENT Level of Mangosteen Rind Powder (MRP)	**BASOPHIL**							
	DAY 7				**DAY 14**			
	I	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**
Control	-	-	+	-	+	-	-	-
Commercial Antioxidant	-	-	+	+	-	+	-	-
33g of MRP	-	-	-	-	-	-	-	-
66g of MRP	+	-	-	-	+	-	-	-
100g of MRP	-	+	-	-	+	-	-	-

Legend: - means basophil was not found upon examination
+ means basophil was seen and present upon examination

Heterophils at Day 14

The heterophils at day 14 of broiler chickens fed with different levels of mangosteen rind powder is shown in Table 1-2. The heterophil results revealed significant differences among treatment means. The levels of heterophils were significantly higher in 66 g of MRP and 100 g of MRP compared to the control, commercial antioxidant and 33 g MRP groups. The results at day 14 are different from the day 7 results. Results show that increased mangosteen rind powder at 66 g and 100 g also increased the heterophil count.

Lymphocytes at Day 14

Lymphocytes count at day 14 of broiler chickens fed with different levels of mangosteen rind powder is shown in Table 1-2. Results of lymphocyte count revealed no significant differences among treatment means. The lymphocytes ranged from ranged from 54.50 to 59.25 ($x10^9$/L). Lymphocyte count results for day 14 is similar to the lymphocyte count results at day 7.

Basophils at Day 7 and Day 14

Presence of basophils at day 7 and day 14 of broiler chickens fed with different levels of mangosteen rind powder are shown in Table 1-3. For day 7, the commercial antioxidant results showed that 2 out of 4 blood samples had presence of basophils. The 66 g of MRP, 100 g of MRP and control had 1 out of 4 samples with presence of basophils. Results showed that only the 33 g of MRP did not have any count of basophils.

At day 14, presence of basophils of broiler chickens fed with different levels of mangosteen rind powder is shown in Table 1-3. The commercial antioxidant, 66 g of MRP and 100 g of MRP and control had 1 out of 4 samples with presence of basophils. Furthermore, only the 33 g of MRP did not have any count of basophils.

Table 1-4. Presence of eosinophil at day 7 and day 14 of broiler chickens fed diets with different levels of mangosteen rind powder.

TREATMENT Level of Mangosteen Rind Powder (MRP)	**EOSINOPHIL**							
	DAY 7				**DAY 14**			
	I	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**
Control	+	+	+	+	+	+	+	+
Commercial Antioxidant	+	+	+	+	+	+	+	+
33g of MRP	+	+	+	+	+	+	+	+
66g of MRP	+	+	+	-	+	+	+	-
100g of MRP	+	+	+	+	+	+	+	+

Legend: - means eosinophil was not found upon examination
+ means eosinophil was seen and present upon examination

Eosinophils at Day 7 and 14

Results of eosinophil presence at day 7 and 14 of broiler chickens fed with different levels of mangosteen rind powder are shown in Table 1-4. The commercial antioxidant results showed that the control, commercial antioxidant, 33 g of MRP and 100 g of MRP had 4 out of 4 samples with presence of eosinophils. Results showed that only the 66 g of MRP have 3 out 4 samples with eosinophils.

For day 14, presence of eosinophils of broiler chickens fed with different levels of mangosteen rind powder is shows that the control, commercial antioxidant, 33g of MRP and 100 g of MRP had 4 out of 4 samples with presence of eosinophils. Furthermore, only the 66 g of MRP have a 3 out of 4 samples with presence of eosinophil.

Monocytes at Day 7 and Day 14

The presence of monocytes at day 7 and day 14 of broiler chickens fed with different levels of mangosteen rind powder is shown in Table 1-5. For day 7, the control and commercial antioxidant results showed that 4 out of 4 blood samples had presence of monocytes. The 33 g of MRP had 3 out 4 samples which had presence of monocytes while both the 66 g and 100 g of MRP had 2 out of 4 samples with presence of monocytes.

Monocyte of broiler chickens fed with different levels of mangosteen rind powder at day 14 shows both the 33 g of MRP and 66 g of MRP had 3 out of 4 samples with presence of monocytes. The control had 2 out of 4 samples with presence of monocytes. While the 100 g of MRP had 1 out 4 samples with presence of monocytes. Furthermore, only the commercial antioxidants did not have any count of monocytes for day 14.

Histological Examination of Bursa of Fabricius and Spleen

Semi-qualitative scoring of the bursa of Fabricius and spleen in broiler chickens fed diets with different levels of mangosteen rind powder at 7 and 14 days is summarized in Table 2.

Table 1-5. Presence of monocyte at day 7 and day 14 of broiler chickens fed diets with different levels of mangosteen rind powder.

TREATMENT **Level of Mangosteen Rind Powder (MRP)**	**MONOCYTE**							
	DAY 7				**DAY 14**			
	I	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**
Control	+	+	+	+	-	+	-	+
Commercial Antioxidant	+	+	+	+	-	-	-	-
33g of MRP	+	-	+	+	+	+	+	-
66g of MRP	-	-	+	+	+	+	-	+
100g of MRP	+	-	+	-	-	-	+	-

Legend: - means monocyte was not found upon examination
+ means monocyte was seen and present upon examination

Table 2. Semi-qualitative scoring of lymphocyte concentration of bursa of Fabricius and spleen lymphatic nodule formation of broiler chickens fed diets with different levels of mangosteen rind powder.

TREATMENT **Level of Mangosteen Rind Powder (MRP)**	**DAY 7**		**DAY 14**	
	Semi-Qualitative Scoring of Lymphocyte Concentration And Lymphatic Nodule Formation			
	Bursa of Fabricius Lymphocyte Concentration	**Spleen Lymphatic Nodule Formation**	**Bursa of Fabricius Lymphocyte Concentration**	**Spleen Lymphatic Nodule Formation**
Control	+	+	+	+
Commercial Antioxidant	++	++	++	++
33g of MRP	+	+	+	+
66g of MRP	+++	+++	+++	+++
100g of MRP	+++	+++	+++	+++

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Microscopic examination of the bursa of Fabricius reveals many lymphocyte concentrations in the cortex and medulla of follicles in treatments with 66 g of mangosteen rind powder and 100 g of mangosteen rind powder (Fig 1). The bursa of Fabricius have large active follicles with little interfollicular tissue (Fig.1.B). The cortex is darker compared to the medulla due to abundant concentration of lymphocytes.

Only few lymphocytic infiltrates were observed in follicles of birds supplemented with the 33 g of mangosteen rind powder and the control group (Fig 2). Moreover, in the control group, bursal follicles undergo mild fibrosis with cyst formation in the epithelium. Furthermore, the treatment with commercial antioxidant had moderate amount of lymphocytes found in the cortex and medulla (Fig. 3).

Histology of spleen in treatments with 66 g of mangosteen rind powder and 100 g of mangosteen rind powder reveals many large formations of lymphatic nodules in the white pulp area (Fig. 4. A). The lymphocytes are diffusely scattered in white and red pulp (Fig. 4.B). The nodules are larger compared to other treatments. In the treatments with 33 g of mangosteen rind powder and control, only few lymphatic nodules were observed in the white pulp area (Fig 5).

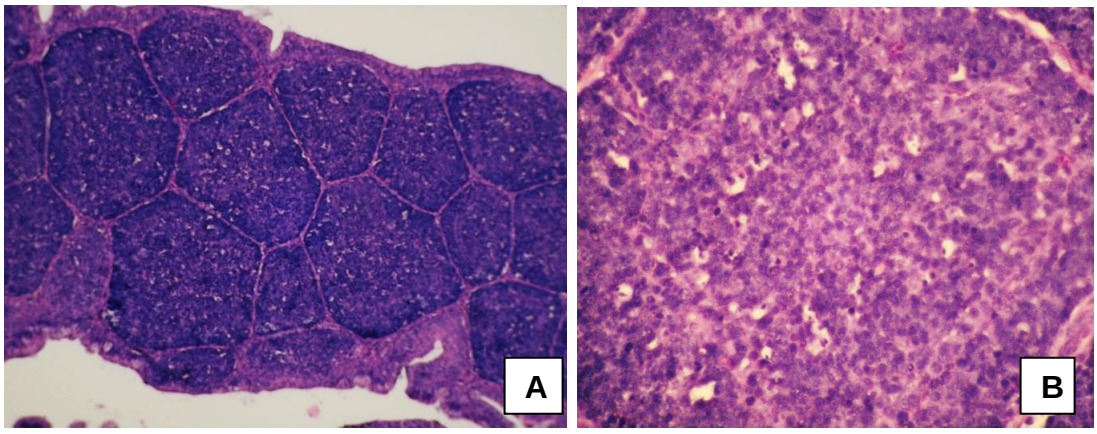

Fig. 1. Microscopic section of the bursa of Fabricius of broiler chickens fed diets with 66 g of MRP and 100 g of MRP. H & E. Magnification 10 X (A) and 40X (B). Many lymphocyte concentrations in cortex and medulla (A), large active follicles with little interfollicular tissue (B).

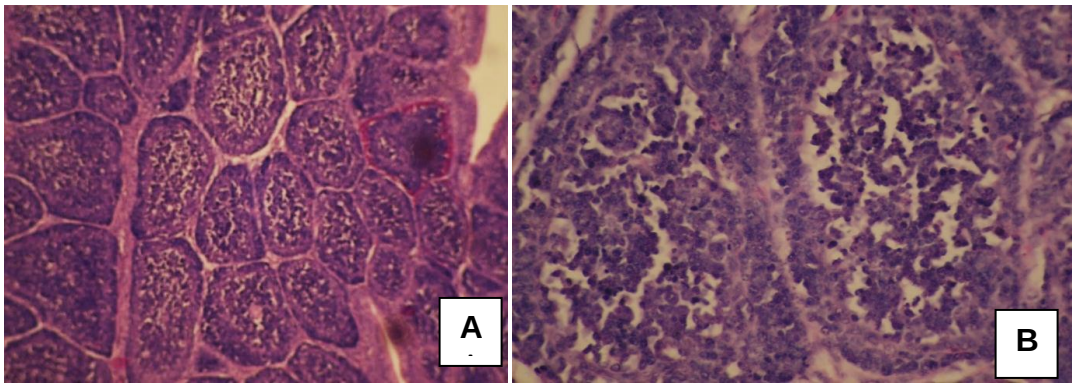

Fig. 2. Microscopic section of the bursa of Fabricius of broiler chickens fed diets with of 33 g of MRP and the control group. H & E. Magnification 10 X (A) and 40 X (B). Few lymphocytic infiltrates was observed in follicles.

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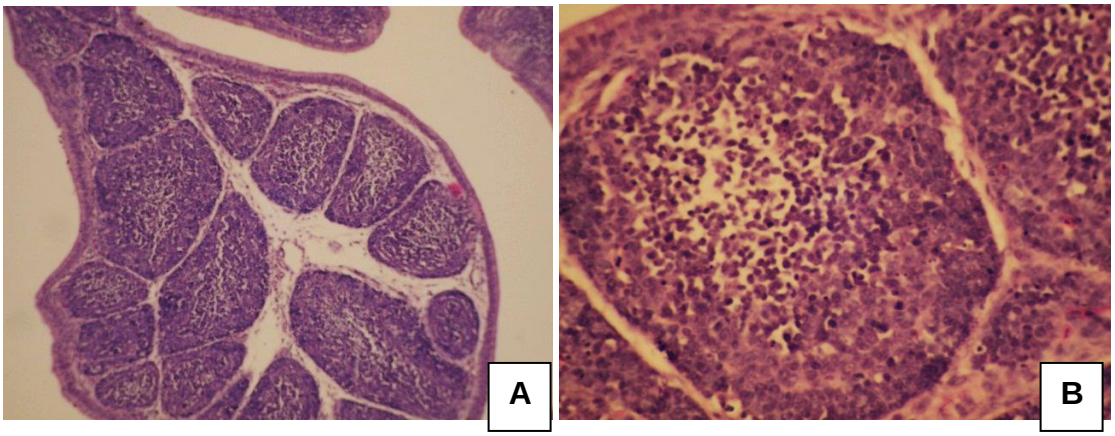

Fig.3. Microscopic section of the bursa of Fabricius of broiler chickens fed diets with commercial antioxidant. H & E. Magnification 10 X (A) and 40X (B). Moderate amount of lymphocyte was found in the cortex and medulla.

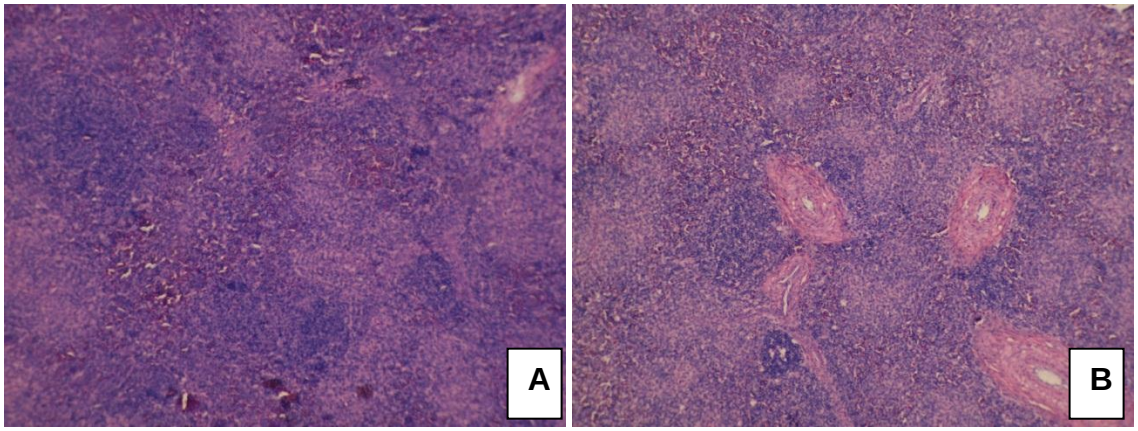

Fig. 4. Microscopic section of the spleen of broiler chickens fed diets with 66 g of MRP and 100 g of MRP. H & E. Magnification 10 X (A) and 40X (B). Many large formations of lymphatic nodules in the white pulp area (A) lymphocytes diffusely scattered in white and red pulp and nodules are larger compared to other treatments (B).

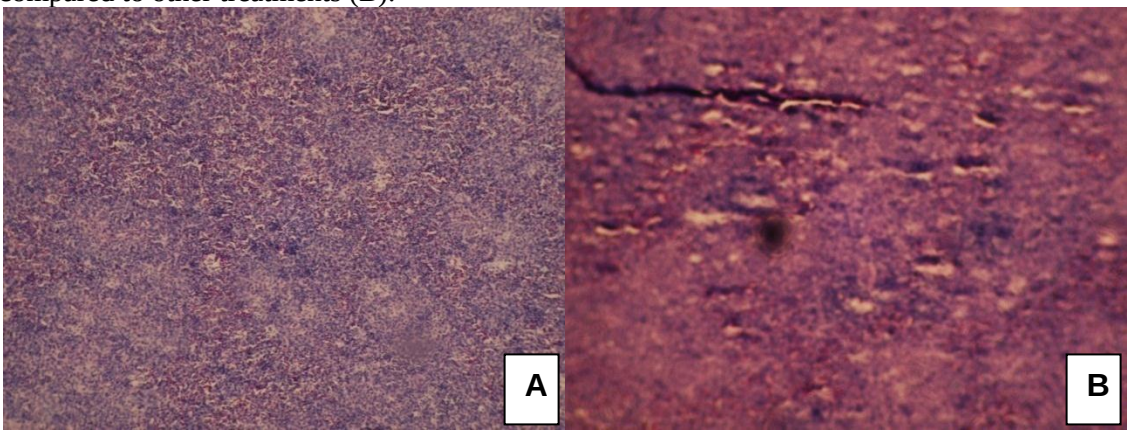

Fig.5. Microscopic sections of the spleen of broiler chickens fed diets with 33 g of MRPdiet and control groups. H & E. Magnification 10 X (A) and 40X (B). Few lymphatic nodules were observed in white pulp area.

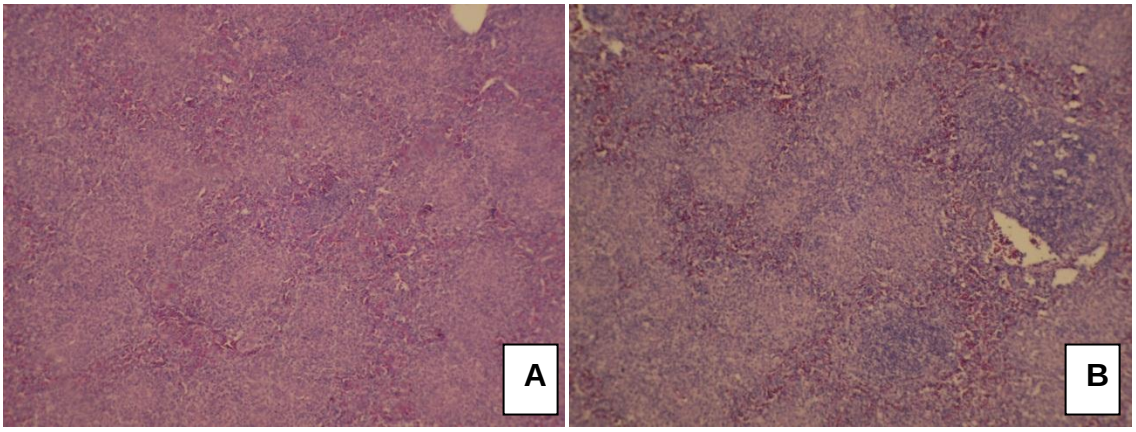

Fig.6. Microscopic sections of\ the spleen of birds fed diets with commercial antioxidant. H & E. Magnification 10 X (A) and 40X (B). Moderate amount of lymphatic nodules were observed in white pulp area.

Furthermore, many lymphocytes were destroyed in the parenchyma of the spleen in the control group. The commercial antioxidant treatment had moderate lymphatic nodules observed in the white pulp area (Fig.6).

The result of the study illustrates the disease fighting properties and immune enhancing capabilities of incorporating mangosteen rind powder in the diet of broiler chickens.

This is further shown by the results of the treatments with 66 g of MRP and 100 g of MRP groups which had many lymphatic concentrations in the cortex and medulla of follicles of the bursa of Fabricius and many large formations of lymphatic nodules in the white pulp area of the spleen and diffusely scattered lymphocytes in the white and red pulp. Moreover, nodules appeared larger compared to other treatments.

The 33 g of MRP group failed to show such immunity attribute. This could possibly be supported by Spinella [19] who stated that some medicinal plants have some of their chemical constituents identified, it may contain the appropriate constituents but the compounds given maybe insufficient in order to account for observed effects. This could be a possible reason why 33 g of MRP failed to show characteristics similar to that of the higher MRP treatments.

CONCLUSION AND RECOMMENDATION

Based on the results of the study, the increasing total white blood cell count, increasing heterophil count, increasing lymphocyte concentration in the bursa of Fabricius and increasing spleen lymphatic node formation shows that mangosteen rind powder at 66 g/kg of feed and 100 g/ kg of feed is capable of elucidating the disease fighting properties and enhances the immune system of broiler chickens. The inclusion of the mangosteen rind powder in the diet of chickens prevents incidence of diseases and further improves the health status of the birds.

The findings of the study further elucidates that mangsoteen rind powder is a natural antioxidant and a natural antibiotic which can be used as a feed additive substitute for synthetic antibiotics to eliminate the presence antibiotic residues in poultry meat for increased safety of food and minimize the incidence of antibiotic resistance which is harmful to animals and humans.

The study also shows that mangosteen rind powder as a feed additive promotes productivity and increased health benefits to broiler chickens. Furthermore, the established amount of inclusion in the study allows poultry farmers to have access and use mangosteen rind powder which is a plant based supplement. Moreover, the study suggests provision of a benchmark which allows animal raisers to have guides in the proper use and level of mangosteen rind powder as a natural antibiotic and antioxidant for broiler chickens. Moreover, mangosteen rind powder also provides alternative biological, medicinal and health benefits in Mindanao and throughout the country as a whole which would reduce requirements for expensive and imported animal drugs.

The Department of Agriculture – Bureau of Animal Industry could consider the results of the study to direct policies on the use of natural and organic antioxidants and antibiotics for broiler chicken production. Moreover, the Department of Health - Bureau Food and Drug Administration could also cite the results of the

study and develop low cost nutraceutical or alternative medicine.

The researchers recommend that the immune responses of different farm and food producing animals such as pigs, goat and cattle to mangosteen rind powder should also be studied. Moreover, microbiological experiments should be conducted to test if mangosteen rind powder could also reduce harmful bacteria and enhance beneficial microorganisms in the gut and intestinal tract of farm animals. Furthermore, aside from utilizing mangosteen rind as powder, the other forms of using mangosteen rind such as extracts and decoction for farm animals should also be experimented. Lastly, digestibility trials for chicken and other species should be conducted to determine if the mangosteen rind powder affects absorption of nutrients.

REFERENCES

[1] Gillespie, James R. 1997. Modern Livestock and Poultry Production. Delmar Thomson Learning. USA. p.632.

[2] The Philippines Recommends for Broiler Production. 1988. PCARRD Technical Bulletin Series No. 10-A. Philippines. p. 3.

[3] Cullison, A.E. and R.S. Lowrey. 1987. Feeds and Feeding. 4th Ed. A. Reston Book, Prentice-Hall, Inc. USA. p.448.

[4] Tizard, I. R. 2000. Veterinary Immunology: An Introduction. WB Saunders Company. p. 60.

[5] Bao,Y.M and M. Choct. 2010. Dietary NSP nutrition and Intestinal Immune System for broiler chickens. World's Poultry Science Journal. Vol. 66. No.3. p. 513

[6] Iji, P.A., Saki, A. and D.R. Tivey. 2001. Body and intestinal growth of broiler chicks on a commercial starter diet. 1. Intestinal weight and mucosal development. British Poultry Science: 42. pp. 505-513.

[7] Wattenberg, L.W. 1985. Chemoprevention of cancer. Cancer Res;45:1-8.

[8] Zarena, A. S. and K.U. Sankar. 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.

[9] Pedraza-Chaverri, J., Cárdenas-Rodríguez, N., Orozco-Ibarra, M. and J.M. Pérez-Rojas 2008: Medicinal properties of mangosteen (*Garcinia mangostana*). Food Chem. Toxicol., 46: 3227.3239.

[10] Miwako, K., Zhang, L., Ji, H., Kou, Y. and B. Ou. 2009. Bioavailability and Antioxidant Effects of a Xanthone-Rich Mangosteen (*Garcinia mangostana*) Product in Humans J. Agric. Food Chem. 57, 8788–8792

[11] Dharmaratne, H.R., Piyasena, K.G. and S.B. Tennakoon. 2005. A geranylated biphenyl derivative from *Garcinia mangostana* Nat. Prod. Res.;19(3):239-43.

[12] Ratiporn, H., Poovarodom, S., Leontowicz, H., M. Leontowicz, Sajewicz, M., T. Kowalsca, T., Licon, T., Guzman, N., Infante, J.A., Trakhtenberg, S. and S. Gorinstein. 2007. Comparative Study of Health Properties and Nutritional Value of Durian, Mangosteen, and Snake Fruit: Experiments In vitro and In vivo. J. Agric. Food Chem. 55: 5842-5849.

[13] http://www.stuartxchange.org/

[14] Campbell, T. W.1995. Avian Hematology and Cytology, Second Edition. Iowa State University Press. pp 7-11.

[15] Zarena, A. S. and K.U. Sankar. 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.

[16] PHILSAN. 2003. Feed Reference Standards. 3rd Ed. 441pp.

[17] Tollba, A.H., Shabaan., A. M. and M. A. A. Abdel-Mageed. 2010. Effects of using aromatic herbal extract and blended with organic acids on productive and physiological performance of poultry – the growth during cold winter stress. Egypt. Poult. Sci. Vol (30) (I): (229-248).

[18] Toghyani, M, Tohidi, M., Ali Gheisari, A. and K. Ali Tabeidian. 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 Vol. 9(40), pp. 6819-6825.

[19] Spinella, M. 2002.The Importance of Pharmacological Synergy in Psychoactive Herbal Medicines. Herbal Synergy. Alternative Medicine Review. Vol. 7. No. 2.

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