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Effect of Adding Different Levels of Duckweed (*Lemna minor* Linn.) in the Diet on Live Body Weight, Hematological Traits and Production Cost of Free-range Chickens, *Gallus domesticus* Linn. (Black Austrolorp x Barred Playmouth Rock)

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Abstract

The present study was conducted at Bataan Peninsula State University Abucay Campus to evaluate the growth performance and hematological profile of *Gallus domesticus* Linn. (Black Austrolorp x Barred Playmouth Rock) chicken fed formulated diets of varying inclusions of lesser duckweed (*Lemna minor* Linn.). Three formulated treatments diets of homogenous crude protein level were prepared: 0% duckweed (control), 10% duckweed, and 15% duckweed inclusion. Five chickens (average weight 202.5 g) per replicate were reared in a single factorial experiment and the feeding trial was carried-out for three months. Chicken fed diet containing 15% duckweed meal treatment had significantly ($P < 0.05$) higher body weight (1,425.88 ± 55.24 g) compared to chicken fed normal diet (1,223.48 ± 174.47 g). Mean cost to produce a kilogram of meat was significantly cheaper in the treated diets ($F = 4.82$; $P < 0.05$). Mean values of hematological variables were not significantly different among treatments.

Keywords: Bataan, duckweed meal, feed conversion ratio, feed formulation

1. Introduction

Demand for chicken meat has been increasing tremendously over the years globally at an average 2.4% per annum and in the Philippines at an average of 3.4% per annum. Using local sourced alternative for feed ingredient relatively a timely and practical option in increasing the production yield and economic gains of the small animal poultry holders (Espino and Bellotindos, 2020). In 2021, the total number of chickens inventories in the Philippines was about 179.78 million birds. This was about 0.9% higher than the 178.26 million birds reported in the same period of 2020. Native / improved chicken and layer chicken inventory increased by 3.1 % and 4. 2%, respectively (PSA, 2021).

Backyard free-range chickens require sustainable sources of nourishment for optimum production efficiency and performance. Commercial feeds are usually complemented to the forage and free-range activities of the birds to have a consistent and stable marketable weight. The use of commercial feeds with increases the cost of production, thereby, supplemental feeding is more economical (Mananghaya, 2017). The highest cost of production is from feeds, which accounts for about 50 % to 70%; the feed cost can go as high as 75% of the total cost of production, being the major portion of the variable costs. (Dozier et al., 2008). As the price of commercial feeds is constantly rising, it is necessary to explore the potentials of different alternative protein feedstuffs as practical replacements to imported feedstuffs such as soybean meal and fishmeal.

Various studies have explored the different alternative protein feedstuffs that are locally available and abundant (Haustein et al., 1994; Anderson et al., 2011; Ahammad et a., 2003). One of the promising alternative forages is duckweed, a small nitrogen-fixing aquatic plant found worldwide and often seen growing in thick, blanket-like mats on still or slow moving, nutrient-rich fresh or brackish water (Van der Spiegel et al., 2013). Duckweeds have been fed to animals and fish to complement diets, largely to provide a protein of high biological value (Leng et al., 1995) and essential nutritional components (Culley Jr et al., 1981).

Community-based organic farming schemes has been adopted to promote and demonstrate eco-friendly and cost-effective agri-fisheries production in Central Luzon, Philippines (Flores et al., 2016; Paguia et al., 2019, 2020; Vinzon et al., 2021). The extent of the project is now directed towards the use duckweed as a diet for livestock, which requires confirmatory trials on various breeds of chicken and other livestocks. Therefore, the present study established to evaluate the impact of adding different levels of duckweed meal, *L. minor* on performance, hematological traits, and production cost of free-range chickens, *Gallus domesticus* Linn. (Black Austrolorp x Barred Playmouth Rock).

2. Method

2.1 Experimental Chicken and Feeds

Out of 150 pre-acclimatized chickens, a total of 75 chicken individuals (*G. domesticus*), 35-day old (Black Austrolorp and Barred Playmouth Rock crossed) were used in the feeding experiment. Experimental chickens were initially reared in Bataan Peninsula State University (BPSU) Abucay.

The locally available feedstuffs such as rice bran, molasses, vegetable oil, oyster shells, salt, fish meal, soybean meal and yellow corn were used in the production of experimental feeds. The experimental diets were prepared following the formulation in Table 1. The experimental plant (*L. minor*) that is predominantly available in the locality was cultured in the 2 m x 10 m (60 cm deep) concrete pond. Duckweed meal was prepared through the conventional process such as partial washing of the fresh duckweeds using clean water, draining, and five days sun drying.

Duckweed samples were also oven dried for 15 min to attain the 14.0% moisture content. The formulated feeds containing 14.0% crude protein and 2,600 ME/kcal/kg were achieved and standardized among treatment groups. Proximate composition and nutrient attributes of formulated feeds are shown in Table 1.

2.2 Research Design and Feeding Experiment

A single factor experiment of three (3) dietary treatments with five (5) replications (five birds per replication) were employed for this study following a completely randomized design (CRD). Initial mean weight (ca. 200 g each) of birds were homogenous. The treatments groups were as follows — T1 (control): corn-based diet without duckweed meal, T2: corn-based diet with 10% duckweed meal, and T3: corn-based diet with 15% duckweed meal. The experimental feeds were formulated on the basis of duckweed meal proximate composition — 5.80% moisture, 21.30% crude protein, 16.30% ash, 1.20% crude fat, 21.30% crude fiber, 0.30% Phosphorous, 34.10% Nitrogen Free Extract, and 2,041 kcal kg^{-1} Metabolizable Energy. The acclimation phase and the actual experiment was conducted from July 2021 until December 2021 at the Poultry Experimental Facility in BPSU Abucay following the floor space of 2.0 ft^2 per bird in a full litter system. Birds were fed with pre-weighed experimental ration throughout the feeding trial.

2.3 Production Parameters

The weight (g) of each chicken individual was determined monthly using a digital balance (0.01 g), whilst daily gain in weight (%), gained in weight (g), final mean weight (g), Feed Conversion Ratio [FCR = (feed consumed / gain in weight), and mortality were determined after three months of experimental trial. Similarly, the cost per kg of bird produced was determined and calculated as:

$$\frac{feeds\ cost\ and\ other\ operating\ costs\ (PhP)}{gross\ live\ weight\ (kg)}$$

2.4 Hematological Parameters

At the end of the experiment, one chicken per replicate were used for blood sample analysis. Blood samples (1.0 ml per bird) was collected from a wing vein into anticoagulant ethylenediaminetetraacetic acid treated tubes for determination of hematological parameters including erythrocytes, leukocytes, lymphocytes, granulocyte, MID (other types of leukocytes not classified as lymphocytes or granulocytes), hemoglobin, mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration, and hematocrit. The hematological parameters were analyzed using Automatic Fully Digital Hematological Analyzer, BC 3000 Plus, ShenzhenbMinday, Bio-Medical Electronics Co. LTD.

Table 1. Ingredients used in the ration of the experiment

Ingredients	Treatment 1	Treatment 2	Treatment 3
Yellow corn %	56.9	45.27	48.538
Fish meal, 60% %	2.10	4.93	5.763
Soybean meal (full fat) %	19.8	9.60	7.253
Duckweed meal %	-	10.00	15.00
Rice bran (D1) %	15.0	24.00	17.561
Molasses %	5.0	5.00	4.683
Limestone (oyster shell) %	1.0	1.00	1.00
Salt %	0.20	0.20	0.20
Total	100.00	100.00	100.00
Calculated Analysis			
Crude Protein, %	14.2 ± 2.0	14.2 ± 2.0	14.2 ± 2.0
ME, kcal kg^{-1}	2,639	2,629	2,697
Moisture Content, %	12.5	12.9	13.7
Crude fat, %	1.0	1.32	2.3
Ash, content %	11.1	12.6	4.9
Crude Fiber, %	4.0	6.0	8.5
Phosphorus, %	0.28	0.53	.61
NFE, %	61.3	66.03	59
Calcium, %	0.826	0.78	0.826
Lysine, %	1.3	1.16	1.31
Methionine, %	0.410	0.382	0.411
Methionine + Cysteine, %	0.923	0.824	0.924

Chemical and nutritional composition of the dry duckweed samples was determined according to standard AOAC methods (AOAC, 1975).

2.5 Statistical Analyses

Treatment means of each parameter in growth performance, production efficiency, and hematological profile of experimental birds were compared using analysis of variance for single factor CRD experiment ($P < 0.05$). Tukey's post-hoc test was employed to determine the significant variation between treatment groups ($P < 0.05$). Statistical analyses were performed using a statistical package software, Statistical Tool for Agriculture Research.

3. Results and Discussion

Data of growth and feeding performance of experimental chicken is presented in (Table 2). Inclusion of duckweed meal in the diets significantly improved the mean final weight of the experimental chicken; the highest final weight was observed in T3 ($P < 0.05$). After three months, no mortality was observed and growth performance of chicken reared under T3 diet was 16.54% higher than T1, whilst T2 was 6.45% higher than T1 (Figure 1). The present findings concur with the results of previous feeding trials estimated that performance of broiler chicken fed diets containing corn-duckweed based diets *L. minor* (Paguia, 2021), and *L. gibba* (Haustein et al., 1994) was better compared to control. On the other hand, Kusina et al. (1999) reported that inclusion of duckweed in broiler finisher diets at 10% level did not compromise growth performance and carcass quality of broiler chickens. The findings also demonstrated the potential of duckweed, *L. minor* as a viable substitute to soybean for free-range chicken diet considering the plant higher crude protein and mineral contents (37.7%, and 3.8%, respectively). However, the types of species, and the rearing medium of duckweed must be taken into account as these can influence the nutrient concentration of the aquatic plant (Du Thanh et al., 2009).

The efficiency of duckweed as a poultry feed for improved poultry production is attributed to its nutritional composition and balance amino acid profile (Porath et al., 1979). Comparing to other plant protein sources, duckweed is known to possess higher levels of balanced essential amino acids (e.g., lysine and methionine) and bear a similitude to that of animal protein composition (Mbagwu and Adeniji, 1988). While the present finding is promising, Islam et al. (1997) did not suggest for full replacement of animal protein components of feeds with plant-based ingredients, but rather recommended for partial replacement of fish meal with duckweed and soybean meal.

Table 2. Growth and feeding performance (mean ± SD) of experimental free-range chicken (*Gallus domesticus*) fed treatment diets with varying inclusion of duckweed meal.

Growth and Feeding Performance	**T1 (*n* = 25)**	**T2 (*n* = 25)**	**T3 (*n* = 25)**	***F* value**
Initial weight (g)	201.20 ± 38.95^{a}	205.5 ± 26.37^{a}	202.67 ± 36.00^{a}	0.11^{NS}
Final Weight (g)	1,223.48 ± 174.47^{b}	1,302.40 ± 56.26^{b}	1,425.88 ± 55.24^{a}	4.26*
Daily Gain (%)	12.78 ± 3.68^{a}	14.31 ± 4.52a	14.87 ± 3.35^{a}	1.17^{NS}
Gained in Weight (g)	89.46 ± 25.73^{a}	93.98 ± 24.37^{a}	101.52 ± 23.46^{a}	0.92^{NS}
Feed Conversion Ratio	6.17 ± 3.39^{a}	5.22 ± 1.64^{a}	4.62 ± 0.82^{a}	2.03^{NS}
Cost per kg of meat produced (PhP)	121.53 ± 70.36^{a}	87.91 ± 49.14^{b}	80.64 ± 14.40^{b}	4.82*

1 $ = PhP 55; In a row, means with different superscript letter are significantly different ($P < 0.05$). a > b. ^{NS} not significant at 5% level of confidence; *significant at 5% level of confidence

It is worthy to note that the cost per kg of meat produced was significantly lower ($P < 0.05$) for birds fed diet containing 10% and 15% duckweed meal compared to control diet (Table 3, Figure 2). This finding corresponds with Khang and Ogle, (2004) who reported a reduced in cost when a duckweed-based diet was used and compared with 100% soya bean. Moreover, Olorunfemi et al., (2006) reported that using diet containing duckweed, *L. paucicostata* at approximately 30% is cost-effective to reduce the cost of feed by about 21%, thereby improving profitability in broiler finisher production.

Variation in gained in weight, and FCR were found to be not significant among treatment means (Table 3). The variation in mean levels of each hematological parameter was also not significant ($P > 0.05$), despite the inclusion of duckweed meal diets (Table 4). Similar results in daily gains and in feed conversion can be attributed to the decreasing intakes of digestible energy and of total and digestible protein. It can be speculated that the results might have been better if the feed mixture was supplemented with additives and natural growth promoters like phytobiotics (e.g., garlic, turmeric, and moringa) (Krauze, 2021).

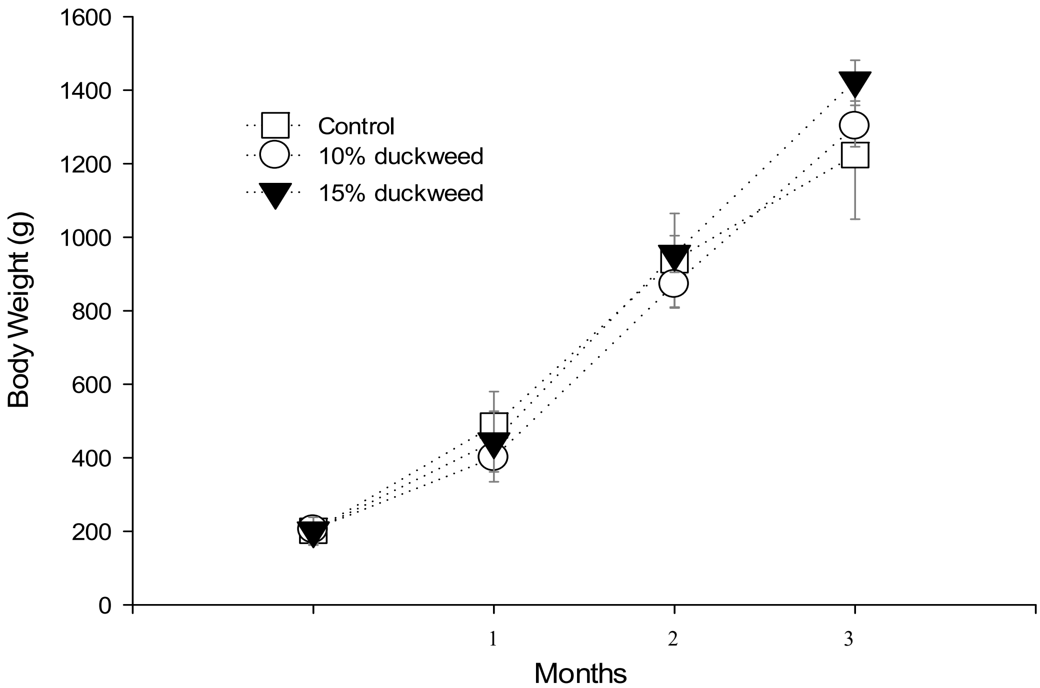

Figure 1. Changes in the mean live body weight of free-range chicken, *Gallus domesticus* (Black Austrolorp x Barred Plymouth Rock) fed diets of varying inclusion levels of duckweed, *Lemna minor*. Means with different letters in each treatment are significantly different ($P < 0.05$). *Vertical bars* = SD

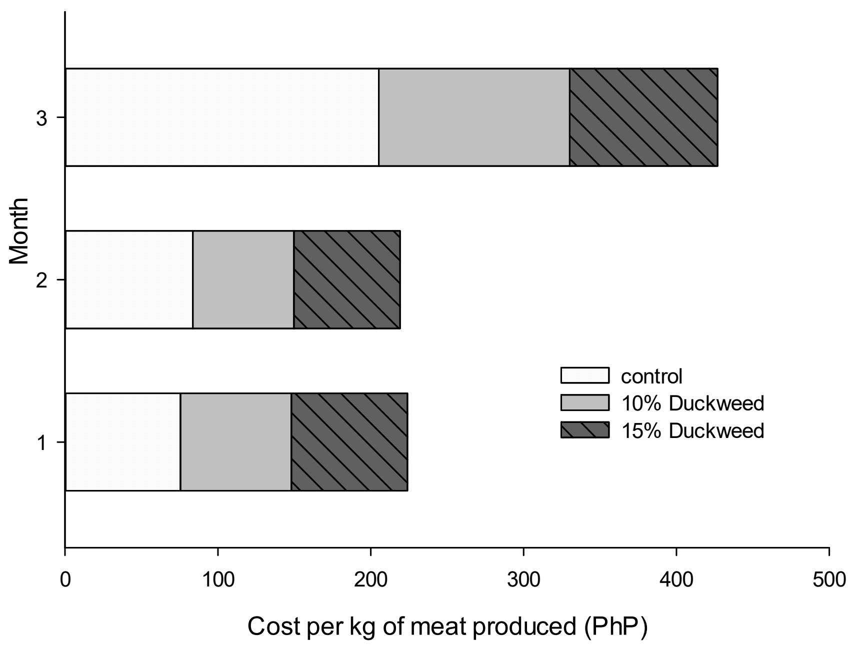

Figure 2. Mean cost (1 $ = 55 PhP) spent to produce a kilogram of live free-range chicken, *Gallus domesticus* (Black Austrolorp x Barred Plymouth Rock)

Table 4. Hematological parameters (mean ± SD) of 100-d old free-range chicken, *Gallus domesticus* (Black Austrolorp x Barred Plymouth Rock) fed diets with varying inclusion of duckweed, *Lemna minor*

Hematological Variables	**T1 (*n* = 3)**	**T2 (*n* = 3)**	**T3 (*n* = 3)**	***F* value**
Erythrocyte (10^6 /mm^3)	2.65 ± 0.29	2.87 ± 0.31	2.83 ± 0.36	0.08^{NS}
Leukocyte (10^3 / mm^3)	28.74 ± 6.22	27.88 ± 7.54	26.80 ± 11.39	0.06^{NS}
Lymphocyte %	85.68 ± 2.29	84.18 ± 2.45	85.48 ± 3.83	0.38^{NS}
Granulocyte %	7.14 ± 1.34	8.42 ± 1.70	7.80 ± 2.43	0.58^{NS}
MID %	7.18 ± 0.97	7.40 ± 1.12	6.72 ± 1.63	0.37^{NS}
Hb, g dL^{-1}	9.74 ± 12.54	9.44 ± 15.99	9.77 ± 14.77	0.07^{NS}
MCV, fL	101.66 ± 1.91	100.82 ± 2.29	100.8 ± 2.14	0.27^{NS}
MCH, %	44.36 ± 3.12	40.98 ± 0.99	42.76 ± 2.33	2.66^{NS}
MCHC, g mL^{-1}	43.7 ± 2.71	40.81 ± 1.61	43.63 ± 2.36	2.49^{NS}
Hematocrit, %	29.56 ± 3.69	27.72 ± 3.64	29.30 ± 3.78	0.36^{NS}

MID: other types of leukocytes not classified as lymphocytes or granulocytes; Hb: hemoglobin; MCV: mean corpuscular volume; MCH: Mean Corpuscular Hemoglobin; MCHC: Mean Corpuscular Hemoglobin Concentration; ^{NS} not significant at 5% level of confidence

4. Conclusion and Recommendations

The present study demonstrated the efficiency of duckweed meal-based diets in improving the growth performance of free-range chicken and reducing the cost of production. The finding provides evidence of the potential of *L. minor* as a replacement to soya bean meal or fish-meal as a main protein source for poultry feed. Further studies can be done using other species or varieties of duckweeds of varying inclusion to diet, with emphasis on growth and reproduction performance, nutritional profile, and sensorial quality of various chicken breeds commonly raised in the country.

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