Growth and Carcass Performance of Male White Leghorn Fed with Organic and Commercial Free-Range Diets raised under Extensive Rearing System

Noel B. Lumbo, Agapita J. Salces, Maria Cynthia R. Oliveros, Jose Alberto I. Nuez III, Blessy Hanna M. Albaladejo and Jorge Michael D. Dominguez*
Institute of Animal Science – College of Agriculture and Food Science
University of the Philippines Los Baños
College, Laguna 4031 Philippines
jddominguez1@up.edu.ph

Date received October 20, 2022
Revision accepted: February 13, 2024

Abstract

In layer industry, male White Leghorns are considered production wastes and are commonly killed after hatching. However, these chickens are overlooked as an additional source of meat for human consumption. With the current decline of chicken meat supply in the country, this study raised 400 hardened (45 days [d]) male White Leghorns to determine their suitability in meat production and profitability to be raised under a free-range system fed with different diets (i.e., organic and commercial free-range diets). Chickens were randomly distributed to eight houses with ranging areas. All management practices and feed composition strictly adhered to the Philippine guidelines. Growth performance data were collected twice a month. To assess the carcass traits, five chickens per house were randomly sacrificed at 75 and 90 d. Results revealed that chickens that received commercial free-range diet had significantly better growth (45 to 87 d and 45 to 101 d) and carcass performance. On the other hand, chickens fed with organic diets had significantly yellower skin and lean meat in the leg part. More mature chickens upon slaughter significantly had higher carcass traits. Moreover, male White Leghorns fed with organic or commercial free-range diets had high positive margin over feed cost. In conclusion, raising male White Leghorn under extensive rearing system and fed with either organic and commercial free-range diets can be a profitable business venture and additional source of chicken meat.

Keywords*:* free-range, male layer chicken, organic production system

1. Introduction

Demands on products derived from chickens that are raised under extensive production system such as free-range and organic systems are on the rise (Yan, 2019; Masilang, 2021). Meat products derived from alternative production systems (e.g., free-range, cageless, and organic system) have been associated with high meat quality and have high positive impact on animal welfare by marketers and consumers (Fanatico *et al.*, 2005; Fanatico *et al.*, 2008; Wang *et al.*, 2009; Michalczuk *et al.*, 2014; Castellini *et al.*, 2016). However, annual volume of chicken production in the Philippines is declining from 2019 to 2021 (Philippine Statistics Authority [PSA], 2022). Therefore, producers should maximize all the available resources, especially chicken genetic resources, not just to meet the quantity but also the quality of poultry meat.

Two standards were created to guide producers on choosing which chicken breeds or chicken genetic resources can be used for organic agriculture and free-range system. The Philippine National Standard/Bureau of Agriculture and Fisheries Standards (PNS/BAFS) 07:2016 (BAFS, 2016) (organic agriculture) states that in organic livestock production the choice of breeds should consider the capacity to adapt to local conditions; chickens should have reasonable productivity level even with low external input; and chicken breed should maintain genetic diversity. On the other hand, the PNS/BAFS 262:2018 (BAFS, 2018) (free-range chicken) mentions that producers should only use strains or breeds that are available and suited for free-range production.

Poultry breeds used for meat production are classified into three: a) fast-growing (FG) chickens are adapted to intensive rearing systems and able to reach ~2.2 kg in about 45 d with very high breast yield; b) slow-growing (SG) chickens are selected by poultry companies for outdoor farming and can take almost twice as long as FG to reach market weight; and c) local breeds are used mainly in niche market and to maintain genetic diversity (Mancinelli *et al.*, 2017; Canogulları *et al.*, 2019). In terms of performance under alternative rearing systems, the SG chickens performed better than FG (Castellini *et al.*, 2016). Moreover, male layer chickens are comparable to the performance of SG (Mancinelli *et al.*, 2017).

Under PNS/BAFS 07:2016 (BAFS, 2016), the use of native/local breeds should be promoted but are not compulsory, and the standard does not indicate which genotypes should be used in organic system. Meanwhile, PNS/BAFS

262:2018 (BAFS, 2018) enumerated several breeds and strains and classified them according to usage (e.g., for meat and egg). However, both standards failed to mention the utility of male layer chicken for meat production.

In other countries, rearing male layer chicks for meat is currently practiced (Gerken *et al.*, 2003; Lichovníková *et al.*, 2009; Choo *et al.*, 2014; Giersberg and Kemper, 2018; Mueller *et al.*, 2018; Mueller *et al.*, 2020, Murawska *et al.*, 2019; Popova *et al.*, 2022). Based on the previous study of Lumbo *et al.* (2022), raising male layer chickens, such as ISA Brown and Bovans White, in a free-ranged production system can be a profitable business venture in the Philippines. Additionally, performance of other male chickens from different layer and dual-purpose genotypes should be tested under alternative production system and determine their suitability as meat source.

White Leghorns are considered egg-type chicken and used to create commercial layer strains. Leghorns are also active and efficient foragers which is great for alternative production system (Senbeta, 2017). Since egg production and growth rate is negatively correlated (Buzala and Janicki, 2016), male Leghorn chicks are culled immediately after hatching. Limited chick availability for chicken production is one of the current problems facing the poultry industry. Rather than culling male layer chicks, producers should invest in raising these chickens for meat production. However, performance and profitability analysis of raising male layers under alternative production system in the Philippines is scarce. Hence, this study was conducted to determine the growth and carcass performance of male White Leghorns raised under extensive rearing system fed with organic and commercial free-range diets. Moreover, the profitability of rearing male layer chickens under free-range production system were also accounted in the study using income over feed cost analysis.

2. Methodology

2.1 Animal Care and Management

The study conformed with the Institutional Animal Care and Use Committee of the University of the Philippines Los Baños (UPLB) (Approval No. CAFS-2021-010). A total of 400 hardened chickens (45 d) were raised at the University Animal Farm, Institute of Animal Science, College of Agriculture and Food Science, UPLB, Philippines from June 28, 2021 to October 7, 2021. All management practices strictly adhered to the guidelines set on PNS/BAFS 07:2016 (BAFS, 2016) and PNS/BAFS 262:2018 (BAFS, 2018). Chicken

houses and range area were constructed with a stocking density of six chickens/m^2 and one chicken/m^2, respectively. Paddocks were uniformly prepared and constructed. The experiment was conducted using a completely randomized design. Chickens were randomly distributed to eight houses with range area. A total of 50 heads of chicken per house were allocated. Outdoor access to the range area was provided during daylight hours and chickens were confined to indoor pens at night.

Chickens had free access to feed and water *ad libitum* (both in the range area and indoor pens). Two treatment diets were tested (Table 1): organic feed diet and free-range commercial crumble feed (B-MEG Integra 2000, Philippines). Organic feed diet was formulated based on the list of permitted substances for organic agriculture on the department circular of Department of Agriculture (2020) (national list of permitted substances for organic agriculture).

Table 1. Chemical composition and ingredients of organic feed and commercial free-range diet

Composition	Organic diet[a]	Commercial free-range diet[b]
Chemical Composition		
Dry Matter	97.33	88.00
Crude Protein	13.24	19.5
Crude Fiber	3.65	4.50
Crude Fat	8.78	3.00
Calcium	1.22	1.10
Phosphorus	0.53	0.55
Ingredients		
IPB variety 6 corn	25.00	Corn, cassava meal, soybean meal, feed wheat, full fat soya, rice bran, wheat pollard, fish meal, brewers spent grain and yeast, meat and bone meal, crude coconut oil, palm olein, limestone, inorganic phosphates, iodized salt, L-Lysine, DL-Methionine, L-Threonine, probiotic, organic selenium, choline chloride, vitamin-mineral premixed, enzymes, toxin binders, mold inhibitor, and antioxidants
Virgin coconut oil	25.00	
Sapal meal		
Rice bran, D1	20.00	
Non-GMO yellow peas	20.00	
Ulva lactuca meal	5.00	
Poultry mineral and vitamins	5.00	

[a] – Based on the calculated analysis; [b] – based on chemical composition

Body weights and feed intake of each house were recorded twice a month. The average daily feed intake (ADFI) and average daily gain (ADG) were used to calculate the feed-gain ratio (F/G).

2.2 Animal Slaughter and Carcass Traits Evaluation

At 75 and 90 days of age, five chickens per pen were withdrawn to evaluate the carcass performance. Chickens were slaughtered by manual

exsanguinations. Furthermore, chickens were scalded, defeathered, eviscerated, and chilled using an ice bath at 12 °C for 15 min. After weighing the carcass, major cut-up parts were separated and yield of breast, wings, legs, and back was recorded. Yield was computed as a percentage of carcass weight. Legs and wings were further dissected, and yield of separable lean, fat-and-skin, and bone were determined. Skin and lean color were measured on breast and leg parts using the *Commission internationale de l'éclairag*e (CIE) L^* (lightness), a^* (redness), and b^* (yellowness) values of Konica Minolta CR-400 chroma meter (Konica Minolta, Japan).

2.3 Statistical Analysis

Descriptive analysis was conducted (Figures 1 to 3). Growth performance and carcass composition were assessed with t-Tests to evaluate the effects of diets. For slaughter weight, carcass weight and yield, skin and meat color data, the effects of diets, slaughter age, and their interaction were analyzed using two-way analysis of variance (ANOVA). All statistical analyses were conducted in RStudio (RStudio Team, 2020). Significance was set at $p \leq 0.05$.

2.4 Profitability Analysis

Profitability of rearing male White Leghorns under free-range system was determined using income-feed cost analysis. Feed cost per chicken was computed by multiplying the total feed consumed by price per kilogram of feed. Value of gain per chicken was calculated by multiplying the total weight gain by the live weight price per chicken. Feed cost per kilogram of gain was computed by dividing the feed cost per chicken by the total weight gain. Lastly, margin over feed cost (MOFC) was computed by subtracting the feed cost per chicken from the value of gain per chicken.

3. Results and Discussion

3.1 Production Performance

The growth performance of chicken fed with different diets significantly diverged from 87 up to 101 days (d) (Table 2). Chickens fed with commercial free-range diet had significantly higher ADG that resulted in significantly higher body weight and better F/G than the other group.

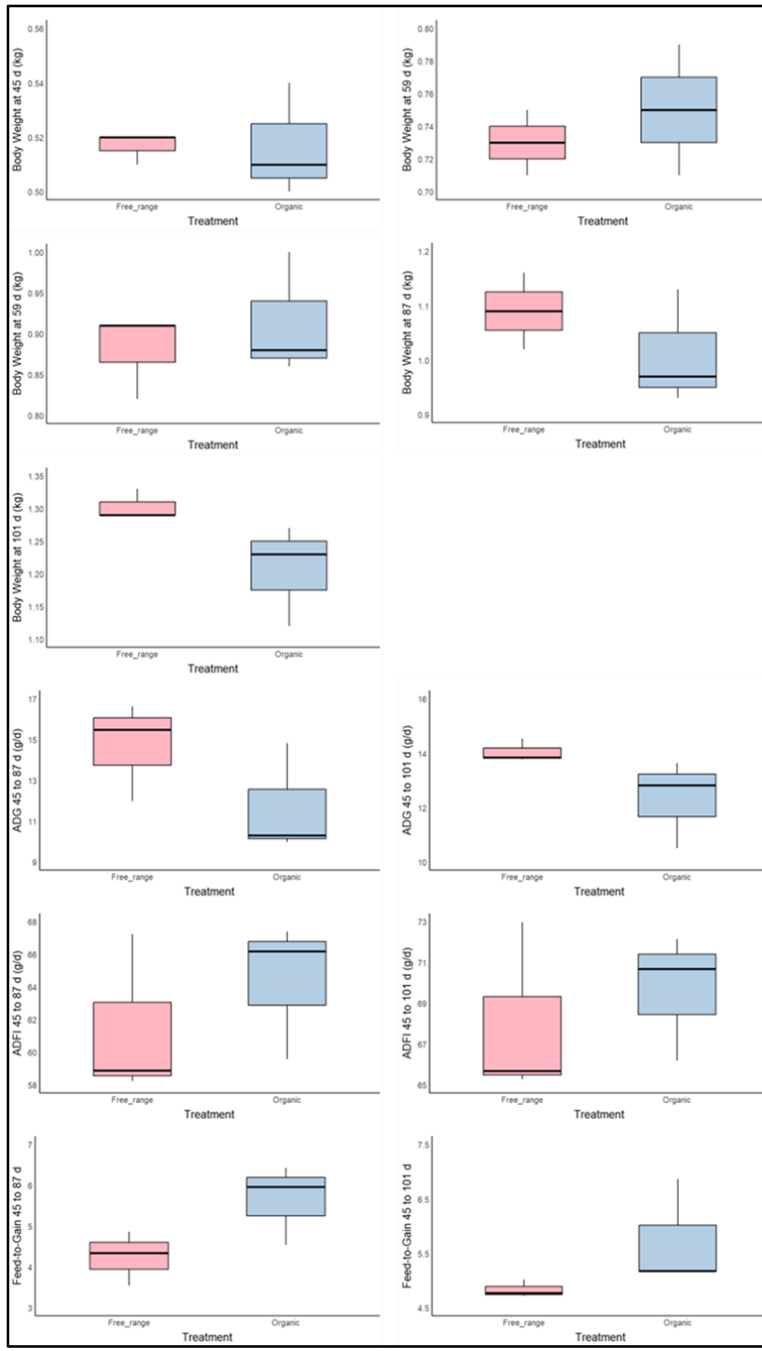

Figure 1. Boxplots of growth performance of male White Leghorns fed with organic and commercial free-range diets raised under extensive rearing system

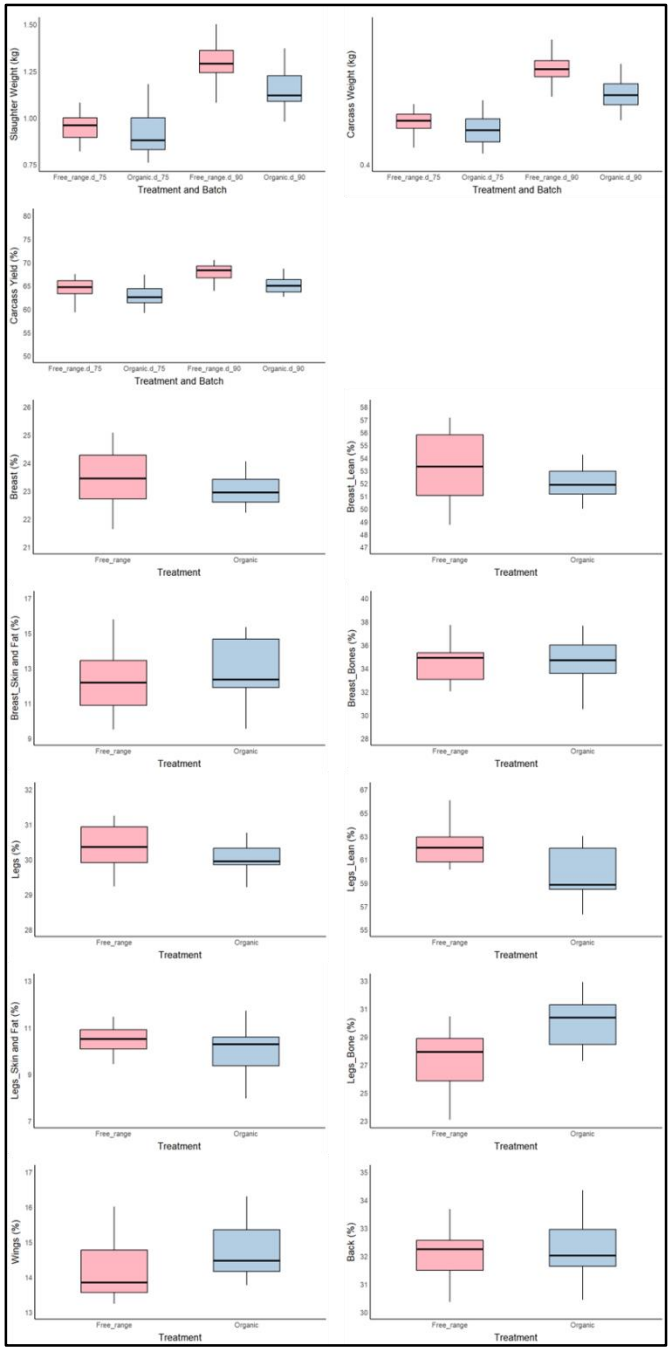

Figure 2. Boxplots of carcass characteristics and composition of male White Leghorns fed with organic and commercial free-range diets raised under extensive rearing system

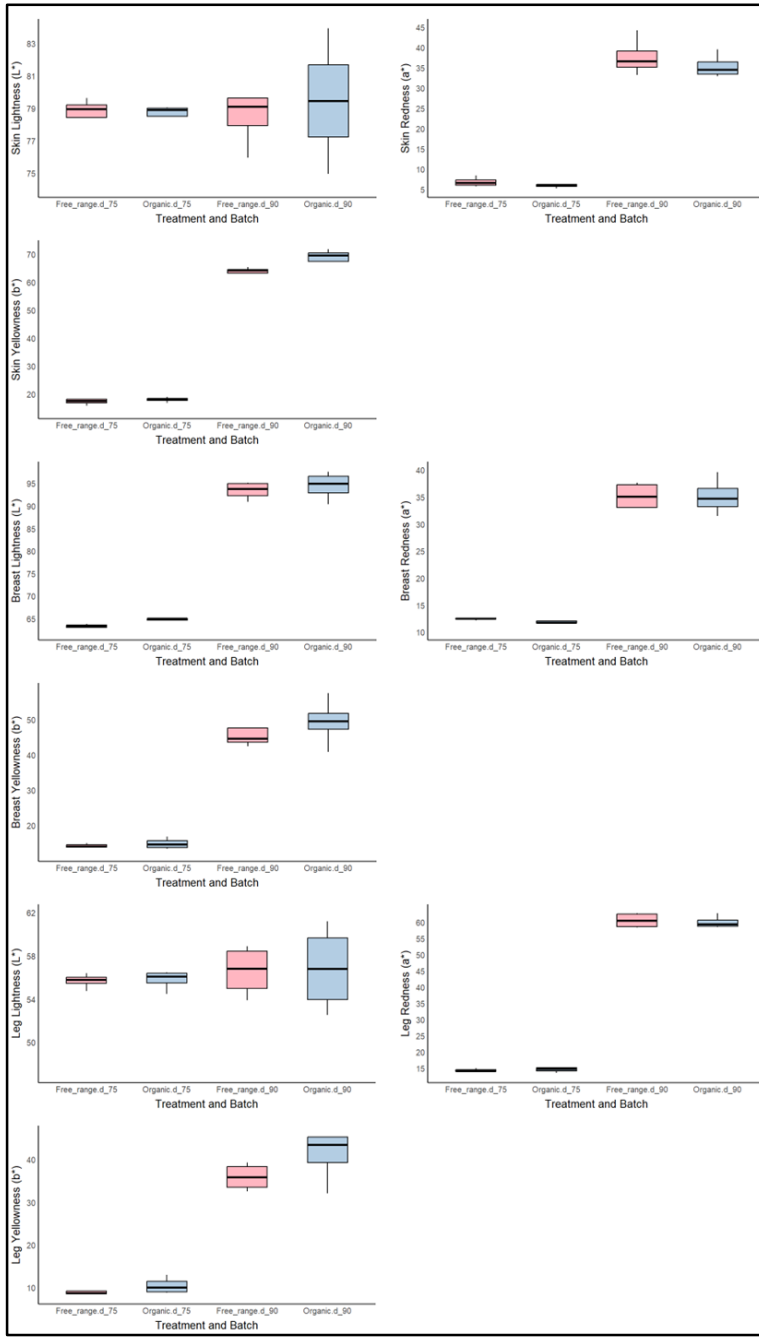

Figure 3. Boxplots of skin and meat color of male White Leghorns fed with organic and commercial free-range diets raised under extensive rearing system

Table 2. Growth performance of male White Leghorns fed with organic and commercial free-range diets raised under extensive rearing system

Growth performance	Free-range diet	Organic diet	MoE
Body weight (kg)			
45 d[ns]	0.52	0.52	0.02
59 d[ns]	0.72	0.75	0.04
73 d[ns]	0.88	0.92	0.08
87 d[*]	1.13	1.01	0.08
101 d[*]	1.30	1.21	0.06
Average daily gain (g/d)[*]			
45 to 87 d	14.7	11.7	2.90
45 to 101 d	14.1	12.3	1.33
Average daily feed intake (g/d)[*]			
45 to 87 d	61.4	65.4	3.27
45 to 101 d	68.0	70.7	2.29
Feed-to-gain[*]			
45 to 87	4.25	5.64	0.94
45 to 101	4.83	5.73	0.79

[ns] – not significant ($p > 0.05$); [*] – significant ($p < 0.05$); MoE – margin of error at 95% confidence interval

Moreover, differences in diet significantly affected the ADFI of White Leghorns. Higher feed consumption of chickens fed with commercial free-range diet led to an increase in F/G. The body weight of both groups was below 2 kg which was lower than the FG and SG. Depending upon diet, FG broilers can reach 2.5 kg in approximately 42-49 d and medium or SG broilers in 56-84 d (Gordon and Charles, 2002). Moreover, the ADG in the current study was lower than the observation of Castellini *et al.* (2016) on medium- and SG chickens. According to Petkov (2013) growth rate, feed intake, and feed conversion of male layer chicken resembles the slow-growing broilers. This demonstrates the intense genetic programming of this breed, which directs energy toward egg production rather than the accumulation of body tissue (Mueller *et al.*, 2018). Castellini *et al.* (2016) also noted that ADG higher than 50 g/d should be avoided in an organic system. Chickens with higher ADG than 50 g/d tend to have lower adaptability for organic production system. Furthermore, under extensive production system, chickens with a slow ADG express more natural behavior and should be favored more (Castellini *et al.*, 2014). However, strains with excessively low growth rates will require a very

long growing period that can result in high production costs (Castellini *et al.*, 2006). The differences in foraging and activity level between the two groups likely contributed to the different degree of feed intake and feed conversion of the two groups (Fanatico *et al.*, 2008). Although not quantitatively measured, chickens fed with organic diet grazed more than the other group.

3.2 Carcass Characteristics

Slaughter weight (SW), carcass weight (CW), and carcass yield (CY) were significantly affected by the interactive effects of age at slaughter and diet (Table 3). Chickens fed with commercial layer diet consistently had higher SW, CW, and CY than the other groups since they had higher growth performance. Likewise, chickens slaughtered at 90 d consistently had higher SW, CW, and CY than chickens slaughtered at 75 d. Dal Bosco *et al.* (2014) also observed the direct relationship of age at slaughter and carcass performance in their study.

Although there was no significant difference between leg percentage and diet, there was a significant difference between the composition of legs and treatments. Chickens fed with organic diet tended to have significantly higher bone percentage. Differences in the leg composition can be attributed to the foraging time of the chickens. As stated earlier, chickens fed with organic diet had higher foraging time in the range area. This activity can improve the development of the bone and reduce leg weakness problems (Mikulski *et al.*, 2011). Meanwhile, chickens fed with commercial free-range diet appeared to have significantly higher lean percentage. According to Coban *et al.* (2014), muscle weight is the function of the total number of fibrils, the fibril cross-sectional area, and the fibril length. As for the case of broiler chickens, among animals of the same age, those with a greater muscle weight are considered to have a greater number of fibrils of a greater width and length.

Skin and meat color is one of the first characteristics noticed by consumers when buying meat products. In the market, where carcasses are often marketed whole, the color of the skin plays a particularly important role (Fanatico *et al.*, 2007). The color of the skin and meat of chickens can be affected by feeds. Naturally occurring or supplemented carotenoid pigments that can be found in the feed or roughages accumulate in the skin and meat (Ba Baéza *et al.*, 2022).

Table 3. Carcass characteristics and composition of male White Leghorns fed with organic and commercial free-range diets raised under extensive rearing system

Parameter	75 days		90 days		MoE	Significance		
	Free-range diet	Organic diet	Free-range diet	Organic diet		A	D	A x D
Slaughter weight (kg)	0.96[c]	0.90[d]	1.30[a]	1.14[b]	0.04	**	**	*
Carcass weight (kg)	0.62[c]	0.57[d]	0.89[a]	0.75[b]	0.04	**	**	*
Carcass yield (%)	64.20[c]	62.80[d]	68.20[a]	65.30[b]	1.25	**	**	*
Breast (%)	-	-	23.40	22.90	0.51	-	ns	-
Lean	-	-	52.70	52.10	1.69	-	ns	-
Skin-and-fat	-	-	12.40	13.0	1.06	-	ns	-
Bone	-	-	34.90	34.90	1.57	-	ns	-
Legs (%)	-	-	30.40	30.10	0.41	-	ns	-
Lean	-	-	62.10[a]	59.80[b]	1.14	-	*	-
Skin-and-fat	-	-	10.51	9.94	0.61	-	ns	-
Bone	-	-	27.40[b]	30.30[a]	1.14	-	*	-
Wings (%)	-	-	14.20	14.70	0.53	-	ns	-
Back (%)	-	-	32.00	32.20	0.61	-	ns	-

** – $p < 0.001$; * – $p < 0.05$; ns – not significant; [a,b] – means with different superscript are significantly different ($p < 0.05$); MoE – margin of error at 95% confidence interval; factors: age at slaughter and diet

In the current study, it was found that the older the chicken upon slaughter, the more pigments were observed in the skin, breast, and legs (Table 4). The higher color values in older chickens in the current study are in contrast with the results of Popova *et al.* (2023). Lightness (L^*) and redness (a^*) of the meat are mainly affected by haem protein concentration (myoglobin, haemoglobin, and cytochromes). As the chicken matures, the content of haem pigments increases and the meat becomes redder and darker (Baéza *et al.*, 2022). Significant effects of diet were only observed in the yellowness of skin and leg part. Higher foraging time of chickens fed with organic diets led to an increased consumption of grasses. According to Dal Bosco *et al.* (2016), chickens with greater ability to forage can ingest higher amounts of grasses that can lead to higher consumption and storage of bioactive compounds, such as carotenoids. Ingestion of larger amounts of carotenoid-rich forage by slow-growing chickens provide a higher intensity of yellow color in the meat, resulting in higher *b** values (Faria *et al.*, 2009). Faria *et al.* (2015) reported that SG, free-range males have darker muscle and skin color, such that thigh skin and muscle of SG group chickens were significantly darker (L^*) and breast skin was darker and yellower (b^*) compared with the medium-growing chickens. These results further support the market demands for the free-range products to be yellower and darker as preferred by selective consumers (Almasi *et al.*, 2015).

3.3 Profitability

Feed cost accounts for 70 to 80% of the total production cost in poultry production. Hence, the margin between the returns and feed cost (Table 5) can be used to measure the profitability of raising male layer chickens under free-range system. An MOFC greater than 1 means that the production is profitable. Across rearing period, chicken fed with organic diet had higher MOFC than chickens that received commercial free-range diet. This is because carcass from organic chicken commands higher price than the other group. According to van de Braak (2021), the higher price of male layer chicken can be justified due to the animal welfare label. Therefore, chickens that received free-range diet should be sold at 87 d to gain more profit. On the other hand, chickens fed with organic diet to be sold at 101 d for the same reason.

Table 4. Skin and meat color of male White Leghorns fed with organic and commercial free-range diets raised under extensive rearing system

Parameter	75 days		90 days		MoE	Significance		
	Free-range diet	Organic diet	Free-range diet	Organic diet		A	D	A x D
Skin color								
L* value	78.70	78.60	78.50	79.50	2.16	ns	ns	ns
a* value	6.83	6.02	37.68	35.37	2.82	**	ns	ns
b* value	17.30^{y}	18.00^{x}	63.60^{b}	68.30^{a}	2.35	**	*	ns
Breast color								
L* value	63.30	64.70	93.40	94.50	1.88	**	ns	ns
a* value	12.40	12.00	35.20	35.10	2.10	**	ns	ns
b* value	14.20	14.80	46.50	49.30	4.31	**	ns	ns
Leg color								
L* value	55.70	55.80	56.0	56.80	2.35	ns	ns	ns
a* value	14.40	14.60	60.60	60.00	1.53	**	ns	ns
b* value	8.98^{y}	10.45^{x}	35.91^{b}	41.05^{a}	3.57	**	*	ns

** – $p < 0.001$; * – $p < 0.05$; ns – not significant; ^{a,b} – means with different superscript are significantly different ($p < 0.05$); ^{x,y} – means with different superscript are significantly different ($p < 0.05$); L^{*} – lightness value; a^{*} – redness value; b^{*} – yellowness value; MoE – margin of error at 95% confidence interval; factors: age at slaughter and diet

Table 5. Income over feed cost analysis of male White Leghorns fed with organic and commercial free-range diets raised under extensive rearing system

Parameters	Feed cost per chicken	Value of gain per chicken	Feed cost/kg gain	Margin over feed cost
45 to 87 days				
Free-range diet	92.84	134.20	152.19	41.36
Organic diet	81.44	156.80	166.21	75.36
45 to 101 days				
Free-range diet	137.09	171.60	175.75	34.51
Organic diet	117.39	220.80	170.13	103.41

Assumed liveweight price of free-range chicken = Php 220.00/kg; assumed liveweight price of organic chicken = Php 320.00/kg; price of commercial free-range diet= Php. 36.00/kg; Price of commercial organic diet = Php29.65/kg

4. Conclusion and Recommendation

Overall, chickens fed with commercial free-range diet had significantly better growth and carcass performance. On the other hand, chickens fed with organic diets had significantly yellower skin and lean meat on the leg part. When slaughtered, more matured chickens appeared to have significantly higher carcass traits. Moreover, both diet groups had a high positive margin over feed cost. The study provided information on the profitability of using male White Leghorn for meat production. For future studies, it is recommended to test the performance of other male layer or dual-purpose chicken breeds and strains under extensive rearing system for meat production.

5. Acknowledgement

This work was supported by the Philippine College of Poultry Practitioner, Inc.

6. References

Almasi, A., Andrassyne, B.G., Milisits, G., Kustosne, P.O., & Suto, Z. (2015). Effects of different rearing systems on muscle and meat quality traits of slow- and medium-growing male chickens. British Poultry Science, 56(3), 320-324.

Baéza, E., Guillier, L., & Petracci, M. (2022). Review: Production factors affecting poultry carcass and meat quality attributes. Animal, 16 (Supplement 1). https://doi.org/ 10.1016/j.animal.2021.100331.

Bureau of Agriculture and Fisheries Standards Philippine (BAFS). (2016). National Standard/Bureau of Agriculture and Fisheries Standards (PNS/BAFS) 07:2016: Organic Agriculture. Quezon City, Philippines: Department of Agriculture.

Bureau of Agriculture and Fisheries Standards Philippine (BAFS). (2018). National Standard/Bureau of Agriculture and Fisheries Standards (PNS/BAFS) 262:2018: Free-range Chicken. Quezon City, Philippines: Department of Agriculture.

Buzala, M., & Janicki, B. (2016). Review: Effects of different growth rates in broiler breeder and layer hens on some productive traits. Poultry Science, 95(9), 2151-2159. https://doi.org/10.3382/ps/pew173

Canogulları, S., Baylan, M., Bulancak, A., & Ayaşan, T. (2019). Differences in performance, carcass characteristics and meat quality between fast- and slow-growing broiler genotypes. Progress in Nutrition, 21(3), 558-565. https://doi.org/10.23751/pn .v21i3.7747

Castellini, C., Dal Bosco, A., Mugnai, C., & Pedrazzol, M. (2006). Comparison of two chicken genotypes organically reared: Oxidative stability and other qualitative traits. Italian Journal of Animal Science, 5(1), 29-42. https://doi.org/10.4081/ijas.2006.29

Castellini, C., Mugnai, C., Pedrazzoi, M., & Dal Bosco, A. (2014). Productive performance and carcass traits of Leghorn chickens and their crosses reared according to the organic farming system. Retrieved from http://www.equizoobio.it/downloads/ca stellini_01.pdf

Castellini, C., Mugnai, C., Moscati, L., Mattioli, S., Amato, M.G., Mancinellia, A.C., & Dal Bosco, A. (2016). Adaptation to organic rearing system of eight different chicken genotypes: Behavior, welfare and performance. Italian Journal of Animal Science, 15(1), 37-46. https://doi.org/10.1080/1828051X.2015.1131893

Choo, Y.K., Oh, S.T., Lee, K.W., Kang, C.W., Kim, H.W., Kim, C.J., Kim, E.J., Kim, H.S., & An, B.K. (2014). The growth performance, carcass characteristics, and meat quality of egg-type male growing chicken and white-mini broiler in comparison with commercial broiler (Ross 308). Korean Journal for Food Science of Animal Resources, 34(5), 622-692. https://doi.org/10.5851/kosfa.2014.34.5.622

Coban, Ö., Lacin, E., Aksu, M.I., Kara, A., & Sabucuoglu, N. (2014). The impact of slaughter age on performance, carcass traits, properties of cut-up pieces of carcasses, and muscle development in broiler chickens. European Poultry Science, 78(1). https://doi.org/ 10.1399/eps.2014.60.

Dal Bosco, A., Mugnai, C., Amato, M.G., Piottoli, L., Cartoni, A., & Castellini, C. (2014). Effect of slaughtering age in different commercial chicken genotypes reared according to the organic system: Welfare, carcass and meat traits. Italian Journal of Animal Science, 13(2). https://doi.org/10.4081/ijas.2014.3308.

Dal Bosco, A., Mugnai, C., Mattioli, S., Rosati, A., Ruggeri, S., Ranucci, D., & Castellini, C. (2016). Transfer of bioactive compounds from pasture to meat in organic

free-range chickens. Poultry Science, 95(10), 2464-2471. https://doi.org/10.3382/ps/pev383

Fanatico, A.C., Cavitt, L., Pillai, P., Emmert, J., & Owens, C. (2005). Evaluation of slower growing broiler genotypes grown with and without outdoor access: Meat quality. Poultry Science, 84(11), 1785-1790. https://doi.org/10.1093/ps/84.8.1321

Fanatico, A.C., Pillai, P., Emmert, J., Gbur, E., Meullenet, C.M., & Owens, L.J. (2007). Sensory attributes of slow- and fast-growing chicken genotypes raised indoors or with outdoor access. Poultry Science, 86(11), 2441-2449. https://doi.org/10.3382/ps.2007-00092

Fanatico, A.C., Pillai, P.B., Hester, P.Y., Falcone, C., Mench, J.A., Owens, C.M., & Emmert, J.L. (2008). Performance, livability, and carcass yield of slow- and fast-growing chicken genotypes fed low-nutrient or standard diets and raised indoors or with outdoor access. Poultry Science, 87(6), 1012-1021. https://doi.org/10.3382/ps.2006-00424

Faria, P.B., Bressan, M.C., Souza, X.R., Rodrigues, E.C., Cardoso, G.P., & Gama, L.T. (2009). Physical-chemical characteristics of meat in chickens of the paraiso Pedres and label Rouge Lines. Revista Brasileira de Zootecnia, 38(12), 2455-2464.

Gerken, M., Jaenecke, D., & Kreuzer, M. (2003). Growth, behaviour and carcass characteristics of egg-type cockerels compared to male broilers. World's Poultry Science Journal, 59(1), 46-49.

Giersberg, M.F., & Kemper, N. (2018). Rearing male layer chickens: A German perspective. Agriculture, 8(11). https://doi.org/10.3390/agriculture8110176.

Gordon, S.H., & Charles, D.R. (2002). Niche and organic chicken products. Nottingham, United Kingdom: Nottingham University Press.

Lichovníková, M., Jandásek, J., Jürzl, M., & Dračková E. (2009). The meat quality of layer males from free-range in comparison with fast growing chickens. Czech Journal of Animal Science, 54(11), 490-497.

Lumbo, N.B., Salces, A.J., Oliveros, M.C.R., Nuez, J.A.I.III., Albaladejo, B.H., & Dominguez, J.M.D. (2022). Utilization of male layer chickens (Bovans White and ISA Brown) for meat production under free-ranged system. Philippine Journal of Veterinary and Animal Science, 48(2), 1-17.

Mancinelli, A.C., Amato, M.G., Zilio, D.M., Dal Bosco, A., Mattioli, S., & Castellini, C. (2017). Chicken adaptability in alternative systems adaptive response of chicken strains to the organic and free-range rearing systems. Journal of Dairy and Veterinary Science, 4(4). https://doi.org/10.19080/JDVS.2017.04.555644

Masilang, J.P. (2021). DA pushes free-range chicken industrialization as demand rises. Retrieved from https://ati.da.gov.ph/archives/ati-main/?q=news/06012021-1235/da-pushes-free-range-chicken-industrialization-demand-rises

Michalczuk, M., Łukasiewicz, M., Zdanowska-Sąsiadek, Ż., & Niemiec, J. (2014). Comparison of selected quality attributes of chicken meat as affected by rearing systems. Polish Journal of Food and Nutrition Science, 64(2), 121-126. https://doi.org/10.2478/v10222-012-0096-y

Mikulski, D., Celej, J., Jankowski, J., Majewska, T., & Mikulska, M. (2011). Growth performance, carcass traits and meat quality of slower-growing and fast-growing chickens raised with and without outdoor access. Asian-Australasian Journal of Animal Science, 24(10), 1407-1416.

Mueller, S., Kreuzer, M., Siegrist, M., Mannale, K., Messikommer, R.E., & Gangnat, I.D.M. (2018). Carcass and meat quality of dual-purpose chickens (Lohmann Dual, Belgian Malines, Schweizerhuhn) in comparison to broiler and layer chicken types. Poultry Science, 97(9), 3325-3336. https://doi.org/10.3382/ps/pey172

Mueller, S., Taddei, L., Kreuzer, M., Siegrist, M., Messikommer, R.E., & Gangnat I.D.M. (2020). Growth, carcass, and meat quality of 2 dual-purpose chickens and a layer hybrid grown for 67 or 84 D compared with slow-growing broilers. Journal of Applied Poultry Research, 29(1), 185-196. https://doi.org/10.1016/j.japr.2019.10.005

Murawska, D., Gesek, M., & Witkowska, D. (2019). Suitability of layer-type male chicks for capon production. Poultry Science, 98(8), 3345-3351. https://doi.org/10.3382/ps/pez146

Petkov, E. (2013). Age dynamics of the main zootechnical indicators for three types of male birds. Bulgarian Journal of Animal Husbandry, 1, 20-31.

Popova, T., Petkov, E., Ignatova, M., Vlahova-Vangelova, D., Balev, D., Dragoev, S., & Kolev, N. (2022). Male layer-type chickens – An alternative source for high quality poultry meat: A review on the carcass composition, sensory characteristics and nutritional profile. Brazilian Journal of Poultry Science, 24(3). http://dx.doi.org/10.1590/1806-9061-2021-1615

Popova, T., Petkov, E., Ignatova, M., Vlahova-Vangelova, D., Balev, D., Dragoev, S., Kolev, N., & Dimov, K. (2023). Meat quality of male layer-type chickens slaughtered at different ages. Agriculture, 13(624). https://doi.org/10.3390/agriculture13030624

Philippine Statistics Authority (PSA). (2022). Chicken situation report, January – December 2021. Retrieved from https://psa.gov.ph/content/chicken-situation-report-january-march-2022

RStudio Team. (2020). RStudio: Integrated development for R [Computer software]. Massachusetts, United States: RStudio.

Senbeta, E.K. (2017). Growth performance and rearing costs of Fayoumi and White Leghorn chicken breeds. East African Journal of Science, 11(1), 37-42.

Wang, K.H., Shi, S.R., Dou, T.C., & Sun, H.J. (2009). Effect of a free-range raising system on growth performance, carcass yield, and meat quality of slow-growing chicken. Poultry Science, 88(10), 2219-2223. https://doi.org/10.3382/ps.2008-00423

Van de Braak, T. (2021). The brother males. Retrieved from https://layinghens.hendrix-genetics.com/en/news/Growing-the-brother-males-instead-of-culling-them-as-day_old_chicks/

Yan, G. (2019). Why free-range is booming in the Philippines. Retrieved from https://www.thepoultrysite.com/articles/why-free-range-is-booming-in-the-philippines