Global Business and Management Research: An International Journal
Vol. 15, No. 1 (2023)

Feed Conversion Ratio (FCR) and Cumulative Weight Gain (CWG) of Organically Farmed Chicken Meat Production in Malaysia: 6 Different Diet Treatments Approach

Wong Yuen Hwa*
Universiti Tunku Abdul Rahman (UTAR),
Sungai Long Campus, 43000 Kajang, Selangor Darul Ehsan, Malaysia
Email: evawong@1utar.my

Khin, Aye Aye
Universiti Tunku Abdul Rahman (UTAR),
Sungai Long Campus, 43000 Kajang, Selangor Darul Ehsan, Malaysia

Lim Chee Seong
Universiti Tunku Abdul Rahman (UTAR),
Sungai Long Campus, 43000 Kajang, Selangor Darul Ehsan, Malaysia

Toong Foo Weng
Managing Director, Bintang Maju Agri Sdn. Bhd.,
43500 Semenyih, Selangor Darul Ehsan, Malaysia

* *Corresponding Author*

Abstract
Purpose: Malaysia has one of the highest rates of poultry consumption in the world. Hence, optimal chicken growth performance is important to ensure Malaysia's poultry consumption can be met. This study aimed to measure the Cumulative Voluntary Feed Intake (CVFI), Cumulative Weight Gain (CWG), Average Daily Gain (ADG) and Feed Conversion Efficiency (FCE) based on the 6 different diet treatments for the growth performance of the organically farmed chicken meat production in Malaysia.
Design/methodology/approach: A total of 3,600 data replications were obtained, i.e. 50 chicken x 6 different diet treatments x 12 weeks in Completely Randomized Design (CRD) of ONE (1) production cycle at Sungai Lalang, Semenyih in Malaysia. The 6 diet treatments chosen for the research are Premium Starter Feed (Treatment 1), Treatment 2, 3, 4, 5, 6 which are Pokok Ketum Ayam (*Trichanthera gigantean*), Protein Larva Askar Hitam (BSFL), Crude Palm Kernel Oil (CPKO), Organic Acid and Yellow Pigment (Brand: SK Gold) mixed into Premium Starter Feed, respectively.
Findings: The results revealed that average CVFI for all treatments increased when the chicken grew from week 1 to week 12. The CWG for total 12 weeks and ADG for Treatment 6 are the highest among the 6 different treatments. Treatment 5 has the best Feed Conversion Efficiency (FCE). This study helps the organic chicken farmers to find out the optimal diet treatments, i.e. Treatment 5 and 6 are superior than other treatments and are proved in this study to have improved chicken growth performance. The results for this study can be used to increase the profitability of the chicken farmers in Malaysia.

Research limitations/implications: This study only focused on the chicken growth performance based on the 6 different diet treatments. The findings of this study were obtained from research in a chicken farm only.
Practical implications: This information from the study can be used to improve the chicken growth performance and subsequently the profitability aspect of the business of the chicken farmers who are in the chicken meat production.
Originality/value: The research model is based on the approach and methodology mentioned in the study.

Keywords: Cumulative Voluntary Feed Intake; Cumulative Weight Gain; Average Daily Gain; Feed Conversion Efficiency; Organically Farmed Chicken Meat Production

Introduction

Chicken is one of the most affordable and widely eaten sources of protein in Malaysia. Its consumption in Malaysia is one of the highest in the world. In 2019, the chicken consumption in Malaysia (48.75kg per capital) was above the OECD average of that year (Statista, 2021). Organic chicken, i.e. Kampung chicken, is much in demand as the trend of eating healthy is increasing dramatically; health-conscious consumers today want their chicken meat to be safe and free of antibiotics, growth hormones and other substances which are commonly used in conventional poultry farming (Murugesan, 2018). The organic chicken is lean meat which generally has 30% less fat than normal chicken and is rich in Omega 3. However, it takes twice as much time to produce organic chicken compared to conventional broiler chicken (Murugesan, 2018). This limits the meat production of organic chicken compared to conventional broiler chicken. In addition, due to Movement Control Orders (MCOs) during COVID-19 pandemic, the normal production capacities of chicken food processing factories have reduced which caused the chicken production to slow down. The feed ingredients to the chicken increased in price which causes the chicken price to increase too (Malaysia Gazett, 2021). Hence, there is an urgent need to source solutions for local organically farmed farmers to increase chicken production with the least feed ingredients. It is important for the farmers to adopt a feeding strategy that is most effective to achieve optimized chicken weight. Many studies have shown that different types of diet systems have significant impact on the chicken growth performance (Tajede & Kim, 2021; Abdelatty, et al, 2021; Libatique, 2021; Simenesh, 2019). Therefore, this study aimed to assess which diet treatment is the most effective for the growth performance of the organic chicken and determine the optimum level of the feeding strategy for the treatments.

Literature Review

Chicken Growth Performance

The body of the chicken consists of a large number of cells that are about the same size in all breeds, regardless of ultimate mature body weight. Most early embryonic increases in growth occur as the result of cell multiplication: 1 cell divides into 2, 2 into 4, 4 into 8, 8 into 16, and so on. But this rhythmic increase does not continue indefinitely. Soon there is cell specialization which is necessary to form different body components (Weaver, 2002).
Weaver (2002) mentioned that growth rate and rate of division among the various specialized cells varies depending on function and age. The older the chick, the lower the daily increments of increased body weight. After hatching, when the number of muscle fibers (single cells) no longer increases, growth of muscle and nerve cells is the result of cell enlargement rather than cell division. Muscle fibers have a maximum dimension, controlled mainly by the genetic makeup of the chick, but can decrease or increase in size with carrying

amounts of activity. Both protein synthesis and protein degradation are involved. Both synthesis and degradation operate simultaneously, with the net result determining whether muscles increase or decrease in size. The muscles of the breast are exceptionally well developed in chicken because these muscles are used to move the wings during flight.

The degree of fatness of chicken rests entirely on the number of fats containing cells. Some breeds and lines of chickens have a greater number of fat cells than others, an indirect consequence of breeding chicken for larger sizes and plumper carcasses. Fat cells reach their maximum number in the early growing period. The ability of a broiler to gain weight rapidly is principally the result of fat deposits in the fat cells rather than increases in the growth of the skeleton or muscle fibers.

For chicken growth performance, Morbos et al. (2016) have identified 4 formulas to determine the growth performance of Philippines native chicken. The four (4) formulas are (1) Cumulative Voluntary Feed Intake (CVFI) (2) Cumulative Weight Gain (CWG) (3) Average Daily Gain (ADG) (4) Feed Conversion Efficiency Ratio (FCE).

Based on the research by Morbos et al., (2016), the voluntary feed intake was influenced by genotype and body size. When the size of the body increases, the feed intake will be more. Also, based on research paper done by Magala, Kugonza, Kwizera, & Kyarisiima (2012), they found out that larger size chicken showed much higher voluntary feed intake compared to smaller sizer chicken throughout the growing period. Large-sized chicken tends to require more dietary nutrients than their small-sized counterparts.

Cumulative Weight Gain (CWG) is the net difference of the body weight of an animal over a period of time. It is calculated in the gram unit. Looking at research findings, when CVFI is higher, the chickens tend to also grow faster.

Average Daily Gain (ADG) is the average weight gain for an animal per day. It is calculated in the gram unit. Similar to the CWG, males show higher ADG than female for the same reason, sexual dimorphism and higher voluntary feed intake level. This finding is supported by Ndegwa, Mead, Shephered, Kimani, & Wachira (2012) who said that cockerels generally grow faster than pullets and show a better response to high dietary protein levels.

Feed Conversion Efficiency Ratio (FCE) is how much voluntary feed is taken per gramme increase in the weight over a period of time. It is calculated in the gram unit. Hardy & Kaushik (2021) and Bestil (2001) mentioned that the smaller the value of FCE, the more efficient it is. It should be noted that as chickens grow older, they become more efficient in utilizing feed containing protein (Morbos, et al., 2016).

Materials and Method

Preparation of the treatment systems (hereinafter called "TS")*:* The feeding ingredients will be mixed using a mixer to ensure the uniformity of the feeding samples. 6 treatments are as follows: (Treatment 1-T1) Premium Starter Feed in 50kg pack. (Treatment 2-T2) 5-10% Pokok Ketum Ayam (*Trichanthera gigantean*) mixed into Premium Starter Feed (Treatment 3-T3) 5-10% Protein Larva Askar Hitam (BSFL mixed into Premium Starter Feed (Treatment 4-T4) 200g Crude Palm Kernel Oil (CPKO) mixed into 50kg Premium Starter Feed (Treatment 5-T5) 100g Organic acid mixed into 50kg Premium Starter Feed and (Treatment 6-T6) 100g Yellow Pigment (Brand: SK Gold) mixed into 50kg Premium Starter.

T1 is the basic feed as it is among the most popular feed for poultry farmers. Adding Pokok Ketum Ayam into the poultry diet, i.e. T2 was found to have positive results to increase chicken body weight (Morbos, et al., 2016). The leaf is known to contain soluble carbohydrates with true protein with low level of anti-nutritional factors that are highly palatable to animals (Hess & Dominguez, 1998). T3 was introduced to the research as there is a growing amount of literature and experts recognize that using insect meals in feed formulation could be a novel way to improve feed (Kouˇrimská, 2016; Van, 2013). It has been established by researchers that insects have a high content of protein, essential amino acids, minerals and vitamins (Spranghers, et al., 2017). T4 is to introduce oils into the chicken diet. Dietary oils have been proven to have high caloric value and thus provide increased energy levels at a lower cost (Abdulla, et al., 2017; Baiao & Lara, 2005). It can improve the absorption of oil-soluble vitamins, increase the palatability of rations and allow for efficient absorption of the nutrients (Baiao & Lara, 2005; Chwen et al., 2013). T5 is to include organic acid to the feed as it has been proven to be effective substitute for antibiotic growth promoters and seem to elicit a positive response in growth performance (Khan & Iqbal, 2015). T6 is a new technology made using stearin derived from the patented first cut cold process that preserves the natural nutrients available from palm oil especially beta carotene and Vitamin E. It is believed by the manufacturer to increase available energy, highly palatable, improve growth performance and feed efficiency (Palma Tech, 2021).

Treatment 1 (T1) **Treatment 2 (T2)** **Treatment 3 (T3)**

Treatment 4 (T4) **Treatment 5 (T5)** **Treatment 6 (T6)**

Source: Pictures from the chicken farm

The research study was conducted in a chicken farm, in Sungai Lalang, Semenyih in Malaysia. A total of 300 chickens were used for the study, i.e. 50 chickens for each block were selected randomly and fed with each TS for the total duration of 12 weeks. Feed was supplied twice daily, morning and afternoon. Fresh, cool and clean drinking water was made available at all the times. The chicken weight and feed information (data) were taken every Friday at the farm from 07/01/2022 to 01/04/2022 (12 weeks, ONE (1) production cycle). Data analysis was tested by Eviews version 12 by simple linear regression analysis for week by week compared average values with CVFI and CWG. The experimental site was properly lighted at night to stimulate feed consumption and fenced to separate the chicken group fed with different TS. Using the FOUR (4) formula (Morbos et al., 2016) for body weight of chicken at i^{th} period of measurement as follows:

1. Cumulative Voluntary Feed Intake (CVFI): This was calculated as
   $$CVFI,\ g = \frac{Total\ Feed\ Given - Feed\ Refused}{Number\ of\ Birds}$$ **Equation (1)**

2. Cumulative Weight Gain (CWG): The CWF of the chicken was calculated as
   $CWG,\ g = BW_i - BW_0$ **Equation (2)**

   Where: BW_i= body weight of chicken at i^{th} period of measurement
   BW_0 = initial body weight

3. Average Daily Gain (ADG), g: The was computed using the following formula.
   $$ADG,\ g = \frac{Final\ live\ weight - Initial\ Weight}{Feeding\ days}$$ **Equation (3)**

4. Feed Conversion Efficiency (FCE): The was calculated.
   $$FCE = \frac{CVFI}{BWi - BW0}$$ **Equation (4)**

   Where: CVFI = the cumulative voluntary feed intake of chicken
   BW_i= body weight of chicken at i^{th} period of measurement
   BW_0 = initial body weight

Findings

Table 1: Cumulative Voluntary Feed Intake, g (CVFI) for 1 chick fed with 6TS

TS	Week						
	1	**2**	**3**	**4**	**5**	**6**	**7**
1	175	245	345	450	525	575	620
2	175	240	340	450	525	570	615
3	180	240	340	445	525	575	615
4	170	240	340	445	520	570	615
5	155	220	320	415	485	535	585
6	160	225	325	415	490	555	605
Average	169.2	235.0	335.0	436.7	511.7	563.3	609.2
p-value	0.00	0.00	0.01	0.22	0.83	0.63	0.27
R2	0.797	0.654	0.647	0.022	0.001	0.003	0.018

TS						Total (1 -12)
	8	9	10	11	12	
1	660	700	715	730	735	6475
2	655	695	710	720	730	6425
3	660	695	710	725	730	6440
4	655	700	710	725	730	6420
5	615	645	665	675	685	6000
6	645	675	700	715	720	6230
Average	648.3	685.0	701.7	715.0	721.7	6331.7
p-value	0.10	0.03	0.02	0.01	0.01	
R2	0.039	0.639	0.639	0.641	0.807	

*Note: the above weight is the average weight for 50 chicken samples per treatment.
Source: Own data analysis

Table 2: Average Cumulative Weight Gain, g (CWG) for 1 Chick Fed with 6 TS

TS	Week						
	1	2	3	4	5	6	7
1	90.8	108.4	105.2	117.2	167.2	265.2	230.0
2	90.6	85.4	112.8	188.4	119.2	270.0	236.0
3	93.0	97.8	106.8	158.8	141.6	172.0	251.0
4	88.8	96.8	95.2	158.4	181.2	237.6	216.0
5	90.2	105.0	96.0	147.6	153.6	287.8	259.2
6	89.8	110.6	88.8	123.6	193.6	283.8	264.2
Average	90.5	100.7	100.8	149.0	159.4	252.7	242.7
p-value	0.00	0.00	0.00	0.10	0.19	0.06	0.13
R2	0.796	0.643	0.636	0.039	0.024	0.048	0.032

TS	Week					Total (1 -12)
	8	9	10	11	12	
1	304.4	256.0	225.6	232.0	263.0	2365.0
2	307.0	249.2	235.8	240.0	268.2	2402.6
3	289.6	254.4	223.2	209.2	226.8	2224.2
4	352.4	237.6	244.0	198.0	270.6	2376.6
5	324.8	277.2	160.8	242.8	285.0	2430.0
6	332.2	256.0	198.2	243.6	277.6	2462.0
Average	318.4	255.1	214.6	227.6	265.2	2376.7
p-value	0.00	0.05	0.58	0.32	0.02	
R2	0.645	0.052	0.004	0.014	0.807	

*Note: the above weight is the average weight for 50 chicken samples per treatment.
Source: Own data analysis

Table 3: ADG and FCE for 1 Chick Fed with 6 TS

Treatment	Average Daily Gain, g for 1 Chick	Feed Conversion Efficiency
1	28.155	2.74
2	28.602	2.67
3	26.479	2.90
4	28.293	2.70
5	28.929	2.47
6	29.310	2.53

Source: Own data analysis

Discussion and Conclusion

Cumulative Voluntary Feed Intake (CVFI): As shown in Table 1, the average CVFI for all treatments increased when the chicken grew from week 1 to week 12. The average CVFI has significant relationship with the duration of feed ($p < 0.01$). This is supported by Ferket et al. (2006) that chicken weight gain is highly dependent on the feed intake. CVFIs are particularly significant effective for all treatments from week 1 to 3 and week 9 to 12 ($p < 0.05$). It shows that CVFIs are effectively significant to chicken meat production during early weeks and late weeks (Willemsen, et al., 2010). T1 and T3 have the highest in total CVFI among all the treatments for total 12 weeks (see Table 1). High CVFI for T3 is in line with study by Marco (2020) that found T3 to have higher feed conversion that requires more feed.

Cumulative Weight Gain: As shown in Table 2, T5 and T6 produced the highest weight chicken while T3 produced the lowest among all treatments over a 12 weeks' period. T2, T4, T5 and T6 produced higher weight chicken compared to T1 which is the normal feed. The average CWG for all treatments has significant relationship with the duration of feed ($p < 0.01$). However, the study shows that the CWGs are not significant for all treatments from week 4 to 7 and 9 to 11. There seems to be no standard specific relationship or no significant effectively increase for CWG with these 6 different feed systems for those particular periods. The chicken body weight is also affected by many factors such as genotype, environment and nutrient supplied (Samadi, 2006, Marco, 2020).

Average Daily Gain: Table 3 shows that the T5 and T6 produced the highest average daily gain while T3 produced lowest average daily gain for the chicken body weight. The results suggested that T2, T4, T5 and T6 are effective in increasing the growth of chicken body weight compared to normal feed (Morbos, et al., 2016, Abdulla, et al., 2017, Khan & Iqbal, 2015, Palma Tech, 2021).

Feed Conversion Efficiency: Feed conversion efficiency (FCE) is "feed per gain" ratio, measured in terms of the amount of feed required to produce a unit of weight gain. The smaller the value, the more efficient it is (Hardy, et al, 2021). Tables 3 show FCR ranging from 2.47 to 2.90. This is in line with the FCE of 2.5 mentioned by Garhukar (2016). However, lesser feed ingredients required for T5 compared to 5 other treatments. T6 is found to be second more efficient compared to T1 to T4. T3 is found to be the least effective in FCE among these 6 different treatment systems.

In conclusion, the use of Organic acid, and Yellow Pigment (Brand: SK Gold), i.e. T5 and T6 are found to be effective in feeding strategy based on CWG, ADG, CVFI and FCE. Chicken fed with T5 and T6 have the highest growth in body weight over 12 weeks' period with the least feeding ingredient. This study helps the organic chicken farmer to get more chicken meat production by using the more effective feeding strategy, i.e. T5 and T6.

References

Abdelatty, A. M., Mandouh, S. A., Mohamed, S., Busato, O. A., Badr, M., Bionaz, A. A., . . . Al-Mokaddem, A. (2021). Azolla leaf meal at 5% of the diet improves growth performance, intestinal morphology and p70S6K1 activation, and affects cecal microbiota in broiler chicken. *Animals, 15(10)*. doi:10.1016/j.animal.2021.100362

Abdulla, N. R., Loh, T. C., Akit, H., Sazili, A. Q., Foo, H. L., Kareem, K. Y., & Abdul Rahim, R. (2017). Effects of dietary oil sources, calcium and phosphorus levels on growth performance, carcass characteristics and bone quality of broiler chickens. *Journal of Applied Animal Research, 45(1)*, 423-429.

Baião, N. C., & Lara, L. J. (2005). Oil and fat in broiler nutrition. *Brazilian Journal of Poultry Science, 7*, 129-141.

Bestil, L. (2001). Performance of broilers fed low-protein diets with lysine and methionine supplementation. *19 Annual Scientific Seminar and the Convention.* Phillipines.

Chwen, L. T., Foo, H. L., Thanh, N. T., & Choe, D. W. (2013). Growth performance, plasma fatty acids, villous height and crypt depth of preweaning piglets fed with medium chain triacylglycerol. *Asian-Australasian journal of animal sciences, 26(5)*, 700.

Ferket PR, et al. (2006). Factors that affect feed intake of meat birds: A review. *Int J Poult Sci.* 2006; 5(10):905–11

Garhukar, R. T (2016). Insects as Sustainable Food Ingredient. *Production, Processing and Food Applications. Academic Press*.

Hardy, R. W., & Kaushik, S. J. (2021). *Fish nutrition.* Academic press.

Hess, H.D. & Domingues, J.C. (1998). Leaves of as a Trichanthera gigantea nutritional supplement for sheep. *PasturasTropicales*. 20(3): 11-15.

Khan, S. H., & Iqbal, J. (2015). Recent advances in the role of organic acids in poultry nutrition. *Journal of applied animal research, 44(1)*, 359-369. doi:10.1080/09712119.2015.1079527

Kouřimská, L., & Adámková, A. (2016). Nutritional and sensory quality of edible insects. *NFS journal, 4*, 22-26.

Libatique, F. (2021). Growth Performance, Blood Dynamics and Sensory Characteristics of Broilers Fed with Madre de Agua (Trichanthera gigantea) Leaf Meal. *The Journal of Emerging Research in Agriculture, Fisheries and Forestry, 2(1)*.

Magala, H., Kugonza, D. R., Kwizera, H., & Kyarisiima, C. C. (2012). Influence of management system on growth and carcass characteristics of Ugandan local chickens. *Journal of Animal Science Advances, 2(6)*, 558-567.

Marco, et al (2020). Black Soldier Fly Larvae Adapt to Different Food Substrates through Morphological & Functional Responses of the Midgut. *International Journal of Molecular Sciences*

increases by 70%? Retrieved January 3, 2022, from Malaysia Gazette: https://malaysiagazette.com/2021/11/16/how-sell-chicken-cheap-when-price-feed-increases-70/

Meera Murugesan. (2018, September 24). *Fresh from the farm*. Retrieved from New Straits Times: https://www.nst.com.my/lifestyle/heal/2018/09/414308/fresh-farm

Morbos, C. E., Espina, D. M., & Bestil, L. C. (2016). Growth performance of Philippine native chicken fed diet supplemented with varying levels of madre de agua (Trichanthera gigantea Nees) leaf meal. *Annals of Tropical Research, 38(1),* 176-184.

Ndegwa, J. M., Mead, R. N., Shephered, D. D., Kimani, C. W., & Wachira, A. M. (2012). Growth characteristics of six reciprocal crosses of Kenyan indigenous chicken. *Journal of Agricultural Science, 4(6)*, 160.

Palma Tech. (2021). SK Gold 1000 Product Brochure.

Samadi, L.F (2006). Estimation of Nitrogen Maintenance Requirements and Potential for Nitrogen Deposition in Fast- Growing Chickens Depending on Age & Sex. 85: 1421 -1429

Simeneh, G. (2019). Review on the effect of feed and feeding on chicken performance. *Animal Husbandry, Dairy and Veterinary Science, 3(4)*, 1-4.

Spranghers, T., Matteo, O., Cindy, K., Anneke, O., Stefaan, D., Bruno, D. M., . . . Stefaan, D. S. (2017). Nutritional composition of black soldier fly (Hermetia illucens) prepupae reared on different organic waste substrates. *Journal of the Science of Food and Agriculture, 97(8)*, 2594-2600.

Tejeda, O., & Kim, W. (2021). Role of Dietary Fiber in Poultry Nutrition. *Animals, 11(2),* 461. doi:10.3390/ani11020461

Statista. (2021). Retrieved from Number of chickens worldwide from 1990 to 2020(in million animals): https://www.statista.com/statistics/263962/number-of-chickens-worldwide-since-1990/

Statista. (2021). Retrieved from Meat consumption worldwide from 1990 to 2021, by meat type: https://www.statista.com/statistics/274522/global-per-capita-consumption-of-meat/

Van Huis, A. (2013). Potential of insects as food and feed in assuring food security. *Annual review of entomology, 58,* pp. 563-583.

Weaver, W. J. (2002). *Commercial Chicken Meat and Egg Production* (5th Edition ed.). New York: Springer Science + Business Media.

Willemsen, H., Debonne, M., SWENNEN, Q., Everaert, N., Careghi, C., Han, H., & Decuypere, E. (2010). Delay in feed access and spread of hatch: importance of early nutrition. *World's Poultry Science Journal, 66(2)*, 177-188.