Effect of different energy to protein ratios in starter diet with dehydrated food waste, superworms and unfertilized eggs on growth performance of village chickens

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Abstract

A study was conducted using 144 day-old chicks of Arabian strain village chicken to determine the effect of dietary protein and energy ratios in starter diets with dehydrated food waste, superworms and unfertilized eggs on growth performance in closed confinement system. Dehydrated food waste was the main energy source, superworms and unfertilized eggs were the main protein sources. Six experimental diets were formulated to have 3 energy to protein ratios (134, 150 and 164) with 150 energy to protein ratio as the control.. Every ratio had two different protein sources with the same inclusion level. Each treatment had 2 replicates with 12 birds each in a complete randomized design. Feed and water were provided *ad libitum* from 0 - 42 d. Proximate analysis of the main ingredients in the diet showed dehydrated food waste had 4,500.54 kcal/kg of gross energy and 25.18% of crude protein while superworms and unfertilized eggs had crude protein of 46.54 and 46.33%, respectively. The study showed that a single diet of energy:protein ratio of 134 kcal ME/kg protein supported optimum growth rate of Arabian strain village chicken from 1 to 42 d of rearing. Feed conversion ratio improved with increasing dietary energy level. These findings have implications on ration formulation for village chickens in Malaysia.

Keywords: energy to protein ratio, village chicken, dehydrated food waste, superworm, unfertilized egg, starter diets

Introduction

The most important trait in poultry production is the efficient utilization of nutrients from feedstuffs as the feed cost is one of the major components of total cost of production. According to Henrich and Steinfield (2007), feed alone contributed about 60 -70 % of the total cost of poultry production. The efficient use of feed is extremely important in poultry production (Attia *et al.*, 2012). Thus, correct formulation of rations is very important to fulfill all the nutrient requirements of the chickens.

The right relationship among nutrients of the feedstuffs requires a good knowledge of needed concentration of energy to protein ratio. In poultry production, it is very important to evaluate the ratio between metabolic energy and protein in the diets. Today’s trend is to reduce protein in the feedstuffs and on the other side to maintain an appropriate level of amino acids in order to optimize the performance (Aftab *et al.*, 2006).

Most of organic food waste and agricultural by-products can be converted into poultry feeds. These unconventional feed materials can reduce feeding cost and at same time recycle the waste materials and reduce pollution problem. Nearly 1.5 billion tons of spoiled and uneaten foods around the world were disposed each year (Park, 2012). By proper processing these waste materials can be utilized efficiently. The use of agricultural by-products, wet food waste, insect meal, unfertilized eggs and other organic materials can be considered as alternative sources of protein-energy rich poultry feed. However, the time-consuming nature of the processing work, low feed efficiency, nutrient imbalance, poor environmental hygiene and the difficulty of disease prevention, make feeding wet food waste to poultry unpopular (Cho, *et al*., 2004). The result of processed wet food wastes into dehydrated food waste product showed some advantages in growth performance, carcass traits and nutrient digestibility of Taiwan native chicken (Chen *et al.,* 2007). The objective of the present study was to evaluate the growth performance of village chicken during the starter growing period fed with different energy:protein ratios containing dehydrated food waste, superworms and unfertilized eggs.

Materials and Methods

Animals and study design

A total of 144 day-old chicks of Arabian strain village chickens were used in the experiment. Upon arrival, the chicks were tagged with wing band individually and supplied with anti-stress (VP 1000). Up to 3 d of age, the chicks were vaccinated against Newcastle Disease and Infectious Bronchitis by intraocular route. The birds were individually weighed and randomly divided into 6 treatment groups. According to the treatment groups, the chicks were arranged in completely randomized design. Each treatment group consisted of 2 replicates of 12 chicks per replicate. The chicks were randomly allocated into wire cages (87 x 122 x 45 cm) and kept at natural lighting until 42 d of age. Temperature and management were maintained according to the conventional brooding rearing practice. Light was provided 24 h daily during the first 21 d of growth. Feed and fresh water were supplied *ad-libitum* during the experiment.

Feedstuffs and feeding management

Dehydrated food waste (DFW) used in this experiment was the main energy source. The food wastes were collected from restaurants in Universiti Putra Malaysia Serdang campus. All food waste was collected from halal food source daily, in early morning. Then, the fresh food waste were cleaned to remove the prominent foreign materials such as plastic materials, spoons, straws, paper tissues and other inorganic wastes. “Clean” food waste were then soaked in hot water at > 90°C - <100°C for 10 min. Waste water with oil were removed via a filter bed. The waste were dried and ground into mashed form of DFW. DFW were then developed into suitable poultry diets. The diets were analyzed for their proximate composition according to AOAC (1997).

Common superworms (*Zophobas morio*) and unfertilized egg (UFE) were the protein supplements in this experiment. Dried superworm –(DSW) and UFE were processed, dried in the oven at 30 to 40ºC, ground and used as additional protein sources for poultry feed.

Six experimental diets were formulated to provide similar nutrient content according to the broiler nutrients requirement of NRC (1994), with different energy:protein (E:P) ratios (Table 1). These diets consisted of three E:P ratios: 134, 150 and 164, with 150 energy to protein ratio as the control. Dehydrated food waste was the main energy source, superworms and unfertilized eggs were the main protein sources. Each ratio had 2 different protein sources. The experimental diets in mashed form contained DFW, rice bran, DSW, UFE and fishmeal (Table 1). Feed and water were provided *ad libitum* throughout the experimental period.

Diets formulated were Diet 1: EP150:1 (DFW+Fishmeal), Diet 2: EP164:1 (DFW+DSW), Diet 3: EP164:1 (DFW+UFE), Diet 4: EP150:1 (DFW+DSW+UFE), Diet 5: EP134:1 (DFW+DSW) and Diet 6: EP134:1 (DFW+UFE). In all treatments DFW was fixed at 50% inclusion level and percentage of rice bran, DSM, UFE and fishmeal were adjusted to obtain the desired E:P ratio. Diet 1 was the control diet with the main ingredients of DFW, rice bran and fish meal.

Feed sample analysis

The content of moisture (MC), dry matter (DM), crude protein (CP), crude fat, crude fiber (CF) and ash were analyzed according to the methods of Association of Official Analytical Chemists (AOAC, 2005). The samples analyzed were DFW, DSW, UFE and the formulated feed rations. The ash content of the feeds was determined by furnace at 550ºC for 3 h. The metabolizable energy of the diets was calculated according to NRC (1994).

Data collection

Individual body weight (BW) and feed intake (FI) per replicate were recorded weekly. FCR was calculated as total feed intake divided by weight gain. No mortality occurred during the experimental period. FI was calculated as follows:

$$\text{FI (g)} = W1\ (g) - W2\ (g)$$

where W1 = total weight of feed given to chicken (g) and W2 = total weight of residual feed (g)

Statistical analysis

Data were subjected to analysis of variance using the General Linear Model procedure (SAS, 2003). The Duncan multiple range test was used to separate treatment means that were significantly different at 5% level of significance.

Table 1: Nutrient composition of experimental diets

Ingredients	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6
DFW (%)	50	50	50	50	50	50
Rice bran (%)	40	45	45	37	35	35
Fishmeal (%)	8	1.5	1.5	4	5	5
DSW (%)	0	1.5	0	3.5	8	0
UFE (%)	0	0	1.5	3.5	0	8
CPO (%)	1	1	1	1	1	1
Limestone (%)	0.5	0.5	0.5	0.5	0.5	0.5
Vitamin Premix (%)	0.2	0.2	0.2	0.2	0.2	0.2
Mineral Premix (%)	0.2	0.2	0.2	0.2	0.2	0.2
Salt (%)	0.1	0.1	0.1	0.1	0.1	0.1
Calculated analysis						
ME (kcal/kg)	3248.74	3157.63	3157.63	3254.98	3005.62	3005.62
CP (%)	21.56	19.22	19.22	21.70	22.38	22.38
ME:CP	150:1	164:1	164:1	150:1	134:1	134:1

Results and Discussion

DFW had the lowest MC compared to DSW and UFE with DFW having the highest ($p<0.05$) ash content than DSW and UFE (Table 2). Dehydrated food waste had the lowest ($p<0.05$) CP than DSW and UFE. CF was significantly different among the major feed ingredients ($p<0.05$). CF of the DSW was the highest followed by DFW. The crude fat content was significantly different among the ingredients ($p<0.05$). Crude fat of the DSW was the highest followed by DFW and UFE.

During the 42-d growing period, body weight gain, feed intake and feed conversion ratio of the village chickens were significantly affected ($p<0.05$) by the dietary regimes (Table 3). The final live weight was the highest ($p<0.05$) for chickens fed with UFE (348.33±12.5 g) with 134 kcal/kg protein ratio and lowest for diet containing combination of DSW and UFE (219.92±8.82 g) with the ratio 150 kcal/kg energy:protein ratio. The body weight gain also followed a similar trend as live weight. However, chickens offered diets having 150 (control) and 164 kcal/kg energy:protein ratios (with DSW and UFE) had similar ($p>0.05$) growth rate. Maximum feed intake was observed in birds with the ratio 134 kcal/kg for diet containing DSW and UFE. Feed consumption was low ($p<0.05$) with the ratio 150 kcal/kg (Control and combination protein of DSW and UFE diets). Chickens offered a diet having 150 kcal/kg energy:protein ratio in diet with fishmeal had lower ($p<0.05$) feed conversion ratio than those on diets having 134 and 164 kcal/kg E:P ratios. Chickens offered diets having 134 kcal/kg for diet with DSW and diet with UFE had highest ($p<0.05$) feed conversion ratio.

The results from the proximate analysis showed DSW and UFE had high CP compared to DFW. This is because DSW and UFE are pure animal proteins. They are also complete protein as they can supply all the essential amino acids including the most lacking amino acids in plant sources such as tryptophan, methionine, isoleucine and lysine (Mader, 2012). The CP of DSW showed lower (46.54%) than 50.05% reported by Nespati (2012) and 47.43% reported by

Abdul Rahman Jabir *et al*. (2011). The CP in UFE was higher than that (38.2%) reported by Al-Harthi *et al*. (2010). The CP in DFW was higher than that reported by Chen *et al*. (2007) of 15.79%. This could be due to the variability of the substances in the fresh food waste that had been used.

The crude fat content in the DFW was 20.38%. This value is in agreement with Rosmadi (2012) who reported DFW had crude fat content ranging from 19 to 21%, but this value is not in agreement with Chen *et al*. (2007) who stated that DFW had 15.98% of crude fat. This result may be caused by the fat source of DFW. The fat source is derived from the cooking styles of the food waste such as use of coconut milk. The processing method can affect the value of the crude fat. In this study the processing method included the removal of fat and oils during the process of soaking of food waste in the hot water. DSW had lower crude fat content of 36.40% compared with 40.01% as reported by Jabir *et al.* (2011). The fat content in the UFE was 28.6%. This value is in agreement with Al-Harthi *et al*. (2010) that UFE had crude fat ranging from 26.1 to 28.6%. The CF content in DSW was 9.5%, but this value is not in agreement with Finke (2012) who reported lower FC of 2.12% on DM basis. The crude fibers found in DSW mostly come from their feed (such as oats, wheat, and rice bran). In eggs also there is no crude fiber detected. This is because, eggs are animal tissues mainly comprising of pure protein.

This experiment was designed to have high and low dietary energy to protein ratios. In this study, differences were observed between different dietary energy to protein ratios on growth performance of chicks. Differences in performance are expected since it is known that alteration in dietary energy to protein ratio will result in differences in animal performance. It is important to maintain the energy to protein ratio as both nutrients play a prominent role in the performance of broiler chickens (NRC, 1994; Aftab *et al*., 2006). An ideal range of ME : protein ratio is 132:1 to 155:1 for broiler chickens and it was suggested that this ratio could be lowered to between 155 and 195 or 10% of the recommended levels when broilers are fed low crude protein concentration (Aftab *et al*., 2006). Results of the present study indicated that dietary energy to protein ratio had significant effect on growth rate, feed conversion ratio and live weight of village chickens. A single dietary energy to protein ratio of 134 kcal/kg was optimal for feed intake and growth rate of the chickens. Results of the present study generally agree with several studies which indicated that the ideal range of energy:protein ratio would result in improved growth performance and reduced cost of production (Temin *et al*., 2000 and Nguyen and Bunchasak, 2005). Similarly, Magala (2008) found that Uganda local chickens showed better growth performance and feed conversion ratio when fed a diet of 21% CP and 3000 kcal/kg ME as opposed to those fed a diet of 16% CP and 2700 kcal/kg ME. All these findings indicate the importance of balancing the energy to protein ratio when formulating poultry diets. However, these observations are contrary to the findings of Ndegwa *et al*. (2001) who found no difference in growth performance of indigenous chickens when dietary energy to protein ratio of the feed was changed by increasing the diet crude protein content from 17 to 23%.

Table 2: Nutritional value of the feed ingredients (on DM basis)

Component	DFW[1]	DSW[2]	UFE[2]
Moisture (%)	9.03^{a}±0.21	12.19^{b}±0.26	12.56^{b}±0.27
Crude protein (%)	25.18^{a}±0.45	46.54^{b}±0.03	46.33^{b}±0.16
Crude fat (%)	20.38^{a}±0.22	36.40^{c}± 0.92	28.6^{b}±0.27
Crude fiber (%)	5.34^{a}±0.18	9.5^{b}±0.07	0.00
Ash (%)	6.01^{a}±0.14	5.04^{a}±0.06	5.96^{a}±0.64
Gross energy (kcal/kg)	4,500.54^{a}±1.04	5,709.0^{b}±0.98	5,744.9^{b}±1.20

^{ab}Means with different letter within a row differed significantly ($p<0.05$)
[1]DFW = Dehydrated food waste, [2]DSW = Dried superworms, [3]UFE = Unfertilized eggs

Maximum feed intake was observed in birds fed on diet containing low energy and high protein with the ratio 134 kcal/kg with superworms and unfertilized eggs (Table 3). Feed consumption was lower ($p<0.05$) with high energy (150 kcal/kg ratio) than low energy (134 kcal/kg ratio) diets. The results of the present experiment are in line with the findings of Nawaz *et al*. (2006) who reported a decrease in feed intake with increasing ME content of the diets. Kamran *et al*. (2008) reported that birds consumed feed to primarily meet their energy requirements. The increased feed intake was probably due to high energy requirements of the birds to complete the high growth rate which was achieved by high intake of feed in low energy diets. Griffith *et al*. (1977) indicated that birds adapted to variable dietary energy level by adjusting their feed intake. These results support that village chicken in this experiment also vary in their feed intake to meet their energy requirements.The results of the present study also showed, that higher body weight gain was obtained when chickens fed with higher crude protein content was used, as was found by Bregendahl *et al.* (2002). Energy and protein are two most important nutrients for good growth and development of animals. These two nutrients are very important at young age as the growth rate is at its optimum. It was also observed that birds fed on low ME and high CP diets gained more weight compared to those fed high ME and low CP diets. The results were also in agreement with Steiner *et al*. (2008) who studied the influence of different protein levels with constant energy level in the diets for broiler breeding and concluded that body mass was positively associated with levels of proteins in the feed. Nguyen and Bunchasak (2005) stated that the growth performance of the Betong chicks was significantly reduced when 17% CP was provided at a very early stage of growth (0-21 d) while Jackson *et al*. (1982) found that a low protein diet below 18% CP reduced growth rate of broiler chickens.

Table 3: Effect of energy to protein ratio on growth rate, feed intake, feed conversion ratio of village chickens between one and six weeks of age

Parameter	Diet (E:P ratio)					
	150[1] (Control)	164[2] (with DFW + DSW)	164[3] (with DFW + UFE)	150[4] (with DFW + DSW +UFE)	134[5] (with DFW + DSW)	134[6] (with DFW + UFE)
Initial BW (g)	33.6^{b}±0.78	32.29^{b}±0.87	32.75^{b}±0.85	31.54^{b}±1.04	33.17^{b}±0.84	36.83^{a}±1.11
Live weight (g)	252.46^{c}±8.20	240.29^{dc}±11.63	246.67^{dc}±8.83	219.92^{d}±8.82	297.17^{b}±10.55	348.33^{a}±12.5
BW gain (g)	218.88^{c}±8.07	208.00^{c}±11.50	213.92^{c}±8.59	188.38^{c}±8.89	264.00^{b}±10.28	311.50^{a}±12.18
Feed intake	702.71^{c}±4.38	716.92^{b}±2.09	717.17^{b}±1.59	703.71^{c}±2.04	726.58^{a}±0.75	725.75^{a}±0.25
FCR	2.99^{d}±0.01	3.04^{d}±0.01	3.07^{dc}±0.02	3.18^{bc}±0.05	3.30^{b}±0.02	3.44^{a}±0.07

^{abcd}Means with different letter within a row differed significantly ($p<0.05$)
[1]Diet 1: EP150:1 (DFW+Fishmeal), [2]Diet 2: EP164:1 (DFW+DSW), [3]Diet 3: EP164:1 (DFW+UFE),
[4] Diet 4: EP150:1 (DFW+DSW+UFE), [5]Diet 5: EP134:1 (DFW+DSW), [6]Diet 6: EP134:1 (DFW+UFE)

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