EFFECTS OF DIETS INCORPORATING MAGGOT CONCENTRATE ON THE GROWTH AND BIOMETRIC PARAMETERS OF LAYER HENS' FIRST EGGS IN BURKINA FASO

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ABSTRACT

The study evaluated the effects of 6 diets incorporating maggot concentrate (MC) as a substitute for fish meal on growth performance, biometric parameters of the first laid eggs of laying hens. To do this, three diets for the growth of pullets composed so as to have a maggot combination rate of 3% (GD3) 5% (GD5) and 10% (GD10) were randomly distributed to three batches of 30 pullets each, between the 12th and 17th week. Three other diets incorporating MC were provided to egg laying hens with the same MM rates of 3% (LD3), 5% (LD5) and 10% (LD10) were also randomly distributed to the same batches starting from the 17th week. Growth and egg-laying diets were compared to control diets GCD and RAP respectively. The results show that the growth of pullets has been continuous with all diets. The average daily gain (ADG) of the GCD was significantly higher than those of GD3, GD5 and GD10 diets (p<0.05). The consumption index (CI) of the GCD was significantly lower than those of GD3, GD5 and GD10 (p<0.05). The cost of production per kg live weight (FCkgLW) of GD5 was significantly higher than that of GD10 (p<0.05). The fCkglw of homogeneous GD3 and GCD (p>0.05) were lower than that of GD5. Between all diet s, no significant differences were observed for the weights, volumes, densities and mean shape indices of the first eggs (p>0.05). The eggs of GD3, GD5 and GCD were larger than those of GD10. The GD3 and GD10 diets showed competitive performance with the GCD diet. Therefore, MC is a good substitute for fish. GD3 and GD10 diets, in this order of preference, can be recommended to farmers. However, further studies over a longer period of the laying phase are needed to better assess the effects of diets on laying performance.

Keywords: Maggot Concentrate Diets, Growth Parameters, Laying hens, Eggs' Biometric Parameters, Burkina Faso

INTRODUCTION

In developing countries, demand for animal products is soaring. In the coming years, this demand should be further wired by the improvement of households' purchasing power, especially those moving from poverty to the middle classes, and by population growth (Pradère, 2014). FAO (2009) estimated the demand for animal products in the next 50 years at 465 million tonnes worldwide. In the Sahel and West Africa, the annual growth of this demand, estimated at 4%, is expected to increase by more than 250% by 2025, while the growth rate of supply is currently estimated at only about 2% (ECOWAS, 2008). Therefore, an increase in the supply of animal products is necessary to meet this ever-increasing demand. In this perspective, initiatives have been developed in Burkina Faso to intensify

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animal farming, particularly poultry production. Thus, intensive poultry farming of layers and broilers of exotic breeds is being developed alongside local poultry farming, which has remained quite unproductive (Baransaka, 1998; Kondombo et al., 2003; Pousga et al., 2007). Raised in permanent confinement, the productivity of these farms depends on many factors, including mainly feeding. The supply of quality poultry feed is often the main problem faced by livestock farmers and especially smallholder farmers in West Africa (Hardouin, 1986). Yet, it is essential to provide animal originated proteins in the diet of monogastric animals to compensate for their impossibility to synthesize certain amino acids (Hardouin, 2003). However, there are major concerns due to difficulties in supplying local livestock farms with animal-based proteins in Burkina Faso and in some West African countries. Indeed, to date, most of the nitrogen concentrates used in poultry feed are imported (Dongmo et al., 2000). Moreover, in Burkina Faso, fish is the main, if not the only, source of animal protein commonly used in intensive poultry and pig farms. This essential resource is expensive and unsustainable (Pomalégni et al., 2016). For example, on the local market in Bobo-Dioulasso in Burkina Faso, fishmeal costs 350-400 CFAF/kg depending on the feed quality. This situation has an upward impact on the cost of diets served on farms. In view of this situation, it is necessary to seek new sources of animal protein, easily accessible, not consumed by humans, but likely to enrich poultry feed and reduce the production cost (Mpoame, 2004). Research in Burkina Faso and elsewhere has focused on the production of maggots and their use as powder in feeding monogastric animals (Bouafou et al., 2006; Pomalégni et al., 2016; Sanou et al., 2019). To help find alternative sources of protein, a protein concentrate based on larvae of houseflies (maggots) has been developed at the Institute of Environment and Agriculture Research (INERA) for rationing pigs and poultry (Ouédraogo, 2019; Oumsaoré, 2019). These larvae are used because of their high protein content, which can reach almost 60% of dry matter (Dordevic et al., 2008) and the ease of production in tropical environments (Bouafou et al., 2011). The objective of this study was to evaluate the effects of diets incorporating maggot concentrate (MC) as a substitute for fishmeal on the growth performance and biometric parameters of the first eggs from laying hens in Burkina Faso.

MATERIAL AND METHODS

Study site

The study was carried out at the Farako-bâ research station of the Institute of Environment and Agricultural Research (INERA). It is located 15 km south of Bobo-Dioulasso, on the road from Bobo-Dioulasso to Banfora. Its geographical coordinates are 04°20' west longitude and 11°06' north latitude. Farako-bâ research station is located in the southern Sudanian climatic zone with annual rainfall between 1000 and 1200 mm (Guinko, 1984). Two seasons alternate: a 6-month rainy season (May to October) and a 6-month dry season (November to April). The highest average monthly temperatures are recorded in April (31.04°C) and May (32.0°C) and the lowest averages in January (21.5°C) and December (23.5°C), according to weather data recorded in Farako-bâ research station in 2015.

Animal material and experimental design

One hundred and twenty (120) pullets from the Isa Brown breed 12-week-old corresponding to their growth stage were used. They were sampled from 2500 pullets ordered by the Farako-Bâ station for egg production for consumption. On arrival, the pullets were individually identified using a looped tag placed on the left wing. They were then weighed and divided into 4 batches of 30 subjects each and homogeneous initial mean weights ($p>0.05$). Prophylactic measures were applied in addition to the regular use of an anti-stress medication. The pullets were subjected to 2 experimental phases, namely growth and egg laying.

Formulation and distribution of diets

Three diets were formulated for chick growth with 3% (GD3), 5% (GD5) and 10% (GD10) of maggot meal. They were randomly distributed to 3 batches of 30 pullets each, aged 12 weeks, for five weeks. Three other diets containing MC formulated as previously with 3% (LD3), 5% (LD5) and 10% (LD10) of maggot meal were distributed to the same batches from the 17th week onwards. Experimental growth and laying diets were respectively compared to a growth control diet (GCD) and laying control diet (LCD). The composition of the diet and its nutritional and energy intakes are presented in Table I. Two meals were distributed per day, in the morning at 7am and in the afternoon at 2pm. The quantities distributed were adjusted every two weeks according to the recommendations of Youness, (1984). To determine the chemical composition of the diets, samples were sent for analysis to the Chemistry Laboratory of the Institut Sénégalais de Recherches Agricoles (ISRA) in Dakar (Senegal). The determinants were percentages of DM, CP, CF, Ca, P, NDF and ADF, ADL, FAT and Inch. Their contents were determined using the AOAC (1975) methods as cited in Kiendrébéogo et al (2013).

Table 1: Centesimal composition and nutritional content of the diets distributed to pullets and layers.

Ingredients	Diets pullets (12-17 weeks)				Diets layers (18-22 weeks)			
	GD3	GD5	GD10	GCD	LD3	LD5	LD10	LCD
Maize	65.5	67.3	73.8	65.76	56.2	59.14	71.48	63.7
Wheat bran	15.38	11.5	1	17.5	24.8	20.5	-	17.5
Maggot meal	5.65	9.42	18.85	-	5.65	9.42	18.85	-
Fish meal	-	-	-	5	-	-	-	5
Cotton cake	4.5	5.5	-	1.5	-	-	-	3.4
Soybean meal	5.5	2	-	8	6.74	4	-	5.45
Shell powder	1.65	1.64	1.65	1.64	4.48	4	4.87	4
Salt	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.25
Methionine	0.2	0.2	0.2	0.2	0.3	0.3	0.2	0.3
Lysine	0.2	0.2	0.2	0.2	0.3	0.3	0.2	0.3
Theoretical nutritional and energy contribution of diets								
DM (%)	93.89	93.13	91.41	95.41	93.07	92.37	91.55	95.45
ME (Kcal/kg)	2750	2750	2749	2750	2800	2801	2801	2801
Crude protein (%)	16.5	16.57	16.58	16.5	16.04	16.09	16.19	16.11
Lysin (%)	0.69	0.83	1.07	0.59	0.7	0.83	1.06	0.69
Methionine (%)	0.56	0.62	0.75	0.5	0.66	0.71	0.74	0.6
Calcium (%)	0.97	1.13	1.53	1.08	1.92	1.92	2.6	1.86
Phosphorus (%)	0.39	0.67	0.34	0.41	0.42	0.4	0.32	0.39
CF (%)	10.8	10.75	10.03	10.18	10.97	10.98	9.63	10.09

GD3: Growth diet with 3% maggot meal; **GD5:** Growth diet with 5% maggot meal; **GD10:** Growth diet with 10% maggot meal; **LD3:** Layer's diet with 3% maggot meal; **LD5**. Layer's diet with 5% maggot meal; **LD10**: Layer's diet with 10% maggot meal; **GCD**: Control growth diet with 5% maggot meal; **LCD**: Control layer's diet; **DM:** Dry matter; **ME:** Metabolizable Energy; **CF:** Crude Fibber

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Data collection and analysis

The data collected concerned the following parameters:

Parameters of the growth stage

- **The weight evolution** was determined weekly by weighing each subject in the morning before the daily meal was served. It was obtained by calculating the average weekly weight of the subjects per batch.
- **The Average daily gain (ADG)** were calculated according to the formula ADG(g)= (FW-IW)/(NJ), where IW= initial weight, FW= final weight and NJ= duration in days.
- **The Consumption indices (CIs)** was calculated according to the formula IC = DFCJ(g)/ADG(g), with DFCJ= food consumption per day obtained by the difference between the quantity of food distributed and the refusal.
- **Food Cost for production of 1kg live weight (FCkgLW)** = IC x Price per kg DM of food. It makes it possible to calculate the cost of weight gain for each diet based on the purchase prices of the feeds it contains and the level of intake by the animals.

Laying parameters of the first eggs

During the first month of laying, eggs were collected every morning before meal service and every afternoon. The number of eggs laid per batch is counted. For each egg, the weight, length (large diameter) and width (small diameter) were systematically measured at collection. These data were then used to calculate the following variables:

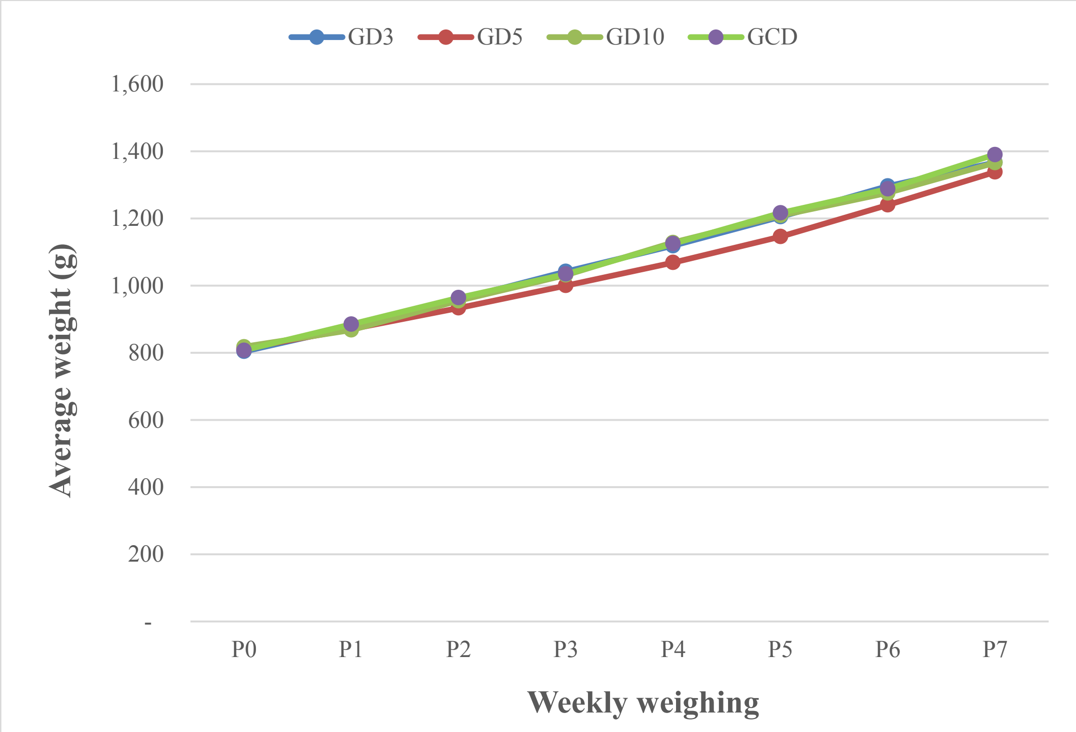
- **The volume of eggs** was calculated according to the following formula: V (cm^3) = 0 ,476 x D (cm) x d2 (cm^2) /1000 where D is the length; d is the width (Hoyt, 1979);
- **The density** of eggs was calculated according to the following formula: D (g/cm^3) = P/V (where P is the weight and V is the volume) (AUGION, 2007)
- **The egg shape index** was calculated according to the following formula IF = (d x D)/100 were d and D are the width and length of the egg, respectively, in mm (Sauveur, 1988).

The collected data were analysed using XLSTAT 2016.02 software. Analyses of variance (ANOVA) with multiple comparisons were performed using the Fischer LSD at 5% significance threshold for the means' separation.

RESULTS

Effects of diets on the zoo-technical growth parameters of pullets

During the growhing phase, a continuous growth of pullets was observed with all diets (GD3, GD5, GD10 and GCD) (Figure 1). The final average weights (FW) of the four batches were not significantly different ($p>0.05$) (Table 2). In absolute terms however, the final average weight of the pullets in the GCD diet was higher than that of the experimental diets. Among the latter, the average weight of very close GD3 and GD10 were higher in absolute terms than that of GD5.



GD3: Growth diet with 3% maggot meal; **GD5:** Growth diet with 5% maggot meal; **GD10:** Growth diet with 10% maggot meal; **GCD**: Control growth diet with 5% maggot meal;

Figure 1: Evolution of the weight of pullets according to the diets in seven weeks

The average voluntary consumption (VC) of growing pullets was similar between all diets ($p>0.05$) (Table 3). The ADG of GD5 was significantly lower than that of GCD ($p<0.05$) but similar to those of other diets ($p>0.05$). The CIs for GD3 and GCD diets were significantly lower than those for GD5 and GD10 diets ($p<0.05$). The CI of the GD10 diet was significantly lower than that of the GD5 diet ($p<0.05$).

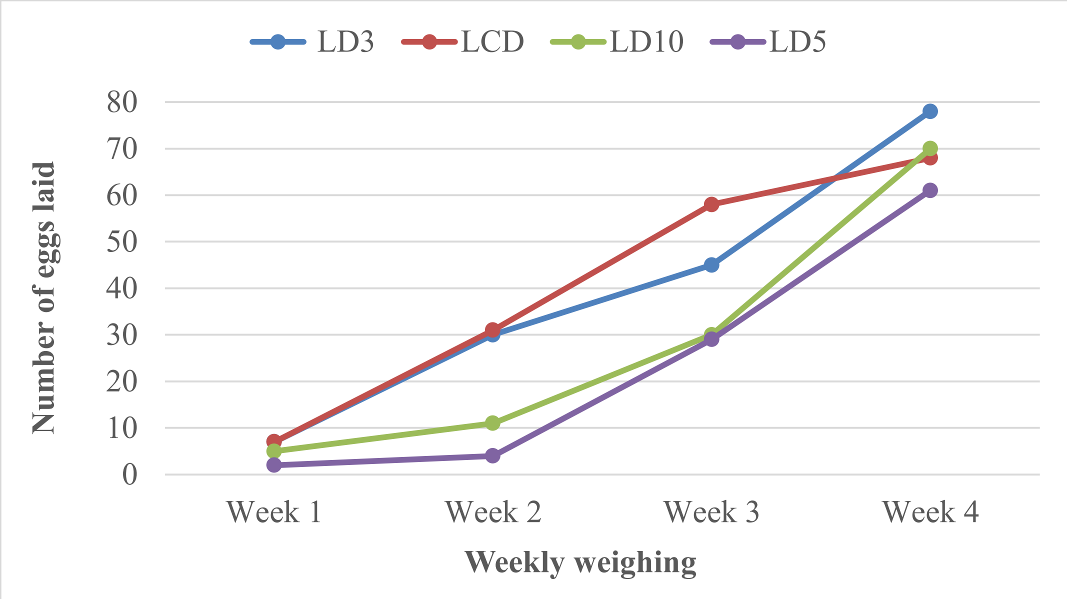
Table 2: Effects of diets on the weight evolution and zootechnical and economic parameters of growing pullets

Variables	Growth diets			
	GD3 $_{(n=30)}$	**GD5** $_{(n=30)}$	**GD10** $_{(n=30)}$	**GCD (n=30)**
Initial weight	803.67±98.64[a]	811.83±94.71[a]	817.67±99.35[a]	807±84.26[a]
Final weight	1366.67±140.45[a]	1337.83±133.45[a]	1365.67±133.89[a]	1390.17±144.01[a]
ADG(g)	11.49±1.72[ab]	10.73±1.72[a]	11.18±1.80[ab]	11.90±1.67[b]
CV(g)	68.87±5.02[a]	69.35±4.79[a]	68.17±3.88[a]	68.93±4.37[a]
IC	6.12±0.87[a]	6.60±0.93[b]	6.25±0.10[ab]	5.90±0.79[a]
FC/kgLW (FCFA)	1154.56[ab]	1204.79[a]	1117.76[b]	1188.82[ab]
Cost/kg DM (FCFA)	188.7	182.52	178.92	201.58

GD3: Growth diet with 3% maggot meal; **GD5:** Growth diet with 5% maggot meal; **GD10:** Growth diet with 10% maggot meal; **GCD**: Control diet for growth without maggot meal; **ADG:** Daily weight gain; **FC/kgLW:** Food production costs per kg live weight

Effects of maggot concenttrate on egg laying and biometric parameters of the first eggs

The hens of the LD3, LD10 and LCD diets started laying eggs at the beginning of the 18th week of age and those of LD5 at the end of the same week. A total of 587 eggs were laid by hens during the first month of laying, including 109 eggs (18.58%); 126 eggs (21.47%); 176 eggs (29.98%) and 176 eggs (29.98%) from hen batches fed with GD5, LD10, LD3 and LCD diets respectively. The number of eggs laid weekly increased from week 1 to week 4 for all diets (Figure 2).



LD3: Laying diet incorporating maggot meal 3% maggot; **LD5:** Laying diet incorporating maggot meal for 5% maggot; **LD10:** Laying diet incorporating maggot meal for 10%; **LCD:** Control diet for the laying phase

Figure 2: Weekly evolution of the number of eggs laid following the diets

The results presented in Table 3 show that egg weight, density, volume, and IF were homogeneous between all diets (p> 0.05). The LCD diet recorded the heaviest egg, the largest and the densest egg. The least heavy and least bulky egg was recorded in the GD10 diet.

Table 3: Comparative analysis of laying parameters

Parameters	Served diets			
	LD_3	LD_5	LD_{10}	LCD
Weight (g)	45.58±0.90a	45.88±0.90a	44.97±0.99a	46.46±00a
Density	1.35±0.02a	1.36±0.02a	1.37±0.02a	1.37±00a
Volume (cm^3)	33.93±0.82a	33.92±0.82a	32.99±0.88a	33.94±00a
Shape Index	0.19±00a	0.19±00a	0.18±00a	0.18±00a

LD3: Layer's diet with 3% maggot meal; **LD5**: Layer's diet with 5% maggot meal; **LD10**: Layer's diet with 10% maggot meal; **LCD**: Control diet for the laying phase

Effects of MC diets on feed cost for pullet production during growth

The Cost / kg DM of GCD was higher than those of all experimental diets (Table 3). The incorporation of MC reduced the cost per kg of dry matter of diets by 6.39%, 9.46% and 11.24% for GD3, GD5 to GD10, respectively, compared with the GCD control diet. The FC/kgLW of the GD3 and GCD diets were similar (p>0.05) but significantly lower than that of GD5 and higher than the FC/kgLWof GD10 (p<0.05). Substitution of fish with maggot meal reduced FC/kgLW by 5.98% for GD10 and 3.64% for GD3 compared with the GCD control.

DISCUSSION

Effects of diets on the growth performance of pullets

Pullets achieved good weight performance at the end of the growth period, irrespective of the diets. Diets with MC were as efficient as the GCD control diet with fishmeal. The average weights were also higher than the reference weight of this race of pullets, between 1250 and 1300g at 17 weeks of age as reported previously (ISA 2009; Barry 2017). Thus, the average weights of pullets under these MC diets, all above 1300g, were higher than that reported by Barry (2017) for pullets of the same age, but fed with mango-based diet incorporating fishmeal as animal protein (RMM=1265.5±100.855). This was so, despite the fact that the initial average weights (894.86±100.855g) of their pullets were higher than in our study. However, it should be noted that in Barry's study, pullets' growth was deliberately delayed to properly prepare the pullets for laying by using mango-based feed, a more fibrous diet. Additionally, our results were consistent with those reported by (Adeniji (2007) who found no significant difference in the final mean weight of broilers fed with 4 levels of diets, with 2.5%, 5.0%, 7.5% and 10.0% maggot meal as a protein source in substitution of fish meal. Furthermore, the voluntary feed consumption of the pullets was higher than that observed with the maize and mango diets (Barry 2017). In summary, the incorporation of maggot meal into pullet diets has resulted in growth performance similar to the control diet with fishmeal as a source of animal protein commonly used locally. These results suggest that MC can replace fishmeal as a source of animal protein in poultry feed, particularly layers and broilers. These results support those obtained by Mensah et al (2007) and Bouafou et al (2011) who recommended the use of maggot meal for feeding other monogastric animals as barbaric ducklings and rats.

Effects of diets on egg laying and biometric parameters of first eggs

Chickens fed with MC LD3 and LD10 were the first to lay eggs as early as 18 weeks. Similar results were found by Dankwa et al (2002) comparing a batch of local hens having a feed supplemented with fresh fly larvae to a control batch. The number of eggs laid during the first month (774 eggs) in this study was 0.79 times higher than that reported by Barry (2017) (442 eggs) laid by the same number of 120 layers in each experiment. The only source of animal protein used by Barry was 5% fish in the mango-based diet and 3% in the control diet. However, the high number of eggs laid in the first month put penalty on their weight, because the eggs from layers fed on the LD5 diet were lighter than those obtained from layers fed with mango-based diet (45.58±0.90g vs. 47.5±3.89g). Similarly, layers under LD3 diet provided eggs lighter than those produced by hen under control diet containing 3% fish (45.88±0.90g vs. 47.26±4.01g). In both cases, eggs were also smaller in volume (33.93±0.82cm3 vs. 39.74±3.81cm3 and 33.92±0.82cm3 vs. 39.48±4.03cm3). This supremacy of the weights and volumes of the first eggs obtained in Barry's study was attributable to the specific preparation of pullets for a good laying career using mango-based feed, which is rich in NDF, ADF and even lignin fibres (Barry 2017). Indeed, non-digestible raw fibres induce what is called the entrainment effect during the rearing phase, allowing the hens' pelvis to be enlarged (Robert 2014). Nevertheless, the weight of the eggs in our experiment reached 45g, the minimum recommended weight for egg marketing (Yaro, 2011). Therefore, the incorporation of the maggot meal into the layers' diet made it possible to produce eggs during the first month of laying with similar dimensions as those from layers under traditional diet with fishmeal.

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Effects of diets on economic performance of growing and laying hens.

The incorporation of MC contributed to reducing the cost per kgDM of all experimental diets, compared with the control diet. The growth diets were similar to that of the control diet for the FCkgLW, which resulted from a better valorisation of the GCD diet and a lower CI. This situation was due to the cost of production of the MC estimated at 160 FCFA/kgDM (Ouédraogo 2019). Indeed, this cost is about 60% cheaper than the cost per that of fishmeal, which is sold on the local market between 350 and 400 FCFA/kgDM with a moisture content of about 10%. These results are in agreement with those of other authors (Bouafou 2011), who showed that from technical and economic view-points, maggot meal could partially replace fish meal in feed for broiler chicken. Therefore, the use of MC diet reduces the production cost of pullets compared with using fishmeal in the diet.

CONCLUSION

The total substitution of fish meal by maggot concentrate in all six diets resulted in good growth performance and first month eggs as heavy as with control diet incorporating traditional fish meal. With the MC diet, the production cost of the pullet was reduced during the growth phase compared with the control diet. The maggot concentratel is therefore an appropriate alternative to fishmeal for farm monogastric animals, especially for pullets and layer hens. In addition to providing a growth performance closest to the control, reducing the production cost per kg live weight and the feed cost per hen, the GD3 diet also produced the same quantity of eggs with similar characteristics with those of the control diet. Therefore, GD3 composition appears as the most suitable for achieving good performance both in the growth stage and in the laying stage of hens. The substitution of fishmeal by MC in the feed of layer hens up to 3% represents not only an opportunity to reduce the production cost, but also to recycle organic matters such as animal manure.

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