Growth and Laying Response of Quail (Coturnix coturnix japonica) Fed with Dietary Fermented Earthworm Meal Silage

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Received:- 06 November 2025/ Revised:- 11 November 2025/ Accepted:- 18 November 2025/ Published: 30-11-2025

Abstract— *A feeding trial was carried out to evaluate the effects of replacing the fishmeal with a dietary fermented earthworm meal silage (FEMS). A 240 ready-to-lay (RTL) quail of 22 days old were used to determine average daily gain (ADG), feed conversion ratio (FCR), average daily feed intake (ADFI), % hen-egg day production (HEDP), average egg weight (AWE), Total Weekly Egg Produced (TWEP), and income over feed cost (IOFC) of quail fed with dietary fermented earthworm meal silage (FEMS). The dietary FEMS was used to replace fish meal in a feed formula at the rate of 0%, 5%, 10%, and 15%. Twenty experimental RTL quails were distributed to a colony panel which served as a replicate in a 4-treatment x 3-replicate randomized complete block experimental design.*

The result showed no significant ($p>0.05$) effect in replacing the fishmeal with a fermented earthworm meal silage (FEMS) in a feed formula. Hence, the feed formula with a 5% FEMS resulted in a heavier average daily gain among the different treatments. The % HEDP resulted in a higher egg production in 15% FEMS substitution, while, IOFC was highest at 10% FEMS substitution. These findings indicate that formulating quail feeds in an attempt to replace fish meal with a dietary FEMS has no detrimental effect on growth and laying performance and has the potential to be included as an animal protein dietary ingredient in the quail diet.

Keywords— Dietary Fermented Earthworm Meal Silage, Flock Uniformity, Ready to Lay, Growth and Laying Response, Quail.

I. INTRODUCTION

The Bureau of Animal Statistics (BAS) in 2015 and in its 2012 special report related that quail comes third in the production of poultry products following ducks and broilers as the secondary and primary source, respectively. Despite being only third, quail raising in the country is promising (BPI-NSPRDC, 2010). This can be started with a much lower capital investment as compared to chicken and ducks.

Quail, locally known as pugo, is a small and tailless bird found in many parts of Asia. It belongs to the Phasianides family under the order of Galliformes. As commercial birds, quails require minimal space, time, and investment. Moreover, they are

quick growers, and fast multipliers (Bolla & Randall, 2012). Also, they are richer in protein, phosphorous, and vitamin A. Quails, unlike other fowl, are not delicate birds. These birds do not easily contract fowl diseases common to poultry (Mulemora, 2013). In addition, there is a growing demand for meat and eggs from quail at present.

The potential of making it grow more for the growing demand for the quail's product is associated with proper nutrition. Fish meal has been widely used as conventional feedstuff since the early times due to its high nutritional content. However, this feedstuff has its nutritional constraints in usage. According to Miculec et. al (2004), it contains high histamine which can cause defects in poultry's gizzard. Moreover, it has a relatively high price because it is both consumed by man and animals. Therefore, there is a need to explore alternative feed ingredients that would satisfy or at least surpass the nutrients present in a fish meal, especially in consideration of the protein content of an ingredient.

According to Palungkun (1999), earthworms contain 64-76% of protein, much higher than the local fishmeal which consists of 49.50 to 59.19%. It was found that fresh earthworm has 61.96% protein and are composed of essential and non-essential amino acids which are considered excellent feed ingredients for poultry (Resnawatti, 2004).

There is very little information on the use of earthworm meals in poultry diets. A study showed that 10% earthworm meal could replace a large portion of the fish meal in the diet with no adverse effect on body weight gain or feed efficiency. Feed intake was reduced at the 15% inclusion level (Prayogi, 2011). However, in the 2004 research of Resnawatti, it was found that earthworm meal can be used up to 15%. Hence, this research aimed to test and verify the potential of earthworms processed to fermented silage at varying levels of inclusion to the diet of quail in an attempt to replace the fish meal in the feed formula.

II. MATERIALS AND METHODS

Time and Place of the study. The study was conducted at #049 Dumadag St. Baraoidan, Gattaran, Cagayan from August 18, 2021 to November 6, 2021.

Experimental Quail and Treatments. Two-hundred forty RTL quails (22 days) were laid out in a Randomized Complete Block Design (RCBD) with four (4) treatments replicated three times. Twenty experimental birds for each replicate were distributed to a colony panel with the dimension of 60 cm x 40 cm x 18 cm with 30 cm x 40 cm egg catcher and 10 cm water trough. The dietary treatments were: Treatment 1 (T1) formulated feeds without substituting fish meal to dietary earthworm meal silage, Treatment 2 (T2) formulated feeds with 5% FEMS substitution, Treatment 3 (T3) formulated feeds substituted with 10% FEMS substitution and Treatment 4 (T4) formulated feeds with 15% FEMS substitution. The composition, proximate and calculated analysis of the experimental diets is presented in Table 1 and Table 2 for the nutritional specifications of the different feed ingredients used. Manual computation for the Crude Protein values was undertaken but a sample of the formulated feeds were subjected to a laboratory analysis. A 250- gram sample per treatment was packed and brought to DA-Cagayan Valley Integrated Animal Laboratory located at Government Center, Carig Sur, Tuguegarao City, Cagayan. The Semi-Automatic Kjeldahl method was followed for the crude protein, Filter Bag Technique (ANKOM) for the crude fiber, and fat and gravimetric was used for the moisture and ash. These tests were used for the confirmation of the nutrient content of the formulated feeds. The table below enumerates the feed ingredients used in different percentages in a 100-kg formulation.

TABLE 1
COMPOSITION, PROXIMATE AND CALCULATED ANALYSIS OF DIETS FOR THE FOUR TREATMENTS

INREDIENTS	1		2		3		4	
Rice Bran, D_1	10		10		10		10	
Yellow Corn, local	46.2		46.2		46.2		46.2	
Copra meal, expeller	4.7		4.7		4.7		4.7	
Coconut oil	0		0.6		0.2		0	
Soybean Meal, US_1	22		32		27		22	
FEMS	**0**		**5**		**10**		**15**	
Fish Meal	**15**		**0**		**0**		**0**	
$CaCO_3$	1.4		0.8		1.2		1.4	
NaCl	0.2		0.2		0.2		0.2	
Premix, ATOVI	0.5		0.5		0.5		0.5	
Total	100		100		100		100	
	Calc	**Anal**	**Calc**	**Anal**	**Calc**	**Anal**	**Calc**	**Anal**
AME, kcal/kg	2774	-	2890	-	3006	-	3122	-
Crude protein, %	23.8	**18.5**	21.7	**18.7**	19.8	**19.7**	17.9	**18.6**
Crude fat, %	5.9	**7.82**	4.07	**8.73**	4.24	**5.59**	4.41	**769**
Crude fiber, %	2.97	**7.32**	3.17	**5.07**	3.01	**3.96**	2.85	**4.92**
Crude Ash, %	5.9	**9.98**	3.88	**5.89**	3.69	**5.74**	2.51	**5.83**
Calcium, %	1.08	**0.95**	0.71	**0.4**	0.98	**0.39**	1.19	**0.31**
Available P,%	0.64	**3.39**	0.19	**0.99**	0.25	**0.09**	0.31	**0.29**
Sodium, %	0.28		0.03		0.03		0.03	
Chlorine, %	0.27		0.06		0.06		0.06	
Linoleic acid, %	0.72		0.78		0.75		0.72	
Lysine, %	1.34		1.52		1.71		1.89	
Methionine, %	0.89		1.09		1.06		1.02	
Meth+Cys%	0.81		0.81		0.84		0.87	
Threonine, %	0.89		1.06		1.23		1.4	
Tryptophan, %	0.26		0.33		0.37		0.41	
Arginine, %	1.59		1.79		1.92		2.05	
Isoleucine, %	1.02		1.15		1.25		1.35	
Leucine, %	1.96		2.15		2.32		2.49	
Valine, %	1.19		1.28		1.4		1.52	

[1]Treatment 1 contains 15% of Fish Meal instead of Fermented Earthworm Meal Silage.
[2]Ttreatment 2 contains 5% of Fermented Earthworm Meal Silage with no Fish Meal.
[3]Ttreatment 3 contains 10% of Fermented Earthworm Meal Silage with no Fish Meal
[4]Ttreatment 4 contains 15% of Fermented Earthworm Meal Silage with no Fish Meal
****The values of FEMS were based on the available data from the researches of Leela, 2018; Istiqomah et al. 2009; Antonova et al, 2021, and; Feedipedia located on the RRL in order to calculate the proximate analysis of the data.***
****The values of the other ingredients were based on the PhilSan's 4th Edition Book***
****Analyzed data were result of the laboratory analysis of the Cagayan Valley Regional Field Chemical Laboratory, Tuguegarao City***

TABLE 2
NUTRITIONAL SPECIFICATION PER FEED INGREDIENTS

Content	Rice Bran	Yellow Corn, local	Copra Meal, expeller	SBMl, US_1	FEMS	Fish Meal, local	$CaCO_3$
Dry Matter%	91.4	89.29	96.2	90.72	-	87.8	99.87
Crude Protein %	12.14	8.05	21	47.65	**10.21**	49.4	
Crude Fat %	13.79	3.4	10.51	1.23	**4.68**	14.6	
Crude Fiber %	5.27	2.44	8.761	3.43	**0.21**	1	
Ash %	6.89	1.42	6.13	6.6	**2.81**	20.7	
Starch %	28	71		4			
ME, Kcal/kg	2400	3300	1800	2500	3000	2500	
TDN %		80					
Calcium %	0.15	0.17	0.22	0.47	**0.59**	5.86	38.55
T Phosphorous	1.48	0.26	0.66	0.71		3.61	0.16
A Phosphorous	0.22	0.07	0.1	0.21	**0.22**	3.61	
Sodium %	0.06	0.004	0.42	0.02		1.67	0.05
Chloride %	0.07	0.04	0.64	0.04		1.35	0.03
Linoleic Acid %	5.52	156	0.21	0.62			
Choline ppm	915	435	650	2640		2800	
Lysine %							
Lysine % (Dig)	0.55	0.26	0.53	3.06		3.12	
Methionine %	0.4	0.21	0.27	2.67		1.82	
Methionine % Dig)	0.25	0.18	0.32	0.69		1.16	
Cystine %	0.2	0.16	0.16	0.62		1.05	
Cystine % (Dig)	0.26	0.19	0.2	0.74		0.44	
Met + Cyst %	0.19	0.17	0.16	0.64		0.36	
Met + Cyst % (Dig)	0.51	0.37	0.63	1.43		1.61	
Threonine %	0.38	0.33	0.32	1.26		1.41	
Threonine % (Dig)	0.45	0.29	0.67	1.86		1.83	
Thryp %	0.31	0.24	0.35	1.6		1.63	
Thryp % (Dig)	0.14	0.07	0.17	0.64		0.4	
Arginine %	0.11	0.06	0.09	0.58		0.34	
Arginine % (Dig)	0.99	0.38	2.31	3.47		3.01	
Isoleucine %	0.77	0.32	1.19	3.32		2.83	
Isoleucine % (Dig)	0.42	0.29	0.74	2.26		2.07	
Leucine %	0.31	0.25	0.38	1.97		1.89	
Leucine % (Dig)	0.87	0.97	1.32	3.72		3.65	
Valine %	0.68	0.84	0.68	3.36		3.51	
Valine % Dig)	0.65	0.4	1.16	2.33		2.54	

Feeds and Feeding. Adult African Night Crawler (ANC) was purchased at Enrile, Cagayan. It was washed in potable water then sacrificially dipped into hot water. The FEMS was prepared by adding molasses to the paste. A 200 g (20%) of molasses was mixed for every 1 kg earthworm paste. The addition of 200 ml water was done to make it more liquid. Rosemary powder was also added to prevent auto-oxidation and 1000 ppm potassium sorbate was added as a mold inhibitor. One gram of potassium sorbate and 0.2 g of RP were mixed with 1 kg of earthworm meal silage. The ensiling process was aided by

incubating the materials in an airtight plastic container at room temperature (28-30°C). The silage was stirred twice daily to ensure the uniform distribution of the molasses. The fermentation process took two weeks. A sample was also sent to DA-CVIAL, Tuguegarao City and Lipa Quality Control Center, Batangas for its proximate analysis. The figure below represents the procedure in the fermentation of the earthworm meal silage (Figure 1).

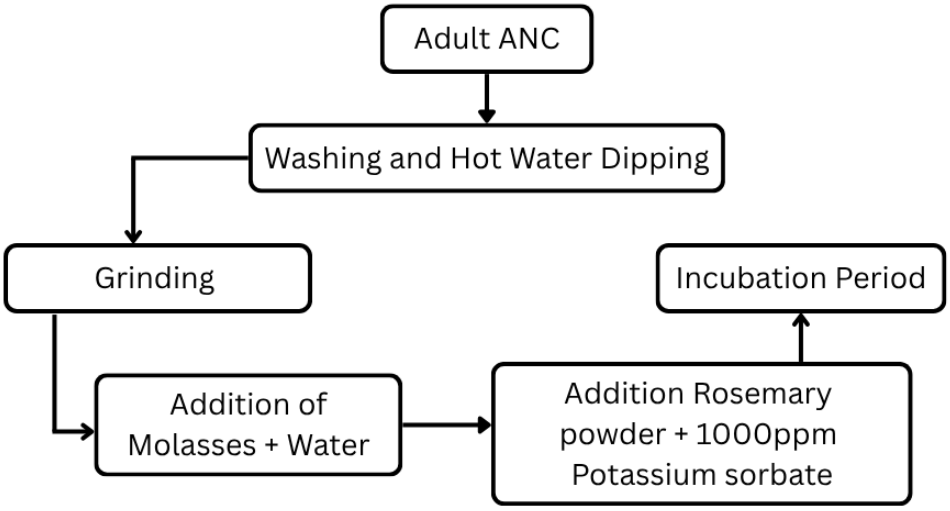

FIGURE 1. Schematic diagram of fermented earthworm meal silage preparation

The FEMS-based formulated feed was based on the basic standard of feeding formulation considering the crude protein content and Metabolizable energy required by a quail at laying stage following the diagram reflected in Figure 2. The experimental birds were fed twice a day and given clean water but changed it to three times a day upon increasing the percentage of feeds given to avoid excessive feed wastage caused by the filled feeding trough. This also helped in managing the feeding stress of the quail brought by the typhoon. Their feeds were based on the different treatments and their feeding was based on the feeding standard for quail. They were fed 17 g/b on their 1st to 2nd week and suddenly increased by 10% every after two weeks until reaching the maximum feeding requirements of 23g/b. The feeding of the FEMS-based formula lasted for 80 days where sufficient data were gathered for the comparability of the different treatments on the different production parameters and the Income Over Feed Cost (IOFC).

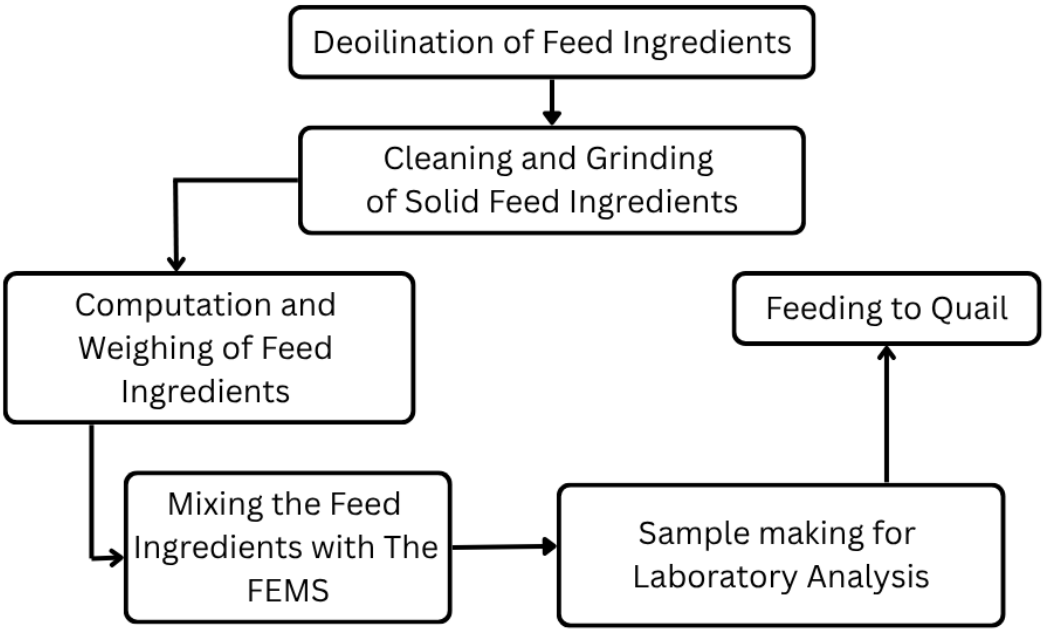

FIGURE 2. Schematic diagram of FEMS-based feed formulation

Data Gathered. The data gathered was Average Daily Gain (ADG), Feed Conversion Ratio (FCR), Average Daily Feed Intake (ADFI), Hen-Egg Day Production (HEDP), Average Egg Weight (AEW) and Income Over Feed Cost (IOFC).

A. Average Daily Gain (ADG):

The formula below was used in determining the ADG;

$$Average\ Daily\ Gain\ (ADG) = Body\ Weight\ Gain\ (per\ bird) - days \quad (1)$$

B. Feed Conversion Ratio:

Feed conversion ratio is the measurement of an animal's efficiency on converting an animal feed into the desired output. Below was the formula used in obtaining the input (feed) versus output (layed egg) in egg production:

$$FCR, egg = \frac{FeedIntake(g)}{Eggs\ Produced\ (g)} \quad (2)$$

C. Average Daily Feed Intake (ADFI):

This data was determined by the formula below;

$$ADFI = Total\ Feed\ Consumed\ /Numer\ of\ feeding\ days \quad (3)$$

D. Hen-day egg production:

This was determined by calculating the number of hen days in the period by adding the number of hen alive on each day of the period. Then, the number of eggs laid during the same period was calculated and multiplied by 100. The formula below was followed.

$$\%\ Hen - Egg\ Day = No.of\ Egg\ Produced\ /No.ofHens\ Alive\ x100 \quad (4)$$

E. Average Egg Weight :

This was determined by weighing the egg produced in each treatment and was divided with the total collected quail eggs.

F. Average Egg Produced, pcs:

This was determined by counting the laid eggs per colony panel and dividing it by the number of days of laying.

G. Income Over Feed Cost (IOFC), Php:

The income over feed cost (IOFC) was computed as:

$$IOFC = Sale\ value\ of\ egg, Php. - Feed\ cost, Php \quad (5)$$

The sale value of the eggs was computed by multiplying the total number of eggs produced by the current price of eggs in the market. The feed cost was determined by multiplying the total feed consumed by the quail for the feeding period by the cost per kg of feed.

Statistical Analysis. The collected data were tabulated using MS Office Excel and were subjected to repeated measure Analysis of Variance (ANOVA) using the Jamovi version 2.2.3 statistical tool. The level of significance considered was 5% level of significance.

III. RESULTS AND DISCUSSION

3.1 Production Performance of RTL Quail:

The production performance of quail on the different rates of Dietary Fermented Earthworm Meal Silage (FEMS) is presented in Table 3. There were no significant differences (P>0.05) in any of the production parameters. Thus, indicating that substituting FEMS for the fish meal as a feed ingredient at any rate does not differ in terms of the different parameters. It is inferred that it did not affect feed palatability thus, feed consumption was not affected, too. According to Leeson and Summers (2005), this result is may be affected by temperature and the quality and quantity of the ration. In contrast, Bahadori, et al. (2017) said that 1 to 3% of earthworm (*E. fetida*) meal in diet decreased feed intake of broiler chicken compared to control diet without EWM. However, Rezaepour et al. (2014), stated that feed intake and weight gain of broilers were not statistically affected by dietary treatment (p>0.05).

TABLE 3
PRODUCTION PERFORMANCE OF RTL QUAIL FED WITH DIFFERENT RATES OF FEMS IN A FEED FORMULA

PARAMETER	MEAN				SEM	P-VALUE				
	0%	5%	10%	15%		Treatment	Block	Week	Treatment x Week	Block x Week
Average Daily Gain, g	0.9	0.9	0.8	0.71	0.09	0.21^{ns}	0.838^{ns}	-	-	-
Average Daily Feed Intake, g	13	14	14.1	13.8	2.54	0.604^{ns}	0.219^{ns}	$<.001^{*}$	$<.001^{*}$	0.701^{ns}
Feed Conversion Ratio	1.4	1.5	1.52	1.49	0.22	0.194^{ns}	0.116^{ns}	$<.001^{*}$	$<.001^{*}$	0.808^{ns}
Average Egg Weight, g	9.6	9.2	9.31	9.16	0.63	0.135^{ns}	0.227^{ns}	$<.001^{*}$	0.236^{ns}	0.696^{ns}
Hen-Egg Day production, %	49	43	47	47.8	15.98	0.634^{ns}	0.719^{ns}	$<.001^{*}$	0.042^{*}	0.161^{ns}
Hen-Housed Egg Production, %	49	43	47	47.8	15.98	0.634^{ns}	0.719^{ns}	$<.001^{*}$	0.042^{*}	0.161^{ns}

ns= not significant; *= significant (p<0.05)

Average Daily Gain (in gram). Treatment 1 (0% FEMS) produced an Average Daily Gain of 0.85 g but had no significant difference (p= 0.21) from the other treatments and from the different blocks (p= 0.838). Meanwhile, T2 (5% FEMS) recorded 0.89 g, T3 (10% FEMS) gained 0.80 g, and T4 yielded 0.71 g. This is contrary to Prayogi's (2011) experimentation revealing that quail fed with 10% of Earthworm Meal had the highest body weight gain. Feed intake was reduced to 15% level of earthworm meal and showed significant differences at 0%, 5% and 10%. This was taken by subtracting the final weight against the initial weight divided by the number of feeding days. The ADG was obtained during the first three weeks of the quails and before they started to lay eggs.

Average Daily Feed Intake (in gram). The findings reveal that there was no significant difference for ADFI among the treatments (p= 0.604) and blocks (p= 219). It can be seen that the different treatments show an ADFI of (13.3 g), (14.2 g), (14.1 g), and (13.8), respectively. This means that the dietary earthworm meal gives the same effect to feed consumption of quail. Prayogi (2011) reported that feed intake was reduced at 15% level of earthworm meal and showed significant differences from 0%, 5% and 10%. On the other hand, the different weeks and their interaction to treatment showed statistically different (p= <0.001) but not with blocks (p= 0.808). This indicates that different weeks give varied results with respect to ADFI but not to its interaction with the different blocks.

Feed Conversion Ratio. Treatment 1 (0% FEMS) showed the lowest Feed Conversion Ratio of (1.38) but not statistically different (p= 0.194) from 5%, 10% and 15% substitution as well as from its respective blocks (p= 0.116). Contrastingly, Prayogi (2011) found out that the percentages of FEMS substitution were statistically significant (p<0.1) which suggest that 5% and 10% usage of earthworm meal in quail diets provide better performance. Feed conversion has been known to be the measurement of the efficiency of the animals to convert input into output whereby smaller values indicate a more efficient use of ration to produce an egg. Hence, weeks and their interaction with the treatments showed significant difference (p= <0.001) indicating that there is an effect of the different treatments on different weeks. However, the interaction of weeks to blocks showed no statistical difference (p= 808). It means that FCR is comparable with blocks and has no different effect as to weeks.

Average Egg Weight (in grams). The results showed that the dietary treatments and their blocks (p= 227) were comparable in terms of egg weight. In fact, T1 (0% FEMS) layed egg with a mean of 9.62 g; T2 (5% FEMS) with 9.22 g, T3 (10% FEMS) with 9.31 g, and T4 (15% FEMS) with 9.16 g. but not significantly different (p= 0.135). These findings are consistent with the study of Istiqomah et al. (2017). However, these results do not agree with Bertechni (2012) who reported that the normal egg weight ranges from 10 to 12 grams, and with Tuleun (2013) who arrived at 9.75 grams with 20% CP diet. These varying results may be attributed, therefore, on the daily protein intake. The weeks and their interaction with the different treatments showed statistically different (p=<0.001) but not significantly different from their block interaction.

Hen-Egg Day Production (in %). The % Hen-Egg Day Production showed no statistical difference in treatments (p= 0.634) and in blocks (p= 0.179) which is supported by the study of Istiqomah et al. (2017) stating that supplementation does not affect the formation of egg and egg production during the experimental period. However, 15% FEMS as substitute for Fish Meal in the ration had 47.8% HEDP thus, 0% FEMS, 5% FEMS and 10% FEMS indicated an HEDP of 48.5%, 43.1%, and 47.0%, respectively. Egg production is, however, determined by genetic and environmental factor. Pavlidis et al. (2002) reported that

in laying hens, the egg production quickly rose after 2 weeks from the onset of lay, reached the peak production in week 8 to 9 and then gradually decreased. Apparently, variation in the age at 50% and age at peak production between studies were affected by genetic/breed of the bird (Luka et al., 2017). Additionally, weeks (p= <0.001) and their interaction with treatments (p= 0.042) showed statistically different but not to their interaction with blocks (p= 0.161). As such, weeks have an effect on feeding using the different treatments with respect to % hen-egg day production but not with the different blocks.

Hen-Housed Egg Production, % had the same values with the HEDP since there was no mortality recorded within the duration of the study. This therefore suggests that HDEP and HHEP are equal.

3.2 Income Over Feed Cost of Quail Egg Production:

The Income Over Feed Cost of Quail Egg Production for T1 (0% FEMS), T2 (5% FEMS), T3 (10% FEMS), and T4 (15% FEMS) is presented in Table 4.

The mean of weekly egg produced in T1 was 66 pcs eggs, 57 pcs for T2, 62 pcs for T3 and 64 pcs for T4. These means had no significant difference(p=590) together with blocks (p= 964). The interaction of weeks and treatments achieved significantly different (p= <0.001) results but was not significant different with the interaction between weeks and blocks (p= 613). This indicates that treatments and blocks give a comparable effect with respect to egg production and that that different week affect the laying process of quail. Because of that, the sale value of eggs reflects Php. 78.7, Php. 68.7, Php. 74.2 and Php. 76.3 for T1(0% FEMS), T2 (5% FEMS), T3 (10% FEMS) and T4 (15% FEMS), correspondingly. It showed however, no statistical difference among the treatments (p=0.590) and blocks (p= 964), and the interaction of weeks x blocks (p=613) but found to be significantly different in terms of the interaction of weeks and treatments (p= <0.001). The feed consumption of the different treatments showed 1.80 kg for T1, 1.91 kg for T2 and T3, and 1.84 kg for T4 These weights yielded no significant difference among the treatments (p= 0.626), blocks (p=0.185), and week x block interaction (p= 870). However, these weights were statistically different on the weeks and their interaction to treatments (p= <0.001). Moreover, the different treatments confirmed T1 (Php. 32.5), T2 (Php. 33.6), T3 (30.0), and T4 (Php. 29.0) as cost of feed but showed statistically no difference among treatments (p= 096), blocks (p= 0.197), and week x block interaction (p= 0.864) but then significantly different to weeks and treatment x week interaction where p= <0.001). Furthermore, the Income Over Feed Cost showed no significant difference among the treatments (p= 0.511), blocks (p= 0.846), and week x block interaction (p= 0.550). It showed that the IOFC for Treatment 1 was Php. 46.2, T2 was Php. 35.1, T3 was Php. 44.2, and T4 was Php. 47.3 thus, showed significant difference in weeks and treatment x week interaction (p= <0.001). This is an indicator that various treatments have the same results as regards income.

TABLE 4
EFFECT OF DIFFERENT RATES OF FEMS SUBSTITUTION ON INCOME OVER FEED COST

ITEM	MEAN				SEM	P-VALUE				
	0%	5%	10%	15%		Treatment	Block	Week	Treatment x Week	Block x Week
Weekly Egg Produced, pcs	65.5	57	61.8	63.6	20.9	0.590^{ns}	0.964^{ns}	<.001*	<.001*	0.613^{ns}
Sale value of Eggs, Php	78.7	69	74.2	76.3	25	0.590^{ns}	0.964^{ns}	<.001*	<.001*	0.613^{ns}
Feed Consumed, kg	1.8	1.9	1.91	1.84	0.32	0.626^{ns}	0.185^{ns}	<.001*	<.001*	0.870^{ns}
Cost of Feed, Php	32.5	34	30	29	5.68	0.096^{ns}	0.197^{ns}	<.001*	<.001*	0.864^{ns}
Income Over Feed Cost, Php	46.2	35	44.2	47.3	29.3	0.511^{ns}	0.846^{ns}	<.001*	<.001*	0.550^{ns}

ns= not significant; *= significant (p<0.05); [1]Price for quail egg was Php 1.20 per piece; [2]Price for feeds based on per feed formula computed were T1-Php 18.00/kg; T2-Php 17.60/kg; T3-Php 15.70/kg; T4-15.74/kg

3.3 Weekly Production Performance:

The weekly average daily feed intake is presented in Figure 3. It shows that there was a significant difference between the interaction of weeks and treatments (p= <0.001). This means that ADFI differs each week and may yield has a significant difference among treatments in varying weeks. Treatment 4 (15% FEMS) obtained the highest ADFI with 15.14g and Treatment 1 (0% FEMS) got the least ADFI with 12.82g on the 4th week of the feeding trial where significant difference was observed as reflected on its Posthoc test in Table 5. Treatment 1(0% FEMS) was significantly different to Treatment 2 (5% FEMS) and Treatment 4 (15% FEMS) but not to Treatment 3 (10% FEMS). It can also be observed that on the following week

(5th and 6th) there is a sudden decreased in ADFI values hence Treatment 3 (10% FEMS) recorded 11.37g ADFI on the 5th week and Treatment 1 (0% FEMS) recorded 10.80g ADFI. It is on the 7th week where all the treatments started to increase again and have continued linearly increasing their feed intake until the 12th week where 12.43g and 13.57g recorded the highest ADFI on Treatment 3 (10% FEMS) for the 7th week and 8th week. Treatment 2 (5% FEMS) dominated on the 9th week showing an ADFI of 14.48g and Treatment 3 (10% FEMS) had the highest ADFI on the 10th week of the feeding trial. Hence, Treatment 2 (5% FEMS) with 18.23g and Treatment 3 (10% FEMS) with 18.68g ADFI were recorded as the highest ADFI on 11th and 12th week, respectively. The sudden decrease in feed intake on the 5th and 6th week might be the effect of the weather disturbances stressing the quails. *(https://3c5.com/wxKhq); (https://3c5.com/vvUPU).*

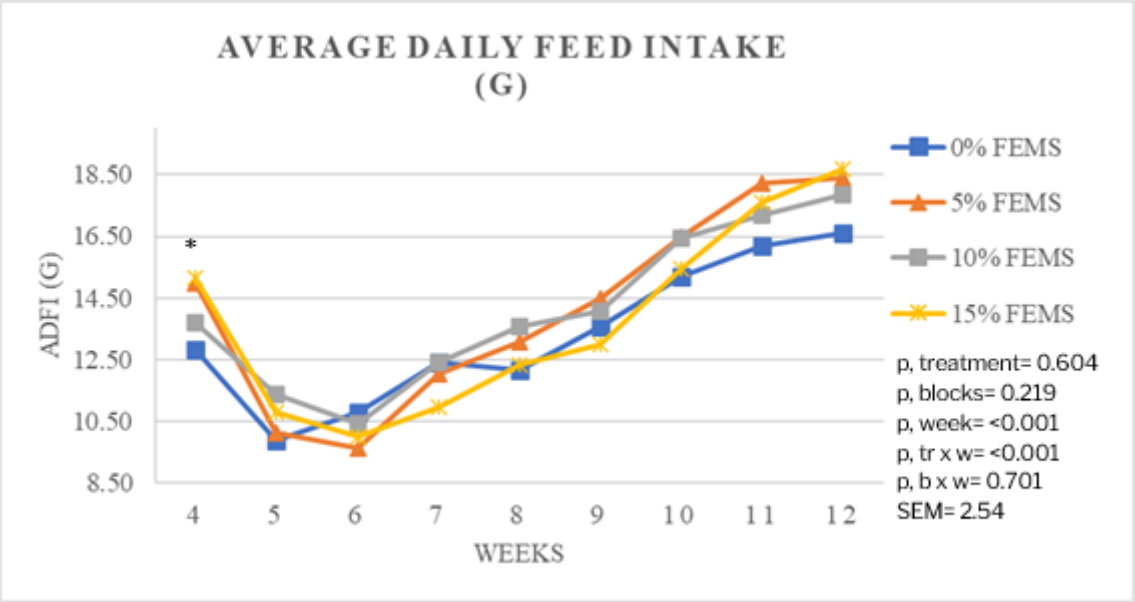

FIGURE 3. Weekly production performance of quail fed with different rate of FEMS substitution in terms of ADFI, g. Two-hundred forty- 22 days old RTL quail were randomly assigned to dietary treatment replicates with 20 birds per colony panel. Dietary treatments were as follows: T1(0% FEMS), T2 (5% FEMS), T3 (10% FEMS) and T4 (15% FEMS). The different rates were used for substituting fish meal as one of the feed ingredients in quail's feed formula

TABLE 5

POST-HOC TEST OF WEEKLY AVERAGE DAILY FEED INTAKE, g

TREATMENTS	WEEKS								
	4	5	6	7	8	9	10	11	12
0%	12.82[b]	9.89[a]	10.80[a]	12.41[a]	12.18[a]	13.59[a]	15.18[a]	16.21[a]	16.59[a]
5%	14.97[a]	10.14[a]	9.63[a]	12.05[a]	13.06[a]	14.48[a]	16.49[a]	18.23[a]	18.40[a]
10%	13.70[ab]	11.37[a]	10.41[a]	12.43[a]	13.57[a]	14.08[a]	16.44[a]	17.17[a]	17.83[a]
15%	15.14[a]	10.79[a]	9.99[a]	10.98[a]	12.34[a]	13.00[a]	15.44[a]	17.61[a]	18.68[a]

Means with the same letter are not significantly different at 5% level

Figure 4 presents the weekly FCR of quail as a response to different rates of FEMS substitution. It can be seen that Treatment 4 (15% FEMS) with 1.73, 1.13 and 1.14 had the highest FCR on the 4th, 5th and 6th weeks of the feeding trial, respectively. On the 7th and 8th week of the feeding trial, the highest FCR was from Treatment 3 (10% FEMS) with 1.41 and 1.45, respectively. Then, Treatment 2 (5% FEMS) had the highest FCR among the treatments on the 9th, 10th, and 11th week which recorded a respective FCR of 1.63, 1.79 and 1.93. Treatment 3 (10% FEMS) dominated the 12th week of feeding trial with 1.95 FCR. Hence, it was on the 4th week where it signifies those treatments differed significantly as shown in Tukey's Post-hoc test for FCR in Table 6 where Treatment 1 (0% FEMS) and Treatment 4 (15% FEMS) differed significantly but not to Treatment 2 (5% FEMS) and Treatment 3 (10% FEMS). Hence, Treatment 2, Treatment 3, and Treatment 4 are not statistically different.

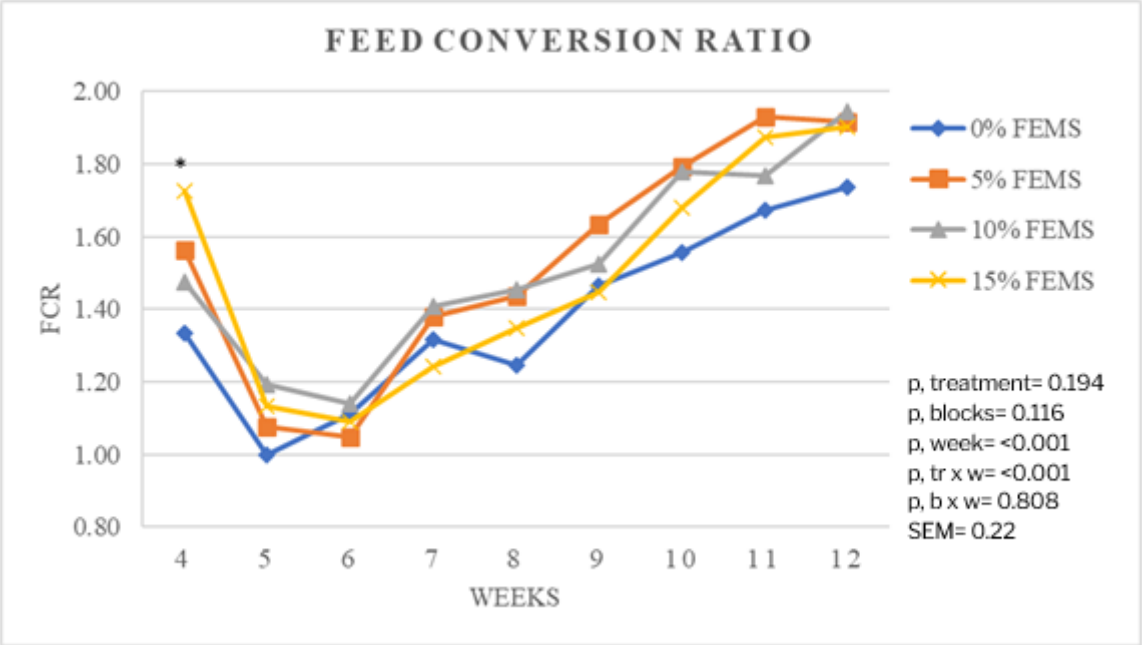

FIGURE 4. Weekly production performance of quail fed with different rate of FEMS substitution in terms of FCR. Two-hundred forty- 22 days old RTL quail were randomly assigned to dietary treatment replicates with 20 birds per colony panel. Dietary treatments were as follows: T1(0% FEMS), T2 (5% FEMS), T3 (10% FEMS) and T4 (15% FEMS). The different rates were used for substituting fish meal as one of the feed ingredients in quail's feed formula

TABLE 6

POST-HOC TEST OF WEEKLY FEED CONVERSION RATIO

TREATMENTS	WEEKS								
	4	5	6	7	8	9	10	11	12
0%	1.34^{b}	1.00^{a}	1.11^{a}	1.32^{a}	1.24^{a}	1.47^{a}	1.56^{a}	1.67^{a}	1.74^{a}
5%	1.56^{ab}	1.08^{a}	1.05^{a}	1.38^{a}	1.44^{a}	1.63^{a}	1.79^{a}	1.93^{a}	1.92^{a}
10%	1.48^{ab}	1.19^{a}	1.14^{a}	1.41^{a}	1.45^{a}	1.52^{a}	1.78^{a}	1.77^{a}	1.95^{a}
15%	1.73^{a}	1.13^{a}	1.09^{a}	1.24^{a}	1.35^{a}	1.45^{a}	1.68^{a}	1.87^{a}	1.90^{a}

Means with the same letter are not significantly different at 5% level

The average egg weight is shown in Figure 5. It can be observed that the weekly average together with week x treatment interaction was significantly different from each other (p= <0.001). The heaviest eggs were recorded on Treatment 1 (0% FEMS) for almost the entire study period. On the 4th week, it recorded a 9.59g and 9.88g on the 5th week of the feeding trial; 9.69g, 9.41g, 9.77g, 9.75g, 9.71g, and 9.62g were recorded on 6th to 12th week, correspondingly. It is on the 11th week where Treatment 3 (10% FEMS) produced the heaviest egg weight of 9.71g and Treatment 2 (5% FEMS) on the 12th week of the feeding trial with 9.62g weight. Furthermore, the 7th, 8th, and 10th week conveyed that the treatments differed significantly based on their Tukey's Post-hoc test for the Average Egg Weight as presented in Table 7. The 7th and 8th weeks demonstrated that Treatment 1 (0% FEMS) was statistically different from all other treatments. In the same period, Treatment 2 (5% FEMS), Treatment 3 (10% FEMS), and Treatment 4 (15% FEMS) were not significantly different from one another. Moreover, on the 10th week, Treatment 1 was significant different to Treatment 2 and Treatment 4 but not to Treatment 3. Hence, Treatment 2, Treatment 3, and Treatment 4 are not significantly different in this particular week.

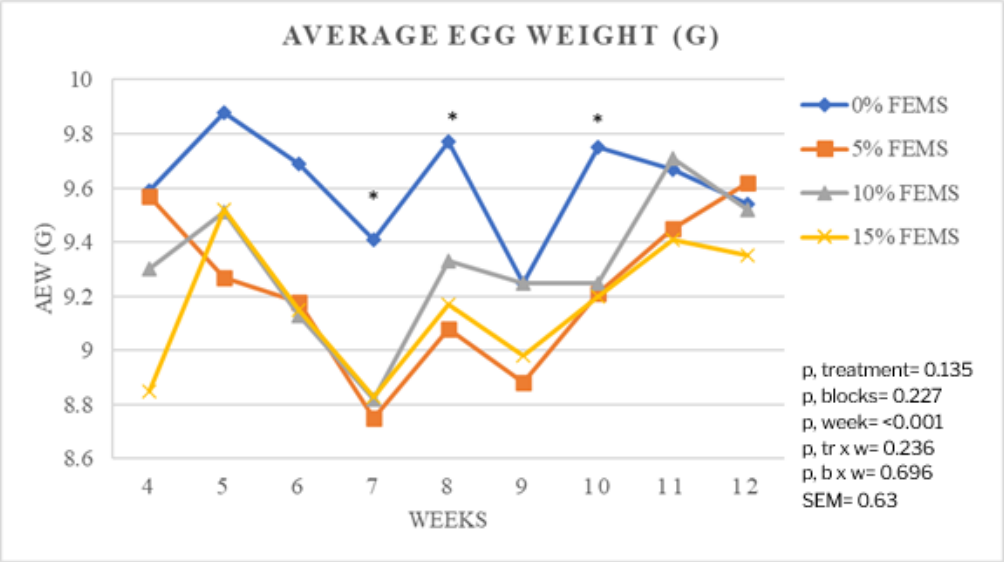

FIGURE 5. Weekly production performance of quail fed with different rate of FEMS substitution in terms of AEW, g. Two-hundred forty- 22 days old RTL quail were randomly assigned to dietary treatment replicates with 20 birds per colony panel. Dietary treatments were as follows: T1(0% FEMS), T2 (5% FEMS), T3 (10% FEMS) and T4 (15% FEMS). The different rates were used for substituting fish meal as one of the feed ingredients in quail's feed formula

TABLE 7
POST-HOC TEST OF WEEKLY AVERAGE EGG WEIGHT, g

TREATMENTS	WEEKS								
	4	5	6	7	8	9	10	11	12
0%	9.59^{a}	9.88^{a}	9.69^{a}	9.41^{a}	9.77^{a}	9.25^{a}	9.75^{a}	9.67^{a}	9.54^{a}
5%	9.57^{a}	9.27^{a}	9.18^{a}	8.75^{b}	9.08^{b}	8.88^{a}	9.21^{b}	9.45^{a}	9.62^{a}
10%	9.30^{a}	9.51^{a}	9.13^{a}	8.82^{b}	9.33^{b}	9.25^{a}	9.25^{ab}	9.71^{a}	9.52^{a}
15%	8.85^{a}	9.52^{a}	9.15^{a}	8.83^{b}	9.17^{b}	8.98^{a}	9.20^{b}	9.41^{a}	9.35^{a}

Means with the same letter are not significantly different at 5% level

The weekly Hen-Egg Day Production, (%) is shown in Figure 6. Based on the figure, a significant difference (p= 0.042) was observed in the interaction between the weeks and the treatments. This means that treatments differed significantly in some of the weeks where 5% level of significance was considered. It also showed an increasing linear production rate. Meanwhile, the 4th week had 18.81% hen-egg day production for Treatment 3 (10% FEMS) which served to be the highest HEDP as well as with week 5 with an HEDP of 32.14%. It can be observed however that 6^{th,} 7th, and 8th week were dominated by Treatment 1 (0% FEMS) with a corresponding HEDP of 45.48%, 47.62% and 60.48%, respectively. As HEDP was dominated by Treatment 1 on the 7th and 8th week, it can be seen on its Tukey's Post-hoc test for HEDP in Table 8 that it was significantly different from Treatment 2, Treatment 3, and Treatment 4. However, Treatment 2 (5% FEMS), Treatment 3 (10% FEMS), and Treatment 4 (15% FEMS) did not differ significantly. Treatment 1 and Treatment 4 were not statistically different as well. The 9th and 10th week showed the highest HEDP (56.67% and 69.76%) on Treatment 4 (15% FEMS). The 11th week of the feeding trial showed that Treatment 3 (10% FEMS) had 71.43% HEDP and the 12th week had 70% HEDP.

The weekly total egg produced is presented in Figure 7. It can be observed that the total mean of collected eggs in the 4th week was 26 pcs from Treatment 3 (10% FEMS) and 45 pcs in the 5th week. Meanwhile, the 6th, 7th, and 8th weeks recorded the highest layed eggs (64pcs, 67pcs and 85pcs, respectively) from Treatment 1 (0% FEMS) and found statistically different with all other treatments based on their Tukey's Post-hoc test shown in Table 14. It was also found out that Treatment 2 (5% FEMS), Treatment 3 (10% FEMS), and Treatment 4 (15% FEMS) were not significantly different; Treatment 1 and Treatment 4 revealed no significant difference on the 7th and 8th weeks data. In the 9th and 10th weeks, it was Treatment 4 (15% FEMS) that showed the highest total of egg produced with 79pcs and 98pcs, respectively. Moreover, in 11th week of the feeding trial, 100pcs total weekly mean collected egg were from Treatment 3 (10% FEMS). Thus, resulted statistically different (p= <0.001).

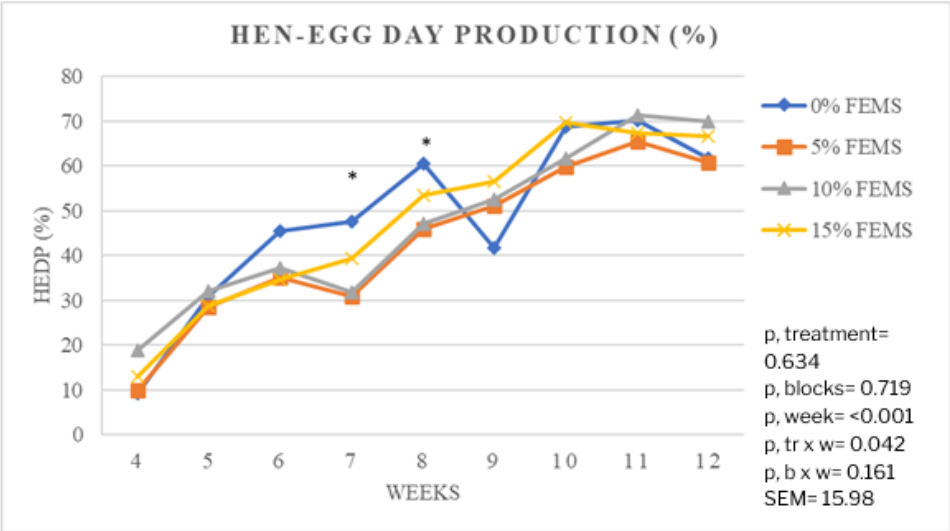

FIGURE 6. Weekly production performance of quail fed with different rate of FEMS substitution in terms of HEDP, %. Two-hundred forty- 22 days old RTL quail were randomly assigned to dietary treatment replicates with 20 birds per colony panel. Dietary treatments were as follows: T1(0% FEMS), T2 (5% FEMS), T3 (10% FEMS) and T4 (15% FEMS). The different rates were used for substituting fish meal as one of the feed ingredients in quail's feed formula

TABLE 8

POST-HOC TEST OF WEEKLY HEN-EGG DAY PRODUCTION, %

TREATMENTS	WEEKS								
	4	5	6	7	8	9	10	11	12
0%	9.29^{a}	30.95^{a}	45.48^{a}	47.62^{a}	60.48^{a}	41.67^{a}	68.81^{a}	70.24^{a}	61.67^{a}
5%	10.00^{a}	28.57^{a}	35.24^{a}	30.95^{b}	45.95^{b}	51.19^{a}	59.76^{a}	65.48^{a}	60.83^{a}
10%	18.81^{a}	32.14^{a}	37.38^{a}	31.90^{b}	47.14^{b}	52.62^{a}	61.67^{a}	71.43^{a}	70.00^{a}
15%	13.10^{a}	28.81^{a}	34.76^{a}	39.29^{ab}	53.57^{ab}	56.67^{a}	69.76^{a}	67.38^{a}	66.67^{a}

Means with the same letter are noy significantly different at 5% level

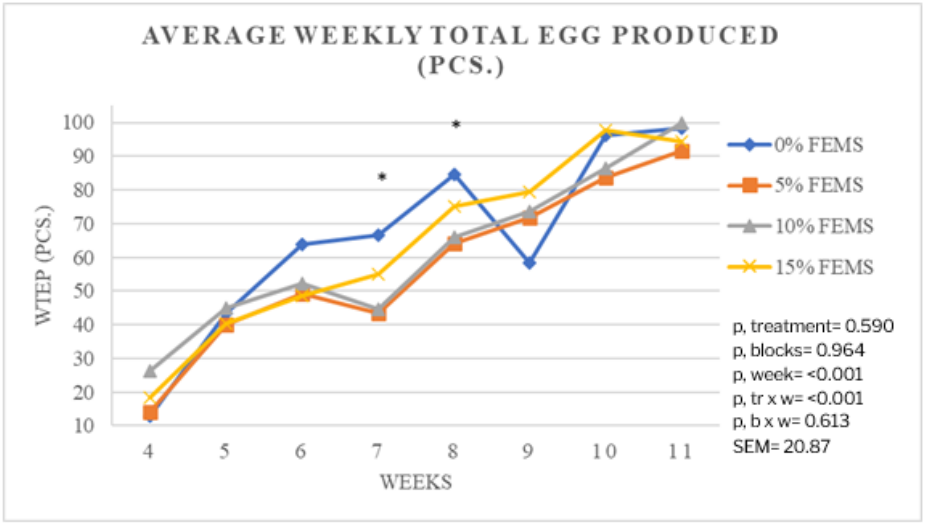

FIGURE 7: Weekly production performance of quail fed with different rate of FEMS substitution in terms of WTEP, pcs Two-hundred forty- 22 days old RTL quail were randomly assigned to dietary treatment replicates with 20 birds per colony panel. Dietary treatments were as follows: T1(0% FEMS), T2 (5% FEMS), T3 (10% FEMS) and T4 (15% FEMS). The different rates were used for substituting fish meal as one of the feed ingredients in quail's feed formula

TABLE 9

POST-HOC TEST OF AVERAGE WEEKLY TOTAL EGG PRODUCED, PCS

TREATMENTS	WEEKS							
	4	5	6	7	8	9	10	11
0%	13.00[a]	43.33[a]	63.67[a]	66.67[a]	84.67[a]	58.33[a]	96.33[a]	98.33[a]
5%	14.00[a]	40.00[a]	49.33[a]	43.33[b]	64.33[b]	71.67[a]	83.67[a]	91.67[a]
10%	26.33[a]	45.00[a]	52.33[a]	44.67[b]	66.00[b]	73.67[a]	86.33[a]	100.00[a]
15%	18.33[a]	40.33[a]	48.67[a]	55.00[ab]	75.00[ab]	79.33[a]	97.67[a]	94.33[a]

Means with the same letter are not significantly different at 5% level

Figure 8 indicates the weekly income over feed cost. The data showed a significant difference (p= <0.001) among weeks and their interaction with treatments. It further indicates that the generation of income over the feed cost in all the treatments had started in the 5th week, but Treatment 3 (10% FEMS) recorded a Php. 1.49 IOFC during the 4th week and continued until the 5th week of the feeding trial with Php. 29.02. It was in 6th, 7th, and 8th week where Treatment 1 (0% FEMS) recorded the highest IOFC of Php. 49.19, Php. 49.73 and Php. 70.91, respectively. Hence, the Ppost-hoctest for IOFC using tukey's method of significant difference as presented in Table 10 indicates that in the 7th week of the feeding trial, Treatment 1 (0% FEMS) was significantly different from the other treatments, however, Treatment 2 and Treatment 3 were not significantly different on the same week. This further revealed that Treatment 1 was significantly different from Treatment 2, Treatment 3, and Treatment 4 but Treatment 2 and Treatment 3 did not differ significantly in the 8th week of the feeding trial. The 9th and 10th weeks of the feeding trial had an income dominated by Treatment 4 (15% FEMS) with an IOFC of Php. 66.55 and Php. 83.17. The 11th week of the feeding trial yielded an income over feed cost of Php. 82.26 on Treatment 3 (10% FEMS).

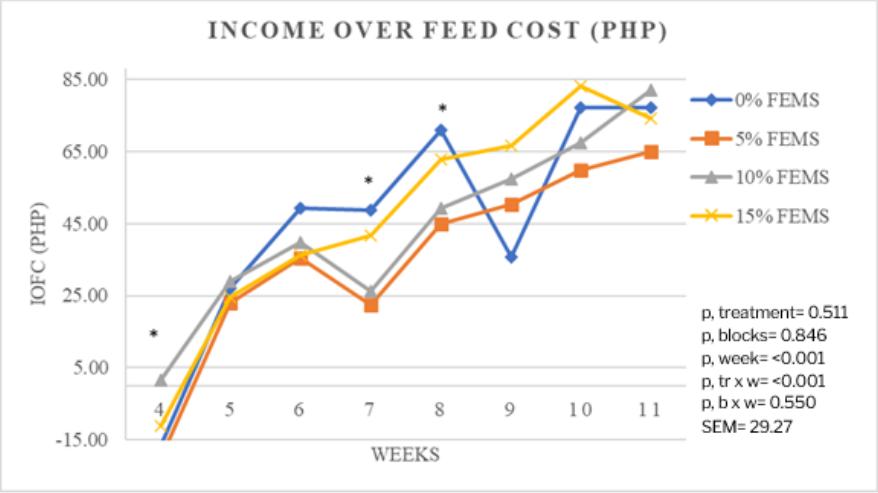

FIGURE 8: Weekly production performance of quail fed with different rate of FEMS substitution in terms of IOFC, Php. Two-hundred forty- 22 days old RTL quail were randomly assigned to dietary treatment replicates with 20 birds per colony panel. Dietary treatments were as follows: T1(0% FEMS), T2 (5% FEMS), T3 (10% FEMS) and T4 (15% FEMS). The different rates were used for substituting fish meal as one of the feed ingredients in quail's feed formula

TABLE 10

POST-HOC TEST OF INCOME OVER FEED COST, Php

TREATMENTS	WEEKS							
	4	5	6	7	8	9	10	11
0%	-16.71[ab]	27.08[a]	49.19[a]	48.73[a]	70.91[a]	35.75[a]	77.35[a]	77.14[a]
5%	-20.09[b]	23.02[a]	35.47[a]	22.31[b]	45.01[b]	50.32[a]	59.76[a]	65.08[a]
10%	1.49[a]	29.02[a]	39.92[a]	26.27[b]	49.38[b]	57.44[a]	67.47[a]	82.26[a]
15%	-11.36[ab]	24.62[a]	36.39[a]	41.81[ab]	62.81a[b]	66.55[a]	83.17[a]	74.39[a]

Means with the same letter are noy significantly different at 5% level

IV. CONCLUSION

The results of the study showed that substitution of FEMS in the formulation of feeds for RTL quail had no prominent effects on the growth and laying parameters and income over feed cost. However, 5% substitution showed a higher average daily gain, 15% substitution had higher percentage of hen-egg day production, and income over feed cost resulted in a greater income in 10% FEMS substitution.

It is concluded that 5%, 10%, and 15% FEMS substitution for fish meal in a quail's feed formula in the study does not have a negative impact on the production performance of quail and can be used as an alternative feed ingredient. However, in the future investigation, increasing the rate of substitution starting from 15% to establish a more definite minimum and maximum value for FEMS as a poultry feed ingredient may also be considered. A different species of earthworm and other insects might also be considered as other sources of animal protein feed ingredient. Furthermore, a comparative evaluation on the fresh earthworm species versus fermented as feed ingredient may also be considered.

ACKNOWLEDGEMENTS

The author would like to acknowledge Almighty God for the source of wisdom. Sincerest appreciation to her professors, Dr. Antonio J. Barroga, Dr. Joice San Andres and Prof. Joseph R. Mendoza who are in one way or another provided guidance, encouragement and intellectual recommendations throughout the research. Also, for DOST-ASHRDP scholarship for the finance extended to pursue the study. The completion of this research could not have been accomplished without the support of his family and friends.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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