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Effects of Levels of Inclusion of Locally Processed Fish Waste Meal in the Diets of White Leghorn Layers on Performance Parameters, Hatchability, Economics, Egg Production and Egg Quality

Research Article

Y. Alemayehu[1], M. Urge[2] and A. Getu[3*]

[1] Department of Animal Production and Technology, Woldia University, Woldia, Ethiopia
[2] School of Animal and Range Science, Collage of Agriculture, Haramaya University, Haramaya, Ethiopia
[3] Department of Animal Science, Faculty of Veterinary Medicine, University of Gondar, Gondar, Ethiopia

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*Correspondence E-mail: belaygetu2004@gmail.com

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ABSTRACT

The study was conducted at Haramaya university poultry farm to evaluate the effects of locally processed fish waste meal (FWM) in the diet of white leghorn layers on the performance and hatchability, egg quality, sensory flavor and profitability of the rations. One hundred eighty chickens at five months of age were randomly distributed (15 layers per each 12 pens). The pens were randomly assigned with three replications for each of four experimental rations. Ninety day age dry matter intake (DMI), laying performance, egg quality of T_1 (conventional layers ration with no FWM), T_2 5% FWM + 10% soybean meal (SBM) + 16% wheat short (WS) + 17% noug seed cake (NSC), T_3 10% FWM + 5% SBM + 8% (WS) + 16.8% (NSC), T_4 15% FWM + 0% SBM + 6% wheat high (WH) + 16.7% (NSC) were considered. The chemical analysis showed that FWM contained 41.2% crude protein (CP) and 2982.04 kcal metabolizable energy (ME)/kg DM. DMI (88.6, 90.1, 89.1 and 89.2 (SEM=2.81, for T1, T2, T3 and T4, respectively) was not statistically different between the treatments. Average daily body weight (BW) gain, (SEM=0.027 g), for T1, T2, T3 and T4, respectively) was significantly lower in T2 and T4 as compared to T3. Hen-day egg production (47.8%, 54.9, 58.1 and 53.8 (SEM=1.32), egg mass (23.0 g, 28.8, 27.1 and 26.8 (SEM=0.73), for T1, T2, T3 and T4, respectively) were significantly higher in diets fed with rations containing FWM as compared to the control group. Feed efficiency ratio (0.26, 0.30, 0.30 and 0.30 (SEM=0.007), for T1, T2, T3 and T4, respectively was significantly higher for groups consumed FWM diet than the control. Eggs from hens fed with rations containing 10 and 15% FWM had moderate fishy flavor (P<0.05) as compared to those consuming the control and T2 diets. The results obtained from partial budget analysis indicated that inclusion of FWM improved the economics of egg production which is attributed to the high cost of soybean meal as compared to FWM and the better efficiency of feed utilization by FWM groups. Thus, FWM inclusion improved egg laying performance and profitability, but imparted moderate fishy flavor beyond 5% inclusion. However, when considering egg production, feed efficiency ratio, net return and egg sale to feed cost ratio, inclusion of FWM in White Leghorn diets at up to 10% is recommended.

KEY WORDS egg production, fish waste meal, hatchability, quality, white Leghorn.

INTRODUCTION

Naturally animals have a capacity to convert feeds into high quality human foods that are rich in protein. But, the production of animal products is not matched by the raised demand by human consumption as a result of the rapid growth of human population which is the major problem in the world in general, and in the developing countries in particular (Rameshwar and Kerthikeyan, 2005). Commonly, protein sources are obtained from cereal grains and important alternatives to fulfill the deficiency of critical amino acids (Reddy, 1999; Smith, 2001). From the total animal population chickens are essential sources of protein and play significant socio-cultural and religious roles in the livelihoods of rural communities of Ethiopia (ESAP, 2009). In ordering to meet the demand of animal protein in developing countries, improving the performance of chickens is mandatory. The total cost of feed in poultry production accounted for about 60-65% of the total cost of poultry production and protein costs account for about 13% of the total feed costs (Hassan *et al*. 2003). A feasible alternative source of feed which is not directly consumed by man is agricultural and aquatic by products. In Ethiopia, there is a possibility of producing more than 5700 tons of fresh fish offal (1900 tons of DM) per annum from fresh water bodies (Asrat *et al*. 2007). The availability of major nutrients and unidentified growth factors, well-balanced amino acid profile and the presence of omega three fatty acids in FWM increases its importance in the feeding of simple stomached animals (Karimi, 2006). In Ethiopia, this potential is not commonly used and the majority of these by products are left unutilized. In some areas of the country, such as rift valley and on Awash River, locally processed fish meal is produced and sold to producers. The available information shows that the inclusion of this by product is small. Therefore the present experimental study was conducted to evaluate the effects of different levels of locally processed FWM on the performance, hatchability, economics and egg quality of White Leghorn layers.

MATERIALS AND METHODS

The study area

The experiment was conducted at Haramaya university poultry farm located 515 km east of Addis Ababa, at an altitude of 1980 masl, 9 ˚26'N latitude and 42 ˚3'E longitude. The mean annual rainfall is 780 mm. The mean annual minimum and maximum temperatures are 8.5 and 24.4 ˚C, respectively (AUA, 1996).

Methodology

The FWM of Nile Tilapia (*Oreochromis niloticus*) was purchased in Zway city and rinsed in clean water and cooked for 20 minutes at a temperature of 95 ˚C (Sotolu, 2009). The mixture was then sun-dried for two consecutive days. At the end of the drying process, the FWM was collected and transported to Bishoftu town. At Bishoftu feed processing plant, the dried FWM was hammer milled to 5 mm sieve size and transported to Haramaya university poultry farm.

Ingredients and experimental rations

The four treatment rations were formulated using Winfeed software version 2.8 to meet the nutrient requirements of approximately 2800-2900 MJ/kg DM of ME and 16-18% CP according to the National Research Council (North, 1984). The FWM was included in the ration at different levels as a substitute for soybean meal, wheat short and Nouge seed cake (Table 1).

Table 1 Proportion of ingredients used in formulating the experimental rations

Ingredients	T1	T2	T3	T4
Fish waste meal	0	5	10	15
Soybean meal	15	10	5	0
Wheat short	17.42	15.77	7.78	6.4
Maize grain	40	43.81	52.1	53.64
Noug seed	19.28	17.12	16.82	16.67
Limestone	7	7	7	7
Vitamin pre-	0.8	0.8	0.8	0.8
Salt	0.5	0.5	0.5	0.5
Total	100	100	100	100

T_1: 0% FWM (control), ration with no fish waste meal (FWM); T_2: ration containing 5% FWM + 10% soybean meal (SBM) + 16% wheat short (WS) + 17% noug seed cake (NSC); T_3: 10% FWM + 5% SBM + 8% WS + 16.8 % NSC; T_4: 15% FWM + 0% SBM + 6% WH + 16.7% NSC.

* Vitamin premix: it has been industrially manufactured and pack of it was purchased from Gasco-trading private limited company found in Addis Abeba; Mineral premix= It has been replaced with limestone due to its limited availability.

The experiment was conducted in a completely randomized design, with 4 treatments each with 3 replications (Table 2).

Management of experimental chickens

Before beginning theexperiment, the experimental house and equipments were carefully cleaned and disinfected. Each replicate was housed in pens of about 0.24 m^2/bird. Each pen was equipped with feeders, waterers and laying nests and covered with dry Tef straw to a depth of about 5 cm. The light was started with 12 hours/day at 5 months of age until 16 hours of light per day was achieved at the age of 8 months. Feed was offered twice a day at 08:00 and 17:00 hours throughout the experimental period. Water was available to the birds at all times. The experimental birds were adapted to the rations for 7 days. Following adaptation, data were collected for 90 days. Turning of litter and changing extremely wet litter with clean and dry was carried out whenever required (Meseret, 2006).

Chemical analysis

Representative samples were taken and subjected to proximate method of AOAC (1990) to determine DM, CP, CF, EE and total ash content. The nitrogen was determined by using the Kjeldhal procedure and CP was computed by

Table 2 Layout of the experiment

Treatments*		Replications	Roasters per replications	Hens per replications
T1	Ration containing 0% FWM	3	2	15
T2	Ration containing 5% FWM	3	2	15
T3	Ration containing 10% FWM	3	2	15
T4	Ration containing 15% FWM	3	2	15
Total		12	24	180

multiplying the N content by 6.25. The ME value was determined indirectly following the method given by Wiseman (1987) as follow: ME (Kcal/ kg DM)= 3951 + 54.4 EE – 88.7 CF – 40.8 ash. The calcium and phosphorus content was determined by atomic absorption spectrophotometry. Chemical analyses were carried out in duplicate at Haramaya university nutrition laboratory.

Dry matter intake

Feed was measured and offered twice a day at 08:00 and 17:00 h to the layers in each pen on an *ad libitum* base. Feed refused from each replicate was collected the next morning before the daily offer was given. The feed offer and refusal were recorded for each replicate and multiplied by the respective DM content. The amount of DM consumed was determined as the difference between the DM offered and refused. The difference between the daily feed offered and refused was divided by the number of birds present that day and experimental period to calculate the mean daily DMI of each bird. Samples of feed offered was taken at each mixing and samples of feed refused were taken every day from each pen and pooled per treatment and sub samples of both were taken at the end of the experiment and analyzed for their nutrient content.

Body weight change

The birds were weighed individually per replicate on the first day with initial body weight of 1039.31 ± 28.14 g after being randomly assigned to individual pens by sensitive balance and the weight per pullet was calculated as average of weights of pullets in the pen and recorded. Final body weight of 1054.93 ± 5.05 g for each replicate was taken at the end of the experiment and recorded. Body weight change per pen per bird was determined as the difference between the final and initial body weight. Average daily body weight gain or loss per bird for each pen was computed by dividing body weight change to the number of experimental days. Average body weights of each replicate were used for data analysis.

Embryonic mortality

Embryonic mortality of the incubated eggs at different stages was determined by breaking eggs on the days of candling (7^{th}, 14^{th} and 18^{th} days) to determine early, mid and late embryonic mortalities, respectively (Bonnier and Kasper, 1990).

Egg production and feed efficiency ratio

Eggs were collected three times a day from each pen at 08:00, 13:00 and 17:00 hours and the sum of the three collections together with the number of birds alive on each day in each pen was recorded and summarized at the end of the experiment. Hen-day and hen-housed egg production for each replicate were calculated following the method given by Hunton (1995).

% Hen-day egg production= no of eggs collected per day / no of hens present that day × 100

% Hen-housed egg production= sum of daily egg counts / no of hens originally housed × 100

Feed efficiency ratio was determined per replicate by dividing the egg mass with the weight of feed consumed.

Egg weight and mass

The eggs were weighed immediately after collection and mean egg weight was determined by dividing the total egg weight with the total number of eggs collected from each pen. The average egg mass per day was computed by multiplying the mean egg weight by percentage hen-day egg production.

Internal egg quality measurement

A total of 5 eggs per replicate were randomly taken from each treatment and their quality was measured for 8 weeks (once in a week). Egg shell thickness was measured using micrometer gauge. Egg shell weight, albumen weight and yolk weight were measured by sensitive balance. The height of albumen was measured by spherometer. Haugh unit measurement technique was used to relate the weight of eggs with the height of thick albumen. The Haugh unit was computed using the following formula (Haugh, 1937).

Haugh unit (HU) in g= 100 log [H – √32.2 [(30W$^{0.37}$–100) / 100] + 1.9]

Where:
H: albumen height (mm).
W: weight of egg (g).
32.2: gravitational constant (G).

Yolk index= [yolk height / yolk diameter] × 100

During yolk color measurement, first the yolk membrane was removed, the whole yolk was thoroughly mixed and yolk sample was taken on a piece of white paper and compared with Roche fan measurement strips. Fertility was determined by candling of the incubated eggs on the 7th day of incubation. Incubation was done using an incubator with a temperature and relative humidity of 37.7 $^{\circ}$C and 85 %, respectively. During the 1st and 18th days and the last three days, the temperature and relative humidity was 37.6 $^{\circ}$C and 90%, respectively. Eggs were turned three times a day. At 21st and 22nd days of incubation, hatched eggs were collected and counted to determine hatchability in relation to the number of fertile eggs (North, 1984).

Sensory evaluation of eggs

A total of 48 egg samples were randomly taken to the food and Postharvest technology laboratory from the four treatment groups (4 eggs from each replication). The samples were cooked for 8 minutes to an internal temperature of 72 $^{\circ}$C using a cooking pan. Then the cooked eggs were allowed to cool at a room temperature for 15 minutes and served to the members of the taste panel in an odorless aluminum plate with a cool drink of water. The average panel assessment value was taken to define the intensity of fishy flavor in eggs of white leghorn chicken fed varying levels of locally processed FWM (González-Esquerra and Leeson, 2001).

Chick quality

A total of 5 chicks were randomly taken from each replication to determine the weight and length of chicks. The body weight of the chicks in grams (g) was measured immediately after hatching using a sensitive balance. Chick length was taken by measuring the length of stretched chick from the tip of the beak to the middle toe using a 50 cm ruler and recorded in centimeters (cm). All the three measurements were conducted on the same chick samples.

Partial budget analysis

The partial budget was calculated as the difference between the feed costs incurred during the experimental periods and sale of eggs. The net income (NI) was calculated by subtracting total cost (TVC) from the total return (TR). The marginal rate of return (MRR) which measures the increase in net income (ΔNI (NI from diets with FWM minus NI from control diets)) associated with each additional unit of expenditure (ΔTVC (TVC from diets with FWM minus TVC from control diets)) was computed as:

$$MRR = \Delta NI / \Delta TVC$$

Feed cost per dozen of eggs, egg sale to feed cost ratio and feed cost per egg mass were also calculated as an additional method of judging cost benefit of feeding FWM (Webster *et al.* 2003).

Statistical analysis

DMI, body weight change, egg mass, egg, shell, albumen and yolk weight, egg production, FCR, yolk height, albumen height, yolk diameter, yolk index, haugh unit, shell thickness, chick weight and length were analyzed by one way analysis of variance and when the analysis of variance indicated the existence of significant difference between treatment means, the least-significance-difference method was used to locate the treatment means that were significantly different from each other (Gomez and Gomez, 1984). The model used for statistical analysis was:

$$Y_{ij} = \mu + T_i + e_{ij}$$

Where:
Y_{ij}: response variable.
μ: mean.
T_i: treatment effect.
e_{ij}: random error.

General logistic regression analysis was employed for data recorded on fertility, hatchability, yolk color, embryonic mortality, visual scoring and sensory evaluation. The general logistic regression model is given below:

Model: $\ln \pi/1\text{-}\pi = \beta_o + \beta_1 \times (X)$

Where:
π: probability
β: slope.
X: b treatment.

Test H_0: No treatment effect (i.e., $\beta_1=0$) *vs.* H_A: significant treatment effect ($\beta_1 \neq 0$).

Where:
p: probability.
B: slope.
X: treatment.

RESULTS AND DISCUSSION

In the case of the chemical composition of feed ingredients used for experimental ration formulation, about nine chemical components were considered and are set out in Table 3, 4, 5, 6, 7, 8, 9, 10 and 11. About the proportion of the chemical composition of feed ingredients, treatment diets, effect of inclusion of different proportion of fish waste meal in white leghorn layers ration on feed intake and performances, ration on egg quality parameters, yolk color, ration on chick quality and dozens of eggs, egg sale to feed cost ratio and feed cost per egg mass are the main areas the investigation. From the above characteristics some traits are recorded a significance and highly significant (P<0.05) differences among different factors in all experimental traits**.** The research result showed that the percentage of (%DM) in FWM is significant higher than DM% of other chemical compositions with the proportional value of 5.60 than SBM, NSC, MG and WS with the index value of 0.32, 0.83 0.92 and 0.71, respectively.

Table 3 Chemical composition of feed ingredients used for experimental ration formulation

Chemical com-	FW	SBM	NSC	MG	WS
DM (%)	92.48	91.93	91.89	89.55	89.77
CP (% DM)	40.54	41.56	27.00	8.67	17.96
EE (% DM)	9.1	8.89	7.93	5.12	5.41
Ash (% DM)	34.43	7.98	7.98	1.79	5.18
CF (% DM)	0.42	6.25	20.26	6.83	9.00
NFE (% DM)	7.99	27.25	28.72	67.14	52.22
Ca (% DM)	4.42	0.35	0.35	0.02	0.147
P (% DM)	5.60	0.32	0.83	0.92	0.71
ME (kcal/kg DM)	3004.02	3554.81	2259.57	3412.15	3235.83

DM: dry matter; CP: crude protein; EE: ether extracts; CF: crude fiber; NFE: nitrogen free extract; ME: metabolizable energy; FWM: fish waste meal; SBM: soybean meal; NSC: noug seed cake; MG: maize grain; WS: wheat short.

Table 4 Chemical composition of treatment diets containing different proportions of FWM

Chemical components	T1	T2	T3	T4
DM (%)	91.62	91.24	91.43	91.81
CP (% DM)	18.04	17.44	16.59	16.38
EE (% DM)	5.34	5.83	6.09	7.13
Ash (% DM)	6.92	7.78	8.7	9.03
CF (% DM)	11.57	11.87	11.72	11.83
NFE (% DM)	49.75	48.32	48.3	55.61
Ca (% DM)	2.94	3.14	3.35	3.55
P (% DM)	0.69	0.96	1.22	1.48
ME (kcal/kg DM)	2897.42	2897.86	2887.77	2919.35

DM: dry matter; CP: crude protein; EE: ether extracts; CF: crude fiber; NFE: nitrogen free extract; ME: metabolizable energy.

The CP content of cooked and sun dried FWM produced under Ethiopian condition has been reported to be 44.7 % (Asrat *et al.* 2008). Biazen (2010) also reported a value of 48.75 % for fish byproduct meal obtained from the same source as that used in our experiment, and both are higher than the present value. A value of 40.48% CP was also reported in Nigeria for locally processed FWM (Ojewola *et al.* 2005), which is slightly lower than the present value. Windsor (2001) noted that fish meal made mainly from filleting offal usually has slightly lower protein content and a higher mineral content, which is the case in FWM used in the present experiment. Moghaddam *et al.* (2007), recorded higher EE (22.9%) for the Iranian Kalka fish meal from which fat was not removed. Asrat *et al.* (2008) and Biazen (2010) reported values of 21.6% and 21.37% for locally produced FWM, respectively which are by far higher than recorded in the present FWM. Similar to the value obtained in the present experiment, a very low value (8.21%) was reported by Ojewola *et al.* (2005) for locally processed FWM in Nigeria. Asrat *et al.* (2008) reported 3160 Kcal/kg dry matter ME for locally produced FWM, which was slightly higher than the present findings. Similarly, Biazen (2010) reported 3987.3 Kcal/kg of feed for locally produced fish byproduct meal, which was very much higher than the present findings. Ponce and Gernat (2002) have reported a value of 2600 Kcal/kg of feed for tilapia by product meal samples which was considerably lower than the present results. According to Koning (2005) the mineral (ash) content of fish meal varies considerably from about 10% to 25% depending on the amount of cannery offal used in its production. Fish meal produced from offal contains a high concentration of minerals as the bony frames of previously filleted fish species are used (Ponce and Gernat, 2002). Biazen (2010) and Asrat *et al.* (2008) reported a value of 27.32% and 24.76% total ash, respectively for FWM obtained from local processors at Ethiopian rift valley lakes. Dale *et al.* (2004) reported a value of 25.5% for eight tilapia byproduct meal samples. The mineral (ash) content of FWM obtained in the present experiment was slightly higher than the values reported by these previous authors. The FWM have higher ash content because the product contains bones and scales than conventional fish meal (Ingweye *et al.* 2008). Nadeem (2003) noted that composition of fish meal can vary depending upon species of the fish and the method used to prepare the meal. Choo and Sadiq (1982) and Khatoon (2006) reported an inverse correlation between fat, ash and crude protein contents of fish meal. That is fish meal with low protein contains high levels of fat and ash and vice versa. Even though the total protein composition of a given feed is important, the quality and quantity of the essential amino acid contents of the protein determine to a consider able extent its nutritive value in poultry ration (Fisher and Boorman, 1986). In this regard FWM is a high value supplement and provides most of the essential amino acids required by monogastric animals (Karimi, 2006). Insignificant differences in average daily dry matter intake between treatment diets was probably related to the closely similar energy content of the diets (Melesse, 2007), or possibly the palatability of the diets was not affected by CP levels. Similarly, feed intake is not significantly affected by dietary crude protein level, and the major dietary factor that affects feed intake is energy concentration (Smith, 2001).

Significantly higher (P<0.001) total and average daily body weight gain recorded in layers fed T3 diet might be due

Table 5 Effect of inclusion of different proportion of fish waste meal in white leghorn layers ration on feed intake and performance

Parameters	T1	T2	T3	T4	SEM	Significant
DMI (g/hen/day)	88.6	90.1	89.1	89.2	NA	**
Initial BW (g)	1020.4	1054.2	1026.2	1056.5	8.12	NS
Final BW (g)	1038.9	1060.2	1047.3	1073.3	5.05	NS
Total BW gain (g/head)	18.5^{ab}	5.9^{c}	21.1^{a}	16.8^{b}	1.79	***
Average daily BW gain (g/day/hen)	0.21^{ab}	0.07^{c}	0.23^{a}	0.19^{b}	0.027	***
Total egg produced†	1748.3^{b}	1999.0^{a}	2114.0^{a}	1957.0^{a}	15.61	*
Total egg per hen†	38.9^{b}	44.4^{a}	47.0^{a}	44^{a}	1.04	*
Hen-day egg production (%)	47.8^{b}	54.9^{a}	58.1^{a}	53.8^{a}	1.32	*
Hen-housed egg production (%)	43.0^{b}	49.4^{a}	52.2^{a}	48.3^{a}	1.17	*
Egg weight (g)	48.0	48.9	50.4	49.9	0.45	NS
Egg mass (g)	23.0^{b}	28.8^{a}	27.1^{a}	26.8^{a}	0.73	**
Feed efficiency ratio (g)	0.26^{b}	0.3^{a}	0.3^{a}	0.3^{a}	0.007	**

[ab] Means with in a row with different superscripts are significantly different (P>0.05).
significant at (P<0.05); ** significant at (P<0.01); *** significant at (P<0.001); NS: non significant; NA: not available.
SEM: standard error of the means.

Table 6 Effect of inclusion of different proportion of fish waste meal in white leghorn layers ration on egg quality parameters

Parameters	T1	T2	T3	T4	SEM	Significant
Sample egg weight	49.64	51.14	50.46	52.54	0.441	NS
Haugh unit	92.50^{a}	91.03^{b}	90.27^{b}	91.23^{ab}	0.303	*
Shell thickness(mm)	0.34^{a}	0.33^{ab}	0.32^{bc}	0.30^{c}	0.006	**
Shell weight (g)	5.90^{b}	5.87^{b}	5.83^{b}	6.17^{a}	0.050	*
Albumen weight (g)	29.95^{b}	30.74^{ab}	30.37^{b}	31.60^{a}	0.176	*
Yolk weight (g)	13.79^{b}	14.53^{a}	14.26^{ab}	14.77^{a}	0.133	*
Albumen height (mm)	8.10^{a}	7.93^{ab}	7.80^{b}	8.03^{a}	0.043	*
Yolk height (mm)	15.39^{b}	15.98^{a}	15.69^{ab}	15.81^{a}	0.080	*
Yolk Diameter (cm)	3.60^{b}	3.62^{b}	3.65^{b}	3.73^{a}	0.018	*
Yolk Index (%)	42.79^{b}	44.14^{a}	42.98^{b}	42.34^{b}	0.229	**

[ab] Means with in a row with different superscripts are significantly different (P>0.05).
significant at (P<0.05); ** significant at (P<0.01); *** significant at (P<0.001); NS: non significant; NA: not available.
SEM: standard error of the means.

Table 6 Yolk color points of egg samples from different experimental diets

Treatments	Roche color fan number				Total	Significant	Probability (5%)
	1	2	3	4			
T1	39	52	25	4	120	**	
T2	31	73	15	1	120	NS	0.74
T3	67	45	8	0	120	**	
T4	56	54	8	2	120	**	
Total	193	224	56	7	480	**	

to the unidentified growth factors in FWM. Oliveira-Goumas (2003) also obtained similar results. The higher egg production in layers fed the diet containing FWM could be due to higher levels of lysine, methionine and a combination of other amino acids (Sohail *et al.* 2003); positive correlation of methionine and lysine with egg production (Uma, 2000); manipulation of essential amino acids increased egg number (Gous and Nonis, 2010); or egg mass followed the same trend as egg production or when the dietary levels of lysine increased from 0.50 to 0.64 % (Fakhraei *et al.* 2010).

The improvement in egg mass in layers fed the diet containing fish waste meal is due to the higher egg production and the slight numerical increase in egg weight. Previous studies (Pesti *et al.* 1992; Bunchasak and Silapasort, 2005; Wu *et al.* 2007 and Fakhraei *et al.* 2010) also showed that increased methionine and lysine intake improves egg production and increases egg weight, as a result egg mass also increases. Significant increases in feed efficiency ratio in layers fed the diet containing fish waste meal is obtained. Since egg production and to some extent egg weight was higher in the FWM groups, egg mass is higher, as a result

Table 7 Effect of inclusion of different proportion of fish waste meal in white leghorn layers ration on yolk color, fertility, hatchability, sensory flavor of eggs, visual quality of chicks and embryonic mortality

Parameters		T1	T2	T3	T4	SEM	Significant	Probability (5%)
YC	1	13	10.33	22.33	18.67	1.885	NS	0.74
	2	17.33	24.33	15.00	18.00	1.597	NS	
	3	8.33^{a}	5.00^{ab}	2.67^{b}	2.67^{b}	0.865	*	
	4	1.33	0.33	0.00	0.67	0.260	NS	
Fertility		39	39	40	40	0.195	NS	1
HFEB		33	32.33	30.67	29.67	0.773	NS	0.15
SFE	ND	2	2.33	0.67	1.33	0.288	NS	0.03
	SLF	2	1.67	1.33	1.67	0.310	NS	
VSC		4	5.67	4.67	4.33	0.607	NS	0.77
EEM		0.33	0.00	1.33	0.67	0.193	NS	0.62
MEM		1.33	2.33	1.33	2.00	0.329	NS	0.74
LEM		3.00^{b}	3.33^{b}	6.00^{ab}	7.33^{a}	0.690	*	0.03

HFESB: hatchability on fertile egg basis; EEM: early embryonic mortality; LEM: late embryonic mortality ND: non-detected; MEM: mid embryonic mortality; SFE: sensory flavor of eggs; SLF: slight fishy; YC: yolk color; VSC: visual scoring of chicks.
[ab] Means with in a row with different superscripts are significantly different (P>0.05).
* significant at (P<0.05); ** significant at (P<0.01); *** significant at (P<0.001).
NS: non significant.

Table 8 Effect of inclusion of different proportion of fish waste meal in white leghorn layers ration on chick quality

Parameters	T1	T2	T3	T4	SEM	F-test
Chick weight (g)	151.8^{b}	220.0^{a}	158.8^{b}	162.1^{b}	8.65	***
Chick length (cm)	16.1^{c}	16.9^{a}	16.6^{b}	15.6^{d}	0.15	***

[a-c] Means with in a row with different superscripts are significantly different.
*** significant at (P< 0.001).
SEM: standard error of the means.

Table 9 Effect of inclusion of different proportion of fish waste meal in white leghorn layers ration on net income and Marginal rate of return

Parameters	T1	T2	T3	T4
Cost/100Kg diet	305.3	298	292.3	283.1
Total feed consumed(kg)	443.8	451.6	447	447
Total egg produced†	1748.3	1999	2114	1957
Total feed cost/treatment (Birr)	1355.2	1345.8	1304.9	1265.6
Egg sell (TR)	2622.4	2998.5	3171	2935.5
Net return(NR)	1267.2	1652.7	1866.1	1669.9
Change in total variable cost	-	-9.4	-50.3	-89.6
Change in total return	-	376.1	548.6	313.1
Change in net return	-	385.5	598.9	402.7
MRR	-	-41	-11.9	-4.5

TC: total cost; TR: total return; NR: net return; †: Values are number; kg: kilogram.
Birr is Ethiopian currency; the price of the egg during the experiment at local market was 1.5 Birr/egg.
MRR: marginal rate of return.

Table 10 Effects of inclusion of different levels of FWM in white leghorn layers ration on feed cost per dozen of eggs, egg sale to feed cost ratio and feed cost per egg mass

Parameters	T1	T2	T3	T4	SEM	Significant
Feed cost per dozen of eggs (b)	8.4^{a}	7.2^{b}	6.6^{b}	6.9^{b}	0.28	**
Egg sale to feed cost ratio (b)	1.94^{b}	2.23^{a}	2.43^{a}	2.32^{a}	0.06	**
Feed cost per egg mass (b)	1.32^{a}	1.12^{b}	1.05^{b}	1.01^{b}	0.04	**

Means with in a row with different superscripts are significantly different.
**=Significant at (P< 0.01); *b=birr.
SEM: standard error of the means.

feed efficiency ratio is improved in the current experiment.

This has already been noted by other authors including Naulia and Singh (1998); Solangi *et al.* (2002) and Oliveira -Goumas (2003). Increased shell weight in the present experiment is in agreement with the results of Amao *et al.* (2010) who obtained increased shell weight when the level of fish meal increased from 1% to 4%. The thickness of an egg shell is determined by the amount of time it spends in the shell gland (uterus), the rate of calcium deposition during egg shell formation, and dietary calcium content. Although dietary calcium content of the present diet increased with increasing inclusion of FWM, thickness of the egg shell is lower at the higher level of FWM inclusion (T4). This might be attributed to the relatively numerically (P=0.096) bigger egg size recorded in T4 group, or other factors, such as Ca:P ratios, which are known to be responsible for thinner egg shell. Significant increase in albumen weight of layers in T4 is consistent with the findings of Amao *et al.* (2010) and Hazim *et al.* (2011).The yolk weight in the present experiment was directly correlated with the yolk height. The increase in yolk weight due to FWM inclusion may be related to the formation of choline from methionine that could be added to the phospholipids to form lipoproteins of yolk (Brumano *et al.* 2010). These findings were in line with the results of Hazim *et al.* (2011). The yolk height in the present study was directly correlated with the same trend in yolk weight. These findings are in agreement with the results of Amao *et al.* (2010) and Hazim *et al.* (2011). The present results indicate that increasing the level of inclusion of fish meal in the diet of layers caused a significant improvement in the yolk diameter of the egg which is consistent with the findings of Hazim *et al.* (2011). The higher yolk index is attributed to the higher yolk height and lower yolk diameter as compared to the other treatments. The result obtained in the present experiment is similar to the findings of Amao *et al.* (2010) who indicated a decreased yolk index value as the level of fish meal in the diet of layers increased from 1% to 4%. The present result is similar to the findings of Amao *et al.* (2010) who found a non-significant result in yolk color between treatments fed different levels of fish meal. The color of the yolk is determined by the presence and absence of xanthophylls some of which are precursors of vitamin A (Smith, 1996). The color of egg yolk is a dietary response, and a suitable degree of pigmentation and xanthophyll content are of concern in table eggs as well as in eggs for manufacturers. The yolk color depends not only on the levels of xanthophylls present in the feed, but also on the type and ratio of these compounds (Galobart *et al.* 2004). For achieving optimal yolk coloration, hens' diets should be supplemented with yellow and red xanthophylls. The present results indicated that inclusion of FWM does not change factors responsible for yolk color. Significantly higher fishy flavor of eggs was detected for layers fed T3 and T4 relative to T2 and the control. These findings were in agreement with the results of North (1978) who concluded that oil from ash imparted a definite fishy taste and odor in poultry eggs when hens' diet contained more than 8 to 10% ash meal. However, González-Esquerra and Leeson (2001) stated that there is a considerable discrepancy among authors about the levels of fish oil or fish meal considered acceptable in terms of egg sensory quality. This is mainly due to differences in experimental procedures such as technique used for sensory evaluations, number of people recruited in panels, cooking procedures, type and quality of fish oil and fish meal used, presence or absence of dietary antioxidants, storage conditions of ingredients and that of the eggs tested. The present results are similar to the findings of Kushak *et al.* (1990) who reported that the cost of feeding chickens decreased with increasing fish meal replaced by protein concentrates. Ahmad *et al.* (2006) indicated that profit was significantly affected by variable feed cost and total cost of production. Increased growth rate and decreased production costs were observed when fishmeal was replaced by different protein concentrate. Feed cost per dozen of eggs must always be the least-cost against expected egg revenue in order to maximize profits (Miles and Jacob, 2000). In order to achieve economic rates of growth or egg production, it is necessary to feed high quality diets with high concentrations of essential nutrients. Fish meal is often the preferred source of protein because of the balance of essential amino acids. (ACAF, 2001).

CONCLUSION

The result of the economic analysis suggested that feeding FWM at the present levels would increase profitability.

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