Effect of Fishmeal Supplementation on Egg Production of Rhode Island Red Layers in Eritrea

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Abstract

Two hudred one-year old Rhode Island Red layers were placed into two groups of 100 each. One group was fed on a control diet (CD) that consisted of sorghum, wheat middlings, maize, meat and bone meal, and salt to make 50, 34, 10, 5, and 1 %, respectively, by weight. The crude protein (CP), crude fiber (CF), lysine and methionine + cystine content in % and ME in MJ/kg of CD was 13.84, 3.82, 0.36, 0.48 and 11.58, respectively. In an attempt to improve the inadequacy of CD, fishmeal, locally produced by sun-drying and grinding, was added to CD to make 4.76 % of the diet by weight. The fishmeal-supplemented diet (FMD) was fed to the other group. The CP, CF, lysine and methionine + cystine content in % and ME in MJ/kg of FMD was 15.88, 3.64, 0.51, 0.54 and 11.54. Both groups had acess to free limestone at all times. The experiment had four periods of two weeks each with the layers in Group 1 being fed on FMD and Group 2 on CD in Period 2. In Period 4, the diets were switched with Group 1 being fed on CD and Group 2 on FMD. In periods 1 and 3, both groups were fed on CD.

Feed intake and egg production were significantly ($P < 0.001$) improved by fishmeal supplementaion. In Period 2, the layers fed CD had a feed intake of 88.9 g per layer per day and an egg production of 40.4 % while the corresponding figures for those fed on FMD were 113.9 g and 65.9 %. In Period 4, feed intake in g per day and egg production percent were 96.1 and 40.7, respectively for the layers fed on CD and 105.4 and 65.9 for the layers fed on FMD. Egg weight was higher and cost per egg was lower for layers fed on FMD compared with those fed on CD.

Keywords: Fishmeal, layers, lysine, sulfur-containing amino acids, supplementation

Introduction

Fishmeal is a high quality animal feed used to provide a good balance of essential amino acids, energy, vitamins, minerals and trace elements for poultry, pigs and ruminants (FAO, 1986; Bimbo and Crowther, 1992; O'Connor et al., 1993). However, the high cost of imported fishmeal (Amadei, 1998; Nwokoro and Olumide, 1996) has increased the need to explore locally available sources of fishmeal either from shrimp by-catch or small pelagic fish (Tuitoek and Ayangbile, 1994). Fishmeals, locally produced mostly through sun-drying and grinding, have been shown to have a comparable nutritive value to imported fishmeals (Lim et al., 1989; Eid et al., 1992; Steiner-Asiedu et al., 1993; Farkhoy et al., 1995). Promising results have been obtained from trials carried out on poultry and pigs using locally prepared fishmeals (Tuitoek, 1992; Bouzouaia and Rekhis, 1994; Tuitoek and Ayangbile, 1994; Nwokoro and Olumide, 1996). Shortage of high quality protein supplement is a major constraint to the development of the poultry industry in Eritrea. The feed for layers that is currently available in Eritrea is so inadequate that unless producers supplement it with a source of protein, the egg production

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obtained is usually low. Eritrea has a big potential to meet the supplementary protein needs of its livestock and poultry from fishmeal. Other than limited attempts that are being made by poultry keepers to make use of fish waste by boiling and feeding it to layers, so far little benefit has been derived from this resource. In contrast to conventional processing of fishmeal, which requires large-scale production and mechanization, fishmeal produced by simple sun drying and grinding can offer Eritrean poultry keepers a high quality protein supplement at a reasonably affordable price. The fishmeal produced in this manner had an average CP content of 56.6 % on dry matter basis.

The objective of this experiment was to examine the effect on egg production of supplementing the commercial diet of layers with locally produced sun-dried and ground fishmeal.

Materials and Methods

Experimental design

A total of two hundred Rhode Island Red layers of about one year of age, which had been laying for 6 months, were divided at random into two groups (Group 1 and Group 2) of one hundred each and placed in two separate, similar pens. Feed intake and egg production for each group were determined daily. The ingredients of the control diet (CD), which was the only commercial layer diet available in the country at the time of the experiment, were sorghum, wheat middlings, maize, meat and bone meal and salt making 50, 34, 10, 5 and 1 %, respectively, by weight. The fishmeal-supplemented diet (FMD) was composed of sorghum, wheat middlings, maize, meat and bone meal, fishmeal and salt making 47.62, 32.38, 9.52, 4.76, 4.76 and 0.95 %, respectively, by weight as shown in Table I. The experiment consisted of four consecutive periods of two weeks each. In Period 1, both groups were fed on CD. In Period 2, Group 1 was fed on FMD and Group 2 on CD. In Period 3, both groups were fed on CD. In Period 4, the diets were switched and Group 1 received CD while Group 2 received FMD. All diets were provided ad lib. Both groups had access to clean water at all times and limestone was provided outdoors ad lib.

Table 1: Composition of the experimental diets (%)

Item	CD	FMD
Sorghum	50.00	47.62
Wheat middling	34.00	32.38
Maize	10.00	9.52
Meat and bone meal	5.00	4.76
Fishmeal	-	4.76
Salt	1.00	0.95
Crude protein	13.84	15.88
Crude fiber	3.82	3.64
ME, MJ/kg (calculated analysis)	11.58	11.54
Arginine	0.60	0.69
Glycine + serin	1.15	1.35
Histidine	0.32	0.35
Isoleucine	0.56	0.64
Leucine	1:50	1.60
Lysine	0:36	0.51
Methionine	0.22	0.27
Methionine + cystine	0.48	0.54
Phenylalanine	0.67	0.74
Phenylalanine + tyrosine	1.17	1.32
Threonine	0.45	0.51
Tryptophan	0.13	0.15
Valine	0.66	0.77

Housing and Management

The layers were housed in two identical pens, each with an open fenced area where they could get fresh air, exercise and have free access to limestone. At the beginning of the experiment, fresh saw dust was put on the floor of both pens. Each pen had an equal and adequate number of feeding and watering troughs. The layers were given feed twice a day, at 8 o'clock in the morning and about 3 o'clock in the afternoon. Before the next meal was given, any left over was collected and weighed.

Chemical analyses

Samples of the diets were collected at regular intervals. The contents of dry matter, crude protein (CP) (Kjeldahl-N x 6.25), crude fat as HCl-ether extract,crude fiber (CF) and ash in the fishmeal and the control diet were analysed according to standard procedures described by the Association of Official Analytical Chemists (AOAC) (1990). Amino acid composition was determined according to OJEC (1998). Tryptophan was determined according to OJEC (2000).

Statistical analysis

The trials were designed according to a completely randomised design. Each group was the experimental unit. Egg production and feed intake were analysed using the GLM procedure of the SAS Institute, Inc. (1990). Results were presented as the least square means (LSMEANS) of the group in each period (treatment), and variance of the data was presented as standard error of the means (SEM).

Results

Analysis of rations

The chemical analysis of CD resulted in the ration having CP, CF, lysine and methionine + cystine of 13.84, 3.82, 0.36 and 0.48 %, respectively, on dry matter basis. The calculated ME was 11.58 MJ/kg. Upon chemical analysis FMD was found to have a CP, CF, lysine and methionine + cystine % of 15.88, 3.64, 0.51, and 0.54, respectively, on dry matter basis. The calculated ME was 11.54 MJ/kg.

Feed intake

During Period 1, the average daily feed intake per layer in groups 1 and 2 was 92.1 and 88.9 g, respectively, the difference being not significant (P=0.50). For some days it went as low as 70 g per day.

During Period 2, the supplementation of fishmeal had a drastic effect on feed intake. Average daily feed intake per layer in Group 1 (FMD) increased to 113.9 g, being significantly higher (P<0.0001) than that of Group 2 (CD), which remained at 88.9 g. After inclusion of fishmeal, the feed intake of Group 1 showed a 23.67 % increase in Period 2 compared to Period 1.

In Period 3, when both groups again received CD, the daily feed intake of the group that received FMD during Period 2 (Group 1), decreased by 29.76 % from 113.9 g in Period 2 to 80 g. Similarly, the control group from Period 2 (Group 2) also had a low daily intake of 78.2 g during this period, the difference not being significant between the two groups (P=0.82).

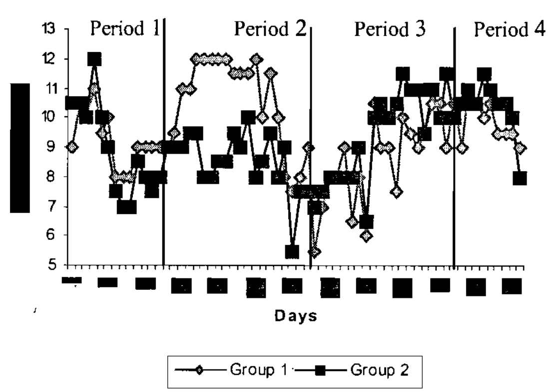
In Period 4, the groups were switched compared to Period 2, and feed intake of the fishmeal supplemented group (Group 2) was 106.4 g while that of the unsupplemented group (Group 1) was 96.8 g. While both groups showed increases in their feed intake, it was more marked for the fishmeal-supplemented group being 36.1 % higher than their intake in Period 3.

Egg production (Hen-day egg production)

The egg production during Period 1, when both groups received CD, was 35.8 % for Group 1 and 36.3 % for Group 2, the difference not being significant (P = 0.85).

In Period 2, egg production significantly (P = 0.003) increased to 53.4 % for Group 1 receiving the fishmeal-supplemented diet, compared to 37.8 % for the control group (Group 2). However, the response to fishmeal supplementation first became fully evident after about one week, and its effect continued for about one week into Period 3, after fishmeal supplementation had been stopped (Figure 1). If the egg production, during this two-week period with full effect of fishmeal supplementation, is compared, it was 65.9 % for the fishmeal-supplemented group, which is even more significantly higher (P <0.001) than the 40.4 % for the control group.

Figure 1. Feed intake of layers fed the control diet or he fishmeal supplemented diet



Period 1. Diets; Group 1, CD[1]; Group 2, CD
Period 2. Diets; Group 1, FMD[2]; Group 2, CD
Period 3. Diets; Group 1, CD; Group 2, CD
Period 4. Diets; Group 1, CD ; Group 2, FMD

Day 20-34 and 48-62: Egg production figures used to show the full effect of fishmeal supplementation in Periods 2 and 4, respectively.
[1]**Control diet,** [2] **Fishmeal supplemented diet**

During Period 3, even though Group 1 produced more eggs than Group 2, their production progressively decreased as shown in Figure 1, and towards the end of the two-week period, egg production for both groups had levelled.

In Period 4, egg production for Group 2 (FMD) was significantly higher ($P < 0.001$) at 50.43 % than for Group 1 (CD), which was 27.36 %. However, a similar effect as in Period 2 was observed, as it took about one week after the start of supplementation of fishmeal until the full effect on egg production was reached, and the effect of fishmeal lingered for about one week after termination of the supplementation. If this period is considered, egg production for the layers in Group 2 increased to 65.9 %, while for the unsupplemented group it was 40.7 %.

Weights of eggs taken during the second week of periods 2 and 4 showed a significant ($P < 0.001$) increase in egg weight with supplementation of fishmeal. In Period 2, mean egg weight for Group 1 (FMD) was 63.6 g compared to 60.2 g for Group 2 (CD). Similarly, for Period 4, the egg weight of Group 2 (FMD) was 63.6 g compared to 60.8 g for Group 1 (CD).

Discussion

It took a few days before the full effect of the addition of fishmeal could be seen in increased egg production and the period of time used in the analysis for egg production was chosen taking this fact into consideration. The reason for this lag period before the higher supply of nutrients were translated into higher egg production could be due to the length of time required for the third stage in the development of a follicle in the ovary. Gilbert (1972) divides the life of a follicle in the adult into three stages: the first lasts for many months and is characterised by the accumulation of only a little fatty material; the second lasts for a few weeks during which time white yolk is deposited, while the third stage is one of rapid growth when the follicle increases from 0.5 g to about 20 g usually within 7 to 11 d, though its duration may be as little as 5 d or as much as 14 d. This is terminated by either ovulation or atresia and regression. The constituents of the yolk of the egg are not synthesised by ovarian tissue. The diverse protein and lipoproteins specific to the egg, in particular phosvitin, lipovitellin and lipovitellenin are synthesised in the liver. They are subsequently transported in the blood stream, and then pass through the wall of the ovocyte through selective mechanisms (Larbier and Leclercq, 1994). The reduction in egg production observed on layers fed on CD could be explained by a lowering in follicular activity, with the third stage of rapid growth of the yolk of the egg slowing down due to deficiency of nutrients while with improvement in the nutrients due to addition of fishmeal, this stage was more enhanced resulting in higher rates of lay. This effect is also expected to continue for a few days even after stopping the supplementation of fishmeal. Williams and Sharp (1978) found that it took about 11 days for dye to disappear from the eggs laid after feeding a dye capsule.

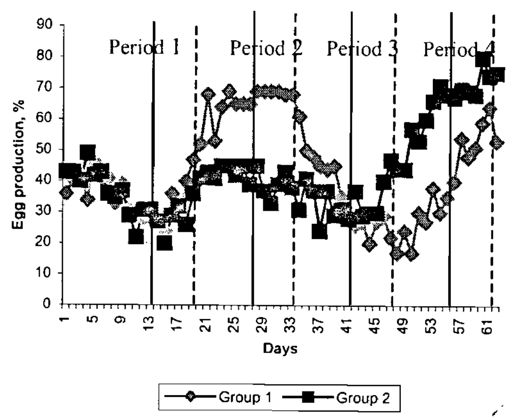


Figure 2. Egg production of layers fed the control diet or fishmeal supplemented diet

Period 1. Diets; Group 1, CD[1]; Group 2, CD
Period 2. Diets; Group 1, FMD[2]; Group 2, CD
Period 3. Diets; Group 1, CD; Group 2, CD
Period 4. Diets; Group 1, CD ; Group 2, FMD

Day 20-34 and 48-62: Egg production figures used to show the full effect of fishmeal supplementation in Periods 2 and 4, respectively.
[1] **Control diet,** [2] **Fishmeal supplemented diet**

Table 2: Performance of layers fed the fishmeal supplemented diet or the control diet

	Period 2		Period 4			
	FMD	Control	FMD	Control	SEM	P value
Laying %	65.9[a]*	40.4[b]	65.9[a]	40.7[b]	9.15	<0.0001
Feed intake, g/day	113.9[a]	88.9[b]	105.4[b]	96.1[c]	1.45	<0.0001
Feed cost in nakfa[z] per egg	0.26	0.31	0.24	0.33	-	-
Cost in nakfa /100 g of egg	0.41	0.51	0.38	0.55	-	-

[a,b]Means in the same row not sharing a common superscript are significantly different (P<0.05).
*Number of replicates was 14 in all observations.
FMD = fishmeal-supplemented diet
SEM = standard error of the mean
[z]1 USD = 10 nakfa

Performance of layers fed on the control diet (CD)

Both groups 1 and 2 had low feed intakes when fed on CD. The reason for the low feed intake could be the inadequacy of the diet in terms of CP content, amino acid imbalance and probably due to amino acid antagonism. The daily feed consumption of a diet deficient in any nutrient may decrease in relation to the severity of the deficiency (NRC 1994).

The control diet had a CP content of 13.84 % and the intake was on average 90.5 g per layer per day duri ng Period 1 for both groups. Leeson and Summers (1997) recommend a CP % of 19 if the feed intake is 90 g. Lee et al (1971) reported that the use of protein-deficient diets during the growing period had apparently very similar results to those of restricted feeding. Thayer et al (1974) evaluated the protein intake requirement of hybrid pullets to be around 14-15 g per day. Aitken et al (1973) suggested 17 g of protein per day to be adequate. Reid (1975) similarly estimated the protein needs of the laying hen during the initial 12 weeks of egg production to be 17.1 g per bird. Ivy and Gleaves (1976) found that 15 g of protein and 1.26 MJ ME per hen per day would be adequate for birds producing 80 percent or more. The protein intake of the layers fed on CD was 12.53, 12.30, 10.95 and 13.40 g per day in Periods1, 2, 3 and 4, respectively, in all cases lower than the recommendations of the authors mentioned above.

A number of studies have shown that satisfactory levels of egg production could be maintained with lower protein contents provided that the amino acid content of the diets is adequate or improved by supplementation. Calderon and Jensen (1990) obtained an egg production percent of 84.5 % using a diet containing 13 % protein, but containing an adequate level of amino acids, namely, 0.76 % lysine and 0.51 % sulfur amino acids. Fernandez et al. (1973) reported a diet containing 13 % protein supplemented with lysine and methionine to be as effective as diets with 15, 17 or 18 % protein for supporting egg production and egg size. The supplementation of the amino acids could probably be the reason the birds fed the amino acid supplemented 13 % protein diet achieved a feed intake of 103.5 g per day compared to 90.5 g only for the layers fed on CD in Period 1 in the current study. Johnson and Fisher (1959) found that a 10.4 % protein diet supplemented with lysine and methionine resulted in egg production levels comparable to that obtained with a 15.7 % protein diet. However, Roland (1980) reported that a significant reduction in egg weight and production when the protein level was lowered to 11.5 %. Pullets fed diets varying in protein from 20 to 13.5 % with a minimum of 0.53 % sulfur amino acids had similar egg production and weight. Keshavarz (1992) obtained an egg production of 65 % using a diet containing a protein content of 13.5 % with an intake of 550 and 457 mg per hen per day of lysine and sulfur amino acids, respectively.

Looking at the amino acids most limiting in egg production, CD had a lysine of 0.36% and methionine + cystine content of 0.48 %. At the intake for CD of about 90 g per day the recommended levels are 0.77 % for lysine and 0.71 % for methionine + cystine (Leeson and Summers, 1997). Kwakkel et al. (1991) found that growing pullets fed 3.0 g/kg digestible lysine consumed 5.8 % less feed compared to the control fed 6.6 g/kg digestible lysine. The authors suggest that the reason for the reduced feed intake in the low-lysine diet was probably due to amino acid imbalances. Jensen et al. (1974) suggested that a level of 666 to 788 mg lysine per hen per day was required for optimum performance. The layers fed on CD in the present study were consuming only 326 mg of lysine per day. Reid and Weber (1974) found that a sulfur amino acid intake of 613 mg per hen per day supported maximum egg production. The diet used in the study by Reid and Weber (1974) was a 14 % protein diet containing 0.55 % total sulfur amino acids. The total sulfur amino acid intake of layers fed on CD in the current study was 434 mg per hen per day. Ivy and Gleaves (1976) concluded that 13.5 g of protein and 1.13 MJ ME per hen per day seemed adequate to support 70 percent egg production. In Period 4 of the present study, each layer fed on CD consumed 13.40 g of protein per day but the egg production was only 40.7 %. The reason for the lower egg production in the present study is believed to be the amino acid inadequacy of the diet. Ivy and Gleaves (1976) further suggested that a 12.5 g of protein and 1.05 MJ ME per hen per day was enough to support 50 % egg production. The egg production percent in the present study was lower than 50 % throughout the experiment even though the layers fed on CD were consuming more than 1.05 MJ ME and about 12.5 g of protein daily.

Excess leucine is known to depress the utilization of the other two branched-chain amino acids, isoleucine and valine (D'Mello, 1992; Leeson and Summers, 2001). Bray (1970) found that as the level of supplemental leucine was increased up to 1.5 percent of the basal diet, there was a progressive reduction in egg yields when no isoleucine was added. The layers had a feed intake of 89.8 g at a dietary isoleucine content of 5.3 g/kg. When the isoleucine content was increased to 6.8 g/kg, the feed intake increased to 112.3 g. In both diets, the level of leucine was maintained high at 1.5 % of the diet. Egg production increased with supplementation of isoleucine from 59.6 % to 80 %. The depression in egg production was mediated by a reduction in feed intake because of the excess leucine. The control diet in the present study contained 1.5 % leucine and 0.56 % isoleucine. Most of the leucine in CD came from sorghum as it contains an excess of leucine relative to isoleucine and valine. The low level of intake of the layers fed on CD could partially be due to the excess leucine. At a feed intake level of 90 g the recommended level is 1.00 % for leucine and 0.69 % for isoleucine. With such a diet having excess leucine, supplemental isoleucine would be required, not only to meet a dietary requirement, but also to alleviate a depression in performance due to excessive leucine as suggested by Bray (1970).

Effect of fishmeal supplementation

In both periods 2 and 4, as a result of fishmeal supplementation, feed intake of the layers was significantly increased. This could be because addition of fishmeal elevated the protein content of the diets to levels normally used for layers, improved the amino acid balance and probably reduced the antagonistic effects between some of the amino acids, the combined effect of which resulted in higher egg production.

Addition of fishmeal to CD increased the protein content of the diet from 13.84 % to 15.88 %. The higher protein level of FMD enabled the layers to consume more protein and amino acids. Keshavarz (1984) investigated the effect of different dietary protein levels in the rearing and laying periods on performance of White Leghorn chickens and found that pullets receiving a 14.5 % protein diet in the laying period produced significantly fewer and lighter weight eggs and consumed significantly less protein and lysine than those fed a 16.5 % protein diet. The protein intake of layers fed on FMD was 17.5 g per layer per day compared to 12.54 g for those fed on CD. This was reflected in improved egg production compared to the unsupplemented diet but the 65.9 % egg production achieved with fishmeal supplementation was lower than egg production achieved by numerous workers (Aitken et al., 1973; Thayer et al., 1974; Ivy and Gleaves, 1976). The reason for this could be that the amino acid composition of the diet was still less than ideal even after supplementation with 4.76 % fishmeal, and probably that the layers passed their peak age of laying.

After supplementation with fishmeal the lysine level increased from 0.36 % to 0.51 % and methionine + cystine level increased from 0.48 % to 0.54 %. Even though this was a significant improvement, it still fell short of the recommended levels of 0.63 % for lysine and

0.58 % for methionine + cystine at a feed intake of 110g (Leeson and Summers, 1997). However, the improvement in the amino acid balance could have resulted in a marginal deficiency of the limiting amino acids, which in turn resulted in increased feed intake to compensate for the deficiencies. The layers in the fishmeal-supplemented diets consumed 562 mg of lysine, which is lower than the 666 to 788 mg of lysine recommeded for optimum production by the work of Jensen et al. (1974). The layers fed the fishmeal supplemented diets also consumed 595 mg of sulfur containing amino acids which is slightly lower than the 613 mg suggested by Reid and Weber (1974) for maximum egg production. Higher levels of fishmeal could have resulted in even better amino acid balance and this could have improved the egg production further. However, cost of the fishmeal and the possibility of fishy flavor that could be imparted into the eggs with higher fishmeal levels should be taken into consideration.

Supplementation with fishmeal resulted in increased feed intake in both trials. The isoleucine content increased from 0.56 % to 0.64 % and the leucine content increased from 1.48 % to 1.58 % with supplementation of the control diet with fishmeal. It has been reported by Bray (1970) and Muramatsu et al. (1991) that excess leucine increases the requirement of isoleucine and that a severe imbalance induced by leucine was completely alleviated by adequate isoleucine supplementation. With supplementation of fishmeal the increase in isoleucine alleviated the antagonistic effect of leucine in addition to meeting the dietary requirements and thus the layers were able to consume more feed and produce more eggs even though the leucine content was also slightly increased.

Weights of eggs

Even though, at the onset of the experiment, egg weight was not taken into consideration, measurements taken during periods 2 and 4 showed improvement of weights of eggs with fishmeal supplementation. This agreed with results obtained by Keshavarz (1984) in which pullets receiving a 14.5 % protein diet in the laying period produced significantly fewer and lighter eggs than those fed a 16.5 % protein diet. Similarly, Leeson and Summers (1979) reported that birds produced significantly ($P < 0.05$) larger eggs when offered 17% versus. 13 % CP. This phenomenon is probably caused by increased level of methionine (Leeson and Summers, 2001).

Economic consideration

The cost of the layer diet was 1.40 nakfa (0.14 US $) per kg. The cost of fishmeal at the time of the experiments was 4.00 nakfa (0.4 US $) per kg. Including fishmeal at 4.76 % by weight raised the price of 1 kg of the supplemented diet to 1.52 nakfa. Mean feed intake for the supplemented group for periods 2 and 4 was 110.2 g per day per layer with mean egg production of 65.9 %. The feed intake per layer per day and the egg production for the unsupplemented group was 92.9% and 40.6%, respectively. The cost of feed for the supplemented group was 0.25 nakfa/egg while for the unsupplemented group was 0.32 nakfa per egg. (The retail price of one egg at the time of the experiment was 1 nakfa).

Even though the feed cost increased because of inclusion of fishmeal, the increase in egg production more than compensated for the added cost of fishmeal. Keshavarz (1984) obtained a similar result in that feed cost for pullets fed 14.5 % protein diets was lower than those fed 16.5 %, but the loss in production with the 14.5 % percent protein made the feeding program less economical than the 16.5 % protein program.

Conclusions

Locally produced fishmeal by simple sundrying and grinding can serve as a supplement of high quality protein for layers in Eritrea. Supplementing the commercial layers' ration with fishmeal to make 4.76 % by weight significantly improved feed intake, egg production and feed cost per unit weight of egg. However, this level was not adequate to meet the recommended balance of amino acids, particularly lysine and sulfur containing amino acids. A higher level of fishmeal would probably result in higher egg production than the one achieved in this study. Further studies are recommended to determine the level that results in maximum egg production without compromising in the cost and flavor of the eggs produced.

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