

## Impact of Protein Source and Its Levels on Egg Production and Egg Quality of Japanese Quail (*Coturnix coturnix japonica*)

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### ABSTRACT:

Fish and soybean meal are known as common utilized crude protein sources in poultry diets. Quail birds often need higher requirements of dietary protein which influences its productive performance. The aim of the experiment is to determine the impact of protein source with different levels on egg production and egg quality characteristics. The experiment was carried out at animal production dept., University of Duhok, Kurdistan Region- Iraq, during spring 2020 for 56 days. The birds were divided into two main groups (fish meal and soybean meal) with three levels of crude protein (CP) as sub groups (20%, 23% and 26%). At 35 days of age, 240 quails were sexed and distributed on wire cages as four replications for each protein level within each group (treatment) as family (8 pullets with 2 cocks). The investigated characters were; Egg weight (EW), egg number (EN), egg mass (EM), egg quality characteristics (shape index, high, weight and diameter of both, yolk and albumen, egg shell thickness and weight and Haugh units); feed intake (FI), feed conversion ratio (FCR), hatchability and fertility percentage. The main results were as follows; EW, EM and most of egg quality characteristics did not show significant difference ( $P>0.05$ ) either by source of protein or its levels; also, FI and FCR did not differ significantly ( $P>0.05$ ) by the effect of protein source; while EN, FI and FCR were affected significantly ( $P\leq 0.05$ ) by CP level. To conclude, there was no obvious trend for the effect of both CP source and level on early egg yield and egg quality in J. quail.

**KEYWORDS:** Japanese quail, protein source, protein level, egg production, egg quality.

## 1. INTRODUCTION

Japanese quails (*Coturnix coturnix japonica*) birds are mainly raised for producing eggs and meat purposes, in addition to their benefits as experimental animals because of their small size, early sexual maturity, having high breeding efficiency and are raised easily (Wilson et al., 1961). The quail prefers and requires a high protein level in the diet for optimum growth and reproduction (Shim and Vohra, 1984). The protein level of hen's diet is one of the major factors affecting egg yield and egg characteristics; different references indicated different optimum level of crude protein in layer diet of quail (20 % of both soybean or fish meal (NRC, 1985; Minoguchi et al., 2000; 22 % of soybean or fish meal - Ohguchi et al., 1997). Some researchers reported that the increase in egg number and weight is related directly to the increase in dietary protein levels (Gunawardana et al., 2008; King'ori et al., 2010; Mohiti-Asli et al., 2012; Shim et al., 2013). On the other hand, some investigators reported that egg production was not influenced by low dietary protein level (Cho et al., 2004; Khajali et al., 2008). A protein deficiency often caused by either one or more limiting amino acids or an overall inadequate consumption of protein, which resulted in decreasing in performance parameters; and feed consumption and utilization (Church, 1991). Eishu et al., (2005), used both sources of crude protein (soybean and fish meals) in layer quails with different levels from 16 up to 26 %; they found that the egg production traits were increased linearly by increasing the protein level from 6 up to 32 weeks old; while the egg quality traits did not have the same trend.

However, Yalcin et al. (2007) reported that quail birds fed 19.40 % dietary protein with 12.53 MJ Metabolizable energy /kg diet during the laying period from 9-21 weeks old recorded average hen day egg production of 80.40 %. In addition Fernando et al. (2008) found that quail hens fed 20 % dietary protein with 2900 kcal Metabolizable energy/kg diet during laying period from 13-28 weeks old resulted in average hen day egg production of 72.30 % . Dahouda et al., (2013) studied protein source (fishmeal and soybean meal) impacts with two levels (20 and 25 %) on the performance of layer quails, and indicated that the best optimal incorporation level was 20% in the diet irrespective to the source. Salih and Hussien, (2018), stated that the Japanese quail birds that fed soybean meal as source of protein with different levels according to the type of ration (starter 26, grower 21 and breeder 15.7 %) resulted in mean egg weight of 10.44 gm., during the first two weeks of laying period. Also, Salih, 2016, reported that the average of nine quail genotypes that fed 15.7 % soybean meal crude protein in laying period resulted in sexual maturity of 41.7 days and egg mass with mean of 50.9 gm., for the second week of production; the author pointed that feed conversion ratio of laying period was worse and not as expected.

The present study aimed to illustrate the effect of two protein sources with three levels for each, on the laying performance and egg quality of Japanese quail.

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## 2. MATERIAL AND METHODS

### 2.1. Management and rearing

The study was conducted at poultry farm in Duhok city/College of Agricultural Engineering Sciences/Animal production department/ Kurdistan Region, Iraq. A total of 360 one-day unsexed quail chicks were divided equally into two treatments of different source of protein (fish meal and soybean meal); within each treatment, three levels of dietary crude protein of 20%, 23% and 26%, respectively were applied as second experimental factor, until 56 days of age for laying performance. At 35 days old, 240 birds were sexed and re-distributed on cages with three replicates for each protein levels within each treatment separately as families (8 females with 2 males). Water and food were submitted *ad-libitum*. The daily ambient temperature (°C) and relative humidity (%) were measured during the experimental period in spring 2020, for 56 successive days, that are illustrated in Figure 1. The submitted dietary rations according to the fed treatments and its levels are presented in Table 1. The light was provided for 15 hour / day during laying period.

### 2.2. Studied traits and parameters

The studied traits were; early Egg weight (EW), egg number (EN), egg mass (EM), egg quality characteristics involved (shape index, height, weight and diameter of both yolk and albumen, egg shell thickness and weight (which were measured using sensitive digital balance with accuracy of 0.0001 gm. and slide calipers accuracy of 0.1 mm) and, feed intake, feed conversion ratio, hatchability and fertility percentage. Egg production was monitored every day from 42 days old, for two successive weeks. However, feed conversion ratio (FCR) was calculated according to the following formula:

FCR = Feed intake (during a certain period) / egg mass (during the same period)

And egg mass was computed according to the following formula:

EM (gm) = Egg number (in a certain period) \* Average egg weight (in the same period)

Regarding external and internal egg quality, the eggs were collected weighed and their length and width were measured to calculate their shape index (Shape index = (Width / length) \* 100), then the eggs were broken to measure their albumen and yolk heights and diameters; the yolk separated from albumen to be weighed; and also the eggshells were weighed; while the albumen weights were calculated by the difference (Albumen weight = Egg weight – (yolk weight + Eggshell weight). Haugh units were computed according to the following formula:

Haugh Unit = 100 log [(albumen height) + 7.57 - 1.7 \* egg weight<sup>0.37</sup>]

The eggshell thickness of dried eggs in (mm) was measured by using the digital caliper.

### 2.3. Statistical Analysis

Collected data were analyzed as factorial experiment (2×3) conducted with completely randomized design with two factors and three levels, using SAS software (SAS Institute, 2014) applied with GLM model.

$$Y_{ij} = \mu + S_i + L_j + (S*L)_{ij} + e_{ijk}$$

Where:  $Y_{ij}$ : the studied trait;  $\mu$  = over all mean;  $S_i$ : The fixed effect of source of protein;  $L_j$ : level of protein;  $(S*L)_{ij}$ : the interaction between source and level;  $e_{ijk}$  = random error.

The differences among means were tested using Duncan multiple range test (Duncan, 1955).

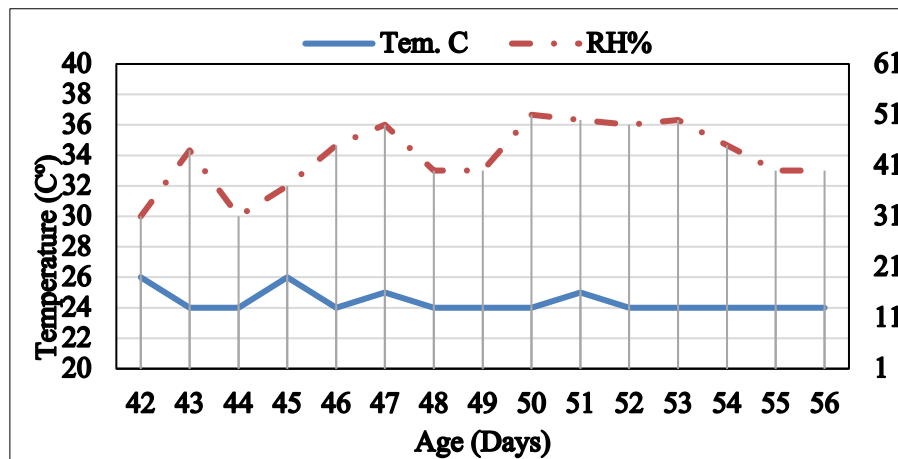


Figure 1. Daily Temperature (°C) and Relative Humidity (%) during laying period

**Table 1.** Dietary rations fed to the quail hens during the experiment

Ingredient	Fish-meal protein			Soybean-meal protein		
	20 (%)	23 (%)	26 (%)	20 (%)	23 (%)	26 (%)
Yellow corn	61	55	50	52	42	34
Soybean meal (48 %)	-	-	-	30	39	47
Fish meal (60 %)	19	25	30	-	-	-
Wheat grain	11	11	11	9	10	10
Wheat bran	4	4	4	4	4	4
Vegetable oil	2	2	2	2	2	2
Limestone	2.1	2.1	2.1	2.1	2.1	2.1
Di-calcium phosphate	0.1	0.1	0.1	0.1	0.1	0.1
Mixture vit. & Min.	0.3	0.3	0.3	0.3	0.3	0.3
Salt	0.5	0.5	0.5	0.5	0.5	0.5
<b>Total</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>
<b>Chemical composition</b>						
<b>ME (k.cal./kg)</b>	3130	3099	3073	2904	2798	2708
<b>CP (%)</b>	19.8	23.07	25.82	19.83	23.05	25.9
<b>C. Fiber (%)</b>	2.25	2.15	2.1	4.1	4.6	4.9
<b>Ether extract</b>	6.44	6.77	7	4.5	4.25	4.01
<b>Methionine</b>	0.34	0.39	0.43	0.33	0.37	0.4
<b>Lysine</b>	0.84	1.02	1.2	1.07	1.3	1.5

**3. RESULTS AND DISCUSSION**

**3.1. Egg Production**

Egg production characteristics of quail fed different protein sources with different levels are presented in Table 2. There is no significant ( $P>0.05$ ) effect of protein source on the studied characteristics. While the effect of protein level within protein source was significant ( $P\leq 0.05$ ) for both egg number and egg mass traits; where the intermediate level of 23 % has the highest values compared to the first studied level (20 %); but as comparison between the level of 23 % and 26 %, the results showed insignificant differences (Table 2); such results are in

favor of adopting the level of 23 % in the quail diets instead of 26 % for egg production traits, due to the economic efficiency. Regarding the interaction between protein source and level, it could be observed from the mentioned table, that just EN was interacted significantly ( $P\leq 0.05$ ); where the highest value (52.33 eggs) was recorded for Soybean at 23 % level and the lowest one was recorded for the same source at 20 % level (33 eggs). These results indicate that the protein level plays a better role than its source. These findings are in agreement with the results of (Shim and Vohra, 1984; NRC, 1985; Minoguchi et al., 2000); they reported the importance of protein level.

**Table 2.** Means  $\pm$  SE of Egg production traits as affected by protein source, level and their interaction (eggs/hen/week)

Trait	Source (S)	Levels (L)			Overall Mean / (Source)	Sig. (p)		
		20	23	26		S	L	S*L
EN	Fish meal	43.66 $\pm$ 1.33 <sup>b</sup>	46.33 $\pm$ 5.66 <sup>b</sup>	45.33 $\pm$ 1.33 <sup>b</sup>	45.11 $\pm$ 1.76	ns	*	*
	Soybean	33.00 $\pm$ 1.52 <sup>c</sup>	<b>52.33<math>\pm</math>0.88<sup>a</sup></b>	44.00 $\pm$ 3.51 <sup>b</sup>	43.11 $\pm$ 3.0			
	<b>Overall mean / (Level)</b>	38.33 $\pm$ 2.55 <sup>A</sup>	49.33 $\pm$ 2.89 <sup>A</sup>	44.66 $\pm$ 1.70 <sup>AB</sup>				
EW	Fish meal	10.31 $\pm$ 0.21	10.18 $\pm$ 0.07	10.32 $\pm$ 0.11	10.27 $\pm$ 0.07	ns	ns	ns
	Soybean	10.59 $\pm$ 0.11	10.12 $\pm$ 0.09	10.11 $\pm$ 0.07	10.28 $\pm$ 0.09			
	<b>Overall mean/ level</b>	10.45 $\pm$ 0.12	10.15 $\pm$ 0.05	10.21 $\pm$ 0.07				
EM	Fish meal	64.52 $\pm$ 3.25	67.28 $\pm$ 8.02	67.15 $\pm$ 1.42	66.32 $\pm$ 2.57	ns	*	ns
	Soybean	49.99 $\pm$ 2.73	75.88 $\pm$ 1.45	63.74 $\pm$ 5.45	63.21 $\pm$ 4.15			
	<b>Overall mean/ level</b>	57.26 $\pm$ 3.76 <sup>B</sup>	71.58 $\pm$ 4.12 <sup>A</sup>	65.45 $\pm$ 2.63 <sup>AB</sup>				

Different superscript small letters (a, b, c...) differ significantly for the interaction between source and level; and different capital superscript letters (A, B, C...) differ significantly for level effect. \*- significant at 0.05 level; ns=non-significant

**3.2. Egg Quality**

Table 3, presents the egg quality characteristics as affected by the studied protein source and its levels. It seems from the table that most studied characters are not affected significantly ( $p>0.05$ ) by the studied factors. However, from the same table, it could be seen that just two traits (EW and YD) are affected significantly ( $P\leq 0.05$ ) by the protein source; where the fish

meal source surpassed soybean one in both studied traits. These results indicate that the weight of Japanese quail egg may be related to its yolk diameter and both of them are affected positively with fish meal protein more than soybean meal, which could be due to specific amino acids in fish meal diet such as methionine or lysine that is insufficient in soybean. Regarding the effect of protein level within each protein source, it could be observed from the previous table that just EW and

AIW are significant ( $P \leq 0.05$ ), where the low level of 20 % surpassed both 23 and 26 % CP. These findings may reflect the low requirements of layer hens of quail to CP.

In respect to the interaction between source of protein and its level, the same table indicates that just AIW has interacted significantly ( $P \leq 0.05$ ), where the fish meal with 26 % resulted in the highest value and, on the contrary, the soybean at the same level resulted in the lowest value. This mean that for laying stage of quail may apply fish meal with high level to

produce eggs with high weight of albumen which will affect positively on egg weight.

However, some factors could have an effect on the egg quality traits such as; live body weight, line, season, and some environment factors such as relative humidity (Narushin, and Romanov, 2002; Khurshid, et al., 2003). Moreover, some investigators have indicated that some traits of egg quality has genetic basis and are effected by the genetic variability in dam which is mainly responsible for the hatchability of fertile egg (Song et al., 2000; Wolc, and Olori, 2009).

**Table 3:** Means  $\pm$  SE of the effect of fish meal and soybean meal and their levels on egg quality in Japanese quails

Trait	Treatment (Source of protein)	Levels (L)			Overall Mean / Treatments	Sig. (p)		
		20	23	26		S	L	S*L
Ew	Fish meal	10.92 $\pm$ 0.19	10.47 $\pm$ 0.17	10.90 $\pm$ 0.17	<b>10.77<math>\pm</math>0.10<sup>a</sup></b>	*	*	ns
	Soybean	10.77 $\pm$ 0.09	10.38 $\pm$ 0.15	10.29 $\pm$ 0.19	<b>10.48<math>\pm</math>0.09<sup>b</sup></b>			
	<b>Overall mean/ level</b>	<b>10.85<math>\pm</math>0.11<sup>A</sup></b>	<b>10.43<math>\pm</math>0.11<sup>B</sup></b>	<b>10.60<math>\pm</math>0.13<sup>B</sup></b>				
ShInd	Fish meal	76.66 $\pm$ 0.72	79.71 $\pm$ 1.16	78.12 $\pm$ 0.69	78.16 $\pm$ 0.52	ns	ns	ns
	Soybean	79.09 $\pm$ 0.82	78.85 $\pm$ 1.11	79.57 $\pm$ 0.77	79.17 $\pm$ 0.52			
	<b>Overall mean/ level</b>	77.87 $\pm$ 0.56	79.28 $\pm$ 0.80	78.84 $\pm$ 0.52				
YH	Fish meal	1.11 $\pm$ 0.01	1.13 $\pm$ 0.01	1.11 $\pm$ 0.01	1.11 $\pm$ 0.01	ns	ns	ns
	Soybean	1.13 $\pm$ 0.01	1.13 $\pm$ 0.01	1.13 $\pm$ 0.01	1.13 $\pm$ 0.00			
	<b>Overall mean/ level</b>	1.12 $\pm$ 0.01	1.133 $\pm$ 0.01	1.12 $\pm$ 0.01				
YW	Fish meal	3.40 $\pm$ 0.02	3.27 $\pm$ 0.02	3.30 $\pm$ 0.03	3.32 $\pm$ 0.01	ns	ns	ns
	Soybean	3.29 $\pm$ 0.02	3.20 $\pm$ 0.01	3.18 $\pm$ 0.03	3.22 $\pm$ 0.01			
	<b>Overall mean/ level</b>	3.34 $\pm$ 0.01	3.23 $\pm$ 0.01	3.24 $\pm$ 0.02				
YD	Fish meal	2.17 $\pm$ 0.10	2.18 $\pm$ 0.09	2.22 $\pm$ 0.08	<b>2.19<math>\pm</math>0.04<sup>a</sup></b>	*	ns	ns
	Soybean	2.14 $\pm$ 0.07	2.12 $\pm$ 0.05	2.10 $\pm$ 0.06	<b>2.12<math>\pm</math>0.04<sup>b</sup></b>			
	<b>Overall mean/ level</b>	2.16 $\pm$ 0.05	2.15 $\pm$ 0.05	2.16 $\pm$ 0.05				
ALW	Fish meal	5.69 $\pm$ 0.01 <sup>b</sup>	5.38 $\pm$ 0.11 <sup>c</sup>	<b>5.84<math>\pm</math>0.11<sup>a</sup></b>	5.64 $\pm$ 0.06	ns	*	*
	Soybean	5.68 $\pm$ 0.10 <sup>b</sup>	5.41 $\pm$ 0.12 <sup>c</sup>	5.33 $\pm$ 0.14 <sup>d</sup>	5.47 $\pm$ 0.07			
	<b>Overall mean/ level</b>	<b>5.68<math>\pm</math>0.07<sup>A</sup></b>	<b>5.39<math>\pm</math>0.08<sup>B</sup></b>	<b>5.58<math>\pm</math>0.09<sup>B</sup></b>				
ALH	Fish meal	0.49 $\pm$ 0.04	0.48 $\pm$ 0.01	0.45 $\pm$ 0.02	0.47 $\pm$ 0.01	ns	ns	ns
	Soybean	0.48 $\pm$ 0.01	0.47 $\pm$ 0.01	0.78 $\pm$ 0.30	0.57 $\pm$ 0.10			
	<b>Overall mean/ level</b>	0.48 $\pm$ 0.01	0.47 $\pm$ 0.01	0.61 $\pm$ 0.15				
ShW	Fish meal	1.53 $\pm$ 0	1.52 $\pm$ 0.05	1.58 $\pm$ 0.04	1.54 $\pm$ 0.02	ns	ns	ns
	Soybean	1.48 $\pm$ 0.01	1.55 $\pm$ 0.05	1.56 $\pm$ 0.04	1.53 $\pm$ 0.02			
	<b>Overall mean/ level</b>	1.51 $\pm$ 0.02	1.53 $\pm$ 0.03	1.57 $\pm$ 0.03				
ShTh	Fish meal	0.10 $\pm$ 0.99	0.10 $\pm$ 0.00	0.10 $\pm$ 0	0.10 $\pm$ 0.00	ns	ns	ns
	Soybean	0.10 $\pm$ 0	0.10 $\pm$ 0	0.10 $\pm$ 0	0.10 $\pm$ 0.01			
	<b>Overall mean/ level</b>	0.10 $\pm$ 0.01	0.10 $\pm$ 0.00	0.10 $\pm$ 0				
HU	Fish meal	91.87 $\pm$ 0.07	91.77 $\pm$ 0.84	89.55 $\pm$ 1.28	91.06 $\pm$ 0.61	ns	ns	ns
	Soybean	91.76 $\pm$ 0.75	91.40 $\pm$ 0.98	95.41 $\pm$ 3.68	92.86 $\pm$ 1.29			
	<b>Overall mean/ level</b>	91.81 $\pm$ 0.61	91.58 $\pm$ 0.64	92.48 $\pm$ 1.97				

Different superscript small letters (a, b, c...) differ significantly for source effect and the interaction between source and level; and different capital superscript letters (A, B, C...) differ significantly for level effect. \*- significant at 0.05 level; ns=non-significant.

### 3.3. Mortality

Figure 2, illustrates mortality percentage, which is obvious that there is no mortal birds fed both 23 and 26 % CP; while the birds that fed 20 % CP of both studied sources of protein resulted in the same rate (10 %); which may reflect the necessary high levels of crude protein in growing periods which may decrease the immunity later in laying age.

However, from statistical point of view, there was insignificant difference ( $P > 0.05$ ) between both studied sources, and highly significant ( $P \leq 0.01$ ) between the lowest level (20 %) and the other two levels (23 and 26 %)

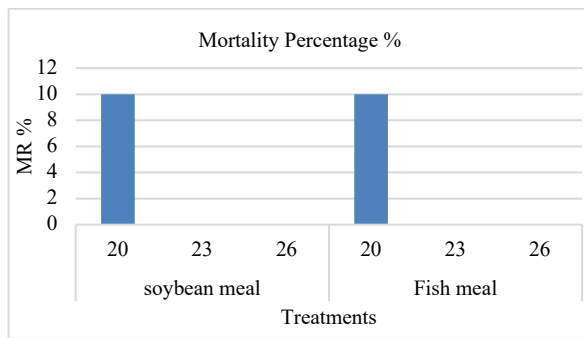


Figure 2. Mortality percentage (%) during laying period of experiment

### 3.4. Feed intake

It could be seen from Figure 4, that the protein source effect was insignificant ( $p > 0.05$ ), while the effect of level was significant ( $P \leq 0.05$ ), where 26 % surpassed significantly 23 % level; but 20 % level recorded the intermediate value. This result has no obvious trend, which could be due to the effect of source of protein, because fish meal in general consumed more than soybean one (but insignificantly). Moreover, the statistical analysis showed insignificant interaction ( $P > 0.05$ ). Therefore, such finding may be recommended to be analyzed as one-way ANOVA (independent source and level) to result in obvious trend. However, the last method of analysis showed the superiority for fish meal of 26 % CP. This last result insure that quail birds need high level of CP and prefer fish meal more than soybean one. Moreover, the results reported by Albinon & Barreto, (2003) and Barreto et al., (2007) determined the feed intake for quail layer as range from 210-231gm feed intake/bird/week. Also, Mori et al., (2005) recorded averages of 259 gm. of feed intake/bird/week at laying period. Berwary et al., (2015) stated that the feed consumed by Japanese quail birds during the period from 12-16 weeks of age was 886 gm. / bird/week.

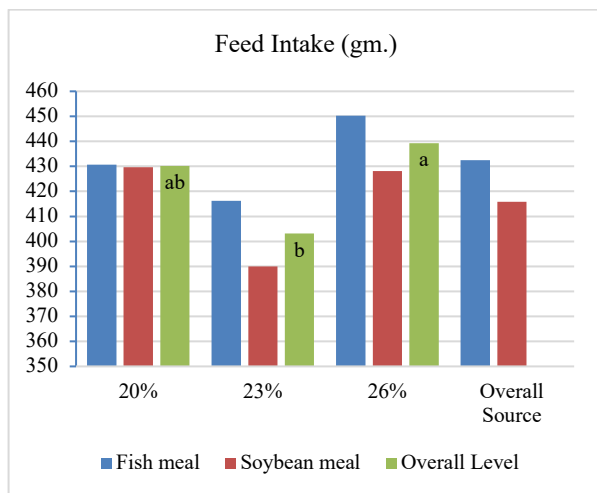


Figure 3. Feed Intake as affected by protein source and levels (for two successive weeks)

### 3.5. Feed Conversion ratio

Figure 4, present the FCR values of quail fed different protein sources with different levels. In contrast to the previous results of feed intake, the figure illustrates that the best significant FCR was recorded for the level of 23 % CP surpassing 20 % level significantly ( $P \leq 0.05$ ), while the level 26 % recorded the intermediate. Also, as mentioned previously in feed intake, the trend in not obvious, which also indicates that the data may be analyzed individually (one-way ANOVA); the last analysis showed that the best FCR was recorded significantly ( $P \leq 0.05$ )

for 23 % CP within soybean source. However, this un-trended finding could be due to the short period of egg recording. Moreover, the source effect was insignificant ( $P > 0.05$ ). In general, the FCR values of this experiment were relatively high and resulted in a bad trend. Similarly, Salih, 2016, reported that the means of nine quail genotypes fed 15.7 % soybean meal crude protein in laying period resulted in high feed conversion ratio of laying period.

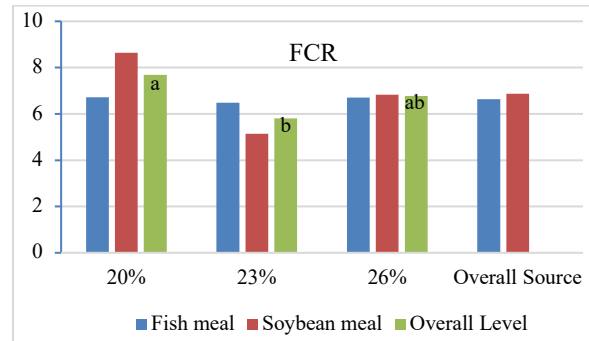


Figure 4. Feed conversion as affected by protein source and levels (for two successive weeks)

## 4. CONCLUSION

It could be concluded from the present research that neither source of protein nor its level play a vital role in early egg yield nor egg quality of J. quail. Moreover, in general such birds consume a high quantity of feed irrespective to the source of the used CP.

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