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Effects of Combined Safflower and Sunflower Meals on Performance and Egg Quality Parameters in Quail

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Abstract

This study was conducted to determine the effects of safflower (SM) and sunflower meal (SFM) combination (SSM) in quail diets on laying performance and some egg quality parameters during 8 week feeding period. A total of 192 (128 female, 64 male) eight-week-old Japanese quails (*Coturnix coturnix japonica*) were divided into 4 groups (n=48) involving one control group and three treatment groups. Each group was then divided into four replicate groups (n=12). The control group was fed with corn-soybean meal based diet without SSM supplementation. SSM was used at ratio of 10% (SSM10), 20% (SSM20), and 30% (SSM30) in treatment diets (safflower and sunflower meal ratio was 1:1 in each treatment group). There were no differences between the experimental groups in terms of initial and final body weights, feed intake, egg production, feed conversion ratio and egg weight (P>0.05). Moreover, egg shape index, shell thickness, albumen index, yolk index, Haugh unit and yolk color index were not affected by SSM supplementation (P>0.05). It may be stated that the combined dietary supplementation of safflower-sunflower meal up to 30% of the ratio, ratio had no adverse effects on laying performance and egg quality parameters in quails.

Keywords: Safflower meal, sunflower meal, performance, egg quality, quail

Bıldırcın Rasyonlarında Aspir ve Ayçiçeği Küspelerinin Birlikte Kullanımının Performans ve Yumurta Kalite Özellikleri Üzerine Etkileri

Özet

Bu araştırma, bıldırcın rasyonlarında, 8 hafta boyunca, aspir küspesi (AK) ile ayçiçeği küspesinin (AÇK) birlikte (AAK) kullanılmasının yumurta performansı ve bazı yumurta kalite özellikleri üzerine etkisini belirlemek amacıyla yapıldı. Araştırmada toplam 192 adet (128 dişi ve 64 erkek) sekiz haftalık Japon bıldırcını (*Coturnix coturnix japonica*) her biri 48 bıldırcından oluşan 1 kontrol ve 3 deneme grubuna ayrıldı. Her bir grup da 12 bıldırcından oluşan 4 alt gruba ayrıldı. Kontrol grubu AAK ilavesi yapılmayan mısır-soya fasulyesi küspesi temeline dayanan rasyonla beslendi. Deneme gruplarının rasyonlarında aspir ve ayçiçeği küspeleri birlikte eşit miktarda % 10 (AAK10), 20 (AAK20) ve 30 (AAK30) düzeylerinde kullanıldı. Araştırmada AAK ilaveli tüm deneme grupları arasında başlangıç ve son canlı ağırlıklar, yem tüketimi, yumurta verimi, yemden yararlanma oranı ve yumurta ağırlığının değişmediği belirlendi (P>0.05). Yumurta şekil indeksi, kabuk kalınlığı, ak indeksi, sarı indeksi, Haugh birimi ve sarı renk indeksinin AAK ilavesiyle etkilenmediği tespit edildi (P>0.05). Bıldırcın rasyonlarına eşit miktarlarda % 30’a kadar aspir ve ayçiçeği küspelerinin birlikte ilavesinin performans ve bazı yumurta kalite özellikleri üzerine herhangi bir olumsuz etkisi olmadığı ifade edilebilir.

Anahtar Kelimeler: Aspir küspesi, ayçiçeği küspesi, performans, yumurta kalitesi, bıldırcın

Introduction

Soybean meal is the most widely used protein source in poultry diets as it has a high protein content, excellent balanced amino acid profile, high protein and amino acid digestibility, and palatability (Ravindran and Blair 1992, Leeson and Summers, 2001). However, inconsistent supply, greater demand, and increasing costs have prompted the search for a substitute (Laudadio et al., 2014). Additionally, the use of soybean meal in diets is also restricted by some anti-nutritional factors (Juskiewicz et al., 2009). Thus, the researchers used other protein sources which could have possibility to replace costly soybean meal in quail diets (Akinci and Bayram, 2003; Erener et al., 2003; Kakani et al., 2012; Bulbul and Ulutas, 2015; Bulbul et al., 2015; Karayagiz and Bulbul, 2015a).

Among other protein sources, the safflower meal (SM) (Kalmendal et al., 2011) and sunflower meal (SFM) (Senkoylu and Dale, 1999; Karayagiz and Bulbul, 2015a,b), which are obtained after oil extraction from their seeds, have a good potential to be used in poultry feed. The nutrient composition of these meals depends heavily on the properties of the seeds and different processing condition during the extraction procedure. SFM contains crude protein in the range of 20-60% which depends on the removal of hulls from the seed during processing. A complete dehulled seed results in a meal with about 60% crude protein but is very difficult to remove hulls from the seed because of its hard structure (Ravindran and Blair, 1992). The partially or averaged dehulled seeds produces meals with 40% crude protein approximately (Evans and Bandemer, 1967). The other important factor which may affect the composition of meal is the over cooking or under cooking of seeds which could lead to changes in amino acid availability (Anderson-Haferman et al., 1993; Zhang and Parsons, 1994). Palatability of this meal is less in poultry (Ravindran and Blair, 1992). The nutritional composition of SFM (solvent extracted) is dry matter 93%, crude protein 42%, crude fiber 21%, oil 2.3% and ash 7%, while SM (solvent extracted) contains dry matter 90%, crude protein 22%, crude fiber 37%, oil 0.5% and ash 5% (Batal and Dale, 2013).

Studies conducted on laying birds have evaluated the effect of the safflower (Petersen et al., 1957, Ehsani et al., 2013) and sunflower (Karunajeewa et al., 1989, Vieira et al., 1992, Senkoylu et al., 2004, Casartelli et al., 2006; Karayagiz and Bulbul 2015b) meals on laying performance and egg quality. However, there are no data on the combined usage of safflower and sunflower meals in quail diets. Therefore, the current study was designed to investigate the effects of combined use of safflower and sunflower meals at different levels in quail diets on laying performance and egg quality parameters.

Material and Methods

Animals, diets and experimental protocol

A total of 192 Japanese quails (128 females and 64 males; *Coturnix coturnix japonica*) aged 8 weeks were used. This study was carried out at the Animal Research Center of Afyon Kocatepe University, Turkey, following ethical committee approval (AKÜHADYEK-225-13). Quails were randomly divided into 4 groups (n=48) involving one control group and three treatment groups. Each group was then divided into four replicate groups, having 12 quials in each, which were composed of eight female and four male quails in each. The quails were kept in California-type cages, and housed until the end of the study. Feed and fresh water were provided *ad libitum* and quails were exposed to light regimen of 16 h light: 8 h dark throughout the experimental period. The experiment was conducted for 8 weeks.

The SM, SFM and other raw feed ingredients were obtained from a commercial company and analyzed for the nutrient compositions. The diets with corn, boncalite, corn gluten meal, soybean meal, SM, SFM, meat-bone meal and vegetable oil were formulated as isonitrogenic and isocaloric to meet the nutritional requirements of quails as recommended by NRC (1994). The diets were prepared with feed grinding and mixing machine for each treatment.

The control group was fed with basal diet (corn-soybean meal based diet) which was not supplemented with safflower and sunflower meals, while the experimental groups were formulated as 5% Safflower meal + 5% Sunflower meal (SSM10), 10% Safflower meal + 10% Sunflower meal (SSM20) and 15% Safflower meal + 15% Sunflower meal (SSM30) instead of soybean meal, respectively (Table 1).

Table 1. Dietary protocol used in the study

Groups	Diets
Control	Basal diet without SSM
SSM10	5% Safflower meal + 5% Sunflower meal
SSM20	10% Safflower meal + 10% Sunflower meal
SSM30	15% Safflower meal + 15% Sunflower meal

The nutritional composition of the SM, SFM and experimental diets was determined according to the AOAC (2000). The meals were also analyzed to determine the neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) content according to procedures described by Van Soest et al. (1991). The metabolizable energy (ME) levels were estimated using the equation by Carpenter and Clegg (Leeson and Summers, 2001): ME, kcal/kg = 53 + 38 [(crude protein, %) + (2.25 × ether extract, %) + (1.1 × starch, %) + (1.05 × sugar, %)]. The content of SM, SFM and diets is presented in Table 2 and 3, respectively.

Laying performance and egg quality parameters

The quails were individually weighed at the beginning and end of the experimental period. Eggs were collected daily, and percentage of egg production was calculated on a quail/day basis. Mortality was recorded when it occurred. Eggs were individually weighed once a week. Feed intake was recorded biweekly and calculated as g/quail/day. Feed conversion ratio was calculated as the amount of feed consumed for per kilogram of egg.

Twenty eggs were collected from each group (5 eggs from each replicate) to determine the egg quality parameters, once every four weeks. Egg quality analyses were completed within 24 h of the eggs being collected. The external quality evaluations were based on shape index and shell thickness. The shape index was derived from the egg width and length. The shell thickness was measured for individual dry egg shells at three different locations to the nearest 0.01 mm using a micrometer screw. The shell thickness was measured with a micrometer gauge (Mitutoyo) on three different locations of the shell from the equator of each egg (Card and Nesheim, 1972). The internal quality evaluations were based on albumen index, yolk index, Haugh unit and yolk color index. Egg width, egg length, yolk width, albumen length, and albumen width were measured to the nearest 0.01 mm using a caliper (Mitutoyo Digimatic Caliper, CDN- P20PMX, Japan). The albumen and yolk heights were measured to the nearest 0.01 mm using a micrometer. The Haugh unit was calculated according to the original equation developed by Haugh (1937). The egg yolk visual color was measured visually using the Roche color fan scale. The formulas used in the measurement of shape, yolk, and albumen indexes of eggs were as follows (Card and Nesheim, 1972):

Shape index (%) = [egg width (mm)/egg length (mm)] x 100

Yolk index (%) = [yolk height (mm)/yolk width (mm)] x 100

Albumen index (%) = albumen height (mm)/[(average albumen length (mm) + width (mm)/2) x 100]

Haugh unit = 100 log [albumen height (mm) + 7.57 - 1.7 x egg weight$^{0.37}$ (g)]

Statistical analyses

The data recorded were subjected to Analysis of Variance Method and significance of differences between the mean values of the groups for body weights feed intake, feed conversion ratio and egg quality parameters were determined. Tukey Test was applied to control the significant difference between groups (SPSS 13.00, Inc., Chicago, IL, USA). A value of $P<0.05$ was considered the limit for statistical significance.

Results

The chemical compositions of SM, SFM and diets used in laying quail feeding are presented in Table 2 and 3, respectively. SM contained low amounts of crude protein (19.5%) and ether extract (0.6%), whereas it was high in amounts of crude fiber (36.1%), NDF (49.42%) and ADF (38.59%). SFM contained low amount of ether extract (0.97%), whereas it was high in amounts of crude protein (36.18%), crude fiber (19.8%), NDF (37.48%) and ADF (22.75%). The measured ME levels were 906.2 and 1803.7 kcal/kg, respectively, in SM and SFM.

Table 2. Chemical composition of the meals (%)

Chemical composition (analyzed)	Safflower meal	Sunflower meal
Dry matter	86.37	89.57
Moisture	13.63	10.43
Crude protein	19.5	36,18
Ether extract	0.6	0.97
Crude fiber	36.1	19.8
Crude ash	3.15	7.07
Nitrogen free extract	27.02	25.55
Neutral detergent fiber	49.42	37.48
Acid detergent fiber	38.59	22.75
Acid detergent lignin	10.78	7.66
Metabolizable energy[1] (kcal/kg)	906.2	1 803.7

[1]Metabolizable energy content of diets was estimated using the equation of Carpenter and Clegg (Leeson and Summers, 2001).

In the present study, the effects of combined SM and SFM supplementation to the diets of quails on laying performance parameters are presented in Table 4. No significant differences were observed between the groups regarding initial and final body weights, feed intake, egg production, feed conversion ratio and egg weight ($P>0.05$).

Table 3. Composition of the experimental diets (%)

Ingredients	Control	Treatment groups		
		SSM10	SSM20	SSM30
Corn	51.8	47.5	43.7	39.6
Boncalite	6	6	4.5	2
Corn gluten meal (58%)	4	8	12	13
Soybean meal (48%)	26	15	5	-
Safflower meal (19%)	-	5	10	15
Sunflower meal (36%)	-	5	10	15
Meat-bone meal (38%)	2	2	2	1
Vegetable oil	3.2	4.2	5.8	7.3
Limestone	5.5	5.5	5.3	5.3
Salt	0.25	0.25	0.25	0.2
Dicalcium phosphate	0.9	0.9	0.78	0.9
L-lysine	-	0.2	0.2	0.2
$NaHCO_3$	0.1	0.2	0.22	0.25
Vitamin-mineral premix[1]	0.25	0.25	0.25	0.25
Chemical composition (analyzed)				
Dry matter (%)	91.62	91.72	91.93	92.11
Crude protein (%)	20.62	20.14	20.06	19.86
Ether extract (%)	6.46	7.16	8.45	9.71
Crude fiber (%)	2.67	4.96	7.21	9.51
Calcium (%)	2.63	2.53	2.42	2.33
Total phosphorus (%)	0.34	0.34	0.33	0.30
Metabolizable energy[2] (kcal/kg)	2 956	2 903	2 933	2 984

[1]Composition per 2.5 kg of product: 12.000.000 IU vitamin A, 2.400.000 IU vitamin D3, 30 g vitamin E, 2.5 g vitamin K3, 2.5 g vitamin B1, 6 g vitamin B2, 4 g vitamin B6, 20 mg vitamin B12, 25 g niacin, 8 g calcium-D-panthotenate, 1 g folic acid, 50 g vitamin C, 50 mg D-biotin, 400 g choline chloride, 1.5 g canthaxanthin, 80 g Mn, 60 g Zn, 60 g Fe, 5 g Cu, 1 g I, 0.5 g Co, 0.15 g Se.

[2]Metabolizable energy content of diets was estimated using the equation of Carpenter and Clegg (Leeson and Summers, 2001).

Table 4. The effects of dietary combined safflower and sunflower meals supplementation on laying performance of quails

	Control	Treatment groups			SEM	P
		SSM10	SSM20	SSM30		
Initial body weight (g)	165.59±0.84	166.50±1.01	166.63±0.94	164.12±0.87	0.890	0.975
Final body weight (g)	182.28±1.25	185.80±1.81	184.97±1.95	183.38±2.30	0.880	0.839
Feed intake (g/day)	32.30±0.54	32.55±0.34	33.21±0.34	33.50±0.42	0.223	0.194
Egg production (%)	87.20±0.36	88.28±0.78	86.80±0.42	86.25±0.35	0.291	0.074
Feed conversion ratio (kg feed/kg egg)	3.12±0.05	3.10±0.03	3.28±0.04	3.33±0.05	0.031	0.057
Egg weight (g)	11.85±0.05	11.87±0.09	11.66±0.06	11.63±0.06	0.040	0.056

No significant differences among the groups (P>0.05), n=5.

The effects of dietary supplementation of SM and SFM on egg quality parameters are shown in Table 5. There were no difference in any of the experimental groups compared with the control group in terms of shape index, shell thickness, albumen index, yolk index, Haugh unit and yolk color index (P>0.05). However, a numerically slight reduction in body weight and increase in feed conversion ratio were observed in birds fed the SSM at 20% and 30%, when compared with the control and SSM10 groups (1.5, 1.7 %, respectively; P＝0.056 and P=0.057).

Table 5. The effects of dietary combined safflower and sunflower meals supplementation on egg quality of quails

	Control	Treatment groups			SEM	P
		SSM10	SSM20	SSM30		
Shape index[2],%						
4th week	80.01±0.72	80.50±0.85	79.53±1.16	79.02±1.19	0.505	0.762
8th week	78.93±1.55	79.04±1.60	78.47±2.48	79.44±2.24	0.359	0.823
Egg shell thickness (mm/100)						
4th week	18.71±1.19	20.94±0.31	20.03±0.45	20.30±0.49	0.323	0.129
8th week	19.93±0.56	20.93±0.54	21.16±0.65	20.35±0.37	0.272	0.412
Albumen index (%)						
4th week	11.15±0.63	10.76±0.35	10.57±0.30	11.31±0.38	0.200	0.542
8th week	11.35±0.35	10.91±0.23	10.74±0.15	11.12±0.32	0.134	0.457
Yolk index (%)						
4th week	50.04±2.58	50.83±1.33	53.14±1.75	54.95±0.97	0.855	0.171
8th week	51.40±1.28	51.62±1.01	51.30±1.24	53.40±1.19	0.584	0.545
Haugh unit						
4th week	79.16±1.34	81.89±0.81	80.10±0.84	80.43±0.63	0.455	0.226
8th week	80.57±0.83	81.81±0.87	79.91±0.61	79.21±0.61	0.394	0.091
Yolk color index						
4th week	5.44±0.43	5.44±0.25	5.75±0.17	6.12±0.27	0.148	0.280
8th week	5.98±0.28	5.85±0.08	5.78±0.14	6.07±0.24	0.094	0.713

No significant differences among the groups (P>0.05), n=15.

Discussion

The present study was conducted to investigate the combined effects of safflower and sunflower meals, at graded levels, in quail diets on laying performance and some egg quality parameters. The inclusion levels of meals used in this study were calculated in accordance with the inclusion levels of those other studies (Akinci and Bayram, 2003; Kocaoglu Guclu et al., 2004; Bulbul and Ulutas, 2015; Karayagiz and Bulbul, 2015b) due to non-availability of data about the combined use of safflower and sunflower meals supplementation to the diets of laying quails.

The crude protein levels of the dietary SM was considerably low (19.5%), compared to SFM (36.18%). The crude fiber content of SM was nearly 2 fold of SFM, while fibrous fractions such as NDF, ADF and ADL were at high levels in both meals (Table 2). Although some researchers (Alvarez-Gonzalez et al., 2007; Karayagiz and Bulbul, 2015a) reported lower crude protein level in SM which depends on the gradually increasing levels of crude fiber in the meal, crude protein and crude fiber value for sunflower was reported to be similar to our study (Villamide and San Juan, 1998; Jankowski et al., 2011) or at lower (Rama Rao et al., 2006; Senkoylu and Dale, 2006) levels compared to our study. Ether extract levels of the meals was determined to be quite low (0.60% and 0.97%) (Table 1). Some other studies reported low ether extract contents in safflower and sunflower meals (Kocher et al., 2000; Farran et al., 2008). The energy value of SM was considerably lower than that of the energy values reported by other researchers (Farran et al., 2008, 2010). The ME value of the SM was detected as lower in comparison to energy levels described by Farran et al. (2010). However, the ME values of SFM was similar to those reported in the literature (Rama Rao et al., 2006). Thus, the composition of the safflower (Farran et al., 2008, 2010) and sunflower (Zhang and Parsons, 1994; Villamide and San

Juan, 1998; Senkoylu and Dale, 2006) meals may change according to many factors such as seed parts and their husk amount as well as processing technique. Because of these differences in chemical composition, the inclusion of SSM in quail diets may result in increase in the concentrations of crude fibre and fibrous fractions.

Diets used in the study were prepared in isonitrogenic and isocaloric to meet the protein and energy requirements of the quails. The dry matter, ether extract and crude fiber contents of the diets have increasing trend depending on the increasing levels of the meals. The calcium and phosphorus levels of diets were sufficient to meet the needs of the quails (Table 3).

In this study, it was determined that combined supplementation of safflower and sunflower meals in laying quail diets did not affect initial and final body weight, feed intake, egg production, feed conversion ratio and egg weight ($P>0.05$, Table 4). These results were in agreement with the results of some other studies where safflower and sunflower meals were used individually. Namely, the use of SM in laying hens did not change feed intake, egg production and egg weight at 2.5-10%, and feed conversion ratio at 2.5% and 5% (Ehsani et al., 2013). It was also reported that supplementation of SM at 9.5, 15 and 20% in laying hens did not affect initial and final body weight, feed intake, egg production, feed conversion ratio and egg weight (Petersen et al., 1957). The other studies showed that the supplementation of SFM at 4-12% (Casartelli et al., 2006), 5.79-18.97% and 15-20% (Karunajeewa et al., 1989) did not change feed intake, egg production and feed conversion ratio. Also, some studies (Serman et al., 1997; Senkoylu et al., 2004; Casartelli et al., 2006) reported that SFM supplementation in the diets did not change egg weight. An other study conducted on laying quail (Karayagiz and Bulbul, 2015b) reported that supplementation of SFM did not change initial and final body weights, feed intake, and egg weight. Other studies with different meals supplementation reported that canola meal did not affect body weight, feed intake, egg production, feed conversion ratio and egg weight at 12.5% and 24.3% (Saricicek et al., 2005), and body weights, feed intake and egg weight at 5-20% (Karayagiz and Bulbul, 2015b); peanut meal did not alter body weight and egg weight at 10, 15 and 20% (Bayram and Akinci, 2001); false flax meal did not change initial body weight, feed conversion ratio and egg weight at 5-20% (Bulbul ve Ulutas, 2015) and alfalfa meal did not affect body weight, feed intake, egg production, feed conversion ratio and egg weight at 3-9% (Kocaoglu Guclu et al., 2004). However, it was noted that SFM increased feed intake and egg weight (Karunajeewa et al., 1989), as well as feed intake and feed conversion ratio (Senkoylu et al., 2004) in laying hens, while its high levels reduced egg production and increased feed conversion ratio in quails (Karayagiz and Bulbul, 2015b). Unchanged feed intake with combined supplementation of safflower and sunflower meals in the presented study might have resulted from isonitrogenous and isocaloric diets used in different groups.

Also, unchanged body weight might be associated with the unchanged feed intake ultimately leading to unchanged egg production and egg weight. SM and SFM contain some antinutritional compounds such as cyanide, oxalate, trypsin inhibitor (Ingale and Shrivastava, 2011) and phytic acid and tannin (Gandhi et al., 2008). Additionally, crude fiber content of both meals is variable and depends on the amount of hulls (Golob et al., 2002). These compounds (Kocher et al., 2000) and high fiber levels (Villamide and San Juan, 1998; Farran et al., 2010) in meals reduced the utilization and bioavailability of nutrients in the poultry. Although a previous study (Karayagiz and Bulbul, 2015b) reported that feed conversion ratio improved in the groups where SFM was used at low levels because fibrous fractions at those levels and anti-nutritional factors in the content did not exert any adverse effect and the quails had a high ability to exploit them. In the present study unchanged feed conversion ratio could be associated with unchanged egg production and feed intake within the groups.

During the study, it was observed that the external and internal quality parameters of eggs were not affected by the supplementation of safflower and sunflower meals, even upto 30% inclusion level (P>0.05, Table 5). Similarly, Karayagiz and Bulbul (2015b) reported that 5-20% SFM supplementation to diets did not change egg shape index, shell thickness, yolk index, white index, Haugh unit and yellow color index. Several studies on other meals reported; false flax meal did not alter egg shape index, shell thickness, yolk index, albumen index and Haugh unit at the levels of 5-20% (Bulbul and Ulutas, 2015); peanut meal did not affect yolk index, albumen index, Haugh unit and yolk color at the levels of 10%, 15% and 20% (Bayram and Akinci, 2001); canola meal did not change the shape index at the levels of 12.5% and 24.3% (Saricicek et al., 2005). However, SFM supplementation to laying hen diets caused an increase in shell thickness at 8% (Casartelli et al., 2006) and a reduce in Haugh unit at 12.19% and 18.97% (Karunajeewa et al., 1989). Increased (Bulbul and Ulutas, 2015) or reduced (Saricicek et al., 2005; Cherian et al., 2009) levels of egg yolk with other meals. It has also been reported that shell thickness, albumen index and Haugh unit improved in laying quails with alfalfa meal supplementation at levels of 9% (Kocaoglu Guclu et al., 2004).

As a result, it may be concluded that the combined supplementation of safflower and sunflower meals at different levels in laying quail diets do not affect body weight, feed intake, egg production, feed conversion ratio, egg weight and some egg quality parameters; therefore, the use of safflower and sunflower meals at rates up to 30% is suitable as an alternative feed to soybean meal for the quails. Moreover, it is believed that further research is required to increase the usability of safflower and sunflower meals in laying quail diets by adding enzyme compositions and/or lacking amino acids which affect cellulase enzyme together with other antinutritional factors.

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