Kafkas Univ Vet Fak Derg
18 (6): 945-950, 2012

Journal Home-Page: http://vetdergi.kafkas.edu.tr
Online Submission: http://vetdergikafkas.org

RESEARCH ARTICLE

The Effects of Using Chicken Drippings oil Instead of the Sunflower Oil on Performance, Blood Parameters, Cholesterol and Fatty Acid Composition of Egg Yolk in Laying Japanese Quail *(Coturnix coturnix japonica)* [1]

Fatma KARAKAŞ OĞUZ * Mustafa Numan OĞUZ * Tülay BÜYÜKOĞLU **

[1] *This research was supported by Mehmet Akif Ersoy University BAP, project number: 0021-NAP-08, 2008*

* Department of Animal Nutrition and Nutritional Disease, Faculty of Veterinary Medicine, University of Mehmet Akif Ersoy, TR-15030 Istiklal Campus, Burdur - TURKEY
** Department of Biochemistry, Faculty of Veterinary Medicine, University of Mehmet Akif Ersoy, TR-15030 Istiklal Campus, Burdur - TURKEY

Makale Kodu (Article Code): KVFD-2012-6826

Summary

This study was carried out to determine the effect of using chicken drippings oil (CDO) instead of the sunflower oil (SO) in laying Japanese quail diets on egg production, feed intake, feed conversion ratio, blood parameters, cholesterol level and fatty acid composition of egg yolk. A total of 192, thirteen week old Japanese quail were allocated to four groups with six replicates containing eight quail each. The diets contained 5% sunflower oil (SO1), 5% chicken drippings oil (CDO1), 7.5% sunflower oil (SO2), 7.5% chicken drippings oil (CDO2). The diets were formulated isonitrogenous and isocaloric, included 20% crude protein and 2900 kcal/kg ME. Experimental diets and water were provided ad libitum throughout the 9 weeks. There were no significant differences in initial body weight among the groups, but there were significant ($P<0.001$) differences in final body weight among the groups: 296.62, 286.62, 308.24, 276.35 g for SO1, CDO1, SO2 and CDO2 respectively. The egg production ($P<0.001$) of chicken drippings oil groups higher than the sunflower oil groups. The cholesterol levels in blood serum among groups were not statistically significant. At the end of the study cholesterol content of the egg yolk was the lowest in ($P<0.05$) the laying quail fed the CDO2 diet. All blood parameters including haemoglobin, heamotocrit, serum cholesterol and serum glucose were not affected by diets except serum triglyceride and serum protein $P<0.01$). Dietary chicken drippings oil had no adverse effect on egg weight, cholesterol and fatty acid composition of the egg yolk and feed conversion ratio. Therefore, chicken drippings oil can be use up to 7.5% of the laying quail diets.

Keywords: *Blood parameter, Egg, Oil, Performance, Quail*

Yumurtlayan Japon Bıldırcınlarında Ayçekirdeği Yağı Yerine Tavuk Çevirme Yağı Kullanımının Performans, Kan Parametreleri, Yumurta Sarısının Kolesterol ve Yağ Asidi Kompozisyonuna Etkisi

Özet

Bu çalışma yumurtlayan Japon bıldırcınlarının rasyonlarında ay çekirdeği yağı yerine tavuk çevirme yağının kullanılmasının yumurta verimi, yem tüketimi, yemden yararlanma oranı, kan parametreleri, yumurta sarısının kolesterol ve yağ asidi kompozisyonuna etkisini belirlemek amacıyla yapılmıştır. Toplam 192 adet 13 haftalık yaştaki Japon bıldırcınları, her biri 8 adet bıldırcın içeren, altı tekerrürlü, 4 gruba yerleştirilmiştir. Gruplara yedirilen deneme rasyonları %5 ay çekirdeği yağı (SO1), %5 tavuk çevirme yağı (CDO1), %7.5 ay çekirdeği yağı (SO2) veya %7.5 tavuk çevirme yağı (CDO2) içermiştir. Rasyonlar %20 ham protein ve 2900 kcal/kg ME içerecek şekilde izonitrojenik ve izokalorik olarak hazırlanmıştır. Bıldırcınlara deneme rasyonları ve su 9 hafta boyunca ad libitum olarak verilmiştir. Gruplar arasında başlangıç canlı ağırlığı açısından önemli farklılık görülmemiştir. Ancak grupların deneme sonu canlı ağırlıkları arasında yüksek derecede önemli farklılık ($P<0.001$) tespit edilmiştir (SO1, CDO1, SO2 ve CDO2 grupları için sırasıyla 296.62, 286.62, 308.24 ve 276.35 g). Tavuk çevirme yağı tüketen gruplardan, ay çekirdeği yağı tüketen gruplara kıyasla daha fazla ($P<0.001$) yumurta verimi elde edilmiştir. Gruplar arasında kan serum kolesterol düzeyleri istatistiki açıdan önemsiz bulunmuştur. Deneme sonunda yumurta sarısı kolesterol oranı CDO2 rasyonuyla beslenen grupta en düşük ($P<0.05$) bulunmuştur. Trigliserit ve serum proteini dışında ($P<0.01$), hemoglobin, hematokrit, serum kolesterol ve serum glikoz dahil tüm kan parametreleri rasyondan etkilenmemiştir. Tavuk çevirme yağı yumurta ağırlığı, yumurta sarısının kolesterol ve yağ asidi kompozisyonu ile yemden yararlanma oranını olumsuz etkilememiştir. Sonuç olarak tavuk çevirme yağı yumurtlayan bıldırcın yemlerine %7.5 oranına kadar katılabilir.

Anahtar sözcükler: *Kan parametreleri, Yumurta, Yağ, Performans, Bıldırcın*

İletişim (Correspondence)
+90 248 2132140
fatmakarakas@yahoo.com

INTRODUCTION

The poultry are capable of rapid development. Metabolic rates and metabolic energy requirements of poultry are very high. Therefore poultry diets should be rich in energy. Oils are important in the diet of poultry as concentrated sources of energy. Use of fats in animal feed has many benefits. Some of these benefits are increase in energy level and palatability of diet, improvement of growth rate, feed efficiency, absorption of fat soluble vitamin and decrease of metabolic heat production during heat stress. Dietary fats are also source of essential fatty acids [1-4]. Besides, diets are containing fats or oil are shown to change the fatty acid composition of egg yolk in laying hens [5]. Because of the high prices, oils being used as a supplement and increases the total cost of diets. Therefore cheaper alternative of by-products from oil industry have been started to be use [6].

Approximately 1.500.000 tons of vegetable oil per year are used for human consumption in Turkey. Approximately 350.000 tons of waste oil is produced from this oil. Dumping waste oils into sewage and garbage is prohibited. Dumping waste oil and animal fats causes lots of problem, especially pollution to surface water and groundwater, creates landfill fires and danger to animals that come to landfill area. Some studies continue for the recovery of vegetable and animal waste oil and fats. These oils and fats can be used as bio-diesel, soap or animal feed [7].

Chicken drippings oil taken, from chicken carcass during cooking of a rotating system, is obtained through a collection reservoir. Chicken drippings oil is differ from restaurant waste oil. Restaurant waste oil is high-temperature exposed and repeatedly used for frying. The objective of this study was to investigate the effects of using chicken drippings oil instead of sunflower oil on feed conversion ratio, cholesterol and fatty acid composition of egg yolk, egg weight of laying quail. Further, the study will contribute to the reduction of environmental pollution.

MATERIAL and METHODS

In this study a total of 192, thirteen week old Japanese quail were divided into four groups with six replicates containing eight quail each. The diets were formulated isonitrogenous and isocaloric, included 20% crude protein and 2900 kcal/kg ME. Diets contained 5% sunflower oil (SO1), 5% chicken drippings oil (CDO1), 7.5% sunflower oil (SO2), 7.5% chicken drippings oil (CDO2). Feedstuffs were weighed, crushed with hammer mill and mixed with 500 kg capacity mixer. The ingredients and chemical composition of the diets are presented in *Table 1*. CDO was collected from a local chicken grill shop. Local ethics committee report was received before beginning of this study. Experimental diets and water were provided *ad libitum* throughout the nine weeks. Eggs were collected each morning and recorded

Table 1. *Composition of experimental diets and results of chemical analyses*
Tablo1. *Denemede kullanılan rasyonların bileşimi ve kimyasal analiz sonuçları*

Ingredients, %	**Diets**			
	SO1	**CDO1**	**SO2**	**CDO2**
Barley	12.50	12.50	35.50	35.50
Corn	39.90	39.90	15.50	15.50
Soyabean meal	34.50	34.50	33.40	33.40
Dicalcium phosfat	1.10	1.10	1	1
Dl-methionin	0.10	0.10	0.10	0.10
Limestone	6.50	6.50	6.60	6.60
Salt	0.30	0.30	0.30	0.30
Vitamin-mineral premix	0.10	0.10	0.10	0.10
Oil	5.00	5.00	7.50	7.50
Total	100	100	100	100
Crude Protein, %	20	20	20	20
Metabolisable energy, kcal/kg	2.903	2.903	2.900	2.900
Analyses				
Dry matter, %	89.98	89.82	90.26	90.59
Crude protein, %	19.35	19.20	19.17	19.12
Ash, %	11.62	11.32	9.62	9.60
Ether extract, %	8.16	8.15	11.10	10.80
Crude fiber, %	2.97	3.19	4.95	4.25

daily. Feed intakes recorded biweekly and feed conversion ratios (FCR) were calculated. Egg productions were also determined. FCR1 was calculated including the consumed feed for one dozen egg. FCR2 was calculated as the consumed feed for one kg egg. Two birds were selected at randomly from each replicate for blood samples at the end of the study.

The nutrient compositions of diets were determined according to the AOAC [8]. The analysis of serum and egg yolk total cholesterols and triglyceride were measured on spectrophotometer (Shimatzu UV-1601 Model) by using commercially available kits (Chema Diagnostica, Italy). Egg yolk cholesterol analysis was performed every 3 weeks from the beginning of the trial. Egg yolk cholesterol was determined according to Kucukersan [9]. Serum protein and glucose levels were estimated by the method of the Biuret [10] and Feteris [11] respectively. Haemoglobin [12] and haematocrit (microhaematocrit centrifuge) were also determined. The analysis of the yolk fatty acid profile was measured end of the experiment, with the collection of six egg yolks to compose a pool for each group. Fatty acid profiles of experimental fats and egg yolks were determined using QP 5050 GC /MS. The fat extracted from each sample was methylated and the fatty acids were separated and identified using a Cp Wax 52 CB 50 m, 0.32 mm, 1.2 µm capillary colon. The temperature of the injector and the detector were 250°C. Helium was used as the carrier gas.

Statistical analyses of data were performed by computer. Differences between obtained values were carried out by analysis of variance (ANOVA) and the significance of mean differences was tested by the Duncan's test [13].

RESULTS

The initial and final live weights of the groups are shown in *Table 2*. There were no significant differences in initial body weights among the groups. Egg weight and cholesterol levels (mg/g) in egg yolk of quail fed diets with different amounts sunflower oil and chicken drippings oil are shown at *Table 3*. The feed intake, FCR and egg production are given in *Table 4*. The some blood parameters and fatty acid composition egg yolk are shown at *Table 5* and *Table 6*.

Table 2. *The body weight of quails*
Tablo 2. *Bıldırcınların canlı ağırlıkları*

Items	Groups				P-value
	SO1	CDO1	SO2	CDO2	
Initial body weight	239.85	243.42	236.33	236.56	NS
Final body weight	296.62^{b}	286.61^{ab}	308.23^{cb}	276.35^{a}	<0.001

P<0.001, Different superscripts ^{a,b,c} in the same row indicate significant differences between groups

Table 3. *Cholesterol levels in egg yolk*
Tablo 3. *Yumurta sarısının kolesterol seviyeleri*

Items	Groups				P-value
	SO1	CDO1	SO2	CDO2	
Egg weight (1), g	13.88	13.35	13.85	13.45	0.392
Boiled egg yolk weight (1), g	4.29^{ab}	4.08^{ab}	4.40^{b}	4.01^{a}	0.063
Egg yolk cholesterol (1), mg/dl	99.02	95.68	99.76	103.48	0.144
Egg yolk cholesterol (1), mg/g	39.61^{ab}	38.27^{a}	39.90^{ab}	41.39^{b}	0.144
Egg weight (2), g	12.97^{a}	13.16^{a}	14.15^{b}	13.37^{a}	0.013
Boiled egg yolk weight (2), g	4.16	4.34	4.59	4.55	0.337
Egg yolk cholesterol (2), mg/dl	111.50	110.58	112.73	113.35	0.879
Egg yolk cholesterol (2), mg/g	44.65	44.17	44.93	45.18	0.917
Egg weight (3), g	13.58^{b}	13.34^{ab}	12.92^{ab}	12.70^{a}	0.048
Boiled egg yolk weight (3), g	4.43^{b}	4.23^{b}	4.26^{b}	3.90^{a}	0.016
Egg yolk cholesterol (3), mg/dl	124.45^{b}	124.07^{b}	113.87^{ab}	110.14^{a}	0.013
Egg yolk cholesterol (3), mg/g	49.70^{b}	49.54^{b}	45.55^{ab}	44.06^{a}	0.016

P<0.05, Different superscripts ^{a,b} in the same row indicate significant differences between groups

Table 4. *The effects of sunflower oil and chicken drippings oil on performance of laying quails*
Tablo 4. *Ayçekirdeği yağı ve tavuk çevirme yağının bıldırcınlarda performansa etkisi*

Items	Groups				P-value
	SO1	CDO1	SO2	CDO2	
Feed intake (g feed/quail/day	40.61^b	42.76^c	40.64^b	38.75^a	<0.001
FCR1* (g, feed/dozen egg)	566.05a	555.98a	680.22b	528.20a	<0.001
FCR2 (kg feed/kg egg)	3.44a	3.28a	4.29b	3.30a	<0.001
Egg production, %	87.15^b	92.91^c	73.42^a	90.26^{bc}	<0.001

** **FCR:** Feed Conversion Ratio, different superscripts ^{a,b,c} in the same row indicate significant differences between groups*

Table 5. *The effects of sunflower oil and chicken drippings oil on blood parameters*
Tablo 5. *Ayçekirdeği yağı ve tavuk çevirme yağının kan parametrelerine etkisi*

Items	Group				P-value
	SO1	CDO1	SO2	CDO2	
Haemoglobin, g/dl	21.21	21.94	18.19	20.23	0.094
Haematocrit, %	37.83	39.33	41.33	39.17	0.164
Serum Cholesterol, mg/dl	195.61	197.13	157.37	176.49	0.073
Serum TG, mg/dl	831.16^b	820.38^b	519.13^a	695.59^b	0.002
Serum glucose, mg/dl	220.71	217.96	259.06	224.59	0.280
Serum protein, g/dl	4.40^b	4.44^b	3.30^a	4.19^b	0.002

P<0.01, different superscripts ^{a,b,} in the same row indicate significant differences between groups

Table 6. *Fatty acid composition of egg yolk*
Tablo 6. *Yumurta sarılarının yağ asidi kompozisyonu*

Items		Chicken Drippings Oil	SO1	CDO1	SO2	CDO2
C14:0	Myristic	0.46	0.20	0.43	0.40	0.42
C16:0	Palmitic	20.29	27.09	28.28	26.10	27.66
C16:1	Palmitoleic	1.95	1.09	2.63	1.00	1.95
C18:0	Stearic	6.63	18.12	11.64	13.24	13.21
C18:1	Oleic (Omega 9)	30.63	32.38	43.24	39.10	37.61
C18:1 (n:7)	Omega 7	1.68	1.10	2.01	1.10	1.40
C18:2	Linoleic Omega 6	35.11	16.42	9.58	17.00	15.24
C18:3	Linolenic	2.81	0.15	0.10	0.10	0.12
C20:4	Arachidonic (omega 6)	-	3.10	1.80	1.83	1.89

DISCUSSION

Final body weight of sunflower oil groups were significantly higher than in chicken drippings oil groups. Also, at the end of the experiment, a decrease (P<0.05) has been observed in the egg weight in CDO2 group compared with CDO1, SO1 and SO2 groups. Our results were different from Atakisi et al.[14] who reported that omega-3 fatty acids had no effects on the body weights, or egg and egg yolk weights. These different results may be due to utilized various oils. The chicken drippings oil has high levels of omega 6, omega 9 and palmitic acid, but very low level of omega 3 fatty acid.

The egg production of CDO1 and CDO2 groups higher than SO1 and SO2 groups (P<0.001). Contrary to our results Celebi and Utku [15] reported that the highest egg production was obtained from sunflower oil group containing high level of linoleic acid. The highest FCR1 and FCR2 (feed conversion ratio) were obtained from SO2 (7.5% sunflower oil). The addition of 5% and 7.5% chicken drippings oil has positive effect on FCR compared with other groups (5% and 7.5% sunflower oil). Shahryar et al.[16] reported that the addition of 3% canola oil or 3% poultry fat has positive effect on feed conversion compared with other groups.

The cholesterol content in the blood serum was not statistically significant. However, the findings of this experiment do not agree with those found by Celebi and Utlu [15] who observed a reduction of serum total cholesterol when quail were fed diets with different oil. This findings are different from Qureshi et al.[17] who reported that the serum cholesterol values were significantly higher (P<0.05) in chickens fed animal fat than fed vegetable oil. On the other hand, at the end of the study cholesterol content of yolk (49.70, 49.54, 45.55 and 44.06 mg/g egg yolk for SO1, CDO1, SO2 and CDO2 respectively) was lower (P<0.05) in laying quail fed the CDO2 diet *(Table 3)*. Our results were confirmed by Filardi et al.[18] who reported that the concentrations of saturated, monounsaturated, and PUFA in the egg yolks were significantly affected by the addition of different fat sources to diets. Mazalli et al.[19] reported that cholesterol content in eggs was significantly (P<0.05) higher for hens fed the control diet than for hens fed the canola, sunflower, flaxseed and fish oil diets.

Blood parameters including haemoglobin, haematocrit, serum cholesterol, serum glucose were not affected by diets except for serum triglyceride and serum protein (P<0.01). Similarly Grobas et al.[20] reported that positive effects from the intake of monounsaturated fatty acid on health, with reduce triglyceride concentration in blood. But Atakisi et al.[14] reported that omega-3 fatty acid supplementation reduced egg and plasma cholesterol as well as plasma glucose level and no change was observed in triglyceride levels with the supplementation in quails. Similarly, Pal et al.[21] reported that the type of fat added to the diet did not affect the glucose levels and omega-3 fatty acids changed the effects of insulin and glucagon on the plasma glucose level.

In this study, the chicken dripping oil fatty acid composition was measured as 0.46% C14:0, 20.29% C16:0, 1.95% C16:1, 6.63% C18:0, 30.63% C18:1, 1.68% C18:1 (n-7), 35.11% C18:2, 2.81% C18:3. The stearic acid level in egg yolk of quails fed the diet with SO1 was higher than those fed the diets with CDO1, SO2 and CDO2). Ceylan et al.[22] reported that fatty acids profile of the egg yolk was significantly altered by type and level of dietary fat, but cholesterol content of yolk was not changed by the treatments. Jiang et al.[23] reported that the high linoleic acid content of sunflower seed diet increased the level of stearic acid in yolk. Similarly, Celebi and Macit [24] reported that the fatty acid compositions of egg yolk lipids were significantly affected by dietary fatty acid composition. Filardi et al.[18] also reported that there was no effect of the fat sources on the concentration of n-3 fatty acids in the yolk. But a significant effect was observed on the level of n-6 fatty acids with the lowest concentration determined by the addition of canola oil in the feed as compared with the other sources (cotton oil, soybean oil, lard, sunflower oil). This finding agrees with our experiment.

As a result, dietary chicken drippings oil had no adverse effect on egg weight, feed conversion ratio, cholesterol and fatty acid composition of egg yolk. If collected and stored properly, chicken drippings oil can use up to 7.5% in the laying quail diets.

REFERENCES

1. Reid BL: Energetic value of fat for layers evaluated. *Feedstuffs*, 4 (March): 32, 1985.

2. Senkoylu N: İç yağ, asit yağ ve bunların karışımının broyler performansına etkileri. *International Poultry Congress,* 23-25 Mayıs, Istanbul, 1990.

3. Ozdoğan M, Sarı M: Kanatlı rasyonlarına yağ katkısı. *Hayvansal Uretim*, 42 (1): 28-34, 2001.

4. Baiao NC, Lara LJC: Oil and fat in broiler nutrition. *Rev Bras Cienc Avic,* 7 (3): 129-141, 2005.

5. Citil ÖB, Yıldırım İ, Parlat SS: The effects of dietary flaxseed oil supplementations on fatty acids composition of the yolks in quail *(Coturnix coturnix japonica)* eggs. *Kafkas Univ Vet Fak Derg,*17 (5): 761-766, 2011.

6. Cetingul IS, Inal F: The effects of utilization of hazelnut oil, sunflower oil and their products on performance and fatty acid composition of yolk in layer hens. *Vet Res Commun,* 33, 535-543, 2009.

7. Ozturk M: Kullanılmıs bitkisel ve hayvansal yağlar. Çevre ve Orman Bakanlığı Yayınları, Ankara, 2004. http://www2.cevreorman.gov.tr/belgeler/yaglar.pdf, *Erişim tarihi:*10.02.2012.

8. AOAC: Official Methods of Analysis. Association of Official Analytical Chemists. Washington, D.C., 1984.

9. Küçükersan S: Kanatlı karma yemlerinde değişik yağ kaynakları ve Vitamin E'nin kullanılma olanakları. Ankara Üniversitesi Bilimsel Araştırma Projeleri Kesin Raporu. http://acikarsiv.ankara.edu.tr/browse/495/795.pdf, 2004, *Erişim tarihi:* 12.02.2012.

10. Karagül H, Altıntaş A, Fidancı UR, Sel T: Klinik Biyokimya. s. 315-316, Medisan, Ankara, 2000.

11. Feteris WA: A serum glucose method without protein precipitation. *Am J Med Technol*, 31, 17-21, 1965.

12. Fairbanks VF, Klee GG: Biochemical aspects of hematology. **In,** Tietz NW (Ed): Fundamentals of Clinical Chemistry. 3rd ed., pp. 803-806, WB Saunders Co. Philadelphia, 1987.

13. Ozdamar K: Paket Programlarla Istatistiksel Veri Analizi. Anadolu Üniversitesi Yayınları, Eskisehir, 1997.

14. Atakisi E, Atakisi O, Yaman H, Arslan I: Omega -3 fatty acid application reduces yolk and plasma cholesterol levels in Japanese quails. *Food Chem Toxicol*, 47, 2590-2593, 2009.

15. Celebi S, Utlu N: Influence of animal and vegetable oil in layer diets on performance and serum lipid profile. *Int J Poult Sci*, 5 (4): 370-373, 2006.

16. Shahryar HA, Salamatdoust R, Lak AN, Lotfi A: Effect of dietary supplemented canola oil and poultry fat on the performance and carcass characterizes of broiler chickens, *Curr Res J Biol Sci,* 3 (4): 388-392, 2011.

17. Qureshi A, H-Khan SA, Chaudhry ZI, Mian NA, Tipu MY, Rai MF: Effects of high dietary fat on serum cholesterol and fatty liver syndrome in broilers. *Pak Vet J,* 24 (3): 153-154, 2004.

18. Filardi RS, Junqueira OM, Laurentiz AC, Casartelli EM, Rodrigues RA, Araujo LF: Influence of different fat sources on the performance, egg quality, and lipid profile of egg yolks of commercial layers in the second laying cycle. *J Appl Poultry Res*, 14, 258-264, 2005.

19. Mazalli MR, Faria DE, Salvador D, Ito DT: A comparison of the feeding value of different sources of fats for laying hens: 1. Performance characteristics. *J Appl Poultry Res*, 13, 274-279, 2004.

20. Grobas S, Mendez J, Lazaro R, Blas C, Mateos GG: Influence of source and percentage of fat added to diet on performance and fatty acid composition of egg yolks of two strains of laying hens. *Poult Sci*, 80, 1171-1179, 2001.

21. Pal L, Grossmann R, Dublecz K, Wagner L, Bartos A, Kovacs G:

Effects of glucagon and insulin on plasma glucose, triglyceride, and triglyceride-rich lipoprotein concentrations in laying hens fed diets containing different types of fats, *Poult Sci,* 81, 1694-1702, 2002.

22. Ceylan N, Ciftci I, Mızrak C, Kahraman Z, Efil H: Influence of different dietary oil sources on performance and fatty acid profile of egg yolk in laying hens. *J Anim Feed Sci*, 20, 71-83, 2011.

23. Jiang Z Ahn U, Sim JS: Effects of feeding flax and two types of sunflower seeds on fatty acid composition of yolk lipid classes. *Poult Sci,* 70, 2467-2475, 1991.

24. Celebi S, Macit M: The effects of sources of supplemental fat on performance, egg quality, and fatty acid composition of egg yolk in laying hens. *J Sci Food Agric*, 88 (13): 2382-2387, 2008.