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Effects of cinnamon and rosemary oils on egg production, egg quality, hatchability traits and blood serum mineral contents in laying quails (Coturnix coturnix Japonica)

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Summary: This study was carried out to evaluate the effects of cinnamon (CO), rosemary (RO) and a mixture (MO) of these plants oil on egg production, feed intake, feed conversion rate, external and internal egg quality, blood serum mineral contents and hatchability traits in different sex ratios of [1/3 and 1/5, (♂/♀)] in laying quails. A total of 192 quail were distributed into special cages (12 quails/per cage) including three experimental diets and control. The experiment was continued two months. At the end of the study, 12 birds from each group were slaughtered in order to collect blood samples. The levels of Cu, Co, Cr, Zn, Fe, K, Na and Mg in serum were determined. The highest egg weight was found in RO group, while it was lowest in MO group (P<0.05). Addition of diatery CO improved hen-day egg production as well as feed conversion rate (P<0.05). Feed intake was found to be similar among the groups (P>0.05). While egg shell rate increased in CO group (P<0.05), the ratios of egg yolk, egg albumen and shape index did not differ among the treatments (P>0.05). Although the effect of diets implemented in the experimental groups on the fertility was found to be significant (P<0.05) this effect on the hatchability traits in both sex ratios was not significant (P>0.05). While the serum K level was significantly higher in CO group (P<0.05) the level of Zn in group CO (P=0.078) and the level of Co in group RO were found slightly higher (P=0.086). The other findings of mineral contents were similar among the groups (P>0.05). Consequence of this study showed that CO had a positive effects on egg production and egg shell quality. Mixture of CO and RO had negative effects on egg weight and cumulative egg weight.

Key words: Cinnamon and rosemary oils, hatchability, performance, quail, serum mineral.

Tarçın ve biberiye yağlarının yumurtacı bıldırcınlarda (Coturnix coturnix Japonica) yumurta üretimi, kabuk kalitesi, kuluçka özellikleri ve serum mineral düzeyleri üzerine etkileri

Özet: Bu araştırma, tarçın (CO), biberiye (RO) ve bu bitkisel yağların karışımının (MO) yumurtacı bıldırcınlarda yumurta üretimi, yem tüketimi, yemden yararlanma oranı, iç ve dış yumurta kalite özellikleri, serum mineral düzeyleri ve farklı cinsiyet oranlarında [1/3 and 1/5, (♂/♀)] kuluçka özelliklerini tespit etmek amacıyla yapılmıştır. Toplam 192 adet bıldırcın kontrol ve üç deneme grubunu içeren özel kafeslere yerleştirilmiştir (12 bıldırcın/kafes). Araştırma iki ay sürmüştür. Araştırmanın sonunda her gruptan 12 adet bıldırcın kesilerek kanları alınmıştır. Serum örneklerinde Cu, Co, Cr, Zn, Fe, K, Na ve Mg düzeyleri tespit edilmiştir. En yüksek yumurta ağırlığı RO grubunda tespit edilirken, en düşük yumurta ağırlığı MO grubunda bulunmuştur (P<0.05). Diyete CO ilavesi bıldırcın-gün yumurta üretimini ve yemden yararlanmayı iyileştirmiştir (P<0.05). Yem tüketimi gruplar arasında benzer bulunmuştur (P>0.05). Yumurta kabuk oranı CO grubunda artarken (P<0.05), yumurta sarı ve ak oranları ile şekil indeklerinde deneme grupları arasında farklılık tespit edilmemiştir (P>0.05). Deneme diyetlerinin fertilite üzerine etkisi önemli (P<0.05) olmasına rağmen, her iki erkek/dişi oranının kuluçka özellikleri üzerine etkisi önemsiz (P>0.05) bulunmuştur. Serum K düzeyi CO grubunda önemli (P<0.05) şekilde yüksek iken, serum Zn düzeyi CO grubunda (P=0.078) ve serum Co düzeyi ise RO grubunda önemsiz şekilde yüksek bulunmuştur (P=0.086). Mineral içeriklerine ait diğer bulgular gruplar arasında benzerdir (P>0.05). Bu çalışmanın sonucu tarçın yağının yumurta üretimi ve kabuk kalitesi üzerine olumlu etkileri olduğunu göstermiştir. Tarçın ve biberiye yağı karışımları yumurta ağırlığı ve kümülatif yumurta ağırlığını olumsuz etkilemiştir.

Anahtar sözcükler: Bıldırcın, kuluçka, performans, serum mineral, tarçın ve biberiye yağları.

Introduction

Plants and their oils have been used extensively for keeping healthy over the years, because they have some active items like phenolics, polyphenols, alkaloids, lectins, terpenoids, polypeptides and essential oils (34). Medicinal effects of the items include antibacterial (33), antiviral (11), anti-inflammatory (14), antioxidant (25), insecticide (4) and fungicide (24) properties.

Especially after 2006, banning the addition of antibiotics in the feed of poultry by EU has increased interest in aromatic plants and their oils. Numerous researches focused on the clarification of the biochemical structures and physiological functions of various plants and their oils. Due to the wide variety of active components, the additives affect beneficial processes differently. Most of them stimulate appetite and feed intake, others enhance the secretion of saliva, synthesis of bile acids, digestion and absorption of lipids (9, 19). They can either stimulate the activity or the secretion of enzymes such as amylase, protease and lipase, a result improve digestibility (18). On the other hands, the plants and their oils influence the gastro-intestinal ecosystem by inhibiting pathogenic microorganism and their toxins of microbiological origin (11, 13). Some plants have immuno-stimulant effect because of richness from vitamins, carotenoids and flavonoids. The active items can improve immune cells and support immunity of the organism (14). The additives also have some antioxidant properties. They can prevent lipid peroxidation and production of free radicals and enhance antioxidant enzyme activity because of phenolic structure and richness from some vitamins like vit A, C, E (25).

Cinnamon (*Cinnamomum zeylanicum L.*) originates from tropical Asia, especially Sri Lanka and India. Rosemary (*Rosmarinus officinalis L.*) is native for Mediterranean region and widely used as a spice. Nowadays, they are grown in every tropical region of the world because of their medicinally characters (6, 29).

The present study was conducted to determine how the cinnamon, rosemary and their mixture affect on the laying quail's performance, egg quality, and hatchability traits in different sex ratios of [1/3 and 1/5, (♂/♀)].

Material and Methods

Experimental Design and Dietary Regimens: A total of 192 Japanese quail (*Coturnix Coturnix Japonica*) at 40 days of age was brought from a commercial seller in the Elazig province of Turkey. The experiment was conducted at the Poultry Unit of Veterinary Faculty of Firat University, after the local ethic committee approval (Official form date and number: 02.08.2012 and 2012/08). The quails were fed randomly with basal diet, are given in Table 1, by the time starting egg production of hen-day 5% in female birds. All male and female birds were weighted at this age and assigned to experimental groups, balanced according to their body weight. There were 4 dietary treatment groups [Control, Cinnamon oil (CO), Rosemary oil (RO) and Mixture oil (MO)] with 48 quails each. The quails were assigned to dietary treatments by 2 replicates of 3 male/9 female and 2 replicates of 2 male/10 female. Experimental design was established 4 dietary treatments x 2 gender relations x 2 replicates and given in Figure 1. Chemical analysis of the

Table 1. Ingredients and chemical composition of standard diet.
Tablo 1. Standart karma yemin bileşimi ve kimyasal kompozisyonu.

Feed ingredients	%	Nutritional composition	%
Maize	53.00	Dry matter	90.50
Wheat Bran	3.50	Crude protein	20.20
Soybean meal (44 CP)	31.36	Crude fibre	3.29
Vegetable oil	3.00	Ether extract	4.25
Dicalcium phosphate	3.00	Ash	5.15
Ground limestone	4.50	Calcium ****	2.51
Salt	0.30	Available phosphorus****	0.39
DL-Metiyonin	0.04	Meth+Sis ****	0.69
Vitamin mix *	0.20	Lysine ****	1.10
Mineral mix**	0.10	ME, kcal/kg****	2919
Additive***	1.00		

*Vitamin premix supplied per 2.5 kg; Vitamin A 12.000.000 IU; vitamin D3 2.000.000 IU; vitamin E 35.000 mg; vitamin K3 4.000 mg; vitamin B1 3.000 mg; vitamin B2 7.000 mg; niacine 20.000 mg; calcium D-pantotenat 10.000 mg; vitamin B6 5.000 mg; vitamin B12 15 mg; folik Asit 1.000 mg; D-biotin 45 mg; vitamin C 50.000 mg; choline chloride 125.000 mg; canthaxanthin 2.500 mg; apo karotenoik acid ester 500 mg
**Mineral premix supplied per kg; Mn 80.000 mg; Fe 60.000 mg; Zn 60.000 mg; Cu 5.000 mg; Co 200 mg; I 1.000 mg; Se 150 mg
*****:** Group Control (1000 g zeolit); Group Cinnamon (20 g cinnamon oil+980 g zeolit); Group Rosemary (20 g rosemary oil+980 g zeolit); Goup Mix (10 g cinnamon oil+10 g rosemary oil+980 g zeolit)
******:** Calculated
*Vitamin karması: Her 2.5 kg'lık karışımda; A vitamini 12.000.000 IU; D3 vitamini 2.000.000 IU; E vitamini 35.000 mg; K3 vitamini 4.000 mg; B1 vitamini 3.000 mg; B2 vitamini 7.000 mg; niasin 20.000 mg; kalsiyum D-pantotenat 10.000 mg; B6 vitamini 5.000 mg; B12 vitamini 15 mg; folik fsit 1.000 mg; D-biotin 45 mg; C vitamini 50.000 mg; kolin klorit 125.000 mg; kantaksantin 2.500 mg; apo karotenoik asit ester 500 mg bulunmaktadır.
**Mineral karması: Her 1 kg'lık karışımda; manganez 80.000 mg; demir 60.000 mg; çinko 60.000 mg; bakır 5.000 mg; kobalt 200 mg; iyot 1.000 mg; selenyum 150 mg bulunmaktadır.
***: Kontrol Grubu (1000 g zeolit); Tarçın Grubu (20g tarçın yağı+980 g zeolit); Biberiye Grubu (20 g biberiye yağı+980 g zeolit); Karışım Grubu (10 g tarçın yağı+10 g biberiye yağı +980 g zeolit)
***: Hesaplama yolu ile tespit edilmiştir.

CO: *Cinnamaldehyde* (88.2%), *benzyl alcohol* (8.0%), e*ugenol* (1.0%) and *others* (2.7%). RO: *1,8 cineole* (%39.3), *camphor* (14.6%), *α-pinene* (13.8%), *β- pinene* (9.8%), *camphene* (6.1%), *limonene* (3.1%), *p-cymene* (2.5%), *borneol* (2.3%), *α-terpineol* (2.2%) *myrcene* (2.0%), *bornyl acetate* (1.4%) and *others* (2.9%). Zeolite was used as a carrier for essential oils in ratio of 1 % and it added to diet of control group at the same ratio. The birds were fed with the experimental diets from the hen-day 5% until the end of the experiment. The used diets were formulated to be isonitrogenic and isoenergic

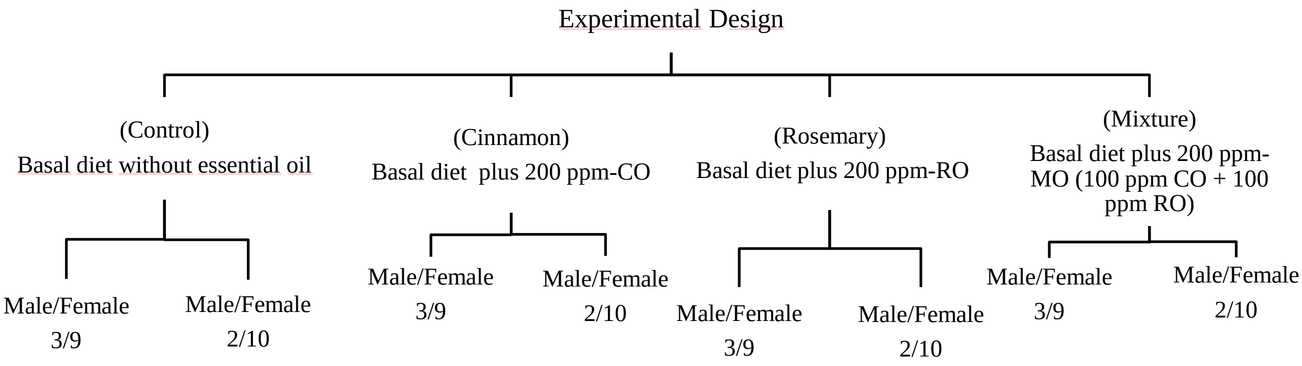

Figure 1. Experimental design.
Şekil 1. Deneme düzeni.

according to the National Research Council (27) recommendations. Diets and fresh water was provided for *ad libitum*. A photoperiod of 16 hours/day was maintained. All birds were kept under standard laying cages with 12 birds per cage under the same environmental conditions. The experiment was continued during two months. Feed intake, feed conversion ratios (FCR) of the groups were weekly determined. Egg production was daily determined and all eggs were weighted individually. Eggs were collected every Wednesday to determine the egg quality parameters. The next day, eggs were evaluated for external and internal characteristics. Egg shells were washed under tap water gently and dried in the air at 24 hours and then evaluated. Approximately, 150 eggs were evaluated at each dietary treatment for egg quality parameters. Hatchability traits was determined at a commercial quail hatchery of the region, with six replications. A total of 300 eggs per group were incubated. After the artificial incubation, all un-hatched eggs were cracked and classified as infertile, embryonic mortality and cull (weak) chicks. At the end of the experiment (second month), 4 males and 8 females of quails from each Control, Cinnamon and Rosemary groups were randomly selected and slaughtered with decapitation in order to collect blood samples. Serum was separated and stored at -20°C until analysis.

Analysis of The Feed: Chemical composition of feed ingredients (dry matter, crude protein, ash and ether extract) were analyzed according to the Association of Official Analytical Chemists (2) procedures and crude fiber was determined by the methods of Crampton and Maynard (12).

Gas Chromatographic (GC) Analysis: The chemical analyses of cinnamon and rosemary oils were performed using HP 6890 GC equipped with and FID detector and an HP- 5 MS (30 m x 0.25 mm i.d., film thickness 0.25 µm) capillary column was used. The column and analysis conditions were the same as in GC-MS. The percentage composition of the essential oils was computed from GC – FID peak areas without correction factors.

Gas Chromatography / Mass Spectrometry (GC-MS) Analysis: The oils were analyzed by GC-MS, using a Hewlett Packard system. HP- Agilent 5973 N GC-MS system with 6890 GC in Plant Products and Biotechnology Research Laboratory in Firat University. HP-5 MS column (30 m x 0.25 mm i.d., film thickness 0.25 µm) was used with Helium as the carrier gas. Injector temperature was 250 ^{0}C, split flow was 1 ml / min. The GC oven temperature was kept at 70 ^{0}C for 2 min and programmed to 150 ^{0}C at a rate of 10 ^{0}C / min and then kept constant at 150 ^{0}C for 15 min to 240 ^{0}C at a rate of 5 ^{0}C / min. Alkanes were used as reference points in the calculation of relative retention indices. MS were taken at 70 eV and a mass range of 35-425. Component identification was carried out using spectrometric electronic libraries.

Analysis of The Serum: Blood samples were centrifuged at 4000 rpm for 10 min, the serums were separated. Cu, Co, Cr, Zn, Fe, K, Na and Mg levels of the serums were determined according to AOAC (3) by atomic absorption spectrometry (Perkin- Elmer 800) with flame system. Before analysis, all materials were washed with firstly HNO3 (10 %) and later with ultra-pure water and dried. The four mediate standards were prepared from concentrated element standard (1000µg/mL). All mediate standards were divided to four working standards. Hallow- Cathode lamp was used for each element. Assessments were performed 0.99500-1.00000 confidence interval for standards and 99.5 % calibration coefficient.

Statistical Analyses: Data including egg performance, egg characteristics and hatchability traits were evaluated with two-way anova by using General Linear Model (GLM) procedure. Data including blood serum mineral contents were subjected to one-way anova by using analysis of variance. Significant differences were further subjected to Tukey HSD test. All analyses were performed by using Statistical Packages for the Social Sciences (32) for Windows (2012). The results were considered as significant when P values were lower than 0.05.

Results

The effects of supplementation the essential oils to the diet on the performance in laying quails are given in Table 2. Between 1-60 days, the highest egg weight was found in RO group while the lowest egg weight was in MO group (P<0.05). Egg production per bird increased in CO group (P<0.05) and the other groups were found similar (P>0.05). Cumulative egg production and egg weight value were highest in CO group. Feed intake was similar among the groups (P>0.05). The best FCR per female were obtained in CO group (P<0.05). The differences in FCR among the Control, Rosemary and Mix group were not significant (P>0.05).

The best dried shell thickness was determined in Control and CO groups followed respectivelly by MO and RO groups (P<0.05). The best dried shell rate was found in CO group while the wost rate was found in MO group (P<0.05). Whereas this rates in other groups were found to be similar to CO and MO groups (P>0.05) (Table 3).

According to Table 4, fertility rate was found higher in all essential oil groups than Control group (P<0.05). There were no significant difference in hatchability, hatchability of fertile, embryonic mortalities and cull chicks rate in both 1/3 and 1/5, male/female ratios (P>0.05).

The serum mineral levels are given in Figure 2. As shown in the graphs, serum potassium (K) levels were found highest in CO group (P<0.05). The differences among the groups in serum copper (Cu), cobalt (Co), chromium (Cr), zinc (Zn), iron (Fe), sodium (Na) and magnesium (Mg) levels were not significant (P>0.05). Serum zinc level in CO group (P=0.078) and serum Co level in RO group was found slightly higher (P=0.086).

Table 2. Effect of plant oils on performance in quails.
Tablo 2. Bitkisel yağların bıldırcınlarda performansa etkisi.

TRAITS	Plant Extracts, 200ppm				Pooled SEM	P (Statistical significance)
	Control	Cinnamon	Rosemary	Mixture		Main effects of feed additives
Cumulative egg number (*n*)	1156	1354	1141	1090	-	-
Cumulative egg weight (*kg*)	13.872	16.166	13.931	12.807	-	-
TRAITS						
Egg weight (*g*)						
1-15 days	11.79	11.64	11.87	11.27	0.09	NS
16-30 days	12.17^{a}	12.09^{ab}	12.36^{a}	11.78^{b}	0.07	*
31-45 days	11.94	12.21	12.38	12.16	0.06	NS
46-60 days	12.12^{ab}	11.85^{bc}	12.25^{a}	11.80^{c}	0.05	**
1-60 days	12.01^{ab}	11.94^{ab}	12.21^{a}	11.75^{b}	0.05	*
Egg production % (*egg production/100 female birds/day*)						
1-15 days	31.51	34.40	28.12	27.79	1.80	NS
16-30 days	38.84^{b}	56.88^{a}	47.31^{ab}	44.38^{b}	2.41	*
31-45 days	65.04	69.62	58.19	59.80	2.06	NS
46-60 days	68.27^{ab}	76.69^{a}	67.31^{ab}	59.45^{b}	2.17	*
1-60 days	50.92^{b}	59.40^{a}	50.23^{b}	47.85^{b}	1.66	*
Feed intake (*g/bird/day*)						
1-15 days	22.67	22.77	20.86	20.21	0.53	NS
16-30 days	23.80	25.35	23.22	23.08	0.39	NS
31-45 days	28.44	30.25	29.22	29.65	0.38	NS
46-60 days	30.01	28.70	28.27	27.34	0.47	NS
1-60 days	26.23	26.77	25.39	25.06	0.28	NS
Feed conversion (*g feed intake x female number/egg production x egg weight*)						
1-15 days	6.10	5.68	6.24	6.45	0.24	NS
16-30 days	5.03^{a}	3.68^{b}	3.97^{b}	4.41^{ab}	0.22	*
31-45 days	3.66	3.46	4.05	4.07	0.14	NS
46-60 days	3.62	3.15	3.42	3.89	0.22	NS
1-60 days	4.30^{a}	3.77^{b}	4.13^{ab}	4.45^{a}	0.11	*

-: Statistical analyse was not performed. SEM: Standart Error of Mean.
NS: P>0.05, *: P<0.05, **: P<0.01. ^{a,b,c}: Mean values wirth different superscripts within a row differ significantly.
-: İstatistiki analiz yapılmamıştır. SEM: Ortalamanın standart hatası.
NS: P>0.05, *: P<0.05, **: P<0.01, $^{a, b, c}$: Aynı satırda farklı harflarle ifade edilen ortalamalar önemli şekilde farklıdır.

Table 3. Effect of plant oils on egg characteristics in quails.
Tablo 3. Bitkisel yağların bıldırcınlarda yumurta özelliklerine etkisi.

TRAITS	Plant Extracts, 200ppm				Pooled SEM	P (Statistical significance)
	Control	Cinnamon	Rosemary	Mixture		Main effects of feed additives
Dried shell thickness, mm	2.42[a]	2.42[a]	2.35[b]	2.36[b]	0.01	*
Dried shell rate, *(Sw/ Ew)*100*	10.79[ab]	11.32[a]	10.62[ab]	10.45[b]	0.09	*
Albumen rate, *(Aw/ Ew)*100*	49.48	50.01	49.74	49.16	0.70	NS
Yolk rate, (*(Yw/ Ew)*100*	35.62	35.43	35.79	35.58	0.42	NS
Shape index, *(egg with/egg length) *100*	71.58	71.41	71.87	71.95	0.21	NS

EW: Egg weight, SW: Shell weight, AW: Albumen weight, Yw: Yolk weight.
-: Statistical analyse was not performed. SEM: Standart Error of Mean.
NS: P>0.05, *: P<0.05. [a,b]: Mean values wirth different superscripts within a row differ significantly.
EW: Yumurta ağırlığı, SW: Kabuk ağırlığı, AW: Ak ağırlığı, Yw: Sarı ağırlığı
-: İstatistiki analiz yapılmamıştır. SEM: Ortalamanın standart hatası.
NS: P>0.05, *: P<0.05. [a, b]: Aynı satırda farklı harflarle ifade edilen ortalamalar önemli şekilde farklıdır.

Table 4. Effect of plant oils on hatchability traits in quails in different male and female ratios.
Tablo 4. Bitkisel yağların bıldırcınlarda farklı erkek ve dişi oranlarında kuluçka özelliklerine etkisi.

(♂/♀)	3/9				2/10					P (Statistical significance)	
	Plant Extracts, 200ppm								Pooled SEM	Main Effects	
TRAITS	Control	Cinnamon	Rosemary	Mixture	Control	Cinnamon	Rosemary	Mixture		Ratio (R)	Feed additive (A)
Inital body weight (♀), g *(hen day-5 %)*	194.80	195.72	194.45	194.93	194.33	194.18	194.05	194.56	1.78	NS	NS
Inital body weight (♂), g	178.25	177.00	178.17	178.00	174.31	176.60	174.78	178.50	2.08	NS	NS
Fertility *(n/100 eggs set)*	86.05[b]	92.50[a]	90.57[a]	90.93[a]	86.28[B]	93.29[A]	92.35[A]	91.16[A]	0.91	NS	*
Hatchability *(commercial chicks/100 eggs set)*	72.24	79.17	70.62	75.27	70.31	77.91	73.70	71.40	1.69	NS	NS
Hatchability of fertile *(chicks/100 fertile eggs)*	83.95	85.58	77.97	82.77	81.49	83.51	79.80	78.32	1.65	NS	NS
Embrionic mortality *(n/100 fertile eggs)*	15.16	13.48	20.42	14.97	15.53	15.76	17.59	19.17	1.08	NS	NS
Cull chick rate *(n/100 fertile eggs)*	0.88	0.71	1.60	2.25	2.97	0.72	2.60	2.50	0.46	NS	NS

SEM: Standart Error of Mean. NS: P>0.05, *: P<0.05. [a,b,A,B]: Mean values wirth different superscripts within a row differ significantly.
SEM: Ortalamanın standart hatası, NS: P>0.05, *: P<0.05. [a, b, A, B]: Aynı satırda farklı harflarle ifade edilen ortalamalar önemli şekilde farklıdır.

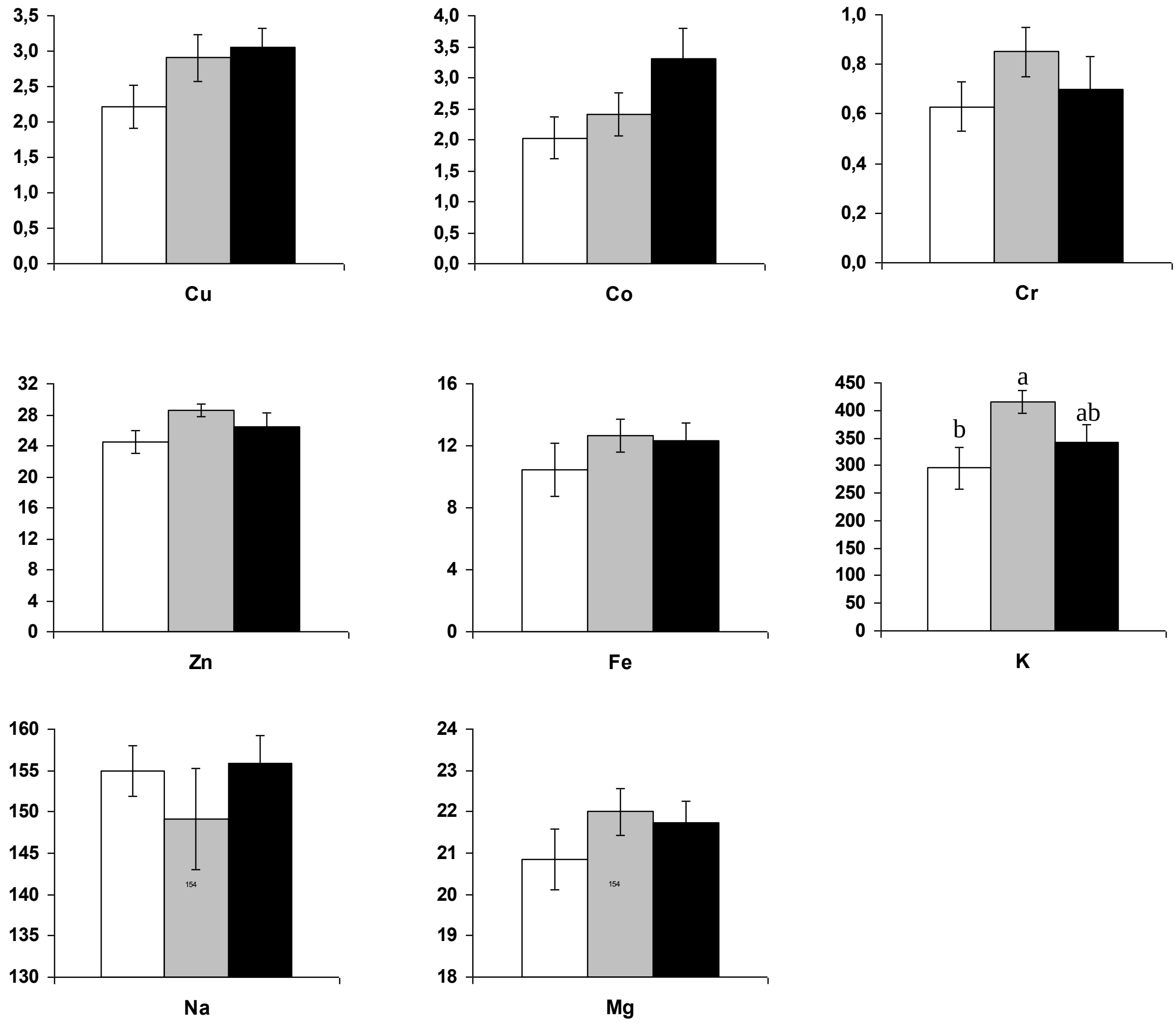

Figure 2. Serum mineral levels (*ppm*) in Control, Cinnamon and Rosemary groups (*White bar: Control, Gray bar: Cinnamon, Black bar: Rosemary*).
Şekil 2. Kontrol, Tarçın ve Biberiye gruplarında serum mineral düzeyleri (ppm) (Beyaz bar: Kontrol, Gri bar: Tarçın, Siyah bar: Biberiye).

Discussion and Conclusion

It was found in the present study that there were a lot of active items in chemical analysis of CO and RO. The items have some bioactive features (14, 17). They are very potent molecules and must be used in small quantities. Adversely, they can affect the function of intestinal microflora, can cause allergies, suppress feed intake and can be stored in tissues (14) by showing synergic or antagonist effects (13, 35). MO group of the present study had lower egg production per bird, cumulative egg number, egg weight and egg shell quality. This deterioration might be resource from synergic or antagonist effect of mixture of the cinnamon and rosemary oils.

The previous researches mentioned about effects of the essential oils on digestive system and digestive enzymes successfully (9, 19) and they have antioxidant, anti-inflammatory, immuno-stimulant and antimicrobial characteristics (6, 18, 25). Although both CO and RO have similar influences on these traits (14), it was found in the present study that only CO increased the egg production. Moreover, the best FCR was obtained in this group. This finding might be pointed that there were probable different mechanisms about the impact of CO on egg production performance of the quails. Qin et al. (29) reported that the oral treatment with cinnamon extract would improve in vivo insulin-regulated whole-body glucose utilization in rats, through enhancing the insulin signaling in skeletal muscle. Anderson (1) indicated cinnamon polyphenols affected glucose and insulin function. It activated insulin receptors by increasing their tyrosine phosphorylation activity and by decreasing phosphatase activity that inactivates the insulin receptor. Insulin has important role in glucose uptake (5) and it is essential for cell proliferation and stimulates glycolytic energy production (15). Cinnamon is also rich from iron, zinc, chromium, manganese, calcium, magnesium, potassium and phosphorus (16, 20). These minerals have positive affects on reproductive performance and egg production of laying poultry (26). The zinc level of the serum in present study was found slightly higher in CO group (P=0.078). Zinc has important role in reproductive performance (28). Sahin and Kucuk (31) indicated that zinc has stronger antioxidant properties. It protected oxidative destruction of cell membrane by reducing free radical generation and caused well-being of animal. All these activities and other potential activities of the cinnamon might lead to more efficient egg production and FCR.

There were contradictory researches about the effect of essential oils on feed intake. Some researches stressed that aromatic plants could be utilized flavor enhancer in diet because of their flavoring properties such as appetizing affect, sensory properties, palatability affect and flavor enhancing qualities (17). The others informed plant extracts did not affect feed intake like reported in the present study (10, 21). The differences among the researches might be derived from environmental factors affecting feed consumption like some stressors, flavoring properties of the plants, chemical value and characteristics of their extracts, physiological needs and well-being of animal (7, 17).

As shown at Table 3, egg shell rate was positively affected in group CO (P<0.05). Gul and Saftar (16) indicated high level of these minerals in cinnamon: K (134.7 mg/g), Ca (83.8 mg/g), Mg (85.5 mg/g), P (42.4 mg/g), Mn (20.1 mg/g). The minerals have significant role on egg shell quality (30). Potassium level of the serum was found highest in group CO of the present study (P<0.05). It could be related with high level of potassium in the cinnamon (16). Leach (22) mentioned about potassium should be added the list of nutrient required for optimum shell formation since potassium had important role in the process of the shell formation.

As shown at Table 4, although fertility rate increased in all of extract groups in both sex ratios of the present study, this success did not obtain in hatchability and hatchability of fertile eggs. Fertility rate might be increased by bioactive characteristics of plant oils containing some active items (14, 17) and it could be associated with vitamin and mineral content of the extracts (20). In a previous study, Lemonica et al. (23) reported embryo toxic effect of rosemary (*Rosmarinus officinalis L.*). Embryonic mortalities were not significantly affected by neither sex ratios nor feed additives in the present study. However, hatching results could have been affected from the numerical differences in all mortalities and culls of hatch among the groups. In agreement with these findings, Cetingul et al. (8) found that oregano (*Oregano Onites*) supplemented in diet increased fertility rate in laying quails, but not hatchability results or embryonic mortalities.

As a result of this study, CO supplementation into diet of 200 ppm level increased egg production, egg shell quality, and improved FCR. Supplementation of RO into diet did not result any positive or negative effects in these traits. Mixture of CO and RO of 200 ppm dose had a negative affect on egg weight and resulted in lower cumulative egg weight. Fertility rate increased in all experimental groups, but no hatching success. This peculiarity of CO on egg production and egg quality may be taken into account by laying poultry. Mixture of RO and CO shouldn't be given to quails because of its toxic effects on egg production parameters.

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