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Egg Quality Traits, Chemical Analysis and Fatty Acid Composition in Chukar Partridges Supplemented with Garlic and Onion Powder

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ABSTRACT

Background: This study was carried out to determine the effect of addition of 1% dietary garlic and onion powder on the internal and external quality characteristics and chemical and fatty acid composition of Chukar partridges eggs.

Methods: A total of 240 Chukar partridges with 60-week age was assigned to four dietary treatment group: control, 1% onion powder, 1% garlic powder and garlic onion powder, respectively. Totally, 92 eggs obtained from partridges were used for the study.

Result: The addition of onion powder had significant effect on yolk weight (P<0.05). Supplementation of the diets with garlic and onion powder did not significantly affect quality traits of chukar eggs (P>0.05). Moisture, ash and protein contents and 16 fatty acid composition of chukar eggs were not statistically affected by the addition of garlic and onion powder either. In conclusion, the addition of 1% dietary garlic and onion powder did not cause a significant change in the internal and external quality characteristics and fatty acid composition of the Chukar partridge eggs. Increasing the rate of garlic and onion powder to the chukar ration may cause some significant differences on the egg parameters.

Key words: Chukar partridge, Egg quality, Fatty acids, Garlic powder, Onion powder.

INTRODUCTION

There are numerous feed additives that could be added to the ration or drinking water of birds to increase production and decrease the spread of diseases (Griggs and Jacob, 2005). Antibiotics in prophylactic doses which had been used to reduce treatment costs, improved yields and welfare in poultry diets (Hajati and Rezaei, 2010). However, increasing of antibiotic resistance, emerged by unregulated and prolonged use of antibiotics, has caused the restriction of antibiotic uses and some feed additives alternative to antibiotics (Ogbuewu *et al*., 2019). Some of the safe and recent natural alternatives are prebiotic compounds, probiotic organisms (Patterson and Burkholder, 2003; Hajati and Rezaei, 2010; Hashemipour *et al*., 2011; Khan and Naz, 2013) and phytobiotics such as some herbs, plant extracts and spices (Barreto *et al*., 2008; Khan *et al*., 2012; Diaz-Sanchez *et al*., 2015; Kocabağlı and Alp, 2015).

Garlic (*Allium sativum*) and onion (*Allium cepa*) are some of the phytobiotics that could be used as feed additives instead of antibiotics in poultry diets (Damaziak *et al*., 2017; Kothari *et al*., 2019). Both garlic and onion, which contain organosulfur compounds such as allicin and quarcentin, is known to have antibacterial (Olobatoke and Mulugeta, 2011; Rahimi *et al*., 2011; Aydoğan, 2018), hypocholesterolemic (Azeke and Ekpo, 2009; Canoğulları *et al*., 2010; Rahimi *et al*., 2011; Al-Shuwaili *et al*., 2015) and antioxidant effects (Slimestad *et al*., 2007; Bozin *et al*., 2008). Garlic has been particularly used as medication due to its therapeutic agent for 5000 years (Amagase *et al*., 2001).

Eggs are highly valuable nutritious foods as they support development of embryo during incubation process. The shape and shell characteristics of eggs are essential for market prices in terms of consumer's acceptability while the interior characteristics and chemical composition of eggs have an important role in egg product industry (Song *et al*., 2000). Like the eggs of other species, the quality of partridge eggs is known to be affected by various environmental factors(Çağlayan *et al*., 2009; Günhan and Kırıkçı, 2017). Therefore, numerous researches have been conducted to determine the factors affecting egg quality for several decades. The effect of adding garlic powder on egg quality in quails (Yalçın *et al*., 2007; Canoğulları *et al*., 2010), in turkeys (Al-Shuwaili *et al*., 2015), in hens (Lim *et al*., 2006; Yalçın *et al*., 2006; Olobatoke and Mulugeta, 2011; Damaziak *et al*., 2017) was comprehensively studied by many researches. The reports of most studies revealed that 0.5-1% amounts of garlic powder (Yalçın *et al*., 2006; Yalçın *et al*., 2007; Canoğulları *et al*., 2010) and 1% amount of

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onion powder (Omer *et al.*, 2019) could be added to rations without any adverse effects on egg quality. Ao *et al.* (2010) also reported the saturated fatty acids, which cause to increase the risk of coronary heart diseases in humans decreased when garlic powder was added to the poultry diets.

The studies about investigating the effect of garlic and onion powder on egg quality were mostly carried out in hens with conflicting results. Even though some studies about investigating adding probiotics and feed additives in rations for various purposes were conducted in literature, such topic is not so well documented in partridge eggs (Arslan, 2004; Gülşen *et al.*, 2010; Hashemipour *et al.*, 2011; Tavakkoli *et al.*, 2014; Sevim *et al.*, 2020). The aim of this study was to investigate the internal and external qualities, chemical compositions of chukar partridge (*Alectoris chukar*) eggs with addition of garlic and onion powder in the diets.

MATERIALS AND METHODS

The study was carried out during the spring period in 2020 at Bahri Dagdas International Agricultural Research Institute (37°52′5.7612″ and 32° 33′12.8088″) where the climate was dominantly seen as steppe. Biochemical analyses were carried out at a commercial food control laboratory in İstanbul. This study was approved by the Ethics Committee of the Experimental Medicine Research and Application Centre of Selcuk University (SUDAM, 2020/60) report.

In this study, 240 partridges with 60-week age were equally divided into control (C) (basal diet) and 3 treatment diet groups, supplemented with 1% onion (O), 1% garlic (G), 1% onion and 1% garlic (OG). The compositions of basal diet were shown in Table 1. The 60 partridges from each group were housed in semi-open wire mesh cages in the ratio of one male to three females with 120×600×150 cm dimensions.

Twenty-three eggs from the partridges of each experimental groups were used in the study. During the first month of the study, twenty daily collected eggs from each treatment cages were assessed by their internal and external qualities in the same day. The eggs and their components were weighed using an electronic balance with 0.01 g sensitivity. The assessment of egg shapes, internal and external characteristics of eggs were determined with an electronic digital calliper (Kanon EMS-150).

Table 1: Basal diet composition.

Corn (%)	41.36
Soybean meal (%)	26.07
Bonkalite (%)	16.58
Marble powder (%)	9.01
Soybean fat (%)	0.91
Sodium (%)	0.16
Lysine (%)	0.75
Methionine (%)	0.36
Calcium (%)	3.40
Dicalcium phosphate 18 (%)	0.80
Phosphorus (%)	0.60
ME (kcal/kg)	2800
Crude protein (%)	17.13
Crude fiber (%)	4.0
Crude fat (%)	4.2
Crude ash (%)	13.42

Egg shapes, internal and external quality traits of eggs were evaluated according to the following equations below (Narushin, 2005; Alkan *et al.*, 2015):

$$\text{Shape index (\%)} = \frac{\text{Egg width}}{\text{Egg length}} \times 100$$

$$\text{Shell surface area (cm}^2\text{)} = 3.9782 \times \text{Egg weight}^{0.75056}$$

$$\text{Unit surface shell weight (g/cm}^2\text{)} = \frac{\text{Shell weight}}{\text{Shell surface area}}$$

$$\text{Shell ratio (\%)} = \frac{\text{Shell weight}}{\text{Egg weight}} \times 100$$

$$\text{Albumen index (\%)} = \frac{\text{Albumen height / Albumen length + Albumen width}}{2} \times 100$$

$$\text{Albumen weight (g)} = \text{Egg weight - (Yolk weight + Shell weight)}$$

$$\text{Albumen ratio (\%)} = \frac{\text{Albumen weight}}{\text{Egg weight}} \times 100$$

$$\text{Yolk index (\%)} = \frac{\text{Yolk height}}{\text{Yolk diameter}} \times 100$$

$$\text{Yolk ratio (\%)} = \frac{\text{Yolk weight}}{\text{Egg weight}} \times 100$$

$$\text{Yolk/albumen} = \frac{\text{Yolk weight}}{\text{Albumen weight}} \times 100$$

$$\text{Haugh unit} = 100 \log [\text{Albumen height} - (1.7 \times \text{egg weight}^{0.37}) + 7.57]$$

$$\text{Egg volume (cm}^3\text{)} = [0.6057 - (0.0018 \times \text{egg width})] \times \text{Egg length} \times \text{egg width}^2$$

$$\text{Egg surface area (cm}^2\text{)} = [3.155 - (0.0136 \times \text{egg length}) + 0.0115 \times \text{egg breadth}] \times \text{egg length} \times \text{egg width}$$

Three chukar eggs from each experimental group were sent to the laboratory for analysis of chemical and fatty acid composition. Water (moisture) content of eggs were determined by azeotropic distillation (TS 1129 ISO 1026). Kjeldahl method was used to calculate protein content in the eggs (TS 1620). Ash content soluble in hydrochloric acid was also determined according to the standards of TS ISO 763. The method of capillary gas chromatography was used for determination of fatty acid composition in chukar eggs (TS EN ISO 12966 - 1, 4).

Differences among diet treatments to determine internal and external egg quality traits were analysed by One-Way ANOVA (SPSS ver. 22.0). Bonferroni correction test was used to determine differences among multiple groups means considering 5% probability. Differences among diet groups in terms of chemical components and fatty acid composition of eggs were analysed by Kruskal-Wallis test.

RESULTS AND DISCUSSION

The egg shape index was found to be 75.44 in Table 2, which was slightly lower than the results of similar studies conducted in chukar eggs (Song *et al.*, 2000; Hashemipour *et al.*, 2011; Çağlayan *et al.*, 2014; Alkan *et al.*, 2015; Aygün and Olgun, 2019). This difference could be attributed to the age of hens which was reported by Han *et al.* (1991).

Addition of garlic and onion powder to chukar rations had no significant effect on egg shape traits (P>0.05). The results were in accordance with the studies of laying hens supplemented with 0.5% to 1%(Yalçın *et al.*, 2006) and between 3% and 5% (Olobatoke and Mulugeta, 2011) garlic powder. Similarly, Omer *et al.* (2019) reported adding onion or garlic powder to poultry ration wouldn't change shape index of laying hens.

The effect of dietary garlic and onion powder supplementation on egg component ratios in Chukar partridge is shown in Table 3.

The proportion of egg components was determined as 57.01% albumen, 33.56% yolk and 9.43% shell, showing that it had been in the normal range (Stadelman, 1995). There was no significant effect (P>0.05) among feeding groups in terms of the proportion of egg components (Table 3). The weight of egg components among treatment groups showed similar trend except the yolk weight (Table 4). Adding 1% onion powder to the ration increased yolk weights of chukar eggs (P<0.05) in agreement with the reports of Damaziak *et al.* (2017) who found a positive increase in eggs of hens supplemented with onion powder. However, Dosoky *et al.* (2021) reported insignificant effect of onion supplementation on egg yolk weight. Garlic supplementation of rations didn't have any significant changes (P>0.05) in egg yolk weight which was in accordance with the reports of similar studies (Chowdhury *et al.*, 2002; Yalçın *et al.*, 2006; Canoğulları *et al.*, 2010; Olobatoke and Mulugeta, 2011). Numerous studies had varied results in egg weight change when the hens were supplemented with different amounts of garlic or onion powders (Lim *et al.*, 2006; Olobatoke and Mulugeta, 2011; Omer *et al.*, 2019). In the study, we carefully collected the chukar eggs with the weights of 19-21 g which were in the range of chukar eggs (Kırıkçı *et al.*, 2018). Since possible inconsistent results might have occurred, there was no need to discuss the comparison of egg quality in this section.

The eggshell was thicker than those of the studies about chukars (Song *et al.*, 2000; Hashemipour *et al.*, 2011; Alkan and Türker, 2021). Adding 1% rate of garlic and onion powder to the chukar rations did not affect eggshell traits significantly (P>0.05) (Table 5). There are numerous studies that reported laying hen or quail eggs supplemented with different amounts of garlic powder showed no significant differences in terms of egg shell quality (Lim *et al.*, 2006; Yalçın *et al.*, 2006; Yalçın *et al.*, 2007; Ao *et al.*, 2010). Damaziak *et al.* (2017) observed an increase of eggshell quality in the groups supplemented with onion extract. Dosoky *et al.* (2021) reported no significant change of quail eggshell thickness when the ration was supplemented with onion powder.

The internal quality traits were found to be higher than those of other chukar partridges (Song *et al.*, 2000; Çağlayan *et al.*, 2014; Alkan *et al.*, 2015; Alkan and Türker, 2021; Çam *et al.*, 2022). The main reason of this difference might be due to the time of egg quality assessment which was conducted in the first hours after collection of fresh eggs. There was no significant effect of 1% addition of garlic powder on the internal traits of chukar eggs (P>0.05) (Table 6). Similarly, various studies also showed that inclusion of different amount of garlic powder in the diets of different poultry species had no significant changes in egg internal quality (Yalçın *et al.*, 2006; Yalçın *et al.*, 2007;

Table 2: Egg shape traits of treatment groups (mean).

Treatment	Egg shape traits				
groups	Width (mm)	Length (mm)	Shape index (%)	Egg surface area (cm^2)	Egg volume (cm^3)
C	30.09	39.91	75.44	35.53	19.94
O	30.34	40.48	75.00	36.27	20.55
G	30.31	39.87	75.06	35.79	20.20
OG	30.31	40.30	75.26	36.11	20.43
SEM	0.82	0.14	0.26	0.18	0.15

C- Control; O- Onion powder; G- Garlic powder; OG- Onion and garlic powder; SEM- Standard error of means.

Table 3: The effect of dietary garlic and onion powder supplementation on egg component ratios in Chukar partridge.

Treatment	Egg proportion components (%)			
groups	Albumen	Yolk	Shell	Yolk/albumen
C	57.19	33.17	9.64	58.23
O	55.34	35.35	9.31	64.94
G	57.56	33.02	9.42	57.73
OG	57.95	32.70	9.36	56.91
SEM	0.37	0.37	0.08	1.16

C- Control; O- Onion powder; G- Garlic powder; OG- Onion and garlic powder; SEM- Standard error of means.

Al Aqil, 2016). Even though no significant effect of internal quality were occurred among dietary groups, an increasing trend was seen in the groups supplemented with onion powder in this study (P<0.1). Likewise, Damaziak *et al.* (2017) reported that adding onion extract in layer hens' diet would improve the quality of eggs. However, quercetin, which is abundant in onion, had no significant effect on egg quality (Liu *et al.*, 2014). Dosoky *et al.* (2021) reported the quality parameters of quail eggs weren't significantly affected by dietary inclusion of onion powder (0.8%). Omer *et al.* (2019) reported that there was no significant effect of adding dietary onion and garlic powder on Haugh unit of laying hens. But, in the same study, they also found a statistical effect in yolk index. The amount of feed additives in poultry ration might affect the success of the study. For instance, 1% addition of garlic and onion powder were implemented in this study. Canoğulları *et al.* (2010) reported that internal qualities of quail eggs might be affected by more than 1% dietary garlic powder. This increment also agrees with the findings of Olobatoke and Mulugeta (2011) who reported a significant increase in Haugh units of the eggs with the addition of 3% garlic powder. As we analysed the quality of eggs in the first month of the study, the duration of the study might change the results of egg traits. For instance, Ao *et al.* (2010) couldn't find any significant differences on dietary groups supplemented with different doses of garlic powder. But in the 5th week of the study period, they reported a significant change in the internal egg qualities of dietary groups supplemented with garlic powder.

Chemical compositions of the eggs are shown in Table 7. The chemical content of the chukar eggs was observed to be slightly lower for moisture content and higher for crude ash and protein content than those of chukars determined by Song *et al.* (2000). Chemical composition of chukar eggs showed no significant difference among treatment groups (P>0.05).

As presented in Table 8, adding neither 1% garlic powder nor 1% onion powder to the diets significantly affected fatty acid composition of chukar eggs (P>0.05) in accordance with the results of Ao *et al.* (2010). However, Ao *et al.* (2010) reported decreasing of SFA and increasing of PUFA occurred when the amount of garlic additives was increased to the rate of 2% or 3%, which was beneficial to human health.

Table 4: The effect of dietary garlic and onion powder supplemetation on egg weight components.

Treatment groups	Egg weight components (g)			
	Means	Albumen	Yolk	Shell
C	19.81	11.34	6.56b	1.91
O	20.30	11.26	7.16a	1.88
G	20.25	11.66	6.69ab	1.91
OG	20.38	11.84	6.64ab	1.91
SEM	0.15	0.13	0.07	0.02

[a,b] Means within a column with different superscripts are significantly different (P<0.05)

C- Control; O- Onion powder; G- Garlic powder; OG- Onion and garlic powder; SEM- Standard error of means.

Table 5: The effect of dietary garlic and onion powder supplementation on eggshell traits in Chukar partridge.

Treatment groups	Egg shell traits		
	Egg shell thickness (mm)	Shell surface area (cm^2)	Unit surface shell weight (g/cm^2)
C	0.295	37.41	0.051
O	0.286	38.10	0.050
G	0.293	38.03	0.050
OG	0.296	38.21	0.050
SEM	0.002	0.21	0.000

C- Control; O- Onion powder; G- Garlic powder; OG- Onion and garlic powder; SEM- Standard error of means.

Table 6: Internal egg traits of chukars among treatment groups.

Treatment groups	Internal egg traits		
	Albumen index	Yolk index	Haugh unit
C	2.92	49.11	88.31
O	2.96	47.51	89.62
G	2.63	46.90	86.65
OG	2.94	48.63	89.65
SEM	0.06	0.40	0.49

C- Control; O- Onion powder; G- Garlic powder; OG- Onion and garlic powder; SEM- Standard error of means.

Table 7: The effect of dietary garlic and onion powder supplementation on egg moisture, ash and protein components in Chukar partridge.

Treatment groups		Moisture, ash and protein components		
		Moisture	Ash	Protein
C	M±SE	70.79±0.28	1.22±0.12	13.10±0.22
	Mdn (Min-Max)	70.62 (70.41-71.33)	1.13 (1.07-1.45)	12.92 (12.85-13.54)
O	M±SE	71.06±0.41	1.09±0.03	13.16±0.16
	Mdn (Min-Max)	71.31 (70.26-71.61)	1.10 (1.03-1.14)	13.12 (12.91-13.46)
G	M±SE	69.56±0.75	1.43±0.01	12.86±0.10
	Mdn (Min-Max)	70.00 (68.09-70.58)	1.43 (1.40-1.45)	12.79 (12.74-13.05)
OG	M±SE	70.57±0.84	1.34±0.07	13.21±0.46
	Mdn (Min-Max)	69.96 (69.52-72.22)	1.38 (1.20-1.44)	13.27 (12.38-13.97)

C- Control; O- Onion powder; G- Garlic powder; OG- Onion and garlic powder; Mdn- Median.

Table 8: The effect of dietary garlic and onion powder supplementation on egg fatty acids composition in Chukar partridge.

Fatty acids	Egg fatty acids composition (%)				
	C	O	G	OG	Means
	Mean±S.E. Mdn (Min-Max)	Mean±S.E. Mdn (Min-Max)	Mean±S.E. Mdn (Min-Max)	Mean±S.E. Mdn (Min-Max)	Mean±S.E. Mdn (Min-Max)
SFA					
C14:0	0.60±0.01	0.61±0.00	0.64±0.02	0.56±0.03	0.60±0.01
	0.59 (0.59-0.63)	0.61 (0.60-0.61)	0.63 (0.61-0.67)	0.58 (0.51-0.60)	0.61 (0.51-0.67)
C15:0	0.09±0.01	0.10±0.01	0.09±0.01	0.08±0.00	0.09±0.00
	0.09 (0.08-0.11)	0.09 (0.09-0.11)	0.09 (0.07-0.10)	0.08 (0.07-0.08)	0.09 (0.07-0.11)
C16:0	30.43±0.23	30.75±0.23	30.37±0.17	30.06±0.97	30.40±0.23
	30.53 (30.00-30.76)	30.66 (30.39-31.19)	30.45 (30.04-30.61)	30.61 (28.17-31.39)	30.57 (28.17-31.39)
C17:0	0.28±0.01	0.27±0.02	0.25±0.02	0.25±0.02	0.26±0.01
	0.28 (0.25-0.30)	0.25 (0.24-0.31)	0.27 (0.22-0.27)	0.23 (0.22-0.29)	0.26 (0.22-0.31)
C18:0	7.19±0.17	7.24±0.18	7.41±0.10	7.25±0.17	7.28±0.07
	7.33 (6.85-7.39)	7.28 (6.91-7.54)	7.35 (7.28-7.61)	7.22 (6.98-7.56)	7.31 (6.85-7.61)
C20:0	0.05±0.00	0.06±0.00	0.05±0.00	0.05±0.00	0.05±0.00
	0.05 (0.05-0.05)	0.06 (0.05-0.06)	0.05 (0.05-0.05)	0.05 (0.05-0.06)	0.05 (0.05-0.06)
Total	38.643±0.26	39.017±0.36	38.81±0.27	38.25±0.97	38.67±0.25
MUFA					
C14:1	0.09±0.01	0.08±0.01	0.09±0.00	0.07±0.01	0.08±0.00
	0.08 (0.08-0.10)	0.08 (0.07-0.09)	0.09 (0.08-0.09)	0.07 (0.05-0.08)	0.08 (0.05-0.10)
C16:1	3.62±0.39	3.32±0.31	3.39±0.11	3.24±0.40	3.39±0.15
	3.27 (3.19-4.41)	3.49 (2.71-3.76)	3.36 (3.23-3.59)	3.52 (2.45-3.75)	3.43 (2.45-4.41)
C17:1	0.13±0.01	0.13±0.00	0.13±0.01	0.13±0.00	0.13±0.00
	0.13 (0.12-0.14)	0.13 (0.13-0.14)	0.13 (0.12-0.15)	0.13 (0.12-0.13)	0.13 (0.12-0.15)
C18:1n+9c	43.16±0.40	42.11±0.96	43.33±0.79	42.96±0.93	42.89±0.37
	43.34 (42.40-43.75)	42.39 (40.33-43.61)	43.14 (42.08-42.96)	43.80 (41.11-43.98)	43.24 (40.33-44.78)
C20:1	0.25±0.02	0.27±0.01	0.27±0.02	0.27±0.01	0.27±0.01
	0.27 (0.22-0.27)	0.27 (0.26-0.28)	0.27 (0.24-0.30)	0.26 (0.25-0.29)	0.27 (0.22-0.30)
Total	47.26±0.14	45.91±1.28	47.22±0.90	46.66±0.77	46.76±0.41
PUFA					
C18:2n+6c	12.73±0.36	13.86±1.05	12.42±0.70	14.09±1.21	13.27±0.44
	12.95 (12.02-13.22)	13.05 (12.59-15.94)	11.77 (11.67-13.81)	14.29 (11.90-16.07)	13.00 (11.67-16.07)
C18:3n-3	0.45±0.06	0.50±0.05	0.43±0.05	0.48±0.05	0.47±0.02
	0.46 (0.35-0.55)	0.48 (0.43-0.60)	0.42 (0.36-0.52)	0.47 (0.40-0.58)	0.47 (0.35-0.60)
C18:3n-6	0.10±0.02	0.09±0.01	0.90±0.00	0.10±0.00	0.10±0.00
	0.09 (0.08-0.14)	0.09 (0.08-0.11)	0.09 (0.09-0.09)	0.10 (0.09-0.10)	0.09 (0.08-0.14)
C20:2n-6	0.12±0.01	0.12±0.01	0.09±0.01	0.11±0.01	0.11±0.01
	0.11 (0.11-0.13)	0.11 (0.10-0.14)	0.09 (0.08-0.10)	0.11 (0.09-0.14)	0.11 (0.08-0.14)
C20:4n-6	0.25±0.04	0.23±0.02	0.28±0.02	0.27±0.03	0.26±0.01
	0.26 (0.18-0.31)	0.22 (0.20-0.27)	0.28 (0.24-0.31)	0.26 (0.23-0.32)	0.26 (0.18-0.32)
Total	13.65±0.52	14.80±1.09	13.31±0.73	15.05±1.29	14.20±0.46
PUFA:SFA	0.35±0.01	0.38±0.03	0.34±0.02	0.40±0.04	0.37±0.01

SFA: Saturated fatty acids; MUFA: Mono-unsaturated fatty acids; PUFA: Poly-unsaturated fatty acids.

The differences in implementing methods and duration of adding garlic and onion powder to the feeding groups might be responsible for the variations among the studies.

CONCLUSION

As a result of this study, addition of 1% garlic and onion powder to the ration did not have any significant effect on internal and external quality characteristics and fatty acid composition of eggs except a statistical effect on yolk weight in the group supplemented with 1% onion powder. Considering the beneficial effect of human health, our results proves that garlic and onion powder can be added to chukar ration without any adverse effect against the egg quality parameters. Therefore, further studies aiming at the

beneficial effects of different doses of onion and garlic powder addition in poultry rations on egg internal and external quality characteristics, fatty acid composition and thus on human health are needed.

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Conflict of interest

The authors declare no conflict of interest.

REFERENCES

Al-Shuwaili, M.A., Ibrahim, E. and Naqi Al-Bayati, M. (2015). Effect of dietary herbal plants supplement in turkey diet on performance and some blood biochemical parameters. Global Journal of Bio-Sciences and Biotechnology. 4(2): 153-157.

Al Aqil, A.A. (2016). Effects of adding different dietary levels of garlic *(Allium sativum)* powder on productive performance and egg quality of laying hens. International Journal of Poultry Science. 15(4): 151-155. doi: 10.3923/ijps.2016.151.155.

Alkan, S., Galiç, A., Karslı, T. and Karabağ, K. (2015). Effects of egg weight on egg quality traits in partridge (Alectoris Chukar). Journal of Applied Animal Research. 43(4): 450-456. doi: 10.1080/09712119.2014.980419.

Alkan, S. and Türker, İ. (2021). Effects of Egg Shape Index on Egg Quality in Partridges. Ordu Üniversitesi Bilim ve Teknoloji Dergisi. 11(2): 140-151. DOI: 10.54370/ordubtd.996530.

Amagase, H., Petesch, B.L., Matsuura, H., Kasuga, S. and Itakura, Y. (2001). Intake of garlic and its bioactive components. The Journal of Nutrition. 131(3): 955S-962S. DOI: 10.1093/jn/131.3.955S.

Ao, X., Yoo, J., Lee, J., Jang, H., Wang, J., Zhou, T. and Kim, I. (2010). Effects of fermented garlic powder on production performance, egg quality, blood profiles and fatty acids composition of egg yolk in laying hens. Asian-Australasian Journal of Animal Sciences. 23(6): 786-791. DOI: 10.5713/ajas.2010.90543.

Arslan, C. (2004). Effect of dietary probiotic supplementation on growth performance in the Rock partridge (*Alectoris graeca*). Turkish Journal of Veterinary and Animal Sciences. 28(5): 887-891.

Aydoğan, İ. (2018). Kanatlı beslemede sarımsak *(Allium sativum)* kullanımının etkileri. Yem Magazin. 81: 41-46.

Aygün, A. and Olgun, O. (2019). Comparison of egg quality, yolk cholesterol and fatty acid contents of chicken, quail, partridge and pheasant eggs. Akademik Ziraat Dergisi. 8(2): 323-328. DOI: 10.29278/azd.591257.

Azeke, M.A. and Ekpo, K.E. (2009). Egg yolk cholesterol lowering effects of garlic and tea. Journal of Medicinal Plants Research. 3(12): 1113-1117. DOI: 10.5897/JMPR.900 0554.

Barreto, M., Menten, J.F.M., Racanicci, A., Pereira, P. and Rizzo, P. (2008). Plant extracts used as growth promoters in broilers. Brazilian Journal of Poultry Science. 10(2): 109-115. DOI: 10.1590/S1516-635X2008000200006.

Bozin, B., Mimica-Dukic, N., Samojlik, I., Goran, A. and Igic, R. (2008). Phenolics as antioxidants in garlic [*Allium sativum* (L.) *Alliaceae*]. Food Chemistry. 111(4): 925-929. DOI: 10.1016/j.foodchem.2008.04.071.

Çağlayan, T., Kırıkçı, K. and Aygun, A. (2014). Comparison of hatchability and some egg quality characteristics in spotted and unspotted partridge *(Alectoris chukar)* eggs. Journal of Applied Poultry Research. 23(2): 244-251. DOI: 10.3382/japr.2013-00899.

Canoğulları, S., Baylan, M., Erdoğan, Z., Duzguner, V. and Kucukgul, A. (2010). The effects of dietary garlic powder on performance, egg yolk and serum cholesterol concentrations in laying quails. Czech Journal of Animal Science. 55(7): 286-293. DOI: 10.17221/126/2009-CJAS.

Chowdhury, S., Chowdhury, S. and Smith, T. (2002). Effects of dietary garlic on cholesterol metabolism in laying hens. Poultry Science. 81(12): 1856-1862. DOI: 10.1093/ps/81.12.1856.

Çağlayan, T., Alaşahan, S., Kırıkçı, K. and Günlü, A. (2009). Effect of different egg storage periods on some egg quality characteristics and hatchability of partridges (*Alectoris graeca*). Poultry Science. 88(6): 1330-1333. DOI: 10.3382/ps.2009-00091.

Çam, M., Kaya, Z., Güler, S., Harman, H. and Kırıkçı, K. (2022). Quality assessment of Chukar partridge (*A. Chukar*) eggs during different conditions (time, turning and position) of storage. Journal of Animal Science and Technology. 64(2): 365-379. DOI: 10.5187/jast.2022.e9.

Damaziak, K., Riedel, J., Gozdowski, D., Niemiec, J., Siennicka, A. and Róg, D. (2017). Productive performance and egg quality of laying hens fed diets supplemented with garlic and onion extracts. Journal of Applied Poultry Research. 26(3): 337-349. DOI: 10.3382/japr/pfx001.

Diaz-Sanchez, S., D'Souza, D., Biswas, D. and Hanning, I. (2015). Botanical alternatives to antibiotics for use in organic poultry production. Poultry Science. 94(6): 1419-1430. DOI: 10.3382/ps/pev014.

Dosoky, W.M., Zeweil, H.S., Ahmed, M.H., Zahran, S.M., Shaalan, M.M., Abdelsalam, N.R., Abdel-Moneim, A.-M.E., Taha, A.E., El-Tarabily, K.A. and Abd El-Hack, M.E. (2021). Impacts of onion and cinnamon supplementation as natural additives on the performance, egg quality and immunity in laying Japanese quail. Poultry Science. 100(12): 101482. DOI: 10.1016/j.psj.2021.101482.

Griggs, J. and Jacob, J.P. (2005). Alternatives to antibiotics for organic poultry production. Journal of Applied Poultry Research. 14(4): 750-756. DOI: 10.1093/japr/14.4.750.

Gülşen, N., Umucalılar, H., Kırıkçı, K., Hayırlı, A., Aktümsek, A. and Alaşahan, S. (2010). Sunflower oil supplementation alters meat quality but not performance of growing partridges (*Alectoris chukar*). Journal of Animal Physiology and Animal Nutrition. 94(2): 196-203. DOI: 10.1111/j.1439-0396.2008.00899.x.

Günhan, Ş. and Kırıkçı, K. (2017). Effects of different storage time on hatching results and some egg quality characteristics of Rock partridge (*A. graeca*) (management and production). Poultry Science. 96(6): 1628-1634. DOI: 10.3382/ps/pew443.

Hajati, H. and Rezaei, M. (2010). The application of prebiotics in poultry production. International Journal of Poultry Science. 9(3): 298-304. DOI: 10.3923/ijps.2010.298.304.

Han, S.W., Sang, B.C. and Kim, H.K. (1991). Estimation of the genetic parameters on egg components and egg qualities in Korean Native Ogol fowl. Korean Journal of Agricultural Science. 18(1): 10-20.

Hashemipour, H., Khaksar, V. and Kermanshahi, H. (2011). Application of probiotic on egg production and egg quality of chukar partridge. African Journal of Biotechnology. 10(82): 19244-19248. DOI: 10.5897/AJB11.2566.

Khan, R. and Naz, S. (2013). The applications of probiotics in poultry production. World's Poultry Science Journal. 69(3): 621-632. DOI: 10.1017/S0043933913000627.

Khan, R.U., Naz, S., Nikousefat, Z., Tufarelli, V. and Laudadio, V. (2012). *Thymus vulgaris*: Alternative to antibiotics in poultry feed. World's Poultry Science Journal. 68(3): 401-408. DOI: 10.1017/S0043933912000517.

Kırıkçı, K., Çam, M., Başer, E., Akbulut, N.K. and Bilgiç, M.A. (2018). Kınalı keklikerde yumurta ağırlığının kuluçka sonuçları üzerine etkisi. Bahri Dağdaş Hayvancılık Araştırma Dergisi. 7:(1) 1-6.

Kocabağlı, N. and Alp, M. (2015). Kanatlı beslemede kullanılan yem katkı maddeleri. Turkiye Klinikleri Animal Nutrition and Nutritional Diseases - Special Topics Journal Identity. 1(2): 17-24.

Kothari, D., Lee, W.D., Niu, K.M. and Kim, S.K. (2019). The genus *Allium* as poultry feed additive: A review. Animals. 9(12): 1032. DOI: 10.3390/ani9121032.

Lim, K., You, S., An, B. and Kang, C. (2006). Effects of dietary garlic powder and copper on cholesterol content and quality characteristics of chicken eggs. Asian-Australasian Journal of Animal Sciences. 19(4): 582-586. DOI: 10.5713/ajas.2006.582.

Liu, H., Liu, Y., Hu, L., Suo, Y., Zhang, L., Jin, F., Feng, X., Teng, N. and Li, Y. (2014). Effects of dietary supplementation of *quercetin* on performance, egg quality, cecal microflora populations and antioxidant status in laying hens. Poultry Science. 93(2): 347-353. DOI: 10.3382/ps.2013-03225.

Narushin, V. (2005). Egg geometry calculation using the measurements of length and breadth. Poultry Science. 84(3): 482-484. DOI: 10.1093/ps/84.3.482.

Ogbuewu, I., Okoro, V., Mbajiorgu, E. and Mbajiorgu, C. (2019). Beneficial effects of garlic in livestock and poultry nutrition: A review. Agricultural Research. 8(4): 411-426. DOI: 10.1007/s40003-018-0390-y.

Olobatoke, R. and Mulugeta, S. (2011). Effect of dietary garlic powder on layer performance, fecal bacterial load and egg quality. Poultry Science. 90(3): 665-670. DOI: 10.3382/ps.2010-00736.

Omer, H.A., Ahmed, S.M., Abdel-Magid, S.S., El-Mallah, G.M., Bakr, A.A. and Fattah, M.M.A. (2019). Nutritional impact of inclusion of garlic (*Allium sativum*) and/or onion (*Allium cepa* L.) powder in laying hens' diets on their performance, egg quality and some blood constituents. Bulletin of the National Research Centre. 43(1): 23. DOI: 10.1186/s42269-019-0061-6.

Patterson, J.A. and Burkholder, K.M. (2003). Application of prebiotics and probiotics in poultry production. Poultry Science. 82(4): 627-631. DOI: 10.1093/ps/82.4.627.

Rahimi, S., Teymouri, Z.Z., Karimi, T.M., Omidbaigi, R. and Rokni, H. (2011). Effect of the three herbal extracts on growth performance, immune system, blood factors and intestinal selected bacterial population in broiler chickens. Journal of Agricultural Science and Technology. 13: 527-539.

Sevim, B., Gümüş, E., Harman, H., Ayasan, T., Başer, E., Altay, Y. and Akbulut, K. (2020). Effects of dietary rosemary essential oil on growth performance, carcass traits and some hematological values of Chukar partridge. Turkish Journal of Agriculture - Food Science and Technology. 8(2): 430-435. DOI: 10.24925/turjaf.v8i2.430-435.3121.

Slimestad, R., Fossen, T. and Vågen, I.M. (2007). Onions: A source of unique dietary flavonoids. Journal of Agricultural and Food Chemistry. 55(25): 10067-10080. DOI: 10.1021/jf0712503.

Song, K., Choi, S. and Oh, H. (2000). A comparison of egg quality of pheasant, chukar, quail and guinea fowl. Asian-Australasian Journal of Animal Sciences. 13(7): 986-990. DOI: 10.5713/ajas.2000.986.

Stadelman, W.J. (1995). Egg Science and Technology. 4th Edition CRC Press, New York.

Tavakkoli, H., Derakhshanfar, A. and Salandari, S. (2014). Effect of dietary *Pistacia atlantica* oil on performance and pathological conditions in Chukar partridge. Journal of Livestock Science and Technologies. 2(2): 19-25. DOI: 10.22103/JLST.2014.875.

Yalçın, S., Onbaşılar, E.E., Reisli, Z. and Yalçın, S. (2006). Effect of garlic powder on the performance, egg traits and blood parameters of laying hens. Journal of the Science of Food and Agriculture. 86(9): 1336-1339. DOI: 10.1002/jsfa.2515.

Yalçın, S., Onbaşılar, İ., Şehu, A. and Yalçın, S. (2007). The effects of dietary garlic powder on the performance, egg traits and blood serum cholesterol of laying quails. Asian-Australasian Journal of Animal Sciences. 20(6): 944-947. DOI: 10.5713/ajas.2007.944.