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## Effects of garlic and onion powders on egg production, antioxidant status and some blood parameters in chukar partridges

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**ABSTRACT:** The study aimed to evaluate the effect of onion (*Allium cepa*) and garlic (*Allium sativum*) powders on egg production, antioxidant capacity and blood biochemistry in chukar partridges (*Alectoris chukar*). The study was conducted for 12 weeks during the laying period and a total of 240 partridges were divided into 4 groups (control, 1% onion, 1% garlic, and mixture of 1% onion and 1% garlic powders). The highest total antioxidant capacity, feed consumption and egg production were determined in the garlic group ( $P < 0.05$  and  $P < 0.01$  respectively) and the lowest egg production and feed intake were observed in the onion group. Egg production in the mixture of garlic and onion group was also higher than the control and only onion group ( $P < 0.01$ ). While there was no statistical difference in blood HDL (High Density Lipoprotein), LDL (Low Density Lipoprotein), glucose, alkaline phosphatase, calcium, and phosphorus levels ( $P > 0.05$ ), blood urea, ALT (Alanine Aminotransferase), AST (Aspartate Aminotransferase) levels were higher ( $P < 0.05$ ) in the garlic group with the highest egg production and feed intake ( $P < 0.01$ ) compared to the control and onion groups. Unlike many studies, the highest cholesterol levels were determined in the garlic supplemented group ( $P < 0.05$ ) and the expected positive effects were not seen in onion powder.

**Keywords:** Partridge, onion, garlic, egg production, antioxidant status, blood biochemistry.

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## INTRODUCTION

Partridges are commonly maintained for hobby purposes and chukar partridges are the most adapted species for commercial production and breeding is mostly done to provide birds for hunting (Kirikci et al., 2002, Alkan et al., 2008). It has been reported that raising partridges for meat production has become more widespread (Özek et al., 2003). However, the number of birds in the wild has diminished in recent years due to excessive hunting, habitat destruction and indiscriminate use of pesticides and fertilizer (Kirikci et al., 1999, Karabag et al., 2010).

Chukar partridges have a wide natural habitat in Turkey. It has been known that chukar partridge's laying period is between April and August in Turkey in natural conditions. Approximately 20-60 eggs can be taken in the 10-16 weeks of laying period, depending on the age, care, feeding, and rearing system in chukar partridges (Woodard et al., 1978, Alkan et al., 2008). Studies on age, lighting, body weight, and feeding, which are among the environmental factors that affect egg production, are limited (Kırıkçı et al., 2007).

Bulbous plants have high antioxidant activity due to the flavonoids in their structure. Both garlic (*Allium sativum*) and onion (*Allium cepa*) are in the family of *Alliaceae* and are used in nutrition and raw material in the drug industry. It has been reported that both garlic and onion contain phenolic compounds like gallic acid, quercetin, myricetin in considerable amounts (Yünlü and Kır., 2016). Polyphenolics have wide biological effects such as antibacterial, anti-inflammatory, antiallergic, hepatoprotective, antithrombotic, antiviral, anticarcinogenic and vasodilatory actions. In addition, it has been expressed that free radical scavenging and antioxidant activity cause these biological functions (Middleton et al., 2000). The sources of the pharmacological actions of phenolic antioxidants are their free radical scavenging, metal chelating properties, their effects on cell signalling pathways and on gene expression. The antioxidant capacities of phenolic compounds were evaluated by using the Trolox equivalent antioxidant capacity (TEAC), the ferric reducing antioxidant power (FRAP), the hypochlorite scavenging capacity, the deoxyribose method and the copper-phenanthroline-dependent DNA oxidation analyzes (Soobrattee et al., 2005).

Dietary strategies are important in improving egg and meat production in the poultry industry. Allicin and its species that are active ingredient of garlic have properties such as antibacterial, anticoccidial,

antifungal, antiviral, immune-enhancing and antioxidant capacity-enhancing, and its use is becoming widespread in poultry feeding (Wang et al., 2017). Studies in animals and humans have also revealed that garlic has hypotensive and hypoglycemic properties (Yang et al., 2018, Borgohain et al., 2019, Zhu et al., 2018). The hypolipidemic effects of garlic are mediated by different mechanisms. Garlic reduces the lipogenic and cholesterologenic activities of enzymes such as malic enzyme, fatty acid synthase, glucose-6 phosphate dehydrogenase, and 3-hydroxy-3-methyl-glutarylCoA (HMGCoA) reductase in liver cells (Yan and Liu, 2001). In the literature, there are studies about proving the positive effect of onion and garlic powders on egg production, in laying hens (Khan et al., 2012, Damaziak et al., 2017, Mahmoud et al., 2010) but no studies were found about garlic or onion supplementation in chukar partridges. The present study aimed to determine the effects of onion and garlic powders on egg production, feed intake and total antioxidant status in chukar partridge.

## MATERIALS AND METHODS

### Animals, housing and experimental design

The study was carried out between April and July at Bahri Dagdas International Agricultural Research Institute (37° 52' 5.7612" and 32° 33' 12.8088"), the climate condition was dominantly seen as steppe. This study was approved by the Ethics Committee of the Experimental Medicine Research and Application Centre of Selcuk University, 2020 / 60 report.

Chukar partridges were obtained from Bahri Dagdas International Agricultural Research Institute's poultry farm. 240 partridges at 60 weeks of age were used in the study and were kept in 4 outdoor cages which 120 cm × 115 cm × 600 cm dimensions. 45 female and 15 male partridges were placed in each cage. The period of 16 hours light and 8 hours dark was applied throughout the experiment total of 12 weeks.

### Diet

The study was conducted in four groups as control, 1% onion, 1% garlic and mixture of 1% onion and 1% garlic powders (Omer et al., 2019). Onion and garlic powders which produced by oven drying were obtained from a local spice shop (Kurucum Gıda) in Isparta / TURKEY and mixed to the commercial laying hen feed which the composition is given in Table 1.

The mixing process was conducted with a 5 kg ca-

capacity bucket. Firstly 100 g onion and / or 100 g garlic powder added to 1 kg feed and mixed and shook for 5 minutes manually. After this step, 9 kg of feed was added to this mixture and mixed for 15 minutes manually with a hand shovel on the ground.

Feed was given ad-libitum with 15 kg capacity ground feeders and feed consumption was recorded with weekly intervals. Water was given ad-libitum with a nipple system. The study was carried out for 12 weeks and feed adaptation was conducted first 2 weeks. The data of the adaptation period wasn't used.

### Sample collection and measurement of blood parameters.

At the end of the study, 8 female partridges were randomly selected from each group and jugular vena was cut with a sterile lancet, and 5-6 ml blood was taken to the clot activator tubes. Samples were centrifuged at 3000 g for 10 minutes and stored at -20 °C until the analysis. Serum calcium, phosphorus, glucose, total cholesterol, HDL, LDL, alkaline phosphatase, urea, ALT, and AST levels were determined with an autoanalyzer (Abbott Architect C8000) by colorimetric method.

For determining total antioxidant status, ABTS ((2,2'-Azino-bis (3-ethylbenzothiazoline-6-sulfonic acid)) radical was used and analysis was performed with Mindray BS400 autoanalyzer by colorimetric method.

### Statistical analysis.

Statistical analysis was performed with SPSS 23.0 software. Data distribution of blood parameters were abnormal and nonhomogeneous to the Kolmogorov Smirnov and Shapiro - Wilk test and therefore Kurskal - Wallis test was performed for determining the statistical difference between groups. The daily egg production rate was calculated with [ (Number of eggs / number of live female partridge) x 100] formula and differences were analyzed by one-way ANOVA. Duncan's multiple tests was performed to determine statistical significances in egg production rate between groups. Feed consumption data was recorded with weekly intervals and calculated with [weekly feed consumption (g) / weekly live partridge number] and analyzed by one-way ANOVA. Duncan's multiple test was performed to determine statistical significances between groups.

### RESULTS

The highest egg production rate was observed in the garlic group ( $P < 0.01$ ). At the same time, feed consumption increased with garlic powder and the lowest egg production and feed consumption were obtained in the onion group ( $P < 0.01$ ). Onion and garlic mixture provided a positive effect on egg production with less feed consumption compared to the control group.

The total antioxidant status of the garlic group was

**Table 1.** Composition of diet

Ingredients		Nutrients	
Corn (%)	42.50	ME (kcal/kg)	2700
Soybean meal (%)	27.67	Crude protein (%)	17.00
Boncalite (%)	17.58	Crude fiber (%)	4.0
Marble powder (%)	9.41	Crude fat (%)	4.20
Soybean fat (%)	0.91	Crude ash (%)	14.00
Sodium (%)	0.16		
Lysine (%)	0.75		
Methionine (%)	0.36		
Calcium (%)	4.00		
Dicalcium phosphate 18 (%)	0.80		
Phosphorus (%)	0.60		

**Table 2.** Egg production and feed consumption, (per partridge)

Groups	Daily egg production rate (%)	Weekly feed consumption (g)
Control	21.93 ± 1.15 <sup>b</sup>	366.89 ± 7.98 <sup>a</sup>
Onion	21.20 ± 0.98 <sup>b</sup>	293.13 ± 8.10 <sup>b</sup>
Garlic	32.95 ± 1.58 <sup>a</sup>	376.40 ± 5.43 <sup>ac</sup>
Onion and Garlic	26.24 ± 0.67 <sup>a</sup>	325.02 ± 4.93 <sup>b</sup>

a, b; Different letters mean statistical significance in the same row ( $p < 0.01$ ).

**Table 3.** Effects of garlic and/or onion on blood parameters (mean  $\pm$  standard error of mean)

Parameters (n=8)	Control	Garlic	Onion	Onion and Garlic
TAS (mmol/L)	2.65 $\pm$ 0.25 <sup>ab</sup>	2.85 $\pm$ 0.17 <sup>a</sup>	2.39 $\pm$ 0.13 <sup>b</sup>	2.66 $\pm$ 0.17 <sup>ab</sup>
LDL (mg/dl)	81.87 $\pm$ 9.54	100.22 $\pm$ 19.91	65.25 $\pm$ 6.63	76.55 $\pm$ 13.95
HDL (mg/dl)	49.4 $\pm$ 9.39	48.7 $\pm$ 7.94	52.96 $\pm$ 10.97	64.67 $\pm$ 12.26
Cholesterol (mg/dl)	188 $\pm$ 15.10 <sup>a</sup>	265.63 $\pm$ 42.65 <sup>b</sup>	164.03 $\pm$ 14.57 <sup>a</sup>	203.12 $\pm$ 68 <sup>ab</sup>
Glucose (mg/dl)	353.87 $\pm$ 14.64	333.125 $\pm$ 7.98	344.25 $\pm$ 8.98	325.75 $\pm$ 10.62
ALT (U/L)	10.68 $\pm$ 1.18 <sup>a</sup>	13.32 $\pm$ 3.39 <sup>b</sup>	10.78 $\pm$ 0.84 <sup>a</sup>	12.61 $\pm$ 0.97 <sup>ab</sup>
AST (U/L)	292.37 $\pm$ 34.95 <sup>a</sup>	403.37 $\pm$ 48.19 <sup>b</sup>	266.75 $\pm$ 25.86 <sup>a</sup>	308 $\pm$ 31.51 <sup>ab</sup>
Urea (mg/dl)	2.24 $\pm$ 0.56 <sup>a</sup>	2.96 $\pm$ 0.9 <sup>b</sup>	2.52 $\pm$ 0.48 <sup>ab</sup>	3.02 $\pm$ 0.33 <sup>b</sup>
Alk P (U/L)	815.12 $\pm$ 151.67	731.62 $\pm$ 72.22	672.37 $\pm$ 138.01	686.19 $\pm$ 125.55
Ca (mg/dl)	18.37 $\pm$ 5.01	18.66 $\pm$ 4.5	16.72 $\pm$ 5.67	16.2 $\pm$ 5.63
P (mg/dl)	5.96 $\pm$ 1.8	6.38 $\pm$ 1.01	5.02 $\pm$ 1.49	5.65 $\pm$ 2.05

a, b; Different letters mean statistical significance in the same row ( $p < 0.05$ ).

(TAS: Total antioxidant status, LDL: Low-density lipoprotein, HDL: High-density lipoprotein, ALT: Alanine aminotransferase, AST: Aspartate aminotransferase, Alk P: Alkaline phosphatase, Ca: Calcium, P: Phosphorus)

higher than the onion group and ALT, AST, urea levels in the garlic group were higher than the control and onion group ( $p < 0.05$ ). Although the numerical differences in HDL, LDL, and alkaline phosphatase levels, there was no statistical significance between groups and also glucose, calcium and phosphorus levels were similar ( $P > 0.05$ ).

## DISCUSSION

The present study aimed to determine the effect of onion and / or garlic powder supplementation on egg production in chukar partridges. It was observed that egg production increased significantly in partridges fed with 1% garlic powder and the highest egg production rate was observed in the garlic group ( $P < 0.01$ ). Also, egg number in the onion and garlic group was significantly higher than the control and only onion group ( $P < 0.01$ ), (Table 2). Damaziak et al has been reported that onion and garlic powder extracts increased egg production in laying hens (Damaziak et al., 2014). Omer et al reported that garlic and onion powders increased egg production and decreased feed consumption in layers (Omer et al., 2019) and Ooi et al proved that 1% onion powder increased egg production (Ooi et al., 2018). Kolawole and Folake has been reported that 1% garlic powder has no effect on feed consumption and egg production in laying hens, and 2% garlic powder decreased both of them (Kolawole and Folake, 2019). In another study, Mahmoud et al has been reported that garlic juice has no effect on egg production in layers (Mahmoud et al., 2010). In the present study, it was seen that the highest egg production in the garlic group with highest feed consumption ( $P < 0.01$ ) and egg production

in chukar partridges was positively affected by using the garlic powder and, mixture of onion and garlic powders ( $P < 0.01$ ). It can be said that using mixture of garlic and onion powders increased egg production with lower feed consumption than the control group. Contrary to the expected effect in the onion powder group, the feed consumption and egg production were lower than the control group and so that it has been thought that chukar partridges did not like the onion powder supplemented feed. According to the results of this study, it can be said that the positive effect on egg production that observed in mixture of onion and garlic powders is due to garlic powder.

Spices contain well-known antioxidants such as ascorbic acid (vitamin C), tocopherols (vitamin E), phenols, thiols, sulfur components and carotenoids. In addition to these ingredients, it has been reported that allicin, the active ingredient of garlic, scavenges reactive oxygen species, and protects lipids from peroxidation (Wilson and Adams, 2007). It has been reported that egg production increased with vitamin E supplementation in chukar partridges (Şengül et al., 2008). Choi et al reported that malondialdehyde levels in chicken meat decreased in parallel with increasing garlic doses in broilers (Choi et al., 2010). Pourali et al determined that 5% garlic powder decreased nitric oxide and malondialdehyde levels, but did not affect superoxide dismutase and glutathione peroxidase levels in broilers infected with *Eimeria* (Pourali et al., 2014). Ismail et al proved that garlic powder significantly increased the superoxide dismutase and total antioxidant capacity levels in the broilers while decreasing the malondialdehyde levels (Ismail et al., 2020).



In the literature, there is no study on the effect of onion and /or garlic on the antioxidant capacity of chukar partridges. Yardibi and Türkay reported that vitamin E supplementation provided a significant decrease in MDA levels and a significant increase in egg production in laying hens (Yardibi and Türkay, 2008). In the present study it has been determined that total antioxidant status in the garlic group was higher than the control and mixture of onion and garlic group but no significance ( $P > 0.05$ ) and significantly higher than the onion group ( $P < 0.05$ , Table 3). The lowest total antioxidant status and the lowest egg production were observed in the onion group, while the highest egg production and total antioxidant status were observed in the garlic group. So it can be said that there is a relationship between antioxidant status and egg production in chukar partridges.

It has been reported that garlic reduces blood cholesterol levels and this effect is caused by a component called S-methylcysteine sulfoxide (Thomson and Ali, 2003). Studies in chickens have also demonstrated the hypolipidemic effects of garlic powder or extracts (Khan et al., 2012, Choi et al 2010., Kim et al., 2009, Ao et al., 2011). It has been reported that cholesterol levels in rock partridges were 182.54 - 212.91 mg/dL (Özbey and Esen, 2007), in chukar partridges, were 176.46-191.83 mg/dl (Özek and Bahtiyarca 2004), 194.1 mg/dL (Khaksar et al., 2013), and 174.50-189.80 mg/dl (Sevim et al., 2020) on out of the egg production season. There is no study in the literature investigating garlic and / or onion powder's effect on cholesterol levels during the egg production season in chukar partridges. In the present study, cholesterol levels were similar to the other studies (Özbey and Esen, 2007, Özek and Bahtiyarca 2004, Khaksar et al., 2013, Sevim et al., 2020). Unlike lots of literature,

in the present study, cholesterol levels in the garlic group ( $265.63 \pm 42.65$  mg/dl) were higher than the control and onion groups ( $P < 0.05$ ), and HDL and LDL levels were not affected by garlic or onion supplementation. The highest egg production rate, feed consumption and cholesterol levels were determined in the garlic group but these parameters were lowest in the onion group. With this information, it has been thought that cholesterol levels were affected by egg production and feed consumption in chukar partridges. The highest levels of ALT, AST, urea and cholesterol were observed in the garlic group. It has been thought that high egg production and high feed consumption have negative effects on liver functions. (Table 3).

## CONCLUSIONS

Egg production and total antioxidant status increased by using the 1% garlic powder and, mixture of 1% onion and 1% garlic powders. Only onion powder had a negative effect on egg production and feed consumption. According to the results of this study, it can be said that there is a relationship between egg production and antioxidant capacity. Chukar partridges are a type of game bird that give fewer egg and difficult to breed. With this study's results, it can be said that garlic and mixture of onion and garlic powders may be beneficial on egg production in game birds like chukar partridges.

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## CONFLICT OF INTEREST

None declared.

## REFERENCES

1. Kırıkçı K, Tepeli C, Cetin O, Yılmaz A (2002) Kekliklerin (*A. graeca*) yumurta ve bazı kuluçka verimleri üzerine farklı ham protein içeren rasyonların etkisi. *Veteriner Bilimleri Dergisi* (1-2): 53-55.
2. Alkan S, Karabağ K, Galiç A, Balcioglu MS (2008) Kınalı kekliklerde (*alektoris chukar*) erkek-dişi oranının kuluçka özelliklerine etkileri. *Lalahan Hayvancılık Araştırma Enstitüsü Dergisi* 48 (1): 45-50.
3. Özek K, Yazgan O, Bahtiyarca Y (2003) Effects of dietary protein and energy concentrations on performance and carcass characteristics of Chukar Partridges (*Alectorischukar*) raised in captivity. *Br Poult Sci* 3: 419-426.
4. Kırıkçı K, Tepeli C, Cetin O, Günlü A, Yılmaz A (1999). Farklı barındırma ve aydınlatma şartlarında Kaya Kekliklerinin (*A. graeca*) bazı verim özellikleri. *Veteriner Bilimleri Dergisi* 15 (1): 15-22.
5. Karabağ K, Alkan S, Mendes M (2010). Classification tree method for determining factors that affecting hatchability in chukar partridge (*Alectoris chukar*) eggs. *Kafkas Univ Vet Fak Derg* 16 (5): 723-727.
6. Woodard AE, Ernst RA, Vohra P, Nelson L, Price F. (1978) Raising game birds. University of California, Division of Agriculture and Natural Resources; Publication 8155 pp: 2-3.
7. Kırıkçı K, Günlü A, Çetin O, Garip M (2007) Effect of hen weight on egg production and some egg quality characteristics in the partridge (*Alectoris graeca*). *Poultry Sci* 86 (7): 1380-1383.
8. Yünlü S, Kir E (2016) Soğan (*Allium cepa*) ve sarımsaktaki (*Allium sativum*) bazı fenolik bileşiklerin HPLC yöntemiyle tayin edilmesi. *Süleyman Demirel Üniversitesi Fen Bilimleri Enstitüsü Dergisi* 20 (3):566-574.
9. Middleton Jr E, Kandaswami C, Theoharides TC (2000) The effects of plant flavonoids on mammalian cells: implications for inflammation, heart disease, and cancer. *Pharmacol Rev* 52 (4):673-751
10. Soobrattee MA, Neergheen VS, Luximon-Ramma A, Aruoma OI, Ba-

- horun T (2005) Phenolics as potential antioxidant therapeutic agents: Mechanism and actions. *Mutat Res- Fund Mol M579*: 200-213.
11. Wang J, Yue H, Wu S, Zhang H, Qi G (2017) Nutritional modulation of health, egg quality and environmental pollution of the layers. *Anim Nutr* 3:91-96.
  12. Yang C, Li L, Yang L, Lu H, Wang S, Sun G (2018) Anti-obesity and hypolipidemic effects of garlic oil and onion oil in rats fed a high-fat diet. *Nutr Metab* 20:15-43.
  13. Borgohain B, Mahanta JD, Sapkota D, Handique B, Islam R (2019) Effect of feeding garlic (*Allium sativum*) on haematological, serum biochemical profile and carcass characteristics in broiler chicken. *Int J Curr Microbiol Appl Sci* 8 (10):492-500.
  14. Zhu Y, Anand R, Geng X, Ding Y (2018) A mini review: garlic extract and vascular diseases. *NeurolRes* 40 (6): 421-425.
  15. Yan YY, Liu L (2001) Cholesterol lowering effect of garlic extracts and organosulfur compounds: human and animal studies. *J Nutr* 131:989-993.
  16. Khan RU, Nikousefat Z, Tufarelli V, Naz S, Javdani M, Laudadio V (2012) Garlic Supplementation in poultry diets: effects on production and physiology. *Worlds Poult Sci J* 68 (3):417-424.
  17. Damaziak K, Riedel J, Gozdowski D, Niemiec J, Siennicka A, Rog D (2017) Productive performance and egg quality of laying hens fed diets supplemented with garlic and onion extracts. *J Appl Poultry Res* 26 (3): 337-349.
  18. Mahmoud KZ, Gharaibeh SM, Zakaria HA, Qatramiz AM (2010) Garlic (*Allium sativum*) supplementation: influence on egg production, quality, and yolk cholesterol level in layer hens. *Asian Australas J Anim Sci* 23 (11): 1503-1509.
  19. Omer HAA, Ahmed SM, Abdel - Magid SS, El Mallah GMH, Bakr AA, Abdel Fettah MM (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. *Bull Natl Res Cent* 43:23.
  20. Ooi PS, Rohaida AR, Nur Hardy AD, Devina D1, Borhan AH, Kartini S, Jupikely JS, Abdul Rahman M, Alimon AR (2018) Effect of local medicinal herbs as feed additives on production performance and faecal parameters in laying hens. *Mal J Anim* 21 (2):59-67.
  21. Kolawole FSO, Folake AO (2019) Egg traits and productive performance of isa-brown laying hens fed garlic supplemented diets. *Asian J Appl Sci* 7 (4):398-403.
  22. Wilson EA, Adams BD (2007) Antioxidant, anti-inflammatory, and antimicrobial properties of garlic and onions. *Nutr Food Sci* 37 (3): 178-183.
  23. Şengül T, Çetin M, Söğüt B, Yurtseven S (2008) Effects of dietary vitamin e levels on egg production traits, fertility and hatching rate in laying partridges. *J Appl Anim Res* 34 (1): 77-80.
  24. Choi IH, Park WY, Kim YJ (2010) Effects of dietary garlic powder and  $\alpha$ -tocopherol supplementation on performance, serum cholesterol levels, and meat quality of chicken. *Poultry Sci*; 8: 1724-1731.
  25. Pourali M, Kermanshahi H, Golian A, Razmi GR, Soukhtanloo M (2014) Antioxidant and anticoccidial effects of garlic powder and sulfur amino acids on eimeria-infected and uninfected broiler chickens. *Iran J Vet Res* 15 (3):227-232.
  26. Ismail IE, Alagawany M, Taha AE, Puvača N, Laudadio V, Tufarelli V (2020) Effect of dietary supplementation of garlic powder and phenyl acetic acid on productive performance, blood haematology, immunity and antioxidant status of broiler chickens. *Asian-australas. J. Anim. Sci* 34 (3) online.
  27. Yardibi H, Türkay G (2008) The effects of vitamin E on the antioxidant system, egg production, and egg quality in heat stressed laying hens. *Turk J Vet Anim Sci* 32 (5):319-325
  28. Thomson M, Ali M (2003) Garlic [*Allium sativum*]: A Review of its potential use as an anti-cancer agent. *Curr Cancer Drug Targets* 3 (1):67-81.
  29. Kim YJ, Jin SK, Yang HS (2009) Effect of dietary garlic bulb and husk on the physicochemical properties of chicken meat. *Poultry Sci*; 88 (2): 398-405.
  30. Ao X, Yoo JS, Zhou TX, Wang JP, Meng QW, Yan L, Cho JH, Kim IH (2011). Effects of fermented garlic powder supplementation on growth performance, blood profiles and breast meat quality in broilers. *Livest Sci* 141 (1):85-89.
  31. Özbey O, Esen F (2007) The effects of breeding systems and stocking density on some blood parameters of rock partridges (*Alectoris graeca*). *Poultry Sci* 86:420-422.
  32. Özek K, Bahtiyar Y (2004) Effects of sex and protein and energy levels in the diet on the blood parameters of the chukar partridge (*Alectoris chukar*). *Br Poult Sci* 45 (2):290-293.
  33. Khaksar V, Veldkamp T, Hashemipour H (2013) Effect of a prebiotic on performance of partridge. *J Anim Physiol Anim Nutr* 98 (3):511-516.
  34. Sevim B, Gümüş E, Harman H, Ayasan T Başer E, Altay Y, Akbulut K (2020) Effects of dietary rosemary essential oil on growth performance, carcass traits and some hematological values of chukar partridge. *Turjaf* 8 (2):430-435.