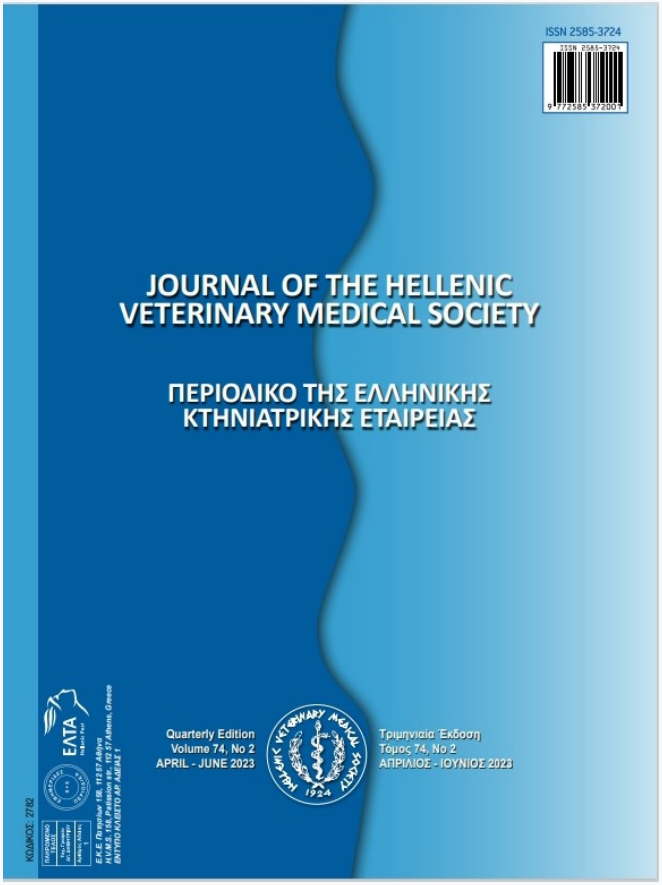
Journal of the Hellenic Veterinary Medical Society

Vol 74, No 2 (2023)



- Effects of Reishi Mushroom (Ganoderma Lucidum) Powder Inclusion into Quail Diets on Animal Performance, Carcass Traits, Intestinal Microflora and Serum Parameters

İ Ulger, M Kaliber, H Hizlisoy, T Ayasan

doi: 10.12681/jhvms.30440

To cite this article:

Ulger, İ, Kaliber, M., Hizlisoy, H., & Ayasan, T. (2023). - Effects of Reishi Mushroom (Ganoderma Lucidum) Powder Inclusion into Quail Diets on Animal Performance, Carcass Traits, Intestinal Microflora and Serum Parameters. *Journal of the Hellenic Veterinary Medical Society*, *74*(2), 5829–5836. https://doi.org/10.12681/jhvms.30440 (Original work published July 6, 2023)

J HELLENIC VET MED SOC 2023, 74 (2): 5829-5836
ΠΕΚΕ 2023, 74 (2): 5829-5836

Research article
Ερευνητικό άρθρο

Effects of Reishi Mushroom (*Ganoderma lucidum*) Powder Inclusion into Quail Diets on Animal Performance, Carcass Traits, Intestinal Microflora and Serum Parameters

İ. Ülger[1]*, M. Kaliber[2], H. Hizlisoy[3], T. Ayaşan[4]

[1,2]*Animal Science Department, Agricultural Faculty, Erciyes University, Kayseri Turkey*

[3]*Erciyes University, Faculty of Veterinary Medicine, Department of Veterinary Public Health, Kayseri – Turkey*

[4]*Osmaniye Korkut Ata University, Kadirli Faculty of Applied Sciences, Osmaniye, Turkey*

ABSTRACT: This study was carried out to determine the effects of Reishi mushroom (*Ganoderma lucidum*) powder inclusion into quail diets on live weight, live weight change, feed consumption, feed conversion ratio, carcass traits, intestinal microflora and serum biochemical parameters of the animals. A total of 200 Japanese quail (*Coturnix coturnix Japonica*) were used in present experiments. Quail were separated into 4 groups (one control and three treatment). Control group was fed with a basic ration and treatments groups were fed with 0.5, 1 and 2% Reishi mushroom-supplemented diets. Differences in live weight changes, feed consumptions, feed conversion ratios, overall carcass parameters and blood serum total protein, total cholesterol, glucose and triglyceride levels of the treatment groups were not found to be significant (P>0.05). Also, there were not any significant differences in intestinal bacteria populations of the treatment groups (P> 0.05). The results of the current study indicated that using Reishi mushroom in quail diet had not any negative effect on growth performance or other evaluated parameters. Also, further research is recommended to be conducted with greater ratios of Reishi mushroom in quail diets or with different poultry species.

Keywords: *Reishi; mushroom; fattening performance; carcass characteristics; poultry*

Corresponding Author:
İ. Ülger, Animal Science Department, Agricultural Faculty, Erciyes University, Kayseri Turkey
E-mail address: i_ulger@hotmail.com

Date of initial submission: 27-05-2022
Date of acceptance: 14-03-2023

INTRODUCTION

Number of poultry operations is continuously increasing to meet the deficit in animal protein and to solve nutritional problems in several countries. The efforts spend on poultry meat production mostly focus on diversification of poultry meat. In this sense, quail meat production has the second place after chicken meat in poultry meat production. As it was in broilers, the primary target in quail breeding is to achieve the greatest live weight with the least feed consumption in the shortest time. As compared to broilers, quail are quite motile, thus have a faster metabolism, therefore they need greater metabolic rates. Such a case requires the diets to be rich in nutrients (Guo et al., 2019).

Intensive feeding programs are applied in poultry breeding to achieve high live weight gain rates. To achieve such a target, poultry diets are either enriched in nutrients or growth promoting factors are supplemented into the diets (Wang et al., 2009; Ekizoğlu et al. 2020). Among the growth-promoting feed additives, antibiotics play a great role in animal nutrition (Kheiri et al., 2018). Anabolic effect of antibiotics was discovered the first in 1940s through supplementing chick diets with certain ratios of antibiotics and observing accelerated live weight gains with these supplementations (Gustafson and Bowen, 1997). Excessive and improper use of antibiotics result in development of antibiotic-resistant bacteria, therefore, use of antibiotic-originated growth factors in poultry breeding was largely banned in EU countries in 1998-1999 (Anadon and Martinez-Larranaga, 1999; Casewell et al. 2003). In recent years, researchers have been in search for alternative native and growth-promoting substances as an alternative of antibiotics (Shamsi et al., 2015a; Siadati et al., 2017; Fouladi et al., 2018; Asghar et al., 2022; Turgud and Narinç, 2022).

Among these additives, there is not much known about mushrooms. Mushrooms have antimicrobial activities, boost the immune system and reduce potential stress of animals (Wang et al., 1998; Smith et al., 2002). Therefore, such positive effects of mushrooms should be experimented as an alternative source of feed supplements to be used in poultry diets (Giannenas et al., 2010; Shamsi et al., 2015b). In present study, effects of Reishi mushroom (*Ganoderma lucidum*) powder inclusion into quail diets on animal performance, carcass traits, blood parameters and intestinal microflora were investigated.

MATERIAL AND METHOD

Ethical approval

Experiments were conducted with the 12.10.2016 dated and 16/126 numbered decision of Erciyes University Local Ethics Committee.

Animal Material

As the animal material of the experiments, 200 Japanese quail (*Coturnix coturnix Japonica*) chicks at the age of 10 days were randomly separated into 4 treatment groups comprising 5 replicates of 10 birds each. During the fattening period, quail chicks were fed on mixed diets prepared based on norms recommended by NRC (1994). While one of the groups was fed on control mixture diet (control), the other groups were fed on 0.5%, 1% and 2% Reishi mushroom (RM) powder-supplemented diets. Required heating and lighting were supplied and feed and water were supplied ad libitum throughout the experiments. Cage experiments lasted for 4 weeks.

Feed Material

Composition of concentrate feed used in preparation of experimental diets and calculated chemical composition are provided in Table 1. Quail diets contain 24% crude protein (CP) and 2900 kcal/kg metabolic energy (ME).

Reishi mushroom powder was supplied from a commercial dealer and supplemented into above-specified concentrated feed homogeneously at different ratios (0.5, 1 and 2%). Chemical composition of Reishi mushroom was analyzed according to methods reported by AOAC (2005) and presented in Table 2.

Live weight and Live Weight Gain

Animal live weights (LW) were weighed at the beginning of experiments and in 1st, 2nd, 3rd and 4th weeks of experiments. Weighing was performed with the use of precise balance (± 0.01 g). The difference between consecutive weighing was taken as live weight change (LWC).

Feed Consumption and Feed Conversion Ratio

The feed remaining in feeders in the 1, 2, 3 and 4th weeks were weighed and deducted from the quantity of feed supplied at the beginning of each week to get weekly feed consumption (FC) of each group. The feed consumption between two consecutive weighing was divided by live weight change of that period to get feed conversion ratios (FCR).

Table 1. Composition of concentrate feed and calculated chemical composition

Feed Materials, %	Composition
Maize	53.32
Soybean Meal	39.69
Corn Gluten	3.07
Vegetable Oil	1
Marble Powder	1.22
Dicalcium Phosphate	0.77
Lysine	0.06
Methionine	0.12
Vitamin-Mineral Premix*	0.50
Salt	0.25
Calculated Nutrients**	
Metabolic Energy, Kcal/kg	2900
Dry Matter, %	89.91
Crude Protein, %	24.00
Calcium, %	0.81
Phosphorus, %	0.30
Sodium, %	0.12
Lysine, %	1.30
Methionine + Cysteine, %	0.89

*: Vitamin-Mineral premix is for per 2.5 kg: vitamin A, 12.500.000 IU; vitamin D3, 3.000.000 IU; vitamin E, 20.000 mg; vitamin K3, 3.000 mg; vitamin B1, 2.500 mg; vitamin B2, 7.000 mg; vitamin B6, 5.000 mg; vitamin B12, 20 mg; niacin, 20.000 mg; Cal-D-Pan, 15.000 mg; folic acid, 1.000 mg; biotin, 20 mg; vitamin C, 50.000 mg; choline chloride, 300.000 mg; manganese, 80.000 mg; iron, 70.000 mg; zinc, 50.000 mg; copper, 6.250 mg; iodine, 1.250 mg; cobalt, 200 mg; selenium, 150 mg; canthaxanthin, 0 mg; apo-carotenoic acid est., 0 mg; lasolosid sodium, 90.000 mg.
**: Apart from dry matter, values were calculated from the tables in NRC (1994).

Table 2. Chemical composition of Reishi mushroom powder

Parameters	Composition
Crude protein, DM %	17.21
Crude ash, DM %	4.33
Crude oil, DM %	1.14

DM: Dry matter

Slaughter

At the end of the experiments (39 days of age), final live weights of the animals were measured and 2 male and 2 female quail representing mean final live weight of each cage were slaughtered in a controlled fashion following standard procedure (Landy et al., 2012).

Hot Carcass Dressing Percentage

Following the completion of slaughter process, carcasses were weighed to get hot carcass weight. Hot carcass weight was then divided by slaughter weight to get hot carcass dressing percentage:

Hot carcass dressing percentage (%) = [Hot carcass weight (g) / Slaughter weight (g)] x 100

Liver, Heart and Visceral Organ Weights

Liver, heart, gizzard, empty intestine, spleen, bursa and testes (only male quail) weights of slaughtered animals were measured with the use of a precise scale (±0.01 g) and also calculated as a percentage of slaughter weight.

Serum Biochemical Parameters

At the end of the experiments, blood samples were taken from 20 quail of each treatment group (two male and two female in each cage). Blood samples were centrifuged (Hettich Universal-320, Germany) to separate blood serums. Then serums were kept in a deep freezer at -20 °C until the analyses. Commercial kits (AMS Spa, Italy) were used to determine serum triglyceride, cholesterol, protein and glucose levels spectrophotometrically (Shimadzu Corp. UV–1601, Australia).

Intestine bacteria populations

Conventional methods were used for isolation and identification of bacterial agents. Quail intestine samples were sent to laboratory and subjected to microbiological analyses in the same day. Serial dilutions of the samples were prepared and sown into Plate Count Agar (Oxoid, United Kingdom) and total microorganism loads were determined. For isolation and identification, samples were inoculated to bloody agar supplemented with Chromagar mastitis Gram positive and Chromagar orientation (CHROMagar, USA), Mac Conkey Agar (Merck, Germany) and 7% sheep blood (Oxoid, United Kingdom). Broth media were incubated under aerobic conditions at 37 °C for 18-24 hours. Suspicious isolates developed at the end of incubation were subjected to Gram staining, carbohydrate fermentation, catalase, coagulase, oxidase and nitrate reduction tests for phenotypic identification. Phenotypically identified microorganisms were preserved in cryotubes including 10% glycerine (Merck, Germany) Brucella Broth (Oxoid, United Kingdom) medium in a deep freezer at -80 °C.

Statistical analysis

All data were analyzed using the General Linear Model procedures of SPSS (1998) software. Means were compared using Duncan test at 5% probability. The results of statistical analysis were shown as mean values and standard error of means (SEM) in the tables.

RESULTS

Live weights of experimental groups are provided in Table 3. As can be seen form Table 3, RM supplementation into quail diets did not influence live weights in 1st and 2nd weeks of the experiments (P>0.05). In the 3rd week of the experiments, the greatest live weight (152.28 g) was observed in the control and the lowest live weight (146.16 g) was observed in 2% RM-supplemented group (P<0.05); however, they have compensated the live weights in the 4th week (P>0.05).

Weekly and overall live weight changes (LWC) of treatment groups are provided in Table 4. The differences in weekly live weight changes of the treatment groups were not found to be significant (P>0.05). Also, RM supplementations into quail diets did not influence LWC of treatment groups throughout the experimental period (P>0.05).

Weekly and overall feed consumptions of treatment groups are provided in Table 5. Differences in weekly and overall feed consumptions of the treatment groups were not found to be significant (P>0.05).

Weekly and overall feed conversion ratios (FCR) of treatment groups are provided in Table 6. As can be seen form Table 6, RM supplementation into quail diets did not influence FCR in 1st, 3rd and 4th weeks and the general of the experiments (P>0.05). However, in the 2nd week of the study, higher feed conver-

Table 3. Mean live weights of treatment groups

	Live Weight, g					
Period	Control	0.5% RM	1% RM	2% RM	SEM	P
ILW	35.20	35.15	34.67	34.97	0.252	0.879
1st week	75.999	72.94	74.89	73.18	0.457	0.056
2nd week	115.87	113.40	112.38	107.18	0.566	0.886
3rd week	152.58^{a}	148.58^{ab}	148.60^{ab}	146.16^{b}	0.719	**0.018**
4th week	177.57	175.14	178.09	177.02	1.069	0.785

$^{a, b}$: Means indicated with different letters in the same row are significantly different; ILW: Initial live weight; RM: Reishi mushroom; SEM: Standard error of the mean; P: Probability value.

Table 4. Weekly and overall live weight changes of experimental groups

	Live Weight Change, g					
Period	Control	0.5% RM	1% RM	2% RM	SEM	P
1st week	40.68	37.36	40.53	38.21	0.541	0.068
2nd week	34.66	40.88	36.60	31.49	1.254	0.061
3rd week	36.71	35.18	36.00	38.98	1.255	0.178
4th week	24.99	26.56	29.49	30.86	1.703	0.067
General	133.88	138.85	135.45	133.55	2.101	0.803

RM: Reishi mushroom; SEM: Standard error of the mean; P: Probability value.

Table 5. Weekly and overall feed consumptions of the treatment groups

	Feed Consumption, g					
Period	Control	0.5% RM	1% RM	2% RM	SEM	P
1st week	95.00	98.78	92.84	91.44	3.447	0.645
2nd week	122.74	133.60	120.29	126.71	2.666	0.331
3rd week	134.42	114.68	131.00	120.91	3.459	0.155
4th week	163.29	155.80	155.74	161.79	3.426	0.828
General	515.40	502.88	499.88	500.84	5.584	0.415

RM: Reishi mushroom; SEM: Standard error of the mean; P: Probability value.

Table 6. Weekly and overall feed conversion ratios of the treatment groups

	Feed Conversion Ratio, g/g					
Period	Control	0.5% RM	1% RM	2% RM	SEM	P
1st week	2.34	2.64	2.29	2.39	0.075	0.767
2nd week	3.25[b]	3.2[b]	3.29[b]	4.02[a]	0.160	**0.050**
3rd week	3.66	3.26	3.64	3.10	0.156	0.571
4th week	6.53	5.87	5.28	5.24	0.327	0.201
General	3.85	3.62	3.69	3.75	0.040	0.251

[a-b]: Means indicated with different letters in the same row are significantly different; RM: Reishi mushroom; SEM: Standard error of the mean; P: Probability value.

Table 7. Slaughter and carcass parameters of treatment groups

	Treatment Groups					
Parameters	Control	0.5% RM	1% RM	2% RM	SEM	P
Hot carcass weight, g	119.74	115.08	117.71	112.11	1.095	0.074
Cold carcass weight, g	118.61	113.95	115.88	111.32	1.074	0.101
Carcass loss, %	0.99	0.99	0.99	1.00	0.001	0.212
Dressing percentage, %	65.60	65.28	64.98	66.79	0.285	0.098
Hot carcass pH	5.67	5.76	5.70	5.76	0.024	0.462
Cold carcass pH	5.80	5.85	5.82	5.85	0.016	0.643

RM: Reishi mushroom; SEM: Standard error of the mean; P: Probability value.

sion ratio (4.02 g/g) was observed in 2% RM-supplemented group than the others (P=0.05).

Slaughter and carcass parameters of the treatment groups are provided in Table 7. RM supplementations into quail diets generally did not influence carcass parameters (P>0.05). It was also observed RM supplementations into mixed feed did not influence pre-slaughter live weights (Table 3). As it was in pre-slaughter live weights, RM supplementations in to mixed feed did not influence hot and cold carcass weights (P>0.05). Similarly, dietary RM did not have significant effects on carcass pH values (P>0.05).

Carcass color parameters of the treatment groups are provided in Table 8. Effects of RM supplementations in quail diets on carcass color parameters (L*, a* and b* values) were not found to be significant (P>0.05).

Visceral organ weights and ratios to slaughter weight of treatments groups are provided in Table 9. Differences in visceral organ weights of the treatment groups were not found to be significant (P>0.05). Similarly, there were not any statistically significant differences in the ratio of intestine, heart, liver, gizzard, bursa and testes weights to slaughter weights between the experimental groups (P>0.05). However, ratio of spleen weight to slaughter weight was calculated as 0.07% in the control group, 0.07% in 0.5% RM-supplemented group, 0.09% in 1% RM-supplemented group and 0.07% in 2% RM-supplemented group (P<0.05).

Intestine bacteria populations of the treatment groups are provided in Table 10. Differences in intestine bacteria populations of the treatment groups were not found to be statistically significant (P>0.05).

Effects of RM-supplementations into quail diets on blood serum biochemical parameters are provided in Table 11. The differences in blood serum total cholesterol, total protein, glucose and triglyceride levels of the treatment groups at the end of the experiments were not found to be significant (P>0.05).

Table 8. Carcass color parameters of the treatment groups

	Treatment Groups					
Color Parameters	Control	0.5% RM	1% RM	2% RM	SEM	P
L*	51.40	51.63	53.87	52.86	0.398	0.098
a*	9.12	8.28	7.87	8.40	0.188	0.121
b*	6.59	5.17	6.89	6.16	0.233	0.080

RM: Reishi mushroom; L*: Brightness value; a*: Redness value; b*: Yellowness value; SEM: Standard error of the mean; P: Probability value.

Table 9. Visceral organ weights and ratios to slaughter weight of treatments groups

	Treatment Groups					
Organ Weights, g	Control	0.5% RM	1% RM	2% RM	SEM	P
Intestine	7.46	6.98	6.86	7.40	0.172	0.524
Heart	1.64	1.50	1.51	1.49	0.024	0.073
Liver	4.48	4.18	4.36	4.60	0.135	0.729
Gizzard	4.14	4.09	3.92	4.18	0.066	0.530
Spleen	0.13	0.12	0.15	0.11	0.006	0.055
Bursa	0.26	0.27	0.24	0.23	0.009	0.358
Testes*	2.78	2.47	2.74	2.27	0.133	0.624
Organ Weight / Slaughter Weight, %						
Intestine	3.98	4.10	3.96	4.23	0.079	0.618
Heart	0.88	0.82	0.82	0.78	0.024	0.485
Liver	2.39	2.32	2.36	2.47	0.078	0.913
Gizzard	2.23	2.38	2.26	2.39	0.032	0.170
Spleen	0.07^{b}	0.07^{b}	0.09^{a}	0.07^{b}	0.003	**0.029**
Bursa	0.14	0.16	0.14	0.14	0.005	0.534
Testes*	1.55	1.42	1.66	1.39	0.097	0.729

$^{a, b}$: Means indicated with different letters in the same row are significantly different; RM: Reishi mushroom; SEM: Standard error of the mean; P: Probability value.
*: Testes weights were taken from male quail.

Table 10. Intestine bacteria populations of the treatment groups

	Treatment Groups					
Microbial Population	Control	0.5% RM	1% RM	2% RM	SEM	P
Total bacteria, logx10^{6} CFU	25.04	25.57	29.91	28.18	1.094	0.341
Escherichia coli, logx10^{6} CFU	3.90	4.00	4.20	4.60	0.234	0.733
Lactobacillus bacteria, logx10^{6} CFU	5.07	6.13	7.89	6.73	0.415	0.099

CFU: Coliform unit; RM: Reishi mushroom; SEM: Standard error of the mean; P: Probability value.

Table 11. Serum biochemical parameters of the treatment groups

	Treatment Groups					
Parameter	Control	0.5% RM	1% RM	2% RM	SEM	P
Total Cholesterol, mg/dL	239.37	248.56	251.13	261.06	6.483	0.703
Glucose, mg/dL	332.00	335.07	312.83	335.77	4.942	0.283
Total Protein, g/dL	1.54	1.53	1.57	1.67	0.044	0.676
Triglyceride, mg/dL	151.47	155.08	145.39	163.91	7.716	0.879

RM: Reishi mushroom; SEM: Standard error of the mean; P: Probability value.

DISCUSSION

In present study, effects of Reishi mushroom supplementation (at 0.5, 1 and 2% ratios) into quail diets on live weight, live weight change, feed consumption, feed conversion ratio, carcass traits, carcass color parameters, visceral organ weights, intestine bacteria populations and serum biochemical parameters were investigated and values observed from treatment groups were compared with the values of a control group which fed with a basal diet.

Dietary RM supplementations did not influence LW of experimental animals, except 3rd week, and LW of RM supplemented groups slightly decreased in the 3rd week, but they have compensated the LW at the end of the experiment; so LWC did not influenced by dietary RM inclusion. As it was indicated by different researchers (Buwjoom and Yamauchi, 2005; Daneshmand et al., 2011; Kavyani et al. 2012; Fard et al., 2014), decreasing live weights were observed with mushroom supplementations into poultry diets; some other researchers have reported improved performance in poultry with the inclusion of mushroom species (Shimadai et al., 2002; Giannenas et al., 2011; Willis et al., 2011; Shamsi et al., 2015b). On the other hand, Guo et al. (2004) incorporated different mushroom powders to broilers diet and concluded that these additives had no significant effects on the birds' body weight. Similarly, Fard et al. (2014) reported that inclusion of mushroom wastes had no significant effect on the whole period LW and LWC of broilers. Similar to LW, different statements were found in the literature regarding to effects of mushroom supplementation to poultry diets on FC. While, Fard et al. (2014) reported that supplementation of 1% mushroom wastes to broiler diets led to the significant increase of FC; Buwjoom and Yamauchi (2005) and Daneshmand et al. (2011) showed that FC were suppressed in broilers subjected to dietary mushroom inclusion. In addition, Asadi-Dizaji et al. (2017) reported that the level of dietary mushroom had no significant effect on LW, FC and FCR of quail. The inconsistency of findings from different studies on the use of different mushroom species in poultry diets are also exists in terms of FCR (De Barros et al., 2012; Toghyani et al., 2012; Willis et al., 2013; Fard et al., 2014; Shamsi et al., 2015b). These results indicated that the birds responded differently to the mushroom type and dietary level. Guo et al. (2003) stated the wide variety of the physicochemical properties of different mushroom polysaccharides, such as sugar composition, molar weights, and structures.

Dietary RM supplementations into quail diets did not influence carcass weights and traits (like carcass pH and color parameters), also visceral organ weights of the treatment groups. However, antibacterial, antiviral and immune regulatory effects of mushrooms were reported in previous studies (Chang, 1996; Hirasawa et al., 1999; Hatvani, 2001; Shieh et al., 2001; Berger et al., 2004). According to this, in our study, RM supplementation did not resulted in significant changes of intestinal microbiota; but there was a slight increase in intestine total bacteria count and *Lactobacillus* bacteria rates in the intestines. Such changes in intestinal microflora by mushroom inclusion to poultry diets were reported also by Guo et al. (2004) and Willis et al. (2007).

The differences in blood serum total cholesterol, total protein, glucose and triglyceride levels of the treatment groups at the end of the experiments were not found to be significant. While, literature does not contain many studies in this area; Shamsi et al. (2015b) reported that serum concentration of total protein, triglycerides and glucose levels did not affected by mushroom supplementation to the broiler diets. Similar findings reported by Daneshmand et al. (2011) for serum triglyceride and cholesterol levels in broilers fed with mushroom supplemented diets. Also, Buwjoom and Yamauchi (2005) indicated that Shiitake mushroom stalk supplementation into broiler diets did not change blood serum cholesterol and glucose levels.

CONCLUSIONS

The results of current study indicated that using up to 2% Reishi mushroom powder in quail diet had not any negative effect on animal performance or other evaluated parameters. It should be noted that greater levels of RM may offer potential as a growth promoting substance in poultry diets. Also, present findings on quail may also be valid for the other poultry species. Therefore, further research is recommended to be conducted with the other poultry species and different types of mushroom.

AUTHOR STATEMENT

All the authors of this manuscript have contributed significantly towards the execution of this work.

CONFLICT OF INTEREST

The authors do not have any conflict of interest.

ACKNOWLEDGEMENT

This study was supported by the Scientific Research Projects Department of Erciyes University, Turkey (Project no: FHD- 2017- 7347).

REFERENCES

Anadón A, Martínez-Larrañaga MR (1999). Residues of antimicrobial drugs and feed additives in animal products: regulatory aspects. Livestock Product Science 59:183-198.

AOAC International (2005). Association of Official Analytical Chemists. AOAC International (21th ed.), Gaithersburg, MD.

Asadi-Dizaji A, Aghdam Shahryar H, Maheri-Sis N (2017). Effect of levels of oyster mushroom (*Pleurotus ostreatus*) on performance and blood biochemical characteristics in Japanese quails (*Coturnix coturnix Japonica*). Iranian Journal of Applied Animal Science 7(4): 687-691.

Asghar MU, Doğan SC, Wilk M, Korczyński M (2022). Effect of dietary supplementation of black cumin seeds (*Nigella sativa*) on performance, carcass traits, and meat quality of Japanese quails (*Coturnix coturnix Japonica*). Animals 12(10): 1298.

Berger A, Rein D, Kratky E, Monnard I, Hajjaj H, Meirim I, Piguet-Welsch C, Hauser J, Mace K, Niederberger P (2004) Cholesterol-lowering properties of G*anoderma lucidum* in vitro, ex vivo and in hamster and minipigs. Lipids in Health and Disease 3(1): 1-12.

Buwjoom T, Yamauchi KE (2005). Effects of shiitake mushroom stalk meal on growth performance, carcass yield and blood composition in broilers. The Journal of Poultry Science 42(4): 283-290.

Casewell, M., Friis, C., Marco, E., McMullin, P., & Phillips, I. (2003). The European ban on growth-promoting antibiotics and emerging consequences for human and animal health. Journal of antimicrobial chemotherapy, 52(2), 159-161.

Chang R (1996). Functional properties of edible mushrooms. Nutrition Reviews 54(11): 91-93.

Daneshmand A, Sadeghi GH, Karimi A, Vaziry A (2011). Effect of oyster mushroom (*Pleurotus ostreatus*) with and without probiotic on growth performance and some blood parameters of male broilers. Animal Feed Science and Technology 170: 91-96.

De Barros R, Vieira SL, Favero A, Taschetto D, Mascarello NC, Cemin HS (2012). Reassessing flavophospholipol effects on broiler performance. Revista Brasileira de Zootecnia 41: 2458-2462.

Ekizoğlu H, Ülger İ, Kaliber M, Ayaşan T (2020) Effects of Spirulina (Algae) supplementation to Japanese Quail (*Coturnix coturnix Japonica*) diets on growth performance and carcass traits. Indian Journal of Animal Sciences 90(6): 923–927.

Fard SH, Toghyani M, Tabeidian SA (2014). Effect of oyster mushroom wastes on performance, immune responses and intestinal morphology of broiler chickens. International Journal of Recycling of Organic Waste in Agriculture 3(4): 141-146.

Fouladi P, Ebrahimnezhad Y, Shahryar HA, Maheri N, Ahmadzadeh A (2018). Effects of organic acids supplement on performance, egg traits, blood serum biochemical parameters and gut microflora in female Japanese quail (*Coturnix coturnix japonica*). Brazilian Journal of Poultry Science 20: 133-144.

Giannenas I, Tontis D, Tsalie E, Chronis EF, Doukas D, Kyriazakis I (2010). Influence of dietary mushroom *Agaricus bisporus* on intestinal morphology and microflora composition in broiler chickens. Research in Veterinary Science 89(1): 78-84.

Giannenas I, Tsalie E, Chronis EF, Mavridis S, Tontis D, Kyriazakis I (2011). Consumption of *Agaricus bisporus* mushroom affects the performance, intestinal microbiota composition and morphology, and antioxidant status of turkey poults. Animal Feed Science and Technology 165: 218-229.

Guo FC, Savelkoul HFJ, Kwakkel RP, Williams BA, Verstegen MWA (2003). Immunoactive, medicinal properties of mushroom and herb polysaccharides and their potential use in chicken diets. World's Poultry Science Journal 59: 427-440.

Guo FC, Williams BA, Kwakkel RP, Li HS, Li XP, Luo JY, Li WK, Verstegen MWA (2004). Effects of mushroom and herb polysaccharides, as alternatives for an antibiotic, on the cecal microbial ecosystem in broiler chickens. Poultry Science 83(2): 175-182.

Guo L, Hua J, Luan Z, Xue P, Zhou S, Wang X, Qin N (2019). Effects of the stems and leaves of *Astragalus membranaceus* on growth performance, immunological parameters, antioxidant status, and intestinal bacteria of quail. Animal Science Journal 90(6): 747-756.

Gustafson RH, Bowen RE (1997). Antibiotic use in animal agriculture. Journal of Applied Microbiology 83(5): 531-541.

Hatvani N (2001). Antibacterial effect of the culture fluid of *Lentinus edodes* mycelium grown in submerged liquid culture. International Journal of Antimicrobial Agents 17(1): 71-74.

Hirasawa M, Shouji N, Neta T, Fukushima K, Takada K (1999). Three kinds of antibacterial substances from *Lentinus edodes* (Berk.) Sing. (Shiitake, an edible mushroom). International Journal of Antimicrobial Agents 11(2): 151-157.

Kavyani A, Zare SA, Porreza J, Jalali Haji-badi SMA, Landy N (2012). Evaluation of dried powder of mushroom (*Agaricus bisporus*) as an antibiotic growth promoter substitution on performance, carcass traits and humoral immune responses in broiler chickens. Journal of Medical Plants Research 6(1): 94-100.

Kheiri F, Faghani M, Landy N (2018). Evaluation of thyme and ajwain as antibiotic growth promoter substitutions on growth performance, carcass characteristics and serum biochemistry in Japanese quails (*Coturnix coturnix Japonica*). Animal Nutrition 4(1): 79-83.

Landy N, Ghalamkari GH, Toghyani M (2012). Evaluation of St John's Wort (*Hypericum perforatum* L.) as an antibiotic growth promoter substitution on performance, carcass characteristics, some of the immune responses, and serum biochemical parameters of broiler chicks. Journal of Medicinal Plants Research 6(3): 510-515.

NRC (1994). Nutrient requirements of poultry. Ninth Revised Edition. National Academy Press. Washington, D.C.

Shamsi S, Seidavi A, Rahati M, Gómez Nieto JÁ (2015a). Effect of mushroom powder and flavophospholipol on carcass in broiler chickens. Revista Mexicana de Ciencias Pecuarias 6(4): 469-481.

Shamsi S, Seidavi A, Rahati M, G Nieto JÁ (2015b). Edible mushroom powder (*Agaricus bisporus*) and flavophospholipol improve performance and blood parameters of broilers. Revista Colombiana de Ciencias Pecuarias 28(4): 291-302.

Shieh YH, Liu CF, Huang YK, Yang JY, Wu IL, Lin CH, Lin SC (2001). Evaluation of the hepatic and renal-protective effects of *Ganoderma lucidum* in mice. The American Journal of Chinese Medicine 29(03n04): 501-507.

Shimadai Y, Morita T, Sugiyama K (2002). Effects of *Lentinus edodes* on fatty acid and molecular species profiles of phosphatidylcholine in rats fed different levels of corn oil. Bioscience, Biotechnology and Biochemistry 66(8): 1759-1763.

Siadati SA, Ebrahimnezhad Y, Salehi Jouzani GH, Shayegh J (2017). Evaluation of probiotic potential of some native *Lactobacillus* strains on the growth performance and serum biochemical parameters of Japanese quails (*Coturnix Coturnix Japonica*) during rearing period. Brazilian Journal of Poultry Science 19: 399-408.

Smith J, Neil R, Richard S (2002). Medicinal mushrooms: their therapeutic properties and current medical usage with special emphasis on cancer treatments. London: Cancer Research, UK.

SPSS (1998). SPSS for windows. Base System User's Guide, Release 9.05. SPSS Inc., Chicago.

Toghyani M, Tohidi M, Gheisari A, Tabeidian A, Toghyani M (2012). Evaluation of oyster mushroom (*Pleurotus ostreatus*) as a biological growth promoter on performance, humoral immunity, and blood characteristics of broiler chicks. The Journal of Poultry Science 49(3): 183-190.

Turgud FK, Narinç D (2022). Influences of dietary supplementation with Maca (*Lepidium meyenii*) on performance, parameters of growth curve and carcass characteristics in Japanese quail. Animals 12(3): 318.

Wang H, Ng TB, Ooi VE (1998). Lectins from mushrooms. Mycological Research 102(8): 897-906.

Wang FR, Dong XF, Tong JM, Zhang XM, Zhang Q, Wu YY (2009). Effects of dietary taurine supplementation on growth performance and immune status in growing Japanese quail (*Coturnix coturnix Japonica*). Poultry science 88(7): 1394-1398.

Willis WL, Isikhuemhen OS, Ibrahim SA (2007). Performance assessment of broiler chickens given mushroom extract alone or in combination with probiotics. Poultry Science 86(9): 1856-1860.

Willis WL, Isikhuemhen OS, Hurley S, Ohimain EI (2011). Effect of phase feeding supplemental fungus myceliated grain on oocyst excretion and performance of broiler chickens. International Journal of Poultry Science 10(1): 1-3.

Willis WL, Wall DC, Isikhuemhen OS, Jackson JN, Ibrahim S, Hurley SL, Anike F (2013). Effect of level and type of mushroom on performance, blood parameters and natural coccidiosis infection in floor-reared broilers. The Open Mycology Journal 7(1): 1-6.