JSAES
Journal of Sustainable Agricultural and Environmental Sciences

Print ISSN : 2735-4377
Online ISSN : 2785-9878
Homepage: https://jsaes.journals.ekb.eg/

Research Article

Effect of Pomegranate Peel Powder Supplementation on Growth Performance, Carcass Characteristics and Blood Metabolites of Japanese Quails

Talaat K. El-Rayes[*1]; Gehad E. Badawy[1]; Wael Awad El-Morsy[2]

[1]Department of Animal Production, Faculty of Agriculture, Tanta University 31527, Tanta, Egypt.
[2]Animal Production Research Institute, Agriculture Research Center, Sakha Research Station, Egypt.
[*] Correspondence: talat.elrayes@gmail.com

Article info: -

- **Received: 10/8/2023**
- **Revised: 22/8/2023**
- **Accepted: 27/8/2023**
- **Published: 29/8/2023**

Keywords:
Pomegranate peel; Japanese quail; Productive performance; Carcass characteristics; Blood metabolites.

Abstract:

This study aimed to assess the impacts of pomegranate peel powder on growth performance, carcass characteristics and blood metabolites of Japanese quails. A total of 300 one-week-old male Japanese quails were randomly distributed into 4 equal groups (75 birds into 5 replicates/group). The 1st group (control) was fed the basal diet without any pomegranate peel powder, while pomegranate peel powder was added at levels of 300, 600, and 900 g per ton of feed, respectively in the 2nd, 3rd and 4th groups. At 5 wks of age, the best values of productive performance represented in body weight, weight gain, feed consumption and feed conversion ratio were achieved in groups fed diet supplemented with 900 g pomegranate peel powder/ton. No significant differences between all treatments for carcass characteristics were observed, except for the relative weights of lymphoid organs (bursa of Fabricius, thymus and spleen) which were improved by using pomegranate peel powder at the level of 900g/ton of feed. Additionally, dietary 900 g/ton pomegranate peel powder improved plasma concentration of total protein, albumin, globulin, triglycerides, cholesterol, HDL-cholesterol, and LDL-cholesterol. It could be concluded that, supplemented diet with pomegranate peel powder up to 900g/ton improved the productive performance traits, carcass characteristics and blood biochemical of Japanese quails.

1. Introduction

The growing concerns of consumers on the use of antibiotic as a growth promoter in poultry feed have fueled the interest in alternative products. In view of the ban on antibiotic growth promoters (AGP) in the European Union and in Egypt and the expected expansion of this trend to the rest of the world, intensive research has been focused on the development of alternative strategies to maintain health and performance status in modern livestock production systems. Different substances, referred to as natural growth promoters (NGP), have been identified as effective alternatives to AGP (Roth et al., 2019; Abd El-Hack et al., 2020).

At present, a large number of NGP are available on the market, including organic acids, immune-modulators, probiotics, prebiotics, enzymes and phytobiotics (Ebeid and Al-Homidan, 2022). All these products have the potential to beneficially affect gut health and growth performance by establishing and maintaining a well-balanced gut microflora which protects the host against pathogenic invasion. In some cases, however, scientific reports are inconsistent regarding the efficacy of NGP, whilst their mode of action remains, at least partly, undiscovered (Alagawany et al., 2018, 2021; Elgeddawy et al., 2020; Rehman et al., 2020).

These feed additives have been tested in the form of extracts, cold-pressed oils, and essential oils in a number of animals but the results are variable. Therefore, their application as feed additives has been limited, largely owing to their inconsistent efficacy and lack of full understanding of the modes of action. The future of these feed additives depends on the characteristics of herbs, the knowledge of their major and minor constituents, the in-depth knowledge of their mode of action, and their value based on the safety of the animal and its products (Saleh et al., 2019; Reda et al., 2021; Hussein et al., 2023).

Phytogenic are a heterogeneous group of feed additives originating from plants and consist of herbs, spices, fruit, and other plant parts. These feed additives are reported to have a wide range of activities including antimicrobial, anthelminthic, antioxidant, growth enhancer, and immune modulator (Al-Homidan et al., 2020). Besides these properties they are also reported to stimulate feed intake and endogenous secretion and enhance production. They include many different bio-active ingredients such as alkaloids, bitters, flavonoids, glycosides, mucilage, saponins, tannins phenolic, polyphenols, terpenoids, and polypeptide (Reda et al., 2021). In this sense, pomegranate (*Punica granatum* L.) peel is one of several natural feed additives that have gained popularity as prophylactics and growth enhancers in poultry feeding throughout the recent years. It is a by-product made from pomegranate fruit that is typically left over following the juice production. Pomegranate peel powder is a novel feed additive because it has a high fiber, lipids and proteins content. In terms of crude

 10.21608/jsaes.2023.228532.1045

fibre (CF), ether extract (EE), ash, and lignin concentration, dried pomegranate peel outperforms yellow corn. In contrast to dried pomegranate peel, yellow maize had higher concentrations of CP, nitrogen-free extract (NFE), neutral detergent fibre (NDF), acid detergent fiber (ADF), hemicellulose, cellulose, and gross energy (GE) (Omer et al., 2019). It may provide health advantages due to its high antioxidant polyphenol content. The principal constituents in pomegranate peels include phenolic compounds with high antioxidant potential, such as punicalagin, gallic acid, fatty acids, catechin, quercetin, rutin, flavonols, flavones, flavanones, and anthocyanidins (Derakhshan et al., 2018 and Sharifian et al., 2019). The peel contains some of the weight-loss and health-improving properties of antibiotics and hormones without the negative side effects, and it may produce meat with higher amounts of beneficial antioxidants (Shabtay et al., 2008).

According to Lansky and Newman, (2007) and Viuda-Martos et al., (2010), the peel of pomegranate fruits can be used as a functional ingredient because it is a good source of crude fibres, which have a number of health benefits, including the ability to lower serum LDL-cholesterol levels, improve glucose tolerance and insulin response, lower hyperlipidemia and hypertension, improve gastrointestinal health, and prevent some cancers, such as colon cancer. Furthermore, the bioactive compound (punicalagin, ellagitannins, ellagic acid, and gallic acid) in the peel have been shown to have strong anti-bacterial and antiviral action. Phenolic chemicals can precipitate membrane proteins and impede enzyme function, resulting in bacterial mortality. In small intestinal colitis, Al-Zoreky et al. (2009) discovered that pomegranate peel extract (PPE) absorption successfully reduced Listeria monocytogenes, Staphylococcus aureus, Escherichia coli, and Yersinia pestis. The antiviral effects are mostly attributable to polyphenol extracts inhibiting virus RNA replication (Haidari et al., 2009). So, the goal of the current study was to evaluate the effect of pomegranate peel powder (PPP) as a feed supplement on quail productivity, carcass traits, and blood metabolites.

2. Materials and Methods

2.1. Experimental Design

2.1.1. Birds and management

Three hundred one-week-old male Japanese quail chicks were randomly divided into 4 experimental groups with five duplicates of fifteen birds. The first group served as control and fed the basal diet without any PPP, while PPP were added at levels of 300, 600, and 900g per ton of feed in the 2nd, 3rd and 4th groups; respectively. Throughout the five-week of study, all experimental groups were raised in conventional cages (100×50×40 cm) and reared under similar managerial and hygienic conditions.

2.1.2. Experimental diet

The basal diet was a commercial corn-soybean meal diet formulated to meet or exceed the nutritional requirement of growing Japanese quail as recommended by the National Research Council (NRC, 1994) as shown in Table (1)

Table (1): The composition and calculated analysis of basal diet.

Ingredients	kg/ton
Yellow corn (8.5%)	518.0
Soybean meal (44%)	367.0
Corn gluten meal (62%)	52.10
Premix[1]	3.00
Soybean oil	29.00
Dicalcium phosphate	16.50
Limestone	7.00
Salt	3.00
Dl-Methionine	1.10
L. Lysine	1.30
Choline chloride	2.00
Total	1000
Calculated analysis [2]	
Crude protein (%)	23.78
ME, MJ/Kg	12.59
Digestible Lys	1.30
Digestible Meth + Cysteine	0.92
Digestible Thr	0.78
Calcium	0.80
Available phosphorus	0.45

[1] Each 3kg of premix contained: Vit. A 12000IU, Vit. D 2200IU, Vit. E 10mg, Vit. K_3 2000mg, Vit. B_1 1000mg, Vit. B_2 3000mg, Vit. B_6 1300mg, Vit. B_{12} 10mg, Pantothenic acid 10mg, Niacin 30mg, Folic acid 1000mg, Biotin 50mg, Choline chloride 300mg, Manganese 60mg, Zinc 50mg, Copper 10mg, Iron 30mg, Iodine 1000mg, Selenium 100mg, Cobalt 100mg and $CaCo_3$ to 3g.

[2] Calculated according to NRC (1994).

2.2. Measurements

2.2.1. Performance traits

Live body weight (LBW), weight gain (WG), feed consumption (FC) and feed conversion ratio (FCR) were evaluated at first and fifth wks of age, as fellow:

$$WG = LBW_2 - LBW_1$$

$$FCR = \frac{\text{Feed consumed (g) during a certain period}}{\text{Body weight gain (g) during the same period}}$$

2.2.2. Carcass characteristics:

At the end of the trial, fifteen birds from each group (3 birds from each replicate) were randomly chosen for the slaughter test, weighed, and then slain by having their jugular veins severed in the morning. The birds were then scalded and defeated following total bleeding. Spleen, bursa of Fabricius, thymus, liver, heart, and gizzard were individually weighed after the carcasses had been carefully dissected and eviscerated. All organ weights were converted to an arcsine expression and represented as a percentage of body weight.

2.2.3. Blood plasma biochemical parameters:

At the end of the trial, blood samples were collected from 5-week-old Japanese quails into heparinized tubes and centrifuged for 15 min at 3000 rpm to obtain plasma. Plasma samples were examined for levels of total protein, albumin, globulin, triglycerides, cholesterols, HDL-cholesterol, LDL-cholesterol, VLDL, and the activity of alanine aminotransferase (ALT) and aspartate aminotransferase (AST) enzymes using a microplate spectrophotometer with a commercial detection kit (Bio-diagnostic, Egypt), following the manufacturer's instructions.

2.3. Statistical analysis

Data were statistically analyzed by one-way ANOVA, using the general linear model procedure (SAS, 1996). Tests of significance for differences among treatments were done according to Duncan (1955). The statistical model was used for the analysis of variance to estimate the effect of PPP supplementation levels on Japanese quail performance and physiological status as follows:

$Y_{ij} = U + T_i + e_{ij}$

Where:

e_{ij} = Residual effects (Random error).

Y_{ij} = The observations

U = Overall mean

T_i = Effect of treatments (i = 1, 2, 3and 4)

3. Results

3.1. Productive performance traits

Data of Japanese quail chick's BW, WG, FC and FCR as influenced by PPP supplementation level (0, 300, 600 and 900 g/ton feed) are illustrated in Table (2). The PPP supplementation significantly impacted BW, WG, FC and FCR at 5 wks of age. Chicks fed diets supplemented with PPP at the level of 300 g/ton showed the highest BW and WG (P≤0.05). On the other hand, feed consumption of Japanese quail chicks was significantly decreased by increasing PPP supplementation levels (P≤0.05). The best FCR value was observed for the group received dietary 900 g PPP /ton followed by those received 600g PPP /ton and then those treated with 300g PPP /ton of feed respectively, as compared to the control.

Table (2): Productive performance of Japanese quail affected by Pomegranate peel powder supplementation levels.

PPP levels (g/ton feed)	Initial BW	BW at 5 wks.	WG at 5 wks.	FC at 5 wks.	FCR at 5 wks.
0	29.18	255.54[b]	226.36[b]	796.69[a]	3.52[a]
300	30.60	266.07[a]	235.47[a]	788.78[a]	3.35[b]
600	30.15	258.67[ab]	228.52[ab]	772.40[b]	3.38[b]
900	29.31	260.30[a]	230.99[a]	761.32[c]	3.30[c]
SEM	±0.48	±3.18	±4.23	±6.42	±0.18
significant	NS	*	*	*	*

-Means of each column followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

-NS indicate not significant -* indicate significance at P≤0.05

Table (3): Carcass characteristics of Japanese quail affected by pomegranate peel powder supplementation levels.

PPP levels (g/ton feed)	% Carcass	% Total giblets			Dressing	% Lymphoid organs		
		Heart	Liver	Gizzard		bursa of Fabricius	Thymus	spleen
0	75.20	0.91	1.88	1.50	79.49	0.07[b]	0.23[b]	0.07[b]
300	74.15	0.88	1.95	1.31	78.29	0.08[b]	0.26[ab]	0.08[ab]
600	72.42	0.89	1.97	1.32	76.60	0.08[b]	0.27[ab]	0.11[a]
900	70.84	0.85	1.75	1.29	74.73	0.12[a]	0.32[a]	0.11[a]
SEM	±1.57	±0.05	±0.12	±0.12	±1.34	±0.01	±0.04	±0.01
significant	NS	NS	NS	NS	NS	*	*	*

-Means of each column followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.

-NS indicate not significant -* indicate significance at P≤0.05

3.2. Carcass characteristics

Data illustrated in Table (3) shows the effect of PPP supplementation levels on carcass characteristics of Japanese quails. Results indicated that there were no significant (P>0.05) differences between all treatments for all carcass characteristics indices except the relative weights of lymphoid organs (bursa of Fabricius, thymus and spleen), which were significantly increased by increasing the PPP supplementation level from 300 up to 900 g/ton of feed, as compared to the control group (P≤0.05).

Table (4): Blood biochemical of Japanese quail affected by pomegranate peel powder supplementation levels.

PPP levels (g/ton feed)	TP mg/dl	Alb. mg/dl	Glob. mg/dl	A/G Ratio	ALT U/l	AST U/l	Trigly. mg/dl	Chols. mg/dl	HDL-Chols. mg/dl	LDL-Chols. mg/dl
0	3.62[b]	1.78[b]	1.84[b]	0.97	10.50	9.33	192.42[a]	191.77[a]	114.18[b]	60.59[a]
300	3.76[b]	1.83[b]	1.93[ab]	0.95	11.16	8.16	176.27[b]	178.21[b]	121.83[ab]	44.29[b]
600	4.14[a]	2.06[a]	2.08[a]	0.99	9.74	8.72	158.71[c]	175.88[b]	124.72[a]	39.16[b]
900	4.00[a]	1.98[a]	2.02[a]	0.98	9.58	8.16	141.07[d]	162.35[c]	128.24[a]	29.12[c]
SEM	±0.23	±0.06	±0.05	±0.04	±0.85	±0.76	±22.5	±7.45	±6.37	±3.48
significant	*	*	*	NS	NS	NS	*	*	*	*

- TP= total protein, Alb= albumin, Glob= globulin, ALT= alanine aminotransferase, AST= aspartate aminotransferase, Trigly= triglycerides, Chols=cholesterol, HDL= high density lipoprotein, LDL= low density lipoprotein.
-Means of each column followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test.
-NS indicate not significant -* indicate significance at P≤0.05

3.3. Blood plasma metabolites

Data illustrated in Table (4) shows the effect of PPP supplementation levels on blood plasma biochemical parameters of Japanese quail. No significant (P>0.05) differences between all treatments were observed for the activity of AST and ALT enzymes and A/G ratio. On the other hand, the concentration of plasma total protein, albumin, globulin and HDL-cholesterol were significantly increased by increasing PPP supplementation level from 300 up to 900 g/ton of feed (P≤0.05). However, the plasma concentration of triglycerides, cholesterol and LDL-cholesterol were significantly decreased by increasing PPP supplementation level from 300 up to 900 g/ton of feed (P≤0.05).

4. Discussion

Results of growth performance that illustrated in Table 2 recorded that when PPP incorporated at different levels (300, 600, and 900g/ton), it caused an improvement in their gain while decreasing their FC and improving their FCR. The positive effect of PPP on productive performance parameters (BW, WG, and FCR) may be due to the higher content of various nutrients and functional ingredients such as fiber and protein which have the capacity to provide the body with the necessary amino acids and non-essential nitrogen needed for protein synthesis, improve gastrointestinal health and stimulates the growth rate (Lansky and Newman, 2007; Khlil et al., 2017; Omer et al., 2019; El- Hamamsy and El- khamissi, 2020). In addition, PPP is an excellent source of natural antioxidants such as punicalagin, ellagitannins, ellagic acid, and gallic acid which can precipitate membrane proteins and impede enzyme function, resulting in pathogenic bacterial mortality and balancing the gut microbial ecosystem (Al-Zoreky et al., 2009; Kanatt et al., 2010; Rowayshed et al., 2013; Rajaian et al., 2013).

Also, the improvement in quail productive performance upon addition of PPP may be attributed to its positive effect in stimulating the gastro-intestinal enzymatic activity, and consequently enhancing nutrient digestibility and absorption (Fayed et al., 2012; Banerjee et al., 2013). The reduction in the amount of feed consumed by group received PPP may be attributed to the high concentration of tannin in PPP which negatively effect on palatability (Reed, 1995; Kushwaha et al., 2013). The current results are compatible with that observed by some authors who studied the effect of PPP or its extract (PPE) as a feed additive on the performance traits of poultry and they revealed that PPP or its extract improved BW, WG, FC and FCR (Abdel-Wahab and Mosad, 2018; Akuru et al., 2020; Ahmadipour et al., 2021; Akuru et al., 2021; Elnaggar et al., 2022). On the other direction, some authors observed that PPP or its extract affected negatively the performance traits (Hamad et al., 2019; Sadabadi et al., 2021;). While, some authors did not find any significant effects of adding PPP on the productive performance of poultry (Abas et al., 2017; Yaseen et al., 2014).

The improvement in the relative weights of lymphoid organs considered a clear evidence for the improvement of the immune response and that may attribute to the functional ingredient and its high antioxidant polyphenol content which can significantly reduce the adverse effects of reactive oxygen and nitrogen species on normal physiological and immunological functions (Saleh et al., 2019; Akuru et al., 2020; Sadabadi et al., 2021). These results are in the line with those observed by Hamady et al. (2015) who found that, the internal organs were not affected by the addition of pomegranate peel extract at a rate of (10g/100kg of feed). Additionally, Elnaggar et al. (2022) and Baqer and Iprahim, (2022) found that supplementation of PPP or PPE are able to improve the relative weight of lymphoid organs significantly.

Results of the present study indicated that the supplementation of PPP in the Japanese quail diet improved liver function, and this was evident in the improvement of plasma total protein, Albumin, globulin, cholesterol, HDL, and LDL concentrations. The current results of blood metabolites agreed with the finding of Rahmani and Aldebasi, (2016) who suggested that dietary supplementation of PPP showed a potential hepatoprotective effect depending on the presence of phenolic and antioxidant compounds in PPP such as punicalagin, gallic acid, fatty acids, catechin, quercetin, rutin, flavonols, flavones, flavanones, and anthocyanidins. Furthermore, PPE is reported to be able to inhibit the activity of pancreatic lipase which depress fat absorption in the intestine and is excreted through feces (Kishawy et al., 2019). This assumption is supported by the findings of Kumar et al. (2018) that a diet of 100 mg/kg of PPE recorded the lowest serum cholesterol levels. Saki et al (2019) found a decrease in the level of plasma total lipids and glucose because of feeding birds pomegranate peels, which may be due to the high percentage of fiber. The lower cholesterol in the blood and triglycerides by PPP could possibly be due to phenol compounds such as pontiacagen and pontiacin, in particular and it may stimulate pomegranate polyphenols and promote cholesterol metabolism by modifying HDL transport (Esmaillzadeh et al., 2004).

The PPP supplementation decreased the LDL levels, which is in agreement with the results obtained by supplementation of PPP (Yaseen et al., 2014; Kishawy et al., 2019; Akbari et al., 2023). This reduction confirmed the lower cholesterol levels observed in this study because HDL and LDL molecules are the chief transporters of cholesterol from its site of synthesis, i.e. the liver, to the body tissues and they consequently decrease cholesterol and triglycerides available for tissue metabolism, lipogenesis in liver and fat accumulation in carcasses (Alvarenga et al., 2011).

5. Conclusions

In conclusion, it could be recommended that, supplemented diet with PPP up to the level of 900g /ton improved productive performance traits and physiological response of Japanese quails.

Author Contributions: T. E. and W. E. planned and supervised the research. G. B. and T.E. conducted the experimental work and analyzed the data. T. E.; W. E. and G. B. wrote the manuscript with the input of all the other authors.

Funding: “This research received no external funding”

Institutional Review Board Statement: The institutional ethical rules of Agriculture College - Tanta University (No. AY 2019-2020/Session 6/2020.01.13) in dealing with animals for scientific purposes were followed during the experiment period.

Informed Consent Statement: “Not applicable”

Data Availability Statement: “Not applicable”

Acknowledgments: The authors are thankful to the lab technicians.

Conflicts of Interest: No conflict of interest regarding the publication of this paper.

5. References

Abbas, R. J.; Al-Salhie, K. C. K. and Al-Hummod, S. K. (2017). The effect of using different levels of pomegranate (Punica granatum) peel powder on productive and physiological performance of Japanese quail (Coturnix coturnix japonica). Livestock Research for Rural Development, 29(12): 1-7.

Abd El-Hack, M. E.; El - Saadony, M. T.; Shafi, M. E.; Qattan, S. Y.; Batiha, G. E.; Khafaga, A. F. and Alagawany, M. (2020). Probiotics in poultry feed: A comprehensive review. Journal of Animal Physiology and Animal Nutrition, 104(6): 1835-1850.

Abdel-Wahab, A. A. and Mosad, A. S. (2018). Effect of adding pomgeranate peels to growing Japanese quail diet on performance, blood and immunity parametrs. Egyptian Journal of Nutrition and Feeds, 21(3): 771-782.

Ahmadipour, B.; Pat, S.; Abaszadeh, S.; Hassanpour, H. and Khajali, F. (2021). Pomegranate peel as a phytogenic in broiler chickens: Influence upon antioxidant, lipogenesis and hypotensive response. Veterinary Medicine and Science, 7(5): 1907-1913.

Akbari, S. M.; Ardekani, H. M. and Sabour, H. (2023). The effect of using pomegranate peel powder and protexin probiotic on carcass traits, blood parameters, jejunal tissue morphology and intestinal microbial population of Japanese quails. Revista Brasileira de Higiene e Sanidade Animal, 17(1): 1-11

Akuru, E. A.; Mpendulo, C. T.; Oyeagu, C. E. and Nantapo, C. W. T. (2021). Pomegranate (Punica granatum L.) peel powder meal supplementation in broilers: effect on growth performance, digestibility, carcase and organ weights, serum and some meat antioxidant enzyme biomarkers. Italian Journal of Animal Science, 20(1): 119-131.

Akuru, E. A.; Oyeagu, C. E.; Mpendulo, T. C.; Rautenbach, F. and Oguntibeju, O. O. (2020). Effect of pomegranate (Punica granatum L) peel powder meal dietary supplementation on antioxidant status and quality of breast meat in broilers. Heliyon, 6(12): e05709.

Alagawany, M.; El-Hack, M.; Farag, M. R.; Tiwari, R. and Dhama, K. (2015). Biological effects and modes of action of carvacrol in animal and poultry production and health-a review. Advances in Animal and Veterinary Sciences, 3(2s): 73-84.

Alagawany, M.; El-Saadony, M. T.; Elnesr, S. S.; Farahat, M.; Attia, G.; Madkour, M. and Reda, F. M. (2021). Use of lemongrass essential oil as a feed additive in quail's nutrition: its effect on growth, carcass, blood biochemistry, antioxidant and immunological indices, digestive enzymes and intestinal microbiota. Poultry Science, 100(6): 101172.

Al-Homidan, I.H., T.A. Ebeid, A. Al-Muzaini, O.K. Abou-Emera, M.M. Mostafa, and M.M. Fathi (2020). Impact of dietary fenugreek, mung bean, and garden cress on growth performance, carcass traits, blood measurements, and immune response in broiler chickens. Livestock Science, 242: 104318.

Alvarenga, R. R.; Zangeronimo, M. G.; Pereira, L. J.; Rodrigues, P. B. and Gomide, E. M. (2011). Lipoprotein metabolism in poultry. World's Poultry Science Journal, 67(3): 431-440.

Al-Zoreky, N. S. (2009). Antimicrobial activity of pomegranate (Punica granatum L.) fruit peels. International Journal of Food Microbiology, 134(3): 244-248.

Banerjee, S.; Mukhopadhayay, S.K.; Haldar, S.; Ganguly, S.; Pradhan, S.; Patra, N.C.; Niyogi, D.; Isore, D.P.; (2013). Effect of phytogenic growth promoter on broiler birds. Journal of Pharmacognosy and Phytochemistry, 1:183–188.

Baqer, H. Q. and Ibrahim, B. M. (2022). Effect of adding pomegranate (Punica granatum) and moringa (Moringa oleifera) in productive performance, relative growth rate, water consumption and production index of broiler chickens. Journal of Karbala for Agricultural Sciences, 9(3): 1-16.

Derakhshan, Z.; Ferrante, M.; Tadi, M.; Ansari, F.; Heydari, A.; Hosseini, M. S. and Sadrabad, E. K. (2018). Antioxidant activity and total phenolic content of ethanolic extract of pomegranate peels, juice and seeds. Food and Chemical Toxicology, 114: 108-111.

Duncan, B.D. (1955). Multiple Range and Multiple F. Test. Biometrics, 11: 1- 42.

Ebeid, T. A., and I. H. Al-Homidan (2022). Organic acids and their potential role for modulating the gastrointestinal tract, antioxidative status, immune response, and performance in poultry. World's Poultry Science Journal, 78: 83-101.

Elgeddawy, S. A.; Shaheen, H. M.; El‐Sayed, Y. S.; Abd Elaziz, M.; Darwish, A.; Samak, D. and Elnesr, S. S. (2020). Effects of the dietary inclusion of a probiotic or prebiotic on florfenicol pharmacokinetic profile in broiler chicken. Journal of Animal Physiology and Animal Nutrition, 104(2): 549-557.

El-Hamamsy, S. M. A. and El-Khamissi, H. A. Z. (2020). Phytochemicals, antioxidant activity and identification of phenolic compounds by HPLC of pomegranate (Punica granatum L.) Peel extracts. Journal of Agricultural Chemistry and Biotechnology, 11(4): 79-84.

Elnaggar, A. S.; Elsebai, A.; Eltahawy, W. and Elattar, F. (2022). Effect of dietary inclusion of pomergranate peel powder (punica grantum) on growth performance and some physiological parameters of broiler chicks. Journal of Agricultural and Environmental Sciences, 21(2): 19-44.

Esmaillzadeh, A.; Tahbaz, F.; Gaieni, I.; Alavi-Majd, H.; and Azadbakht, L. (2004). Concentrated pomegranate juice improves lipid profiles in diabetic patients with hyperlipidemia. Journal of Medicine and Food, 7: 305–308.

Fayed, A. M.; Azoz, A. A.; Zedan, A. H. and Basyony, M. (2012). Effects of pomegranate peel as antioxidant supplementation on digestibility, blood biochemical and rabbit semen quality. Egyptian Journal of Nutrition and Feeds, 15: 343-54.

Haidari, M.; Ali, M.; Casscells III, S. W. and Madjid, M. (2009). Pomegranate (Punica granatum) purified polyphenol extract inhibits influenza virus and has a synergistic effect with oseltamivir. Phytomedicine, 16(12): 1127-1136.

Hamad, K. M. and Kareem, K. Y. (2019). Growth performance, carcass quality, and economics of production of Japanese quails fed with pomegranate peel powder. International Transaction Journal of Engineering, Management, Applied Sciences and Technologies, 10(14): 2228-9860.

Hamady, G. A.; Abdel-Moneim, M. A.; El-Chaghaby, G. A.; Abd-El-Ghany, Z. M. and Hassanin, M. S. (2015). Effect of pomegranate peel extract as natural growth promoter on the productive performance and intestinal microbiota of broiler chickens. African Journal of Agricultural Science and Technology, 3(12): 514-519.

Hussein, E. E.; El Basuini, M. F.; Ashry, A. M.; Habiba, M. M.; Teiba, I. I., El-Rayes, T. K.; Khattab, A. A.; El-Hais, A. M.; Shahin, S. A.; El-Ratel, I. T.; Badr, M. R. and Dawood, M. A. (2023). Effect of dietary sage (Salvia officinalis L.) on the growth performance, feed efficacy, blood indices, non-specific immunity, and intestinal microbiota of European sea bass (Dicentrarchus labrax). Aquaculture Reports, 28: 101460.

Kanatt, S. R.; Chander, R. and Sharma, A. (2010). Antioxidant and antimicrobial activity of pomegranate peel extract improves the shelf life of chicken products. International Journal of Food Science and Technology, 45(2): 216-222.

Kishawy, A. T.; Amer, S. A.; Abd El-Hack, M. E.; Saadeldin, I. M. and Swelum, A. A. (2019). The impact of dietary linseed oil and pomegranate peel extract on broiler growth, carcass traits, serum lipid profile, and meat fatty acid, phenol, and flavonoid contents. Asian-Australasian Journal of Animal Sciences, 32(8): 1161.

Krinsky, N.I.; Beecher, G.R.; Burk, R.F.; Chan, A.C.; Erdman, .J. J. and Jacob R. A.(2000). Dietary reference intakes for vitamin C, vitamin E, selenium, and carotenoids. Washington, DC: National Academies Press, 95–185.

Kumar, K. P.; Reddy, V. R. and Prakash, M. G. (2018). Effect of supplementing pomegranate (Punica granatum) peel extract on serum biochemical parameters and immune response in broilers during summer. Pharma Innovation, 7(1): 591-601.

Kushwaha, S. C.; Bera, M. B. and Kumar, P. (2013). Nutritional composition of detanninated and fresh pomegranate peel powder. IOSR Journal of Environmental Science, Toxicology and Food Technology, 7(1): 38-42.

Lansky, E. P. and Newman, R. A. (2007). Punica granatum (pomegranate) and its potential for prevention and treatment of inflammation and cancer. Journal of Ethnopharmacology, 109(2): 177-206.

NRC (1994). Nutrient requirement of poultry. 9th ed. Nat. Acad. Press, Washington. DC. USA.

Omer, H. A.; Abdel-Magid, S. S. and Awadalla, I. M. (2019). Nutritional and chemical evaluation of dried pomegranate (Punica granatum L.) peels and studying the impact of level of inclusion in ration formulation on productive performance of growing Ossimi lambs. Bulletin of the National Research Centre, 43: 1-10.

Rahmani, A.H. and Aldebasi, Y.H. (2016). Potential role of carica papaya and their active constituents in the prevention and treatment of diseases. International Journal of Pharmacology Science, 8:11-15

Rajaian, H.; Aberumandi, M.; Jalaei, J. and Khosravi, M. (2013). Satureja hortensis as a growth promoter in broiler chickens. Iranian Journal of Veterinary Research, 15: 149–153

Reda, F. M.; El-Saadony, M. T.; El-Rayes, T. K.; Farahat, M.; Attia, G. and Alagawany, M. (2021). Dietary effect of licorice (Glycyrrhiza glabra) on quail performance, carcass, blood metabolites and intestinal microbiota. Poultry Science, 100(8): 101266.

Reed, J.D. (1995). Nutritional toxicology of tannins and related polyphenols in forage legumes. Journal of Animal Science, 73: 1516-1528.

Rehman, A.; Arif, M.; Sajjad, N.; Al-Ghadi, M. Q.; Alagawany,;M.; Abd El-Hack, M. E.; and Swelum A. A. (2020). Dietary effect of probiotics and prebiotics on broiler performance, carcass, and immunity. Poultry Science, 99:6946–6953.

Roth, G. A.; Mensah, G. A.; Johnson, C. O.; Addolorato, G.; Ammirati, E.; Baddour, L. M. and GBD-NHLBI-JACC Global Burden of Cardiovascular Diseases Writing Group. (2020). Global burden of cardiovascular diseases and risk factors, 1990–2019: update from the GBD 2019 study. Journal of the American College of Cardiology, 76(25): 2982-3021.

Rowayshed, G.; Salama, A.; Abul-Fadl, M.; Akila-Hamza, S. and Emad, A.M. (2103). Nutritional and chemical evaluation for pomegranate (Punica granatum L.) fruit peel and seeds powders by products. Middle East Journal of Applied Sciences, 3(4): 169-179.

Sadabadi, M.; Ebrahimnezhad, Y.; Maheri-Sis, N.; Ghalehkandi, J. G. and Shaddel-Teli, A. (2021). Immune response and antioxidant status of broilers as influenced by oxidized vegetable oil and pomegranate peel. Journal of Animal Science and Technology, 63(5): 1034.

Saki, A.; Shamsollah, T. and Ashoori, A.(2019). Egg iron enrichment in response to various levels of pomegranate by-product in laying hen diet. Iranian Journal of Applied Animal Science, 9: 747–754.

Saleh, A.A., Enas A. M. Ahmed and T. A. Ebeid (2019). The impact of phytoestrogen sources supplementation on reproductive performance, plasma profile, yolk fatty acids and antioxidative status in aged laying hens. Reproduction in Domestic Animals, 54: 846- 854.

SAS institute (1996). SAS/STAT User's Guide; Statistics, Ver. 6.04, Fourth edition, SAS Institute, Inc., Carry, NC.

Shabtay, A.; Eitam, H.; Tadmor, Y.; Orlov, A.; Meir, A.; Weinberg, P. and Kerem, Z. (2008). Nutritive and antioxidative potential of fresh and stored pomegranate industrial byproduct as a novel beef cattle feed. Journal of Agricultural and Food Chemistry, 56(21): 10063-10070.

Sharifian, M.; Hosseini-Vashan, S. J.; Nasri, M. F. and Perai, A. H. (2019). Pomegranate peel extract for broiler chickens under heat stress: Its influence on growth performance, carcass traits, blood metabolites, immunity, jejunal morphology, and meat quality. Livestock Science, 227: 22-28.

Viuda-Martos, M.; Ruiz-Navajas, Y.; Martin-Sánchez, A.; Sánchez-Zapata, E.; Fernández-López, J.; Sendra, E. and Pérez-Álvarez, J. A. (2012). Chemical, physico-chemical and functional properties of pomegranate (Punica granatum L.) bagasses powder co-product. Journal of Food Engineering, 110(2): 220-224.

Yaseen, A. T.; El-Kholy, M. E. S. H.; El-Razik, A.; Walaa, M. and Soliman, M. H. (2014). Effect of using pomegranate peel extract as feed additive on performance, serum lipids and immunity of broiler chicks. Zagazig Veterinary Journal, 42(1): 87-92