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Research Article

Effect of various concentrations of pomegranate peel waste on the growth performance and nutrient digestibility of broilers

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Abstract

During present study one hundred-day old broiler chicks were purchased from commercial hatchery. After initial weight, chicks were randomly distributed into five treatments groups, each group consisting of 20 chicks. The chicks of group A were reared as control whereas, group B, C, D and E was fed on ration containing 0.25, 0.50, 0.75 and 1.00% of pomegranate peel waste/kg feed, respectively. Results indicates that significantly, maximum feed intake (3615.7g), water intake (6092.0 *ml*), live body weight (2258.3g) was recorded in group E. Significantly, better FCR was recorded in group E (1.39) and minimum FCR (1.96) was recorded in group A. Significantly, maximum carcass weight (1863.7g) was recorded in group E and minimum carcass weight (1492.3g) was recorded in group A. The liver weight, Spleen weight, Thymus weight, Bursa weight was non-significant. Significantly, maximum dry matter digestibility (81.51), fat digestibility (3.06), protein digestibility (23.64) was recorded in group E. Morbidity was higher in group A was (4%) and lower in group E (1%). The mortality was higher in group A was (3%) and lower in group E (1%). In conclusion, the study demonstrates that adding pomegranate peel waste at the rate of 1.00% /per kg broiler feed has significant and positive effect on feed intake, FCR, live body weight, carcass weight, dressing percentage, and digestibility for better broiler performance.

Keywords: Broilers; Digestibility; Growth performance; Pomegranate; Waste

Introduction

The poultry industry of Pakistan is a major livestock sub-sector, playing a vital role in economic growth and rural development [1]. Nutrients generally include carbohydrates, fats, proteins, minerals, vitamins, water and other components. Depending on the type and style of poultry farming for broilers and the duration of farming, the proportions of the above compounds will be constant and require different types of nutrients. When determining the amount of each nutrient in a poultry diet, it should be noted that economic nutritional, health and of course all basic needs must be met. This has drawn scientists to other food sources, including non-traditional foods, and many efforts have been made to find available food sources [2]. One of the first edible fruits, the pomegranate (*Punica granatum* L.) is a member of the *Punicaceae* family and is widely grown in many tropical and subtropical nations [3]. Pomegranate (*Punica granatum*) is well known fruit belongs to *punicaceae* family having multiple health benefits, not only limited to its edible parts but also in its non-edible parts mostly the peel [4].

Utilizing these wastes to extract important chemicals that may be added to animal nutrition has gained attention recently [3, 5]. According to [6], pomegranate seeds are thought to contain around 24% oil, and the fatty acids they contain are particularly. The predominant type of the C18:3 class is punic acid, also known as 9-cis, 11-trans, 13-cis, or trichosanic acid [3, 6]. Pomegranate seed oil has been shown many signaling pathways linked to inflammation, cell transformation, hyperproliferation, angiogenesis, the start of carcinogenesis, and perhaps the suppression of the tumor's later stages and metastasis. Pomegranate seed oil, for instance, has been proposed by [7] as a powerful inhibitor of human PC-3 prostate cancer cells. Fruit waste is produced; they are often loaded with vitamins, minerals, and other biological components and are an excellent source of fiber. Strong evidence identifies and supports the use of fruit peels or extracts such as nutraceuticals and functional foods. Numerous sources of polyphenols, including pomegranates and their peels [8], have been shown to decrease pathogens and encourage the growth of probiotic organisms in the hindgut. This results in an increased production of fermentation metabolites that are beneficial to health [9]. Additionally scientific investigations have shown that these bioactive ingredients can enhance the growth performance of feed additives, as well as nutrient digestibility, immunity, the reduction of intestinal and fecal pathogenic microorganisms, and the emission of harmful gases from the feces [10, 11]. Since ancient times, pomegranate fruit has been utilized extensively across several civilizations and nations. Pomegranate peel and juice are rich in important polyphenols such gallic acid, ellagic acid, and ellagic tannins [12], polyphenol-rich source with high concentrations of tannins and flavonoids, including gallic acid, ellagic acid, punicalin, pedunculagan, and its glucose esters [13].

Materials and Methods

The present phase-wise experiment was conducted at Poultry Experimental Station, Department of Poultry Husbandry, Faculty of Animal Husbandry and Veterinary Sciences, Sindh Agriculture University Tandojam.

Phase-1 proximate analysis of pomegranate peel waste

After collecting, proximate analysis of pomegranate peel waste was performed to assess the contents of dry matter, crude protein, crude fat, and ash contents according to the Association of Official Analytical Chemists [14] at laboratory of Department of Animal Nutrition (Table 1).

Phase-II groups and treatment

After proximate analysis, one hundred (100) day-old broiler chicks were procured from a well reputed hatchery. After initial weight,

chicks were randomly distributed into five experimental groups, each group consisting of 20 chicks (Table 2). The chicks of group-A was reared as control whereas, group B, C, D and E was fed on ration containing 0.25, 0.50, 0.75 and 1.00 % of pomegranate waste/kg of feed, respectively. Feed was formulated as described in (Table 3).

Phase-III. Proximate analysis of feed samples

The proximate analysis of feed was performed during trial to assess the contents of dry matter, crude protein, crude fat, and ash contents according to the procedure of Association of Official Analytical Chemist [14] at laboratory of Department of Animal Nutrition.

Phase-IV. Nutrient digestibility

The experimental birds were tagged during the study period for their proper identification. At the end of experiment, 03 birds were picked randomly from each group and were kept off feed for 5-6 hours prior to slaughter, to keep their intestines free from undigested feed. Proximate analysis of fecal material was performed to assess the contents of dry matter, crude protein, crude fat, and ash contents according to the procedure of Association of Official Analytical Chemists [14]. The nutrient digestibility was determined by the following formula: -

Nutrients in feed – nutrients in fecal samples x 100

Study Parameters

The following parameters were studied:

Feed intake

Feed was given twice daily (morning & evening) and refusal was weighed and recorded.

Water consumption

Ad libitum water was offered to birds and refusal water weight regularly which was given for 24 hours to broilers allocated in each group for recording the daily water intake.

Body weight gain

From each group two birds were randomly selected than initially and weighed weekly.

Feed conservation ratio

FCR was calculated by the following formula: -

$$\text{FCR} = \frac{\text{Total feed intake} \quad \text{X100}}{\text{Total livebody weight}}$$

Weight of visceral organs

Weight of visceral organs thymus, liver, spleen, and bursa was recorded by slaughtering of chicks on 42nd day.

Dressing %

Three birds from each group were randomly selected and slaughtered on day 42.

Morbidity %

Morbidity% was recorded and calculated by the following formula: -

$$\text{Morbidity (\%)} = \frac{\text{Total birds sick}}{\text{Total reared birds}} x100$$

Mortality%

Mortality% was recorded and calculated by the following formula: -

$$\text{Mortality (\%)} = \frac{\text{Total diered brids}}{\text{Total reared birds}} x100$$

Statistical design

On completion of study data was statistically analyzed using JMP software of SAS, USA, Software. The groups were compared by Analysis of Variance (ANOVA).

Results

Growth performance

Feed intake

Results on the effect of pomegranate peel waste feeding on feed intake of broiler is mentioned in (Table 4) Data indicates that maximum feed intake (3615.7±7.85g) was recorded in A group (control) compared to group B: Pomegranate peel waste 0.25% (3562.3±24.26g), group C: Pomegranate peel waste 0.50% (3492.3±30.91g) and group D: Pomegranate peel waste 0.75% (3483.3±5.05g) respectively. Minimum feed intake (3146.0±9.44g) was recorded in group E: Pomegranate peel waste 1.00%. A significant ($P<0.05$) difference in feed intake of broiler was analyzed among all groups.

Water intake

Water intake of broiler is mentioned in (Table 5) Data indicates that maximum water intake (6092.0±57.35 ml) was recorded in A group (control) compared to group B: Pomegranate peel waste 0.25% (5766.0±49.82 ml), group C: Pomegranate peel waste 0.50% (5584.7±43.64 ml) and group D: Pomegranate peel waste 0.75% (5524.7±41.88 ml) respectively. Minimum water intake (5431.3±35.62 ml) was recorded in group E: Pomegranate peel waste 1.00%. A significant (P<0.05) difference in water intake of broiler was analyzed among all groups.

Live body weight

The live body weight of broiler is mentioned in (Table 6) Data indicates that maximum live body weight (2258.3±101.85g) was recorded in E group: Pomegranate peel waste 1.00% compared to group D: Pomegranate peel waste 0.75% (2034.3±86.98g), group C: Pomegranate peel waste 0.50% (1965.0±74.83g) and group B: Pomegranate peel waste 0.25% (1942.0±67.14g) respectively. Minimum live body weight (1838.0±61.45g) was recorded in group A (control). A significant (P<0.05) difference in live body weight of broiler was analyzed among all groups.

Feed conversion ratio

Feed conversion ratio of broiler is mentioned in (Table 7) Data indicates that better feed conversion ratio (1.39±0.03) was recorded in E group: Pomegranate peel waste 1.00% compared to group D: Pomegranate peel waste 0.75% (1.71±0.01), group C: Pomegranate peel waste 0.50% (1.77±0.03) and group B: Pomegranate peel waste 0.25% (1.83±0.03) respectively. Poor feed conversion ratio (1.96±0.08) was recorded in group A (control). A significant (P<0.05) difference in feed conversion ratio of broiler was analyzed among all groups.

Carcass weight

Carcass weight of broiler is mentioned in (Table 8) Data indicates that maximum carcass weight (1863.7±52.85g) was recorded in E group: Pomegranate peel waste 1.00% compared to group D: Pomegranate peel waste 0.75% (1645.0±45.87g), group C: Pomegranate peel waste 0.50% (1574.0±39.82g) and group B: Pomegranate peel waste 0.25% (1481.7±35.62g) respectively. Minimum carcass weight (1492.3±20.66g) was recorded in group A (control). A significant (P<0.05) difference in carcass weight of broiler was analyzed among all groups.

Dressing %

Dressing weight of broiler is mentioned in (Table 9) Data indicates that maximum dressing (82.52±4.10%) was recorded in E group: Pomegranate peel waste 1.00% compared to group D: Pomegranate peel waste 0.75% (80.86±3.86%), group C: Pomegranate peel waste 0.50% (80.10±2.60%) and group B: Pomegranate peel waste 0.25% (76.26±1.52%) respectively. Minimum dressing (72.17±0.44%) was recorded in group A (control). A significant (P<0.05) difference in dressing % of broiler was analyzed among all groups.

Organ weight

Liver weight (g)

Liver weight of broiler is mentioned in (Table 10) Data indicates that liver weight in A group (control) was (64.33±1.73g), group B: Pomegranate peel waste 0.25% (63.73±2.90g), group C: Pomegranate peel waste 0.50% (62.46±0.98g), group D: Pomegranate peel waste 0.75% (63.66±2.38g) and group E: Pomegranate peel waste 1.00% (63.60±0.29g) respectively. A non-significant (P>0.05) difference in liver weight of broiler was analyzed among all groups.

Spleen weight (g)

Spleen weight of broiler is mentioned in (Table 11) Data indicates that spleen weight in A group (control) was (1.83±0.18g), group B: Pomegranate peel waste 0.25% (1.90±0.37g), group C: Pomegranate peel waste 0.50% (1.67±0.17g), group D: Pomegranate peel waste 0.75% (1.93±0.20g) and group E: Pomegranate peel waste 1.00% (1.43±0.17g) respectively. A non-significant (P>0.05) difference in spleen weight of broiler was analyzed among all groups.

Thymus weight (g)

Thymus weight of broiler is mentioned in (Table 12) Data indicates that liver weight in A group (control) was (4.00±0.00g), group B: Pomegranate peel waste 0.25% (4.32±0.57g), group C: Pomegranate peel waste 0.50% (4.67±0.33g), group D: Pomegranate peel waste 0.75% (4.33±0.33g) and group E: Pomegranate peel waste 1.00% (4.36±0.33g) respectively. A non-significant (P>0.05) difference in the thymus weight of broiler was analyzed among all groups.

Bursa weight (g)

Bursa weight of broiler is mentioned in (Table 13) Data indicates that bursa weight in A group (control) was (1.90±1.73g), group B: Pomegranate peel waste 0.25% (1.67±0.17g), group C: Pomegranate peel waste 0.50% (1.76±0.29g), group D: Pomegranate peel waste 0.75% (2.20±0.32g) and group E: Pomegranate peel waste 1.00% (1.86±0.03g) respectively. A non-significant (P>0.05) difference in bursa weight of broiler was analyzed among all groups.

Digestibility

Dry matter

Results on the effect of pomegranate peel waste feeding on dry matter digestibility in broiler is mentioned in (Table 14). Data indicates that maximum dry matter digestibility (81.51±0.45%) was recorded in E group: Pomegranate peel waste 1.00% compared to group D: Pomegranate peel waste 0.75% (78.92±0.13%), group C: Pomegranate peel waste 0.50% (75.41±0.07%) and group B: Pomegranate peel waste 0.25% (74.21±0.07%) respectively. Minimum dry matter digestibility (72.95±0.30%) was recorded in group A (control). A significant (P<0.05) difference in dry matter digestibility of broiler was analyzed among all groups.

Ash

Ash digestibility in broiler is mentioned in (Table 14). Data indicates that ash digestibility in A group (control) was (2.33±0.08%), group B: Pomegranate peel waste 0.25% (1.66±0.12%), group C: Pomegranate peel waste 0.50% (1.45±0.03%), group D: Pomegranate peel waste 0.75% (1.36±0.18%) and group E: Pomegranate peel waste 1.00% (1.23±0.00%) respectively. A non-significant (P>0.05) difference in ash digestibility in broiler was analyzed among all groups.

Fat

Fat digestibility in broiler is mentioned in (Table 14). Data indicates that maximum fat digestibility (3.06±0.09%) was recorded in E group: Pomegranate peel waste 1.00% compared to group D: Pomegranate peel waste 0.75% (2.61±0.02%), group C: Pomegranate peel waste 0.50% (2.56±0.09%) and group B: Pomegranate peel waste 0.25% (2.39±0.16%) respectively. Minimum fat digestibility (2.26±0.14%) was recorded in group A (control). A significant (P<0.05) difference in fat digestibility of broiler was analyzed among all groups.

Protein

Protein digestibility in broiler is mentioned in (Table 14). Data indicates that maximum protein digestibility (77.64±0.07%) was recorded in E group: Pomegranate peel waste 1.00% compared to group D: Pomegranate peel waste 0.75% (76.23±0.04%), group C: Pomegranate peel waste 0.50% (75.91±0.02%) and group B: Pomegranate peel waste 0.25% (74.39±0.20%) respectively. Minimum protein digestibility

(71.19±0.22%) was recorded in group A (control). A significant (P<0.05) difference in protein digestibility of broiler was analyzed among all groups.

Morbidity & Mortality

Results on the effect of pomegranate peel feeding on morbidity of broiler are mentioned in (Table 15). Data indicates that morbidity in group A (control) was (4%), group B Pomegranate peel waste 0.25% (2%), group C Pomegranate peel waste 0.50% (2%), group D Pomegranate peel waste 0.75% (3%) and group E Pomegranate peel waste 1.00% (1%) respectively. Mortality in A group (control) was (3%), group B: Pomegranate peel waste 0.25% (2%), group C: Pomegranate peel waste 0.50% (2%), group D: Pomegranate peel waste 0.75% (2%) and group E: Pomegranate peel waste 1.00% (1%) respectively.

Discussion

The presence of dietary fiber, polyphenols, and other bioactive compounds in pomegranate peel waste may contribute to enhanced nutrient digestibility by promoting gut health and optimizing gastrointestinal function [15]. Furthermore, studies focusing on specific bioactive components of pomegranate peel waste provide additional insights into their mechanisms of action on nutrient digestibility. For instance, polyphenols found in pomegranate peel waste have been shown to modulate digestive enzyme activity, improve intestinal morphology, and enhance nutrient absorption in broiler chickens [16]. During present study maximum live body weight was noted in E group: Pomegranate peel waste 1.00% compared to group D. A significant (P<0.05) difference in live body weight of broiler was analyzed among all groups. It suggests a potential dose-dependent effect of pomegranate peel waste on growth performance. Additionally, the significant difference (P<0.05) in live body weight among all groups, including the control group (group A), highlights the impact of pomegranate peel waste supplementation on broiler growth. These findings align with previous studies investigating the utilization of pomegranate peel waste in poultry diets. Presence of dietary fibers in fruit and vegetable by-products like pomegranate peel waste may increase intestinal transit time, facilitate nutrient absorption, and promote the growth of beneficial gut microbiota, leading to improved nutrient digestibility [17]. [18] discussed the nutritional value of various fruit and vegetable wastes and their potential as alternative feed ingredients for improving nutrient utilization in livestock, including poultry. Supplemental layer diets up to 300ml/ kg diet pomegranate oil and 300mg/ kg diet orange oil were effective in improving productive performance, biochemical, antioxidant blood parameters and testosterone values of laying hens [19]. Present study suggests a potential dose-dependent effect of pomegranate peel waste on nutrient utilization. Additionally, the significant difference (P<0.05) in nutrient digestibility among all groups, including the control group, highlights the impact of pomegranate peel waste supplementation on nutrient absorption and utilization in broiler chickens. These findings are consistent with previous research investigating the effects of dietary supplementation with fruit and vegetable by-products on nutrient digestibility in poultry. Overall, the findings of this study highlight the potential of pomegranate peel waste as a valuable feed ingredient for enhancing nutrient digestibility and optimizing nutrient utilization in broiler chickens. Overall, the findings of this study, combined with evidence from related research, suggested that dietary supplementation with pomegranate peel waste has the potential to improve nutrient digestibility and optimize nutrient utilization in broiler chickens. Further investigations into the specific mechanisms underlying

these effects, as well as optimization of inclusion levels and processing methods, are warranted to fully exploit the nutritional and functional benefits of pomegranate peel waste in poultry diets. Collaborative efforts between researchers, poultry producers, and feed manufacturers are essential for translating these findings into practical strategies for enhancing the sustainability and efficiency of poultry production systems.

Table 1. Proximate analysis of pomegranate peel powder

Parameters (%)	Control			
	R1	R2	R3	Mean
Dr matter	96.28	95.42	95.12	95.61
Fat	1.80	1.25	1.55	1.53
Protein	6.40	7.30	7.85	7.18
Ash	4.30	3.89	4.15	4.11

Table 2. Experimental design

Groups	A	B	C	D	E
Inclusion of Pomegranate peel waste	*Control*	0.25% /kg feed	0.50% /kg feed	0.75% /kg feed	1.00% /kg feed
Number of Birds	20	20	20	20	20
Number of replication birds	3	3	3	3	3

Table 3. Feed formulation

Ingredients	A	B	C	D	E
PPW	0	0.25	0.50	0.75	1
Rice	40	40	40	40	40
Fish meal	15	15	15	15	15
Soybean	12	12	12	12	12
Canola	18.9	18.65	18.4	18.15	17.9
RSM	5	5	5	5	5
Oil	2	2	2	2	2
DCP	1.6	1.6	1.6	1.6	1.6
Limestone	1	1	1	1	1
DLM	3	3	3	3	3
Premix	1	1	1	1	1
Toxin binder	0.5	0.5	0.5	0.5	0.5
Total	100	100	100	100	100

Table 4. Effect of pomegranate peel waste on feed intake of broiler

	Groups					P-value
	A	B	C	D	E	
Feed intake	3615.7^{a} ±7.85	3562.3^{b} ±24.26	3492.3^{bc} ±30.91	3483.0^{c} ±5.05	3146.0^{c} ±9.44	0.0007

Table 5. Effect of pomegranate peel waste on water intake of broiler

	Groups					P-value
	A	B	C	D	E	
Water intake	6092.0^{a} ±57.35	5766.0^{b} ±49.82	5584.7^{bc} ±43.64	5524.7^{c} ±41.88	5431.3^{c} ±35.62	0.0007

Table 6. Effect of pomegranate peel waste on the live body weight of broiler

	Groups					P-value
	A	B	C	D	E	
Live body weight	1838.0^{d} ±61.45	1942.0^{c} ±67.14	1965.0^{c} ±74.83	2034.3^{b} ±86.98	2258.3^{a} ±101.85	0.0001

Table 7. Effect of pomegranate peel waste on feed conversion ratio of broiler

	Groups					P-value
	A	B	C	D	E	
FCR	1.96^{a} ±0.08	1.83^{ab} ±0.03	1.77^{ab} ±0.03	1.71^{bc} ±0.01	1.39^{c} ±0.03	0.0112

Table 8. Effect of pomegranate peel waste on carcass weight of broiler

	Groups					P-value
	A	B	C	D	E	
Carcass weight	1492.3^{e} ±20.66	1481.7^{d} ±35.62	1574.0^{c} ±39.82	1645.0^{b} ±45.87	1863.7^{a} ±52.85	0.0014

Table 9. Effect of pomegranate peel on dressing % of broiler

	Groups					P-value
	A	B	C	D	E	
Dressing (%)	72.17^{d} ±0.44	76.26^{d} ±1.52	80.10^{c} ±2.60	80.86^{b} ±3.86	82.52^{a} ±4.10	0.0052

Table 10. Effect of pomegranate peel waste on liver weight of broiler

	Groups					P-value
	A	B	C	D	E	
Liver weight	64.33 ±1.73	63.73 ±2.90	62.46 ±0.98	63.66 ±2.38	63.60 ±0.29	0.8716

Table 11. Effect of pomegranate peel waste on spleen weight of broiler

	Groups					P-value
Spleen weight	**A**	**B**	**C**	**D**	**E**	
	1.83 ±0.18	1.90 ±0.37	1.67 ±0.17	1.93 ±0.20	1.43 ±0.17	0.5761

Table 12. Effect of pomegranate peel waste on thymus weight of broiler

	Groups					P-value
Thymus weight	**A**	**B**	**C**	**D**	**E**	
	4.00 ±0.000	4.32 ±0.5773	4.67 ±0.3333	4.33 ±0.3333	4.36 ±0.3333	0.5336

Table 13. Effect of pomegranate peel waste on bursa weight of broiler

	Groups					P-value
Bursa weight	**A**	**B**	**C**	**D**	**E**	
	1.90 ±0.29	1.67 ±0.17	1.76 ±0.29	2.20 ±0.32	1.86 ±0.03	0.2149

Table 14. Effect of pomegranate peel waste on nutrients digestibility (%) of broiler

Parameters	Groups					P-value
	A	**B**	**C**	**D**	**E**	
Dry matter	72.95^{c} ±0.30	74.21^{b} ±0.07	75.41^{b} ±0.13	78.92^{b} ±0.07	81.51^{a} ±0.45	0.0001
Ash	2.33 ±0.08	1.66 ±0.12	1.45 ±0.03	1.36 ±0.18	1.23 ±0.00	0.8980
Fat	2.26^{b} ±0.14	2.39^{b} ±0.16	2.56^{ab} ±0.09	2.61^{ab} ±0.02	3.06^{a} ±0.09	0.0061
Protein	19.19^{d} ±0.22	20.39^{cd} ±0.20	21.91^{bc} ±0.02	22.23^{ab} ±0.04	23.64^{a} ±0.07	0.0002

Table 15. Effect of pomegranate peel waste on morbidity and mortality (%) of broiler

	Groups				
Parameters	**A**	**B**	**C**	**D**	**E**
Morbidity	4	2	2	3	1
Mortality	3	2	2	2	1

Conclusion

In conclusion adding pomegranate waste peel in broiler feed has significant positive effects on various parameters, including feed intake, FCR, live body weight, carcass weight, dressing percentage, and organ weights. Group E, receiving 1.00% peel waste, exhibited the most favorable outcomes. Pomegranate peel, rich in antioxidants like vitamin E, enhances growth and protects against oxidative stress. The observed improvements in digestive enzyme functions, nutrient absorption, and microbial balance

contribute to the overall enhancement of broiler performance.

Authors contributions

Conceived and designed the experiments: SA Unar, A Memon & DH Kalhoro, Performed the experiments: SA Unar, Analyzed the data: FA Samo, IA Kondhar, S Namood & Z Unar, Contributed reagents/ materials/ analysis tools: A Memon, DH Kalhoro, FA Laghari, MI Brohi & FH Tunio, Wrote the paper: SA Unar, DH Kalhoro & WA Kalhoro.

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