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Influence of Calcium and Nonphytate Phosphorus (NPP) on Meat-Type Quail's Growth, Carcass Features, and Tibia Indices

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ABSTRACT

This study aimed to evaluate the role of increasing dietary calcium (Ca) and non-phytate phosphorus (NPP) supplementation on the growth, carcass, edible portions, and tibia indicators of growing quail. The current study was conducted in a 3×3 factorial design, for this, 360 1-wk-old quails were haphazardly assigned to nine groups, each group is with three gradual levels of Ca (0.60, 0.90, and 1.20 %) and NPP (0.20, 0.40 and 0.60 %). Each group was divided into five replicates with eight-quail each. Results of the study suggested that except at 2 and 6 weeks of age, dietary Ca level did not exhibit any significant ($P > 0.05$) impact on body weight. Similarly, in the case of NPP, apart from the live weight at 2 and 3 weeks of age, NPP did not have a significant impact on live body weight. Further, in comparison to the low Ca level, the moderate or high Ca levels have higher values of body weight gain. During all the experiments, dietary Ca, NPP, or their mixtures had no significant ($P > 0.05$) impact on feed consumption. Similarly, feed conversion rate and carcass metrics were also not affected by the individual or combined application of Ca or NPP supplementation Similarly, dietary intakes of Ca or P did not have any significant effect on the various tibia indicators ($P > 0.05$). Results of the study can be concluded that the effect of the Ca and NPP levels in Japanese quail diets is lowered and it does not much affect the growth rate, feed utilization, carcass yields, edible components, or tibia indices.

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1 Introduction

Among the 12 essential elements for poultry, calcium and phosphorus are the two most important elements which highly attract nutritionists, researchers, and producers who are associated with the poultry industry (Alagawany et al. 2020, 2021). These two are accounted for at least 50% of bone ash, so it can be expressed that these are the fundamental skeletal components and are also directly or indirectly participated in both quantitative and qualitative metabolic processes of poultry animals (Mc Donald et al. 2002; Rao et al. 2006; Gautier et al. 2017; Perine et al. 2022).

Calcium is also known to be the connecting material and plays an important role in connecting various blood-clotting proteins, such as protein-protein or protein-phospholipid (Brody 1994; Rousseau et al. 2016). Cytoskeleton components are another Ca-binding protein that comes from the extracellular fluid in the nervous system or cellular calcium storage organelles in muscle, and play a key role in cell communication (Brody 1994). Both nerve impulse transmission and muscle contraction also required calcium (McDonald et al. 1995, Perine et al. 2016).

Phosphorus is another primary component of bone and is also required for many metabolic processes such as protein, carbohydrate, and fat metabolism (McDonald et al. 1995, Abd El-Hack et al. 2018). The body's P content is slightly lower than its Ca content, and the bones account for 80 to 85 % of total body phosphorus. Further, in the synthesis of adenosine di- and tri-phosphates and sugar phosphates, Phosphorus is also used for energy storage and metabolism (Brody 1994; Liu et al. 2017). Moreover, phospho-proteins, phospholipids, and nucleic acids are also made up of phosphorus (Brody 1994).

Despite a long history of research on the role of calcium and phosphorus in poultry nutrition and production, there are only a few studies based on the impacts of calcium and phosphorus interaction in Japanese quail (Rao et al. 2006). Although Japanese quail have more documentation requirements than other birds because they are rare to be compared the other domestic poultry (NRC 1994). The nutrient requirements of Japanese quails are usually extrapolated from other poultry because they are not identical to other broiler chickens in terms of poultry production (Cheng 1990; Minivielle 2004). The most detailed assessment of the Japanese quail diet was reported by Shim and Vohra (1984), and Batool et al. (2021). Quail Ca and available P requirements appear to be higher than those of other birds of comparable age, according to the researchers. The available information on the influence of calcium and nonphytate phosphorus (NPP) on meat-type quail's growth and tibia indices are in scarcity. Therefore, the purpose of this study was to determine the effect of small increases of dietary calcium and nonphytate phosphorus (NPP) on the performance, carcass, edible portions, and tibia markers of the growing quails aged 1-6 weeks.

2 Materials and Methods

2.1 Diets and experimental birds

In this study, 360 growing quails weighing an average of 23.76g were fed on three levels of Ca (0.6, 0.9, and 1.2 %), and nonphytate P in a 3×3 factorial design (0.2, 0.4, and 0.6 %). Each of the nine groups was divided into five replicates, each containing eight unsexed chicks. Table 1 represented the combination of the experimental diet which was given to the one to six weeks age quails to suit their nutritional demands, according to the NRC (1994). The birds were maintained in a normal cage with free access to feed and water ($50\times30\times50$ cm^3; 1,500 cm^2 of floor area). During the experiment, the birds were kept on a 24-hour light cycle. Entire quails were raised in the same clean environment.

2.2 Data collection

At weekly intervals, each chick's body weight (BW) and body weight growth (BWG) were measured. The mortality rate was recorded daily throughout the study and it was reported zero in all experimental groups. These data were used to compute the average feed conversion ratio (FCR) and feed intake (FI) periodically and cumulatively. Daily wastage of feed was recorded, and the information was utilized to estimate FI (Alagawany et al. 2020).

At six weeks of age, six quails (one from each group) were slaughtered at random for carcass assessments and tibia characterization. Carcass weights were calculated for the main body and other edible portions. Carcass and dressed weights were compared to live body weight. The weight of each bird's right tibia was measured. Besides, the length and diameter of each tibia bone were determined using Vernier calipers (El-Faham et al. 2019; Fallah et al. 2019).

2.3 Statistical analysis

SPSS (2008) was used to conduct all of the statistical analyses. According to Snedecor and Cochran (1982), The following model was used to statistically evaluate the data as a 3×3 factorial arrangement:

$$Y_{ijk} = \mu + A_i + S_j + AS_{ij} + e_{ijk}$$

Where Y_{ijk} represents an overall mean, A_i represents the influence of the Ca level (I = 1–3), S_j represents the influence of the NPP level (j = 1–3), AS_{ji} represents the Ca and NPP interactions, and e_{ijk} represents the experimental random error. To find differences between treatments, a post-hoc Tukey's test was used. At $P\leq0.05$, all differences and significance were measured.

Table 1 Effect of calcium and phosphorus and its interactions on live body weight of growing quails

Experimental Diets (%)									
Ca %		0.60			0.90			1.20	
P avail.%	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60
Corn	55.44	54.31	54.15	55.20	55.42	55.90	55.75	55.88	55.72
Soybean meal 44% CP	28.55	23.00	21.65	26.62	27.26	29.28	28.50	28.70	27.76
Gluten	8.85	12.00	12.92	10.19	10.00	9.05	9.50	9.50	10.22
Bran	5.07	8.05	8.19	5.07	4.00	2.05	2.55	1.82	1.73
Mono-Ca phosphate	0.15	0.95	1.75	0.15	0.95	1.75	0.18	0.95	1.77
Limestone	1.24	0.90	0.53	2.05	1.66	1.28	2.82	2.45	2.09
Premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
NaCl	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Methionine	0.04	0.01	0.00	0.02	0.02	0.03	0.03	0.03	0.02
L-Lysine	0.21	0.33	0.36	0.26	0.24	0.21	0.22	0.22	0.24
Chemical analysis[1]									
CP %	24.00	24.00	24.02	24.01	24.00	24.00	24.02	24.00	24.02
ME kcal/kg	2900	2898	2900	2900	2900	2899	2900	2900	2900
Ca %	0.60	0.60	0.60	0.90	0.90	0.90	1.20	1.20	1.20
P avail.%	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60
Lysine %	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30
M+C %	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
CF %	3.92	3.81	3.72	3.77	3.70	3.65	3.64	3.58	3.50

[1]CP: crude protein, ME: metabolizable energy, Ca: calcium, P: phosphorus, M+C: methionine pluscyctine and CF: crude fiber

3 Results And Discussion

3.1 Live body weight

The impact of dietary Ca and NPP levels on the quail's live body weight was demonstrated in Table 2. Except for 2 and 6 weeks of age, dietary Ca had no significant effect on the LBW ($P > 0.05$). As the dietary Ca level was increased, the live body weight was steadily reduced. However, in the case of dietary NPP level, no significant effect was reported on the LBW across all ages except live body weight at 2 and 3 weeks of age at which LBW significantly improved ($P = 0.001$) at the low NPP level (0.20 %) as compared to the moderate and high levels (0.40 and 0.60 %). These results are in agreement with the findings of Wang (2011) and Rao et al. (2006) those who also reported nonsignificant variations in live body weight in birds fed varying quantities of calcium (0.65 %, 0.95 %, and 1.25 %) and Nonphytate phosphorus in their diets (0.40, 0.60, and 0.80 %).

Further, the results of the study suggested that the combination between dietary calcium and phosphorus levels had a significant impact on live body weights at 2, 3, and 4 weeks of age (Table 2). The highest live body weights were found in birds given low calcium and moderate phosphorus diet (0.60 % calcium + 0.40 % phosphorus). In another study, lowering phosphorus levels in broiler chicken diets did not affect live body weight (Farhadi et al., 2017). These findings might be a result of an unbalanced calcium-phosphorus ratio, which causes the development of insoluble molecules, limiting energy and mineral uptake and utilization (Plumstead et al. 2008).

According to Wilkinson et al. (2014), the ratio of calcium to nonphytate phosphorus is more essential than individual absolute calcium and Nonphytate phosphorus dietary intakes. Our results are comparable to those of Zhu et al. (2018), who found that lowering the ratio of dietary calcium to Nonphytate phosphorus reduced live body weight considerably. During the starter and grower stages, reducing dietary calcium and Nonphytate phosphorus to 50% of the NRC (1994) had no impact on body weight (Mohamed et al. 2020). The findings of the current study are contradictory to the findings of Imari et al. (2020) those who reported that during the starting phase of broiler, reducing dietary calcium and Nonphytate phosphorus to 10% to 30% of the recommended quantity lowered body weight.

Table 2 Effect of calcium and phosphorus and its interactions on live body weight of growing quails

Treatments	Live body weight (g/d)					
	1 wk	2 wk	3 wk	4 wk	5 wk	6 wk
Calcium Percentage						
0.60	24.18	56.28[a]	94.60	114.89	137.30	205.18[b]
0.90	24.02	53.18[b]	94.94	114.76	137.06	213.58[a]
1.20	24.00	50.26[c]	94.00	108.67	132.30	213.54[a]
P value	0.69	<0.001	0.907	0.111	0.524	0.032
Phosphorus Percentage						
0.20	24.18	56.28[a]	89.60[b]	114.89	137.30	205.18
0.40	24.02	53.18[b]	99.00[a]	114.76	137.06	213.58
0.60	24.00	50.26[b]	94.94[ab]	108.67	132.30	213.54
P value	0.884	0.001	0.001	0.500	0.280	0.871
Calcium and Phosphorus Interaction						
0.60×0.20	24.22	56.33[b]	95.01[b]	119.51[a]	146.88	206.56
0.60×0.40	24.12	59.46[a]	100.22[a]	122.30[a]	136.46	204.45
0.60×0.60	24.22	53.04[b]	88.57[c]	102.88[c]	128.56	204.52
0.90×0.20	24.13	50.74[c]	86.18[c]	111.64[b]	136.49	210.01
0.90×0.40	24.00	55.44[b]	101.31[a]	114.85[b]	138.15	217.52
0.90×0.60	23.93	53.35[b]	97.32[b]	117.81[b]	136.55	213.20
1.20 ×0.20	23.99	46.78[c]	86.29[c]	108.23[b]	137.23	214.92
1.20 ×0.20	23.89	51.00[c]	95.71[b]	106.33[b]	125.40	213.27
1.20 ×0.20	24.12	53.00[b]	100.01[a]	111.44[b]	134.26	212.43
SEM	0.28	1.06	2.61	3.90	5.96	4.08
P value	0.981	0.003	0.006	0.021	0.411	0.773

Means in the same column within each classification bearing different letters are significantly differ

3.2 Body weight gain

Table 3 shows the effect of dietary Ca and NPP levels on the body weight growth of growing quails. Different levels of calcium affected body weight growth considerably (P<0.05) apart from the time from 4 to 5 weeks of age. When compared to the low level of Ca, the moderate and high levels of Ca recorded the highest values of body weight gain during the study. However, varying quantities of calcium had a substantial (P > 0.05) effect on body weight increase; however, the trend of the data is unclear due to minor changes in the results. The results of this study are in agreement with the findings of Wang (2011) those who reported that birds fed varying amounts of calcium (0.65 %, 0.95 %, and 1.25 %) and Nonphytate phosphorus (0.40 %, 0.60 %, and 0.80 %) in their meals showed no significant effect on body weight gain. According to Hamdi et al. (2015), higher calcium levels (0.9 %), have a detrimental effect on the body weight gain, whereas lower calcium levels were desirable since they fostered improved broiler performance. Our findings are similar to those of Zhu et al. (2018), who discovered that lowering the dietary calcium to Nonphytate phosphorus ratio significantly reduced body weight gain.

Wenli et al. (2005) observed that birds fed on 0.65 % calcium gained more body weight than those fed diets with higher levels of calcium (0.75 %, 0.85 %, and 0.95 %). Furthermore, varying dietary quantities of P (0.30 % vs. 0.40 %) had a substantial impact on body weight increase (Wenli et al. 2005). In another study, lowering phosphorus levels in broiler chicken diets had no impact on BWG from 1d to 7 wks-old (Farhadi et al. 2017).

Apart from the 1-2 week age, the Ca and P interactions had no significant (P > 0.05) impact on body weight gain (BWG) at any

Table 3 Effect of calcium and phosphorus and its interactions on body weight gain of growing quails.

Treatments	Body weight gain (g)					
	1-2 wk	2-3 wk	3-4 wk	4-5 wk	5-6 wk	Overall
Calcium Percentage						
0.60	32.09[a]	38.32[b]	20.29[a]	22.40	67.88[b]	180.99[b]
0.90	29.16[b]	41.76[ab]	19.74[a]	24.70	76.51[a]	189.56[a]
1.20	26.25[c]	43.74[a]	14.88[b]	25.93	81.24[a]	189.54[a]
P value	<0.001	0.040	0.046	0.436	<0.001	0.027
Phosphorus Percentage						
0.20	27.17[b]	37.87[b]	23.96[a]	27.07[a]	70.29[b]	186.38
0.40	31.30[a]	43.78[a]	15.63[b]	20.14[b]	78.41[a]	187.75
0.60	29.04[b]	42.16[ab]	15.32[b]	25.82[a]	76.93[a]	185.96
P value	0.001	0.021	0.001	0.045	0.013	0.854
Calcium and Phosphorus Interaction						
0.60×0.20	32.11[ab]	38.67	24.50	27.37	59.68	182.34
0.60×0.40	35.34[a]	40.76	22.08	14.15	67.99	180.33
0.60×0.60	28.82[c]	35.52	14.31	25.68	75.96	180.30
0.90×0.20	26.61[c]	35.44	25.45	24.85	73.52	185.88
0.90×0.40	31.44[b]	45.87	13.54	23.29	79.37	193.53
0.90×0.60	29.42[bc]	43.97	20.23	25.96	76.65	189.27
1.20 ×0.20	22.78[d]	39.51	21.93	29.00	77.69	190.92
1.20 ×0.20	27.11[c]	44.70	11.27	22.99	87.87	189.38
1.20 ×0.20	28.87[c]	47.01	11.44	25.82	78.17	188.31
SEM	1.08	2.41	2.69	3.33	3.18	4.04
P value	0.004	0.120	0.136	0.445	0.074	0.765

Means in the same column within each classification bearing different letters significantly differ

ages evaluated in this study. The quails fed on a low level of calcium and a moderate dose of phosphorus (0.60 % Ca + 0.40 % P) have the largest body weight gain. However, when birds were fed on a combination of 1.20% Ca + 0.20% P, the lowest body weight gain was obtained (p=0.004). During the starter and grower stages, reducing dietary calcium and Nonphytate phosphorus up to 50% of the NRC recommendation (NRC 1994) did not affect body weight gain (Mohamed et al. 2020). Similarly, Imari et al. (2020) revealed that lowering dietary calcium and Nonphytate phosphorus level at the early stage of broiler growth has lowered the gain of the body weight as compared to the finisher or post-starter stages.

3.3 Feed intake

Results given in Table 4 show the effects of dietary Ca and P amounts, as well as their interaction effect on the feed intake of growing quails. Dietary Ca, P, or their combinations did not have any significant influence on the feed consumption at all examined ages ($P > 0.05$). These results are in agreement with the findings of Rao et al. (2006), and Wang (2011) those who reported the insignificant effect of Ca and P dietary supplementation on the feed intake. Wenli et al. (2005) observed that birds fed on 0.65 % calcium had better feed intake than those fed diets with higher calcium levels (0.75, 0.85, and 0.95 %). Furthermore, varying dietary quantities of P (0.30 % vs. 0.40 %) had a substantial impact on feed consumption. According to Hamdi et al. (2015), higher levels of Ca (0.9%) harmed broiler chicken feed intake. In another study, lowering phosphorus levels in broiler chicks' diets did not affect feed intake from day1 to 42 (Farhadi et al. 2017). The findings of the current study are comparable to those of Zhu et al. (2018), who found that reducing the ratio of dietary calcium to Nonphytate phosphorus reduced feed intake considerably. Further,

Table 4 Effect of calcium and phosphorus and its interactions on feed intake of growing quails

Treatments	Feed intake (g)					
	1-2wk	2-3 wk	3-4 wk	4-5 wk	5-6 wk	Overall
Calcium Percentage						
0.60	11.68	17.20	21.23	21.21	21.22	18.51
0.90	11.31	16.67	20.89	21.89	21.39	18.43
1.20	11.41	16.68	21.61	22.32	21.97	18.80
P value	0.640	0.577	0.728	0.307	0.477	0.699
Phosphorus Percentage						
0.20	10.94	16.07	22.76[a]	22.14	22.45	18.87
0.40	11.51	16.92	20.76[b]	21.24	21.00	18.29
0.60	11.95	17.56	20.21[b]	22.05	21.13	18.58
P value	0.064	0.052	0.028	0.394	0.064	0.451
Calcium and Phosphorus Interaction						
0.60×0.20	11.43	16.64	22.33	22.32	22.33	19.01
0.60×0.40	11.10	16.40	21.27	20.01	20.64	17.89
0.60×0.60	12.52	18.55	20.08	21.30	20.69	18.63
0.90×0.20	10.50	15.68	22.24	21.552	21.89	18.37
0.90×0.40	11.54	16.73	20.69	22.00	21.35	18.46
0.90×0.60	11.90	17.59	19.72	22.12	20.92	18.46
1.20 ×0.20	10.88	15.88	23.72	22.54	23.13	19.23
1.20 ×0.20	11.90	17.63	20.30	21.71	21.01	18.51
1.20 ×0.20	11.44	16.54	20.82	22.72	21.77	18.66
SEM	0.49	0.69	1.11	0.86	0.77	0.55
P value	0.358	0.253	0.847	0.623	0.862	0.839

Means in the same column within each classification bearing different letters significantly differ

the results of this study are also in agreement with the findings of Mohamed et al. (2020), and Imari et al. (2020) who reported a nonsignificant effect of dietary inclusion of calcium and Nonphytate phosphorus on feed consumption at the early stage of growth and other growth phases.

3.4 Feed conversion

The effect of gradually increasing calcium and phosphorus levels in the diet on quail chick feed conversion has been presented in Table 5. Aside from the periods of 4 to 5 and 1 to 6 weeks of age, calcium levels had a significant (P 0.05) impact on feed conversion. These results are contradictory to the findings of Wang (2011) and Rao et al. (2006) those who observed that Ca and P levels had a nonsignificant effect on feed conversion. While, Wenli et al. (2005) observed that birds fed on 0.65% calcium diets had a greater feed conversion ratio than those fed higher calcium diets (0.75, 0.85, and 0.95 %).

At all ages except 3-4 weeks, changes in dietary P had no significant influence on feed conversion and the feed conversion ratio of quail fed a 0.20 % P-based diet was reported considerably lower (P = 0.005). These results are corroborated by the findings of Wen Li et al. (2005) and Farhadi et al. (2017) who found that different dietary levels of P (0.30 % vs. 0.40 %) had no significant effect on feed conversion.

Further, Ca and P interaction also did not show any significant impacts on feed conversion ratio (Table 5), except for the 2nd week, where the higher feed conversion ratio was attained with 0.60 Ca and 0.40 P combination (P =0.011). According to Mohamed et al. (2020) reducing dietary calcium and

Table 5 Effect of calcium and phosphorus and its interactions on feed conversion of growing quails

Treatments	Feed Conversion ratio (g feed/g gain)					
	1-2 wk	2-3 wk	3-4 wk	4-5 wk	5-6 wk	Overall
Calcium Percentage						
0.60	2.58[b]	3.20[a]	2.37[b]	4.88	2.24[a]	3.58
0.90	2.73[b]	2.83[ab]	2.43[b]	6.10	1.96[ab]	3.40
1.20	3.06[a]	2.68[b]	3.41[a]	6.12	1.90[b]	3.47
P value	0.049	0.025	0.005	0.238	0.011	0.136
Phosphorus Percentage						
0.20	2.87	2.99	2.06[b]	5.07	2.28	3.54
0.40	2.62	2.73	3.06[a]	5.87	1.90	3.41
0.60	2.89	2.98	3.09[a]	6.16	1.92	3.49
P value	0.089	0.245	0.005	0.238	0.110	0.136
Calcium and Phosphorus Interaction						
0.60×0.20	2.50[b]	3.06	1.99	4.59	2.68	3.65
0.60×0.40	2.20[b]	2.87	2.14	4.18	2.14	3.47
0.60×0.60	3.05[a]	3.67	2.98	5.87	1.91	3.61
0.90×0.20	2.77[b]	3.10	1.90	5.12	2.09	3.46
0.90×0.40	2.57[b]	2.57	3.22	6.82	1.88	3.34
0.90×0.60	2.83[b]	2.82	2.17	6.37	1.91	3.41
1.20 ×0.20	3.34[a]	2.81	2.30	5.51	2.08	3.52
1.20 ×0.20	3.08[a]	2.76	3.83	6.61	1.68	3.42
1.20 ×0.20	2.77[b]	2.46	4.11	6.24	1.94	3.47
SEM	0.15	0.20	0.37	0.87	0.15	0.079
P value	0.011	0.073	0.085	0.568	0.230	0.978

Means in the same column within each classification bearing different letters significantly differ

Nonphytate phosphorus to up to 50% of the NRC (1994) recommended amounts during the starter and grower stages did not affect the feed conversion ratio. The results of this study are contradictory to the findings of Imari et al. (2020) those who reported a 10% to 30% reduction in the recommended amount of dietary calcium and Nonphytate phosphorus during the post-starter, starter, and finisher periods of broilers did not influence FCR.

3.5 Carcass characteristics

Table 6 revealed how varying levels of calcium and NPP affect the carcass characteristics of quail at different ages. Results of the study suggested that all carcass parameters were unaffected by the increasing calcium and phosphorus levels (i.e., dressing, carcass, giblets, liver, heart, and gizzard). Similarly, the combination of dietary Ca and P also did not affect the various parameters of the carcass such as giblets, liver, heart, and gizzard (Table 5). However, the interaction effect had a substantial (P <0.05) impact on the carcass (p=0.027) and dressing (P=0.046). The best results were obtained with 0.90% Ca and 0.20 % P combinations.

Reduced calcium and Nonphytate phosphorus by 10% to 30% of required levels showed no influence on internal organs and carcass attributes of broilers at 7 weeks of age, as per Imari et al. (2020), which is consistent with our findings. In agreement with this, Han et al. (2015) also observed that dietary levels of

Table 6 Effect of calcium and phosphorus and its interactions on carcass traits of growing quails

Treatments	Carcass traits (%)					
	Carcass	Dressing	Giblet	Heart	Liver	Gizzard
Calcium Percentage						
0.60	72.90	79.21	6.30	3.40	.89	2.00
0.90	72.98	79.18	6.20	3.18	.95	2.06
1.20	72.75	78.58	5.83	2.93	.91	1.98
P value	0.964	0.743	0.146	0.181	0.556	0.761
Phosphorus Percentage						
0.20	72.06	78.17	6.11	3.22	.90	1.98
0.40	73.95	80.24	6.28	3.22	.92	2.14
0.60	72.62	78.56	5.94	3.09	.92	1.92
P value	0.105	0.078	0.391	0.834	0.923	0.144
Calcium and Phosphorus Interaction						
0.60×0.20	71.74[ab]	78.14[ab]	6.40	3.42	.894	2.08
0.60×0.40	74.37[a]	80.50[a]	6.12	3.26	.881	1.97
0.60×0.60	72.60[ab]	79.00[a]	6.40	3.53	.915	1.95
0.90×0.20	74.45[a]	80.58[a]	6.13	3.29	.927	1.91
0.90×0.40	73.33[a]	79.88[a]	6.54	3.32	.950	2.27
0.90×0.60	71.16[ab]	77.09[b]	5.93	2.95	.975	2.00
1.20 ×0.20	69.99[b]	75.80[b]	5.80	2.94	.903	1.95
1.20 ×0.20	74.14[a]	80.34[a]	6.19	3.07	.939	2.18
1.20 ×0.20	74.11[a]	79.60[a]	5.49	2.78	.894	1.81
SEM	1.07	1.13	0.305	0.30	0.063	0.13
P value	0.027	0.046	0.502	0.841	0.966	0.430

Means in the same column within each classification bearing different letters significantly differ

Nonphytate accessible phosphorus did not affect broiler carcasses. Furthermore, Akter et al. (2016) have reported that reducing dietary calcium from 10 to 6 gm/kg and dietary Nonphytate phosphorus from 4 to 3 gm/kg did not affect the relative weights of broiler chicken internal organs. Similarly, Tizziani et al. (2019) also found that decreasing the dietary calcium level to 30% of the standard requirements did not affect carcass yield in broiler chickens. On the other hand, El-Faham et al. (2019) found that reducing the dietary calcium and Nonphytate phosphorus levels to half of the normal requirements reduced the carcass characteristics and dressing percentage age in broilers. Han et al. (2016) also found that a decreased calcium to Nonphytate phosphorus ratio resulted in reduced broiler carcass production.

3.6 Tibia indices

Table 7 showed the impacts of calcium and NPP, as well as their interactions, on the tibia indices of growing quails. All the tibia indicators were unaffected by varying dietary Ca or P intakes (P > 0.05). Regardless of the length and diameter of the tibia, the interaction between Ca and P had a significant impact on weight. Further, treatments fed with 0.60 % Ca and 0.60% P has the maximum tibia weight (0.683kg). Our findings are comparable to those of Ribeiro et al. (2016), who showed no statistical impact of calcium and NPP on bone indices (P>0.05). On the other hand, Keshavarz (2003) pointed out that ash of tibia was reduced when birds were fed diets containing 0.25, 0.20, and 0.15% of calcium.

Table 7 Effect of calcium and phosphorus and its interactions on tibia indices of growing quails

Treatments	Tibia		
	Weight (g)	Length (mm)	Diameter (mm)
Calcium Percentage			
0.60	0.59	5.46	0.28
0.90	0.62	5.47	0.28
1.20	0.61	5.53	0.28
P value	0.325	0.929	0.937
Phosphorus Percentage			
0.20	0.58	5.42	0.29
0.40	0.60	5.48	0.28
0.60	0.64	5.56	0.28
P value	0.144	0.23	0.144
Calcium and Phosphorus Interaction			
0.60×0.20	0.54[b]	5.22	0.29
0.60×0.40	0.54[b]	5.35	0.28
0.60×0.60	0.68[a]	5.82	0.28
0.90×0.20	0.62[a]	5.50	0.28
0.90×0.40	0.62[a]	5.56	0.27
0.90×0.60	0.64[a]	5.34	0.29
1.20 ×0.20	0.60[ab]	5.53	0.30
1.20 ×0.20	0.65[a]	5.54	0.29
1.20 ×0.20	0.59[ab]	5.52	0.26
SEM	0.032	0.232	0.013
P value	0.015	0.480	0.455

Means in the same column within each classification bearing different letters significantly differ

Conclusions

Ca and NPP levels could be lowered in Japanese quail diets without affecting growth rate, feed utilization, carcass yields, edible components, or tibia indices. Results of the current study advise against raising the calcium to phosphorus ratio in the feed since this may have negative NPP on the growth performance and public health of growing quails.

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