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Effect of replacement of shell grit with stone grit in diet on production performance and mineral retention in Namakkal Gold Quail

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ABSTRACT

The present study was undertaken to evaluate the feasibility of using stone grit as an alternative calcium source in diet of egg type Japanese quail. A biological trial was conducted by using 360 of five week old female *"TANUVAS Namakkal Gold quail"* strain, divided into five dietary treatment groups, by replacing shell grit with 2 mm and 4 mm stone grit at 50 and 100 per cent levels in the diet. The study was conducted for 52 weeks, monitoring production performance (body weight, egg production, feed intake, feed efficiency, defective shelled eggs per cent, livability, leg abnormalities) and economic efficiency for every 28 days period. A metabolic trial was conducted for 5 days at the end of 52 weeks to assess the dry matter, calcium and phosphorous retention. Replacement of shell grit with stone grit (2 mm and 4 mm) at both inclusion levels had no significant impact on egg production, egg mass, feed efficiency, defective shelled eggs per cent and livability for the overall experimental period. The overall feed consumption was significantly ($p \leq 0.05$) higher in 100 per cent 2 mm stone grit fed group and the calcium and phosphorous retention were significantly($p \leq 0.05$) higher in 50 per cent 2mm stone grit fed group. It may be concluded that replacement of shell grit with stone grit improved the feed consumption, calcium and phosphorous retention without affecting egg production and feed conversion, supporting the use of stone grit as an efficient alternative calcium source in the diet of egg type quails.

Keywords: Calcium retention, Egg production, Japanese quail, Stone grit

Japanese quail farming is cropping up as a new venture of poultry farming to diverse the choice of taste and strengthen the egg production unit for fulfilling the shortage of animal protein demands. Japanese quails possess an excellent disease resistance quality as compared to chickens, and provides quick return on investment with high vitamin eggs.Incidences of thin shelled eggs, soft shelled eggs and cracked eggs also lead to a considerable loss (3.78 per cent) in total egg production of Japanese quails (Alam *et al.* 2008). There is need to improve the efficiency of egg production through reducing losses caused by egg breakage (Sultana *et al.* 2007). It is therefore, important to identify economically suitable and sustainable source of calcium in order to improve eggshell quality and minimize losses due to breakages.

Calcium source and particle size significantly affect calcium and phosphorus availability, influencing eggshell quality and mineral retention. Limestone particle size is known to be related to its *in vitro* solubility (Zhang and Coon, 1997), but is altered by differences in the physical structure of the limestone rock and geological origin (Plumstead *et al.* 2020). Coarse or medium particle sizes of calcium will lead to better phosphorous availability by promoting the hydrolysis of phytate phosphorus and enhancing the release of sufficient phosphorus in the small intestine. Manangi *et al*. (2018) demonstrated the effect of feeding two limestone particle size (average particle size was 185 and 3,490 mm) in broiler breeder hens for 6 weeks and concluded that the large-particle-size limestone significantly decreased the phosphorous content in the excreta.

Shell grit, the commonly used calcium source in quail feed, contains high calcium but has drawbacks such as irregular particle size, contamination, high labor costs, and expense. Stone grit, derived from limestone rocks, contains a similar calcium level (38%) but is cheaper, uniform in size, and more readily available. Since limited research exists on use of stone grit in egg-type Japanese quails, the study aimed to evaluate replacing shell grit with stone grit and assess its effects on production performance and mineral retention.

MATERIALS AND METHODS

Location and climate: The experiment was conducted in Poultry Farm Complex, Department of Poultry Science, Veterinary College and Research Institute, Namakkal,

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Tamil Nadu. The temperature humidity index (TSI) during the study period was between 77.52 and 83.07 (Anon, 2025).

Ethical and bio-safety committee approval: This study was approved by the Institutional Animal Ethics Committee (IEAC) of Veterinary College and Research Institute, Namakkal (No.16/VCRI/NKL/2024).

Experimental birds: A 52 week trial was conducted by using 360 five weeks old "*TANUVAS Namakkal Gold Quail"*. The birds were wing banded, weighed and randomly assigned to five treatment groups with six replicates of 12 birds each in a completely randomized design. All birds were reared in elevated platform cage system and received an isocaloric, isonitrogenous maize-soya based diet with 3% calcium and 0.40% non-phytate phosphorus. Calcium was supplied by replacing shell grit with stone grit (2 mm and 4 mm) at 50% and 100% levels The dietary calcium of 3 % was provided to dietary treatments as follows.T_1 -100% shell grit (control), T_2 -100 % stone grit with 2 mm size, T_3 -100 % stone grit with 4 mm size, T_4 -50 % shell grit plus 50 % stone grit with 2 mm size, T_5 -50 % shell grit plus 50 % stone grit with 4 mm size.

Production performance: Body weight of Japanese quails was recorded individually at 6 weeks and at 28 day intervals up to 52 weeks. Daily egg production per replicate was recorded from onset of lay to 52 weeks. Hen-day and hen-housed egg production were calculated every 28 days based on surviving birds. Defective eggs including misshapen, cracked, shell-less and other abnormalities were recorded daily, and their percentage was calculated every 28 days. Feed intake, egg mass and livability were recorded at 28-day intervals, and feed conversion ratio (FCR) was expressed as feed per dozen eggs and per kg egg mass. Leg scoring was conducted weekly as per Watson *et al.* (1970) to assess leg abnormalities, using a 0–4 scale based on joint swelling and tendon displacement.

Metabolic trial: At the end of 52 weeks, 240 Japanese quails were assigned to five treatments (6 replicates of 8 birds) and housed individually in platform cages. After 3-day adaptation to the experimental diet, feces were collected daily for 3 days using polythene sheets placed under the cages. Calcium and phosphorus intake were calculated based on feed consumption and nutrient levels. Collected excreta were weighed, labeled, and stored in a deep freezer for further analysis. An aliquot of 100 g was prepared from each stored sample and dried in hot air oven at 55° C for 72 hours. Aliquots were allowed to air cool, weighed and ground. Subsequently, the moisture, calcium and phosphorous were determined as per the method of AOAC (2023) to estimate the retention of dry matter, calcium and phosphorous.

The observations on production and mineral retention parameters were statistically analyzed by one way ANOVA method in SPSS 20th version and the mean of different experimental groups were tested for statistical significance by Duncan's multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

Hen housed and hen day egg production: The mean hen housed and hen day egg production of egg type Japanese quails fed diet with different sizes and replacement levels of stone grit are presented in Table 1 and 2. The study found that different calcium sources (shell grit or stone grit), stone grit particle sizes (2 mm or 4 mm), and replacement levels (50% or 100%) had no significant effect on overall hen housed or hen day egg production in Japanese quails. However, quails in T_3 and T_4 groups showed higher egg production during the early laying phase (6–20 weeks) and started laying earlier than the control group (T_1), which reached 50% production only at 11 weeks. After 20 weeks, egg production was similar across all groups, peaking at 25–28 weeks. The delayed egg production in the control group might be due to lower calcium intake from shell grit. These findings are in accordance with the findings of Moura *et al.* (2020) and Rezende *et al.* (2024) who found no significant effect on egg production when limestone was replaced with eggshell or calcareous seaweed in Rhode Island hens and Japanese quails, respectively. Similarly, Mannangi *et al.* (2018), and Islam and Nishibori (2021) also reported insignificant differences in hen day egg production on varying calcium sources or particle sizes in the diet of layers and Japanese quails.

Egg mass: The mean egg mass (g/ bird) of Japanese quails is presented in Table 3. The calcium source (shell grit or stone grit), particle size of stone grit (2 mm or 4 mm) and the replacement level of stone grit (50 or 100 per cent) did not significantly influence the egg mass of Japanese quails over the entire experimental period. These findings were consistent with Saki *et al.* (2019) and Islam and Nishibori (2021) who reported no significant effect of calcium source (oyster shell, limestone and eggshell) or particle size (fine, medium and coarse) on egg mass in laying hens ($p>0.05$).

Defective shelled eggs per cent: The mean per cent of defective shelled eggs in Japanese quails is presented in Table 4. The source of calcium (shell grit or stone grit), particle size of stone grit (2 mm or 4 mm) and the replacement level of stone grit (50 or 100 per cent) did not significantly influence the per cent of defective shelled eggs in Japanese quails over the entire experimental period. Similar findings were reported by Pelicia *et al.* (2011), Codeiro *et al.* (2017), and Sousa *et al.* (2017), who observed no significant impact of calcium particle size on cracked egg percentage in layers. Studies by Pelicia *et al.* (2006) and Kermanshahi and Golian (2011) also showed no significant differences when alternative calcium sources like marine algae, oyster shell, filter mud and eggshell were used. In the present study, T_3 (100 per cent 4 mm stone grit) had the lowest defective rate, especially during weeks 9–16, while T_5 had the highest defective egg per cent ($p<0.01$). For overall period, the defective shelled egg per cent was lowest (2.64) in T_3 group, suggests the potential benefits of coarser stone grit (4 mm). The defective shelled egg per cent

Table 1. Mean (±S.E.) Hen housed egg production (numbers) of Japanese quails fed diet with different particle sizes and replacement levels of stone grit

Age (in weeks)	T_1	T_2	T_3	T_4	T_5	P-Value
6-8	0.82^{c}±0.29	2.50^{b}±0.51	4.18^{ab}±0.97	4.75^{a}±0.40	2.62^{b}±0.33	0.001
9-12	15.28^{b}±0.61	17.26^{ab}±0.46	19.53^{a}±0.99	20.10^{a}±1.25	17.07^{ab}±1.25	0.011
13-16	19.78±0.71	18.50±0.58	21.15±1.43	20.25±1.26	18.51±0.64	0.281
17-20	18.54^{c}±0.69	21.92^{ab}±0.32	22.78^{a}±0.87	20.40^{abc}±1.34	19.18^{bc}±1.08	0.017
21-24	22.79±0.66	22.89±0.50	23.47±0.92	21.96±1.34	22.03±0.96	0.754
25-28	23.08±0.64	23.24±0.86	24.17±0.87	22.46±0.84	21.56±0.99	0.294
29-32	23.74±0.64	23.15±0.92	22.67±1.30	23.00±0.86	22.44±0.82	0.886
33-36	24.02±0.64	22.81±1.09	21.55±1.55	22.20±0.97	22.05±0.81	0.539
37-40	21.22±0.56	21.61±0.70	20.88±1.02	20.32±1.05	21.39±0.59	0.815
41-44	22±1.00	20.81±0.36	20.95±0.66	20.49±0.38	20.89±0.49	0.511
45-48	20.60±1.01	19.93±0.64	20.14±0.81	19.18±0.88	20.53±1.09	0.805
49-52	19.93±1.10	20.70±0.41	20.63±0.92	19.63±0.63	20.00±0.92	0.752
Cumulative (6-52) 329days	231.79±5.09	235.31±4.55	242.08±10.36	234.72±9.76	229.18±7.60	0.82

Each value is the mean of 6 observations.
Values in each row having common superscript do not differ significantly
T_1- 100 per cent shell grit, T_2- 100 per cent 2 mm stone grit, T_3- 100 per cent 4 mm stone grit, T_4- 50 per cent 2 mm stone grit + 50 per cent shell grit, T_5- 4 mm stone grit + 50 per cent shell grit

Table 2. Mean (±S.E.) Hen day egg production (numbers) of egg type Japanese quails fed with different particle sizes and replacement levels of stone grit

Age (in weeks)	T_1	T_2	T_3	T_4	T_5	P-Value
6-8	0.82^{c}±0.29	2.50^{b}±0.51	4.18^{ab}±0.97	4.75^{a}±0.40	2.62^{b}±0.33	0.001
9-12	15.28^{b}±0.61	17.26^{ab}±0.46	19.53^{a}±0.99	20.10^{a}±1.25	17.07^{ab}±1.25	0.011
13-16	19.78±0.71	18.50±0.58	21.15±1.43	20.25±1.26	18.51±0.64	0.281
17-20	18.54^{c}±0.69	21.92^{ab}±0.32	22.78^{a}±0.87	20.40^{abc}±1.34	19.18^{bc}±1.08	0.017
21-24	22.79±0.66	22.89±0.50	23.54±0.90	22.05±1.39	22.03±0.96	0.762
25-28	23.08±0.64	23.25±0.85	24.75±0.64	23.01±1.04	21.56±0.99	0.167
29-32	23.74±0.64	23.80±0.76	23.29±1.18	23.81±0.87	22.44±0.82	0.773
33-36	24.02±0.64	23.69±0.98	22.14±1.47	23.38±0.90	22.24±0.75	0.571
37-40	21.56±0.75	22.58±0.77	21,51±1.11	21.51±0.94	21.94±0.36	0.868
41-44	22.54±1.08	21.73±0.35	21,56±0.69	21.75±0.49	21.62±0.34	0.827
45-48	21.51±0.93	20.79±0.51	20.71±0.68	20.51±0.67	21.41±0.96	0.852
49-52	20.81±0.99	21.64±0.64	21.25±0.86	21.13±0.65	21.85±0.85	0.9
Cumulative (6-52) 329days	234.45±5.54	240.54±4.65	246.39±9.18	242.64±8.77	232.47±6.91	0.641

Each value is the mean of 6 observations
Values in each row having common superscript do not differ significantly

was highest (5.10) in T_5 group. The slow and continuous dissolution of large particle limestone might have been more beneficial in meeting the calcium requirements for proper eggshell formation, thereby increasing shell mass, thickness and strength.

Feed consumption: The mean feed consumption (g/ bird) of Japanese quails is presented in Table 5. The inclusion of 2 mm stone grit, either at 50 or 100 per cent replacement of shell grit significantly ($p<0.05$) improved the feed consumption in Japanese quails for the entire experimental period as compared to the control, whereas feed consumption of 4 mm stone grit fed groups was comparable or intermediate. This clearly indicated that inclusion of stone grit, particularly smaller particle size (2 mm) at 100 per cent replacement level, significantly increased the feed intake of laying Japanese quails compared to shell grit. This agreed with the findings of Khosht *et al.* (2020), who reported higher intake in birds fed finer calcium particles. Ajani *et al*. (2024) also found increased feed consumption with 50 and 100 per cent bone dust inclusion, Similarly, Poudel *et al.* (2022) and Premkumar *et al*. (2025) observed increased feed intake

Table 3. Mean (±S.E.) egg mass (g/ bird) of Japanese quails fed diet with different particle sizes and replacement levels of stone grit

Age (in weeks)	T_1	T_2	T_3	T_4	T_5	P-Value
6-8	8.89^{d}±3.28	26.45^{cd}±5.59	46.29^{ab}±10.44	52.33^{a}±4.30	28.71^{bc}±3.75	0.000
9-12	165.51^{c}±10.50	177.32^{bc}±7.94	211.06^{ab}±8.08	213.84^{a}±15.01	185.84^{abc}±13.54	0.022
13-16	222.22±10.24	207.92±6.39	239.13±16.93	223.98±16.38	209.22±9.80	0.418
17-20	212.45^{c}±9.44	254.81^{ab}±4.97	265.27^{a}±9.24	229.68^{bc}±15.48	212.16^{c}±15.18	0.008
21-24	277.27±8.29	267.45±6.47	289.91±10.95	272.43±19.94	262.73±10.68	0.577
25-28	275.41±7.04	281.7±9.40	288.72±10.65	275.45±16.97	254.68±13.97	0.379
29-32	285.83±10.69	280.90±10.59	289.60±15.53	292.63±7.14	266.94±12.32	0.556
33-36	278.62±8.84	277.04±12.36	265.06±16.73	280.38±10.15	263.18±8.89	0.767
37-40	265.45±6.39	275.17±9.92	274.69±14.43	280.48±15.42	266.99±3.48	0.858
41-44	280.88±15.31	264.43±7.78	263.35±8.60	274.7±6.57	269.08±6.65	0.673
45-48	257.37±12.06	244.79±7.43	249.55±6.75	248.89±10.57	258.9±12.65	0.843
49-52	240.83±11.72	245.84±7.53	259.21±12.38	257.17±9.24	260.62±11.71	0.608
Cumulative (6-52)	2766.7±70.7	2795.8±73.4	2934.3±103.3	2886.3±125.5	2731±87.7	0.532

Each value is the mean of 6 observations

Values in each row having common superscript do not differ significantly

Table 4. Mean (±S.E.) defective shelled eggs per cent of Japanese quails fed diet with different particle sizes and replacement levels of stone grit

Age (weeks)	T_1	T_2	T_3	T_4	T_5	P-Value
9-12	5.16^{ab}±0.86	4.98^{ab}±0.76	1.35^{c}±0.44	2.77^{bc}±0.70	6.62^{a}±1.86	0.004
13-16	4.80^{ab}±1.25	4.92^{ab}±1.29	2.25^{b}±0.35	2.56^{b}±0.57	7.19^{a}±0.36	0.003
17-20	4.25±1.45	3.79±1.05	1.83±0.26	2.45±0.94	4.90±0.81	0.118
21-24	3.03±1.07	3.25±1.65	2.08±0.38	4.61±1.04	5.61±1.11	0.169
25-28	4.65±1.14	4.36±2.04	1.71±0.39	4.02±0.53	5.98±1.64	0.120
29-32	4.44±1.34	3.53±2.01	2.86±0.64	3.61±0.97	4.24±1.54	0.916
33-36	4.15±1.14	4.16±1.72	3.05±0.56	5.74±1.19	4.32±1.14	0.657
37-40	2.80±0.91	3.89±1.63	2.47±0.50	5.50±1.42	4.47±1.07	0.364
41-44	5.47±1.47	5.84±1.33	5.09±1.16	7.52±1.76	5.83±0.33	0.782
45-48	5.40±1.38	3.60±0.94	4.15±0.78	5.72±1.27	3.71±0.67	0.516
49-52	5.59±1.04	3.18±0.91	3.13±0.35	5.37±1.00	4.69±1.25	0.189
Overall (9-52)	4.49±1.03	4.05±1.08	2.64±0.26	4.49±0.59	5.10±0.62	0.152

Each value is the mean of 6 observations

Values in each row having common superscript do not differ significantly

in layers and meat type Japanese quails fed 100 per cent coarse limestone or stone grit. Variations in feed intake might have been due to differences in calcium composition and particle size. Birds may increase intake to meet calcium needs, possibly influenced by calcium specific appetite and extracellular calcium sensing mechanisms that regulate taste and feeding behavior.

Feed conversion ratio: The mean feed conversion ratio per dozen egg and kg egg were similar among the treatments during the experimental period (Table 6). These findings aligned with the result of Ertas *et al.* (2006) who replaced limestone with macunim shell at 0, 25, 50, 75 and 100 per cent in the diet of laying Japanese quails over 90 days and found no significant differences (p>0.05) in feed conversion ratio. Similarly, Moura *et al.* (2020) and Rathnayaka *et al.* (2020), who also found no significant effect of calcium source or replacement level on FCR per dozen egg in Japanese quails and laying hens. A similar trend of non significant effect of particle size of limestone on feed conversion ratio per dozen egg was observed in Japanese quails (Berto *et al.* 2007), as well as in commercial layers (Codeiro *et al.* 2017 and Sousa *et al.* 2017).

Livability: The mean livability per cent of Japanese quails fed with two different sizes and replacement levels of stone grit from 6 to 52 weeks of age indicated that calcium source, particle size, nor replacement level of stone grit had no significant effect on (p>0.05) on livability. These findings aligned with earlier studies by Ertas *et al.* (2006)

Table 5. Mean (±S.E.) feed consumption (g/bird) of Japanese quails fed diet different particle sizes and replacement levels of stone grit

Age (in weeks)	T_1	T_2	T_3	T_4	T_5	P-Value
6-8	573.24^{b}± 9.38	617.06^{a}± 3.88	568.14^{b}± 9.81	582.57^{b}± 7.74	579.99^{b}± 14.43	0.011
9-12	640.16± 11.77	687.47± 9.13	693.3± 17.71	704.10± 18.77	691.29± 21.65	0.089
13-16	739.04^{bc}± 2.66	766.16^{a}± 5.88	731.11^{c}± 6.73	748.51^{b}± 1.79	731.07^{c}± 7.07	0.001
17-20	839.24± 20.24	869.83± 7.33	849.22± 4.16	828.47± 6.24	810.43± 21.75	0.069
21-24	934.24± 22.69	957.62± 11.14	955.62± 13.59	981.95± 27.63	938.72± 3.38	0.374
25-28	919.76± 9.18	945.34± 14.1	942.74± 15	928.93± 13.99	904.79± 6.69	0.146
29-32	917.1^{bc}± 1.69	952.05^{a}± 16.22	925.02^{c}± 15.02	943.34^{ab}± 17.61	910.79^{cd}± 3.10	0.144
33-36	888.1± 11.64	929.73± 15.99	885.7± 17.72	933.13± 22.7	915.82± 8.31	0.131
37-40	832.71^{b}± 16.55	898.07^{a}± 18.72	886.91^{a}± 14.09	915.7^{a}± 30.58	913.65^{a}± 18.19	0.051
41-44	924.24± 25.98	965.79± 19.25	958.22± 15.73	987.1± 27.42	959.52± 14.10	0.361
45-48	907.48± 31.39	948.98± 14.68	925.86± 18.32	967.13± 16.54	948.74± 19.02	0.321
49-52	891.81± 30.88	943.13± 14.19	940.85± 17.04	966.75± 24.92	970.09± 19.94	0.127
Cumulative(6-52)	9991^{b}± 145	10459^{a}± 85	10242^{ab}± 75	10444^{a}± 137	10249^{ab}± 52	0.028

Each value is the mean of 6 observations
Values in each row having common superscript do not differ significantly

Table 6. Mean (±S.E.) feed conversion ratio of Japanese quails fed diet with different particle sizes and replacement levels of stone grit (9- 52 weeks)

FCR	T_1	T_2	T_3	T_4	T_5	P- Value
FCR/ dozen egg	0.513±0.011	0.523±0.008	0.502±0.021	0.521±0.024	0.531±0.016	0.794
FCR/ kg egg	3.62±0.08	3.75±0.09	3.51±0.13	3.66±0.19	3.77±0.12	0.626

Each value is the mean of 6 observations
Values in each row having common superscript do not differ significantly

and Pelicia *et al.* (2006), who found no significant effect on mortality when replacing limestone with alternative calcium sources in laying Japanese quails and hens. Similar non significant results were reported by Pelicia *et al.* (2009) and Pizzolante *et al*. (2009) in layers fed different limestone particle sizes. The observed livability range of 93.06 - 95.84 per cent among the treatments was within the normal range.

Leg abnormality score: The mean leg abnormality scores of Japanese quails fed with different sizes and replacement levels of stone grit from 6 to 52 weeks of age did not differ significantly (p>0.05). These findings aligned

Table 7. Mean (±S.E.) mineral retention parameters of egg type Japanese quails fed diet with different particle sizes and replacement levels of stone grit

Mineral retention parameters	T_1	T_2	T_3	T_4	T_5	P-Value
Calcium intake (g/day)	0.925^{d}	0.923^{e}	0.998^{c}	1.098^{a}	1.023^{b}	-
Calcium excreted (g/day)	0.498^{c}±0.021	0.547^{b}±0.013	0.572^{b}±0.014	0.636^{a}±0.015	0.575^{b}±0.015	0.000
Calcium retention (g/day)	0.427^{a}±0.021	0.375^{b}±0.013	0.426^{a}±0.014	0.462^{a}±0.015	0.448^{a}±0.015	0.008
Calcium retention (%)	46.16±2.23	40.68±1.43	42.67±1.39	42.07±1.34	43.82±1.50	0.197
Phosphorus intake (g/day)	0.240^{c}	0.228^{e}	0.268^{b}	0.280^{a}	0.233^{d}	-
Phosphorus excreted (g/day)	0.141^{b}±0.005	0.141^{b}±0.005	0.172^{a}±0.005	0.163^{a}±0.005	0.141^{b}±0.004	0.000
Phosphorus retention (g/day)	0.099^{b}±0.005	0.087^{b}±0.005	0.095^{b}±0.005	0.118^{a}±0.005	0.092^{b}±0.004	0.001
Phosphorus retention (%)	41.28±1.99	38.05±2.10	35.59±1.75	41.89±1.61	39.47±1.64	0.135
Dry matter intake (g/day)	22.12^{a}	21.83^{c}	22.01^{b}	21.78^{d}	21.71^{e}	-
Dry matter excreted (g/day)	7.62±0.16	7.56±0.06	7.69±0.13	7.77±0.11	7.44±0.13	0.4
Dry matter retention (g/day)	14.49±0.16	14.27±0.06	14.32±0.13	14.01±0.11	14.27±0.13	0.128
Dry matter retention (%)	65.53±0.72	65.37±0.28	65.07±0.58	64.33±0.51	65.74±0.61	0.445

Each value is the mean of 12 observations
Values in each row having common superscript do not differ significantly

with Khalander (2022) who reported no significant leg abnormalities in 12 week old Aseel chicken fed different calcium and phosphorus levels. In comparison, broilers often show higher leg scores due to rapid growth, as reported by Watson *et al.* (1970), Rama Rao *et al.* (2003) and Panda *et al.* (2006).

Dry matter, Calcium and Phosphorous retention: The mean dry matter, calcium and phosphorous retention of Japanese quails fed diets with different sizes and replacement levels of stone grit is presented in Table7. The dry matter retention was not significantly ($p \geq 0.05$) influenced by the source of calcium, particle size or level of replacement of stone grit. These findings are supported with the findings of Alu (2013) who found that replacing bone ash with eggshell meal at 0, 25, 50, 75 and 100 per cent in the diet of broilers did not affect dry matter retention significantly ($p>0.05$). Similarly, Bassi *et al* (2022) observed that calcium - phosphorous ratios (1.7 and 2.0), two oyster shell meal particle sizes (coarse-1,354 µm and fine- 428 µm) in the broiler diet had no significant effect on dry matter retention ($p>0.05$).

The mean calcium and phosphorous excretion and retention (g/day) were significantly different among the treatment groups ($p<0.01$), whereas per cent retention of calcium and phosphorous were similar. The retention of calcium and phosphorous was significantly higher in T_4 group. This finding aligned with Moura *et al.* (2020) who found that the percentage of calcium in excreta increased linearly with inclusion of eggshell in the diet of Japanese quails.

Larger or coarser particle of calcium sources were found to result in significantly higher calcium retention in broilers (Manangi and Coon, 2007; Bassi *et al.* 2022) in broiler breeders (Ekmay and Coon, 2010; Mannangi *et al.* 2018). Souvik-Mondal *et al*. (2012) found that dicalcium phosphate and limestone in the diet of Japanese quails had significantly higher phosphorous retention than other sources.

Replacing shell grit with stone grit at 2 mm and 4 mm did not significantly affect the body weight, egg production, feed efficiency, livability, leg health and dry matter retention, however, calcium and phosphorous retention were improved. Cent per cent replacement with 4 mm stone grit feeding is recommended in Japanese quail since it resulted in increased egg mass by 167.6 g and 11.94 more hen days egg production and lesser egg breakage 2.64 per cent.

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REFERENCES

Ajani O W, Oladele O A, Adedotun W G, Temitope O O and Opeolouwa O E. 2024. Performance, egg quality characteristics, serum parameters, blood minerals and bone mineralisation of laying chickens fed bone dust as calcium source. *Bulgarian Journal of Animal Husbandry* **61**(1): 19–30.

Alam M S, Howlider M A R, Mondal A, Hossain K and Bostami A B M R. 2008. Pattern of egg production in Japanese quail reared on littered floor and in cages. *Bangladesh Research Publications Journal* **1**(3): 239–243.

Alu S E. 2013. Effect of replacing bone ash with eggshell meal on nutrient digestibility and blood parameters of broiler chickens. *Iranian Journal of Applied Animal Science* **3**: 125–129.

Anonymous. 2025. Experimental Agro- metreological Advisory Service. Veterinary College and Research Institute, Namakkal, Tamil Nadu.

AOAC, 2023. *Oficial Methods of Analysis, Association of Oficial Analytical Chemists*, 22nd Edn, Washington, D.C, USA.

Bassi L S, Durau J F, Zavelinski V A B, Krabbe E L, Surek D and Maiorka A. 2022. Particle size of oyster shell meal and calcium: phosphorus ratios in broiler diets. *Ciencia Rural Santa Maria* **52** (10): e20210524.

Berto D A, Garcia E A, Mori C, Faitarone A B G, Pelícia K and Molino A B. 2007. Performance of Japanese quails fed feeds containing different corn and limestone particle sizes. *Brazilian Journal of Poultry Science* **9**: 167–171.

Cordeiro C N, Bastos-Leite S C, Vasconcelos F C, Goulart C C, Sousa A M and Costa A C. 2017. Chelated minerals and limestone particle sizes on performance and bone quality of brown-egg layers. *Brazilian Journal of Poultry Science* **19**: 35–42.

Duncan D B, 1955. Multiple range and multiple F tests. *Biometrics* **11**(1): 1–42.

Ekmay R D and Coon C N. 2010. The effect of limestone particle size on the performance of three broiler breeder purelines, *International. Journal of Poultry Science* **9:** 1038–1042.

Ertas O N, Ciftci M, Guler T and Dalkilic B. 2006. The use of possibility of mussel shell supplementation as calcium source in Japanese quails raised under heat stress conditions: the effect of mussel shell on egg yield and some blood parameters. *Sagilik Billimleri Dergisi* **20**(1): 15–20.

Islam M A and Nishibori M. 2021. Use of extruded eggshell as a calcium source substituting limestone or oyster shell in the diet of laying hens. *Veterinary Medicine and Science* **7**: 1948–1958.

Kermanshahi H, and Golian A G. 1991. Effects of various sources of calcium upon eggshell quality and laying hen performance. In: *Proceedings of the 4th European Symposium on the Quality of Eggs and Egg Products*, Doorwerth, Holland, pp. 147–158.

Khalander N. 2022. Calcium and phosphorus requirements for growth in Aseel chicken. M.V.Sc Thesis, Department of Animal Nutrition, Tamil Nadu Veterinary and Animal Sciences University, Chennai.

Khosht A R, Abd El-Khalek A and Abdel Magid M. 2020. Influences of calcium levels with limestone particle size on laying performance, and eggshell quality traits of layers. *Egyptian Poultry Science Journal* **40**(3): 631–645.

Manangi M K, and Coon C N. 2007. The effect of calcium carbonate particle size and solubility on the utilization of phosphorus from phytase for broilers. *International Journal of Poultry Science* **6**: 85–90.

Manangi M K, Maharjan P and Coon C N. 2018. Calcium particle size effects on plasma, excreta, and urinary Ca and P changes in broiler breeder hens. *Poultry Science* **97**: 2798–2806.

Moura, G R S, Reis R D S, Mendonça M D O, Salgado H R, Abreu K D S. Madella G D S and Lima M B D. 2020. Substitution of limestone for eggshell powder in the diet of Japanese laying quails. *Revista Brasileira de Saúde e Produção Animal* **21**: 1–13.

Panda A K, Rama Rao SV. Raju M V L N and Sharma S R 2006. Dietary supplementation of Lactobacillus sporogenes on performance and serum biochemico - lipid profile of broiler chickens. *The Journal of Poultry Science* **43**(3): 235–240.

Pelícia K, Garcia E A, Scherer M R S, Mori C, Dalanezi J A, Faitarone A B G and Berto D A. 2006. Alternative calcium source effects on commercial egg production and quality. *Brazilian Journal of Poultry Science* **9**: 105–109.

Pelicia K, Garcia E A, Mori C, Faitarone A B G, SilvaA P, Molino A B and Berto D A. 2009. Calcium levels and limestone particle size in the diet of commercial layers at the end of the first production cycle. *Brazilian Journal of Poultry Science*, **11**: 87–94.

Pelicia K, Mourao J L M, Garcia E A, Pinheiro V M C, Berto D A, Molino A B and Silva A P. 2011. Effects of dietary calcium levels and limestone particle size on the performance, tibia and blood of laying hens. *Brazilian Journal of Poultry Science* **13**: 29–34.

Pizzolante C C, Saldanha E S P B, Lagana C C, Kakimoto S K and Togashi C K. 2009. Effects of calcium levels and limestone particle size on the egg quality of semi-heavy layers in their second production cycle. *Brazilian Journal of Poultry Science* **11**: 79–86.

Plumstead P W, Sinclair-Black M and Angel, C R. 2020. The benefits of measuring calcium digestibility from raw materials in broilers, meat breeders, and layers. In*: Proceedings of the 31st Annual Australian Poultry Science Symposium*, Sydney, Australia (pp. 16–19).

Poudel I, McDaniel C D, Schilling M W, Pflugrath D and Adhikari P A. 2022. Role of conventional and split feeding of various limestone particle size ratios on the performance and egg quality of Hy-Line® W-36 hens in the late production phase. *Animal Feed Science and Technology* **283**: 115153.

Premkumar K, Kannan D, Vasanthakumar P, Rajendran K, and Ramakrishnan S. 2025. Replacement of limestone powder with stone grit on production performance and mineral retention in meat type Japanese Quails. *The Indian Journal of Animal Sciences* **95**(3): 232–238.

Rama Rao S V, Raju M V L N, Reddy M R, Pavani P, Shyam Sunder G and Sharma R P. 2003. Dietary calcium and non-phytin phosphorus interaction on growth, bone mineralization and mineral retention in broiler starter chicks. *Asian-Australasian Journal of Animal Science* **16**(5): 719–725.

Rathnayaka R M D, Mutucumarana R K and Andrew M S. 2020. Free-choice feeding of three different dietary calcium sources and their influence on egg quality parameters of commercial layers. *The Journal of Agricultural Sciences- Srilanka* **15**(1): 50–62.

Rezende E B, Valentim J K, Garcia R G, De Castro Burbarelli M F, Komiyama C M, Serpa F C and Felix G A. 2024. Calcareous seaweed in the diet of growing Japanese quail. *Animal Science Papers and Reports* **42**(1): 65–80.

Saki A, Rahmani A and Yousefi A. 2019. Calcium particle size and feeding time influence egg shell quality in laying hens. *Acta Scientiarum, Animal Sciences* **41**: e42926.

Sousa A M D S, Bastos-Leite C, Goulart C D C, Barroso M L D S and Silva J D B. 2017. Chelated minerals and two limestone particle sizes on production of layers in the second laying cycle. *Revista Brasileira de Saúde e Produção Animal* **18**(1): 103–112.

Souvik Mondal S M, Lalzarzova V and Gautam Samanta G S. 2012. Feeding of different calcium sources on nutrient utilization and egg quality of Japanese quail. *Indian Journal of Animal Nutrition* **29**(2-3): 310–316.

Sultana F, Islam M Sand Howlider M A R. 2007. Effect of dietary calcium sources on levels of egg production and egg quality. *International Journal of Poultry Science* **6**(2): 131–136.

Watson L T, Ammerman C B, Miller S M and Harms R H. 1970. Biological assay of inorganic manganese for chicks. *Poultry Science* **49**(6): 1548–1554.

Zhang B and Coon C N. 1997. The relationship of calcium intake, source, size, solubility *in vitro* and *in vivo*, and gizzard limestone retention in laying hens. *Poultry Science* **76**(12): 1702–1706.