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Research Article
Effect of Feed Supplement with Fermented Maize (Ogi) Powder on Egg-Laying Japanese Quail (*Coturnix coturnix* Japonica)

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Abstract
Background and Objective: Given the high cost of commercial feedstuff in Nigeria and the need to improve the egg yield in poultry birds, especially in quails with high laying capacity, a fortification 'remedy' with fermented maize (ogi) powder is therefore, being evaluated and proposed as a rational approach that can produce the same egg yield as conventional feedstuff and perhaps at a cheaper cost. **Materials and Methods:** Ninety 21 days old quail chicks were randomly divided into nine groups and fed with 1:9, 1:4, 1:3, 1:1, 3:1, 4:1 and 9:1 ratio of commercial and 'ogi' feed (A-G), 100% commercial feed (H) and 100% ogi powder (I), respectively. The proximate and mineral contents of the feeds, the feed conversion rate, egg-laying capacity, egg weight after the trials alongside the physiological and haematological parameters were estimated. **Results:** The average weight of the quails ranged between 111.26 g (1:4 and 9:1 quail groups) and 114.56 g (1:1 quail group) after 21 days of feeding. The ogi meal was poorly consumed resulting in weight loss while the composite feeds comparatively supported growth. The birds fed mainly with the ogi meal produced two unshelled eggs while the birds in group F (4:1) did not produce any egg on the 13th day of feeding but had the highest number of eggs after 20 days. The average weight of eggs laid by the group E (3:1) birds was relatively greater (8.90 g) than other groups. Generally, the concentration of most of the serum biochemical components in the 21 days old female birds (CFm*) before feeding trials was higher than the male birds (CM*). **Conclusion:** The ratio of 4:1 composite feed (group F) met the bird's feeding requirements. Thus, for good quality egg production and providing a cheaper protein source, ogi can form a cheaper component of the dietary feed formulation of Japanese quails.

Key words: Quails, ogi, egg production, fortification, protein, serum, haematological, composite feed

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The consumption of animal protein in Nigeria, generally less than 10 g/head/day is lower than the recommended daily intake prescribed by the Food and Agricultural Organization (FAO) for human growth and development put at 65 g[1-3]. Thus, there is a need to consider the raising of a cheap and alternative protein source to alleviate animal protein deficiency via investment in poultry animals with short generation intervals such as quail birds (*Coturnix coturnix* japonica)[4]. Quails are small game birds with many desirable characteristics such as fast growth, high egg yield producing about 300 eggs/annum and a quick generation time (3-4 generations a year). They also mature rapidly, hatching eggs within a short period, fewer feed requirements (20-25 g/adult bird/day), high resistance to poultry diseases and cheap and less feed cost[5,6]. These properties make them a viable poultry protein source[3,7,8].

Quail birds have been used in commercial production for meat and eggs[9-11]. The eggs have high protein content (13 g) and are rich in sources of folate (60 µg), vitamin B12 (1.58 µg), pantothenic acid (1.761 mg), phosphorus (226 mg), riboflavin (0.79 mg) and selenium (32 µg)[12]. They are also rich in calories (15 g), total fat (11 g), saturated fat (3.6 g), cholesterol (844 mg), sodium (141 mg), vitamin D (55 mcg), calcium (64 mg), magnesium (13 mg), iron (3.65 mg), phosphorus (226 mg) and potassium (132 mg). Quail eggs are rich in antioxidants, selenium, lecithin, iodine and choline. They are three to four times more nutritious than chicken eggs with almost 3 times more vitamin B1 and double the vitamin B2 and vitamin A. The eggs are also rich in vitamin E, amino acids and fatty acids[13-15]. Quail eggs contain around 60% of essential fats, i.e., High-Density Lipoprotein (HDL) or good cholesterol[13]. Quail eggs contain essential nutrients such as vitamin D and lysine for bone development[13]. Vitamin D regulates the amount of other minerals e.g., phosphorus and calcium are involved in bone health[16].

Several studies have shown that quail eggs are richer nutritionally than chicken eggs. The carcass has more moisture and minerals than broiler meat with less fat and fewer calories, forming an ideal food for health-conscious consumers[17,18]. Their small size and quick regeneration time have made them suitable as laboratory experimental animals[19].

To produce fertile eggs, males and females should be enclosed with a maximum of two females per male[20]. Female birds lay between 1-12 brightly coloured eggs (usually 6), that hatch after an incubation period of 23 days. The Japanese quails require about 20-25 g feed/day compared to chicken (120-130 g/day)[21]. Rabie and Abo El-Maaty[22] reported that Japanese quails fed on 26 and 21.6% crude protein had good performance from 1-21 and 22-35 days of age, respectively. Thus, nutritional requirements decrease with age. However, factors that may affect haematological parameters include subclinical infections, age, species, sex, breed, nutritional status, method of analysis and duration of storage of samples, haemostatic disorders such as bacterial and viral infections and vitamin K deficiency[23].

Ogi is a fermented maize gruel consumed by over 25 million people, especially in southwest Nigeria and other parts of West Africa. Microbiological and nutritional studies show that organisms responsible for the fermentation of ogi could also affect their nutritional improvement. Naturally, lactic acid bacteria (LAB) are mainly responsible for such fermentations[24,25]. The LABs' ability to produce antimicrobial substances against other competing microbiota ensures their predominance and food safety[26,27]. The traditional process of retting the maize grains (chance inoculation) to produce ogi usually takes between 36 and 48 hrs, with the appearance of LABs after 12 hrs[28]. However, Aderiye *et al.*[29] reported that pretreatment of maize grains before fermentation drastically reduced the period required for producing ogi to between 3-5 hrs.

Given the high cost of commercial feedstuff in Nigeria and the need to improve the egg yield in poultry birds, especially in quails that have a high laying capacity, a fortification is therefore, a rational approach as this can yield the same output as conventional feedstuff and perhaps at a cheaper cost. Abou-Kassem *et al.*[30] observed that the addition of probiotic foods as supplements enhanced growth performance and meat quality of quails as well as diminished pathogenic bacteria proliferation in their diet and intestine. Thus, fortification of feed will help to save the cost of procuring feeds as well as minimize the direct competition between humans and animals for the availability of commercial feedstuff substrates.

This study is therefore, designed to evaluate the effect of feed supplement with fermented maize (ogi) powder on the egg-laying in Japanese quail.

MATERIALS AND METHODS

Study area: The study was carried out at the Microbiology Laboratory of Ekiti State University, Ado Ekiti from October, 2017-January, 2019.

Source of yellow maize grains (*Zea mays*) and top feed grower mash (commercial feed): A healthy, wholesome, dry yellow variety of maize grains (*Zea mays*) and locally

Table 1: Meal ratio per bird group

Bird groups	Meal ratio (w, w)
A	1:9, i.e., 10 g commercial feed and 90 g experimental feed
B	1:4, i.e., 20 g commercial feed and 80 g experimental feed
C	1:3, i.e., 25 g commercial feed and 75 g experimental feed
D	1:1, i.e., 50 g commercial feed and 50 g experimental feed
E	3:1, i.e., 75 g commercial feed and 25 g experimental feed
F	4:1, i.e., 80 g commercial feed and 20 g experimental feed
G	9:1, i.e., 90 g commercial feed and 10 g experimental feed
H	100% commercial feed
I	100% experimental feed (ogi powder)

fermented maize gruel (ogi) were purchased from Erekesan market Ado-Ekiti, Nigeria. The chick 'top feed' grower mash (commercial feed) was purchased at Lukes Top feed depot, opposite Ile Abiye Hospital, Ado-Ekiti, Nigeria.

Preparation of 'ogi' slurry as an experimental feed: Ogi was prepared as described by Aderiye *et al.*[29] and the slurry was transferred into clean storage cheesecloth bags, pressed to obtain a semi-dried product which was later oven-dried into powder (10% moisture content)[28] and subsequently referred to as the experimental feed.

Compositional feed ratio and feeding trial: Nine different feed ratios were used for the feeding trials while the controls were the dry-milled commercial grower chick mash (H) and ogi powder (I). A total of 90 Japanese quails (*Coturnix coturnix* Japonica), 21 days olds, with average initial body weight, between 20-25 g per bird was placed in cages (2 male and 8 female birds/cage). A completely randomized design of dietary treatments consisting of 7 levels of substitution of commercial feed with fermented maize gruel meal (ogi), i.e., 10, 20, 25, 50, 75, 80 and 90 composites, with 100% commercial and 100% experimental (ogi) feed was used (Table 1).

Determination of proximate and mineral components of feed: The proximate components of the feed were determined[31] while the total carbohydrate content (%) in the samples was calculated by difference. Total titratable acidity and fat content were also determined[32,33]. The modified methods of the association of official analytical chemists[31] using the atomic absorption spectrophotometer (Model 703 Perkin Elmer, Norwalk, CT, USA) and the Flame Photometer 410 (Sherwood Scientific Ltd., Cambridge, UK) were used for mineral constituents' analyses. All the values were expressed in mg/100 g.

Allocation and monitoring of physical changes of birds: A total of ninety, 3 weeks old Japanese quails was purchased from the Poultry Division of Agrocode Farms, Ibadan. Ten quail chicks were weighed and randomly allocated to the nine cage groups of A, B, C, D, E, F, G, H, I, with 8 females and 2 males in each group having similar initial body weights. The birds were not subjected to any vaccination or chemical treatment against parasites or any disease. Each of the birds was tagged, labelled and weighed at the beginning and intermittently during the experiment to determine body weight change.

Physiological parameters such as weight, feather-ruffling, eye colour[34-36], were analyzed before and after the feeding trial. During acclimatization, the birds were also observed for clinical signs of any infection such as depression, weakness, ruffled feathers[37], weight loss, prostration, apathy, drooped wings, loss of appetite, dehydration and greenish-yellow to bloody diarrhoea[38].

Feeding and management of quail birds: Ten-day old quail birds were initially fed with 100 g of commercial feed (top feed grower mash) and allowed to stabilize and acclimatize for 1 week before the birds were introduced to the composite feed. 'ogi' slurry was processed into powdery form[29]. This was followed by the formulation of the experimental feed, which was made up of different ratios of commercial feed to powdery 'ogi' meal. The feed did not contain any antibiotics. The birds were sexed by plumage colour with the initial weights were taken using a netted bowl of known weight and top-loading balance. To maintain the identity of each bird in the different groups, leg bands were placed with wing bands at 4 weeks of birds' age.

Determination of haematological parameters: Before and after the feeding trial, the serum of the quail birds was analysed at Ekiti State University Teaching Hospital (EKSUTH), Ado-Ekiti thus: Packed Cell Volume (PCV) using the micro-haematocrit method, red blood cell (RBC) and leucocyte count[39]. Haemoglobin concentration (HBC) was determined according to Higgins *et al.*[40]. Also, from the values obtained from Red Blood Cells (RBC) count, haemoglobin concentration, the Mean Corpuscular Volume (MCV), Mean Corpuscular Haemoglobin (MCH) and Mean Corpuscular Haemoglobin

Concentration (MCHC) of the serum of the quail birds were determined from the values obtained from the Red Blood Cells (RBC) count and haemoglobin concentration calculated. Scope and Schwendenwein[41] method was employed in determining the serum, urea and creatine levels while the AST and ALT values were evaluated as described by Dolka *et al.*[42].

Feeding trials: Experimental feeding of the birds started after 3 weeks of acclimatization. A completely randomized design with dietary treatments consisting of varying levels of substitution of ogi powder meal with top feed meal was used (Table 1). Feed was weighed according to quail birds feeding capacity as observed during acclimatization and fed to the birds at 7 am, each day with free access to water. The body weights of the birds in each group were also recorded in the morning every 48 hrs before feeding. Every morning, the feed remaining in each feeder tray was weighed as a remnant and the feed spillage collected as the waste was weighed, recorded and later discarded. The feeders were cleaned and reloaded with fresh feed. Fresh daily faeces from each group were collected and weighed separately.

Laying of eggs: The birds were allowed to mate to lay eggs without being given a layer feed ration for 14 weeks. The reaction of the birds to the experimental feed was noted. The weight of each egg was taken, the difference in egg weight and the birds were also noted. All the data were collected and recorded per group. The colour and characteristic shell pattern of the eggs was noted throughout the laying periods.

Statistical analysis: The effects of the treatment were estimated by an analysis of the variables, using linear and quadratic regression models and including the broken-line model, following the best adjustment obtained for each variable and by considering the biological behaviour of the birds. The parameters were submitted for statistical analyses by the software SAS.

RESULTS

Proximate (%) and mineral (mg g^{-1}) composition of the feed: The proximate composition of the composite feed, ogi and commercial grower feed is shown in Table 2. The composite feed ratios of 1:9, 1:1, 3:1, 4:1 and 9:1 with a moisture content of 10.5, 10.53, 10.18, 11.71 and 11.05%, respectively were higher than the commercial feed (9.65%). The least moisture content among the composite feed was 9.76% in feed ratio 1:3. The ogi sample exhibited 10.88% moisture. The crude protein content of the feed ratio 3:1 was the highest among the composite feed (30.78%). Meanwhile, protein content in ogi (27.40%) was higher than that of the grower mash (17.97%).

The crude fibre in the feed ratio of 3:1 (commercial/experimental) was the highest among the composite feed. Interestingly, the crude fibre content of the commercial feed was much lower (2.47%) than the ogi powder (4.37%). The crude fat in the composite feed samples 1:3, 1:1, 3:1 and 9:1 (commercial/experimental) was relatively higher than those of feed ratio 1:9 and 1:4. Similarly, the ogi powder contained 13.03% fat which is higher than that of the commercial feed (10.06%). The composite feed sample ratio 1:9 (commercial/experimental) exhibited a very high carbohydrate content (60.49%). Meanwhile, the CHO content of the commercial feed (58.89%) when compared to the ogi powder (37.84%) was much greater. The ash content of the composite feed ratio 9:1 (commercial/experimental) was 6.64%. while the commercial feed exhibited a relatively low total ash content (0.96%) when compared to the ogi powder (6.48%) ash content.

The minerals detected in the composite and control samples (commercial and ogi powder) are also shown in Table 2. The samples 1:3, 3:1, 9:1 and the ogi powder recorded the highest Calcium value (HC) while the commercial feed exhibited the least value (2.44 mg g^{-1}). The Iron content of the composite feed samples ratio 4:1 and 1:3 was high (1.86 and 1.85 mg g^{-1}, respectively). The ogi powder and the feed ratio 1:3 exhibited the highest zinc concentration (1.21 and 1.25 mg g^{-1} respectively). Both the ogi powder and the commercial feed exhibited very high potassium content, 40 and 39.7 mg g^{-1}, respectively. The commercial feed had the highest Na concentration (35.80 mg g^{-1}) while ogi powder contained relatively lower Na content (33.70 mg g^{-1}). For phosphorus, the composite feed ratio 1:3 recorded the highest values of 54.23 mg g^{-1} however the level of phosphorus in the commercial feed sample was very low, about 23.48 mg g^{-1} while phosphorus was not detected in ogi powder. The composite feed ratios 1:3 and 1:4 recorded the highest salt levels of 9.96 and 8.67 mg g^{-1}, respectively. Generally, the ogi powder was richer in iron, zinc, potassium and sodium (2.27, 1.21, 40.00 and 35.80 mg g^{-1}, respectively). Meanwhile, the commercial feed contained more calcium (2.44 mg g^{-1}) and phosphorus (23.47 mg g^{-1}) than the ogi powder.

Weight of quail birds during feeding trials: The initial average weight of the quails ranged between 111.26 g (1:4 and 9:1 quail groups) and 114.56 g (1:1 quail group) (Table 3). The ogi meal diet was poorly consumed and did not

Table 2: Proximate (%), mineral ($mg\ g^{-1}$) and salt contents of a composite feed

Bird groups*	Proximate component (%) MC	Protein	Fibre	Fat	Ash	CHO	Mineral component ($mg\ g^{-1}$) Ca	Fe	Zn	K	Na	P	Salt (%)
A	10.9	27.4	4.4	6.2	6.5	44.7	5.3	0.6	0.5	24.0	22.5	27.7	4.45
B	9.9	19.0	2.2	7.7	1.9	59.3	7.2	0.7	0.7	25.0	23.5	27.2	8.67
C	9.8	22.5	2.1	12.4	2.8	50.5	HC	1.9	1.3	32.4	28.3	54.2	9.96
D	10.5	21.9	3.1	12.6	5.1	46.8	12.9	1.2	0.8	26.6	23.7	42.2	5.20
E	10.2	30.8	4.9	12.3	5.7	36.2	9.4	0.7	0.7	21.5	21.6	32.5	5.54
F	11.7	28.8	4.8	11.2	4.7	38.8	HC	1.9	1.0	36.0	29.8	49.9	3.15
G	11.1	28.9	4.9	12.0	6.6	36.5	HC	1.7	1.0	38.3	29.6	45.5	5.23
H	9.7	17.9	2.5	10.1	0.9	58.9	2.4	0.4	0.5	39.7	33.7	23.5	7.63
I	10.9	27.4	4.4	13.0	6.5	37.8	HC	2.3	1.2	40.0	35.8	ND	8.42

*As in Table 1, HC: Very high calcium content and ND: Not detected

Table 3: Average weight (g) of birds during 19 days feed trial

*Quail groups	Feeding period (days) 1	3	5	7	9	11	13	15	17	19
A	111.60	111.80	112.20	114.25	115.60	135.20	145.13	118.13	135.80	127.10
B	111.30	111.40	112.70	112.83	113.00	129.00	133.17	117.79	135.85	117.74
C	111.90	112.50	113.00	121.04	131.80	124.50	121.10	118.90	116.80	130.90
D	114.60	115.80	124.60	127.62	131.60	133.60	135.00	138.00	135.85	139.19
E	111.40	112.50	123.50	123.95	131.59	134.00	133.40	137.93	136.21	146.80
F	111.40	112.50	125.00	126.87	129.46	139.40	141.70	145.10	144.20	165.58
G	111.30	111.90	123.80	125.01	120.70	129.01	138.70	143.50	143.16	161.24
H	112.00	111.70	125.60	120.02	121.17	134.20	141.80	143.57	142.26	165.80
I	111.50	111.50	111.20	110.00	93.91	95.80	96.76	97.45	94.16	97.51

As in Table 1

Table 4: Average weight of the bird, feed consumed, droppings and eggs laid by quails after 13 and 21 days of feeding trials

Quail groups[1]	Ave. wt. of birds (g) After 13 days	After 21 days	Weight gain[a]/loss[b] (%) After 13 days	After 21 days	Percentage of feed consumed* After 13 days	After 21 days	Wt. of droppings (g) After 13 days	After 21 days	No. of eggs laid After 13 days	After 21 days	Ave. wt. of eggs laid (g) After 13 days	After 21 days
A	145.13	127.10	30.10[a]	13.92[a]	51.50	78.33	62.50	29.60	2	-	5.70	-
B	133.17	117.74	19.69[a]	19.69[a]	66.45	45.20	94	44.60	2	1	6.70	6.50
C	121.10	130.90	8.25[a]	17.01[a]	69.80	61.40	43.90	40.70	3	2	7.06	6.35
D	135.00	139.19	15.14[a]	21.50[a]	100	82.44	232.40	57.80	1	3	7.05	6.56
E	133.40	146.80	19.74[a]	31.77[a]	100	92.07	222.70	75.90	2	2	8.90	6.55
F	141.70	165.58	27.20[a]	48.64[a]	95.03	88.20	73.40	150.10	-	6	-	8.52
G	138.70	161.24	24.60[a]	44.84[a]	95	97.87	126	85.30	4	4	7.40	7.35
H	141.80	165.80	26.64[a]	48.08[a]	94.92	95.90	65.30	176.7	-	3	-	8.03
I	96.76	97.51	13.23[b]	12.56[b]	62.85	48.54	41.20	48.60	2,	-	3.20	-

[1]Quail group as stated in the footnote of Table 2, [a,b]Percent weight gain/loss, reference to the average weight of birds since the commencement of feeding and *Percentage of the difference between the amount of feed wasted and remnant left from the amount of feed served daily

encourage an increase in body weight of the birds (I quail group), resulting in 0.96 g/day loss in weight. The total average weight loss within 18 days of feeding in the birds was 17.36 g (i.e., 15.56% weight loss). Meanwhile, the composite 4:1 feed comparatively supported 67.28% growth (resulting from 111.4-165.58 g body weight) like the 100% commercial feed after 19 days. The increase in the birds' body weight was at the rate of 3.01 g/day in group 4:1. Birds fed with the commercial feed only gained about 26.64% in the bodyweight, whereas those fed with only the ogi product resulted in weight loss of 13.24%.

Consumption of feed, bird droppings and egg production: The average weight of the birds after 13 days of feeding was between 96.76 and 145.13 g in the bird group fed with ogi diet and 1:9 composite feed (Table 4), with a percent weight loss of 13.23 and a weight gain of 30.10%, respectively. It is pertinent to note that the birds in group A consumed the feed least (51.5%). Meanwhile, the birds in groups 1:1 and 3:1 completely consumed the meal rations. However, very large amounts of the meal consumed by these birds were excreted as droppings (232.40 and 222.70 g, in bird group 1:1 and 3:1, respectively).

Table 5: Serum biochemical components of 10day old quail birds before feeding trials

Parameters	Male birds (CM*)	Female birds (CFM*)
Uric acid (mg dL^{-1})	0.155	0.07
Urea (mmol L^{-1})	4.3	6.2
Iron (Fe) (mmol L^{-1})	28.6	37.1
Mg (mmol L^{-1})	0.97	1.175
Cl (mmol L^{-1})	105	107
K (mmol L^{-1})	7.1	7.9
Na (mmol L^{-1})	126	147
Alb (g L^{-1})	13	12.4
TP (mg dL^{-1})	28.75	32.5
ALP (mg dL^{-1})	408.5	434.5
Creatine (mg dL^{-1})	29	68
CKMB	305.5	225
Calcium (mmol L^{-1})	1.35	1.675
Phosphate	4.095	2.735
Amylase (mg dL^{-1})	144	138
TG (mg dL^{-1})	0.75	0.55
Total cholesterol (mg dL^{-1})	4.85	5.05
HDL (mg dL^{-1})	1.9	2.35
LDL (mg dL^{-1})	2.6	2.45

Mg: Magnesium, Cl: Chloride, K: Potassium, Na: Sodium, Alb: Albumin, TP: Total protein, ALP: Alkaline phosphatase level, CKMB: Creatine kinase MB, TG: Triglyceride, HDL: High-density lipoprotein and LDL: Low-density lipoprotein

Whereas, the birds fed with ogi meal excreted he least number of droppings (41.20 g).

The birds feed mainly on the ogi meal produced two unshelled eggs, each with an average weight of 3.20g (Table 4) while those fed on the commercial feed and the 4:1 composite feed did not produce any egg on the 13th day of feeding. Conversely, the birds in a group on 9:1 meal laid four eggs, with an average weight of 7.40 g. The average weight of eggs laid by the birds in group E was relatively greater (8.90 g) while the birds fed with 1:3 meal produced three eggs, with an average weight of 7.06 g.

After 20 days of feeding, the average weight of the birds in each group ranged between 97.51 g in the group fed with ogi meal and 165.8 g that were fed with commercial feed, resulting in 12.56% weight loss and 48.08% weight gain respectively, when compared to the initial weight of the birds (Table 4). Consumption of feed was high in groups 9:1 meal (97.87%) and commercial feed (95.90%) but relatively poor in birds fed on the ogi meal (48.54%) and those fed with 1:4 composite meals.

The number of droppings was great in the bird groups fed with 4:1 (150.10 g) and commercial feed (176.7 g), with these groups producing six and three eggs, respectively on the 20th day of feeding. The average weight of the eggs laid in these groups was 8.52 and 8.03 g, respectively. The group on 9:1 feed produced four eggs on day 20 while none of the birds in groups on 1:9 and ogi meal laid eggs. Evidence of egg-laying was noticed after 7 days in the bird group fed with 9:1 composite feed, reaching maximum production level 8 after 27 days of feeding. The bird group fed on a 4:1 ratio of composite feed laid 78 eggs (18.8%), while the commercial feed supported the production of 15.9% of the eggs. Ogi meal did not encourage egg laying (0.48%). However, egg-laying by the birds reached the maximum after 5 weeks of feeding (37 days, 45 eggs).

Serum component of birds: The number of mineral nutrients such as Ca (1.68 mg mL^{-1}), Fe (37.1 mmol L^{-1}), K (7.9 mmol L^{-1}), Mg (1.18 mmol L^{-1}) and Na (147mmol L^{-1}) in the female birds CFm* was higher compared to values obtained in the male birds (Table 5). Similarly, the urea (6.2 mmol L^{-1}), total cholesterol (5.1 mg dL^{-1}) and HDL (2.3 mg dL^{-1}) contents were relatively higher. Meanwhile, the concentration of uric acid (0.16 mmol L^{-1}), PO_4 (4.91), TG (0.75 mg dL^{-1}) and LDL (2.6 mg dL^{-1}) contents in the male birds (CM*) was more than those detected in the female birds (Table 5).

When the female birds were fed on the composite feed, most of the serum biochemical components examined were higher than the values obtained from the 21days old birds fed on the commercial feed, with relatively higher values. The serum uric acid content of the female and male birds fed with group FF (0.87 mmol L^{-1}) and group GM (0.74 mmol L^{-1}) feed, respectively was very high compared to those fed on other composite feed (Table 6).

The uric acid content of quail birds fed with group 4:1 (0.87 mg dL^{-1}) and 9:1 (0.48 mg dL^{-1}) composite feed was higher than that of the female 10 day old birds (CFm*) (0.07 mg dL^{-1}). However, there was an appreciable drop in the urea content of birds fed (IF 1.03 and FF 1.57 mmol L^{-1})

Table 6: Serum biochemical properties of quail birds after 21 days of feeding trials

Codes	Uric acid (mg dL^{-1})	Urea (mmol mL^{-1})	Iron (Fe) (mmol L^{-1})	Mg (mmol L^{-1})	Cl (mmol L^{-1})	K (mmol L^{-1})	Na (mmol L^{-1})	Alb (g L^{-1})	TP (g L^{-1})	ALP (u L^{-1})
FM	0.46	1.35	46.7	1.85	85	7.12	145	11.2	16.4	262
FF	0.87	1.57	165.20	1.62	93.00	6.07	124.33	14.70	21.53	497.67
GM	0.74	1.45	55.3	1.68	102	3.7	147	14.6	20.9	287
GF	0.48	1.26	26.8	2.30	97	8.05	115	15.9	23.4	657
HM	0.47	0.59	123.9	1.77	95	2.3	103	15.5	19.0	290
HF	0.62	1.05	56.83	1.75	94.00	4.09	137.00	19.17	20.57	452.00
IM	0.61	0.99	43.6	1.73	95	4.85	170	11.4	16.4	290
IF	0.70	1.03	47.10	1.81	92.67	6.43	141.67	11.00	18.87	1821.67

FM: Group F male, FF: Group F female, GM: Group G male, GF: Group F female, HM: Group H male, HF: Group H female, IM: Group I male, IF: Group I female, Mg: Magnesium, Cl: Chloride, K: Potassium, Na: Sodium, Alb: Albumin, TP: Total protein and ALP: Alkaline phosphatase level

Table 7: Lipoprotein components, metabolic enzymes, calcium, phosphate and potassium levels in quail blood after 21 days of feeding trials

Codes	AST (IU L^{-1})	ALT (IU L^{-1})	TG (mmol L^{-1})	TC (mg dL^{-1})	HDL (mmol L^{-1})	LDL (mmol L^{-1})	Ca (mg m L^{-1})	PO_4 (mg dL^{-1})	CK (IU L^{-1})	Amylase (u L^{-1})	K-MD (x2)
FM	500	20	0.70	4.78	2.9	1.56	0.73	2.39	52	438	240
FF	193.33	16.67	5.60	7.71	2.20	2.96	1.84	3.14	41.67	432.00	193.33
GM	390	20	1.45	6.10	3.2	2.24	1.11	2.78	62	640	90
GF	213.33	13.33	4.74	5.87	1.97	2.77	1.38	2.77	73.67	430.33	213.33
HM	360	20	1.28	5.56	3.6	1.38	1.16	1.21	74	458	240
HF	176.67	26.67	6.44	8.21	2.60	2.68	2.49	1.77	111.67	438.67	176.67
IM	310	20	2.84	7.57	2.5	3.78	0.66	2.44	96	401	90
IF	213.3	20	6.61	6.88	2.53	1.34	1.25	1.57	206.3	500	198

FM: Group F male, FF: Group F female, GM: Group G male, GF: Group F female, HM: Group H male, HF: Group H female, IM: Group I male, IF: Group I female, Ast: Aspartate aminotransferase, Alt: Alanine aminotransferase, TG: Triglycerides, TC: Total cholesterol, HDL: High-density lipoprotein, LDL: Low-density lipoprotein, Ca: Calcium, PO_4: Phosphate and CK: Creatine kinase

Table 8: Haematological properties of quail birds after 21 days of feeding trials

Codes	PCV (%)	RBC ($\times 10^6$)	HB (g dL^{-1})	MCHC (g dL^{-1})	MCH Pg	WBC ($\times 10^9$ L^{-1})	NWT	Lympho (%)	Mono (%)	EOSIS (%)
FM	50	3.37	11.8	236	35	4500	30	56	10	4
FF	41.7	2.41	9.83	233	41.03	8500	25	66	8.7	2
GM_1	52	2.60	12.2	236	46.9	4500	25	61	12	2
GF	43.7	2.43	10.30	236	43.27	5500	27	62	9.3	2
HM	53	3.65	12.5	236	34.2	4200	30	60	8	2
HF	38.7	2.27	9.13	236	36.07	5066	30	58	9.3	2
IM	48	2.73	11.3	235	41.4	3500	30	60	9	1
IF	38.3	2.47	9.02	235	36.93	4667	24	68	7.7	1

FM: Group F male, FF: Group F female, GM: Group G male, GF: Group F female, HM: Group H male, HF: Group H female, IM: Group I male, IF: Group I female, PCV: Parked cell volume, RBC: Red blood cell, HB: Haemoglobin, MCHC: Mean corpuscular haemoglobin concentration, MCH: Mean corpuscular haemoglobin, WBC: White blood cell, NWT: Neutrophils, Lympho: Lymphocytes, Mono: Monocytes and Eosis: Eosinophil

with composite feed as against that of the 10 days old female birds (6.2 mmol L^{-1}). There was an increase in the level of Mg, triglycerides and total cholesterol when the birds were fed on some of the composite feed. For example, the increase in Mg content ranged between 1.62 and 2.30 mmol L^{-1} with the consumption of composite feed 4:1 and 9:1 by the female birds. The consumption of groups 9:1 and ogi powder feed also increased the triglyceride content of the female birds (GF, 4.74 and IF, 6.61 mmol L^{-1}). Similarly, the total cholesterol content increased when birds were fed on HF (5.05-8.21 mg dL^{-1}) but slightly (5.05-5.87 mg dL^{-1}) in group GF birds (Table 7).

The HDL contents of the serum of female birds fed with 100% commercial feed (HF) increased and was the highest recorded (2.60 mmol L^{-1}) while there was a reduction in the groups FF (2.2 mmol L^{-1}) and GF composite feed (1.97 mmol L^{-1}), respectively. Also, the LDL serum levels were highest in the FF group (2.96) after feeding trials but reduced in the Ogi feeding trial group (IF, 1.34 mmol L^{-1}) (Table 7). Also, the percentage PVC was found to be higher in female birds fed the composite feed (38.7-43.7%) than in the commercial feed (38.3%) but the RBC values was more in the bird group fed with commercial feed (2.47×10^6) than either of the composite feed $2.27\text{-}2.43\times 10^6$ (Table 8).

DISCUSSION

The highest protein content exhibited among the composite feed was observed in the 3:1 ratio, made up of 25% ogi flour (with 27.40% protein), which comparatively is higher than that of the grower mash (17.97%). The high crude protein content in ogi could be attributed to the metabolism of its carbohydrates by Lactic acid bacteria[43], resulting in increased cell biomass[44,45]. The crude fibre content of the feed ratio of 3:1 (commercial/experimental) was also the highest among the composite feed. It is the combination of the component units of ratio 3:1 feed (commercial/experimental) that accounted for the higher crude fibre content of the composite feed sample.

In the meantime, the higher fat content detected in ogi powder and the ratio 1:9 composite feed could also be attributed to fermentation. Kiplamai[46] reported increased fat content in fermented blends, from 8.42-10.9% within 48 hrs fermentation. Nkhata *et al.*[47] also reported that fermentation improved the availability of fat due to increased lipolytic enzymes activity, which hydrolyzed the fat to glycerol and fatty acid.

Cereal grains constitute a large proportion (>50%) of poultry diets and contribute largely carbohydrates and to some extent proteins. Fermentation time had a significant decreasing effect on the total carbohydrate contents of the blend. The carbohydrate content of the commercial feed (58.59%) was much greater than that of ogi (37.84%), which reduced with fermentation, resulting from increased activity of α-amylase on starch to simple sugar[48]. Protein and carbohydrate are by far the two most important nutrients in poultry diets due not only to their marked effect on voluntary feed intake of the bird but also the fact that they also represent approximately 90% of the total cost of the ingredients in a ration[49].

Our study revealed that the total ash content of the commercial feed was relatively low (0.96%) compared to the ogi powder (6.48%). This agrees with Assohoun *et al.*[50], Enyisi *et al.*[51] and Ogodo *et al.*[52], who reported an increase in the ash content in their respective work during fermentation. The highest zinc concentration was noticed in the ogi powder and the feed ratio 1:3 with 75% ogi powder (1.21 and 1.25 mg g^{-1}, respectively). The presence of some minerals such as Fe, Zn and Ca in fermented cereals is because they are not readily available for microorganisms since these minerals frequently form complexes with phytate at pH 5[53]. The endogenous grain phytase usually hydrolyses the phytate and releases the minerals from such complexes. The commercial feed had the highest sodium (Na) concentration (35.80 mg g^{-1}) while ogi powder contained relatively lower Na content (33.70 mg g^{-1}). Salt is used to balance the nutritional requirement in the commercial feed. A salt deficiency is possible when there is an error in the process of mixing the feed or during formulation.

It was observed that the ogi meal diet was poorly consumed by the birds during the feeding trial, thus resulting in 0.96 g/day weight loss. The total average weight loss within 18 days of feeding the birds was 17.36 g (i.e., 15.56% weight loss). Meanwhile, the 4:1 composite feed comparatively supported better growth resulting in increased average body weight (from 111.4-165.58 g) like the commercial feed (165.8 g) after 19 days. The 4:1 feed met the feeding requirements for the birds. Sopandi and Wardah[54] fed quails with a composite feed containing different proportions of rice husk distillers' dried grain (DDG) and they observed that increasing the proportion of rice husk DDG in feed formulations tended to reduce feed consumption in the quail birds. However, when feeding continued for another 6 days, the birds fed with 3:1, 4:1, 9:1 and commercial feed gained about 12.03, 21.44, 20.24 and 21.44% in their respective body weights. The nutritional component of each feed met the feeding requirements of the birds. Furthermore, the birds in these groups laid the highest number of eggs during this period.

It is pertinent to note that the birds fed with a 1:9 feed ratio consumed the feed least (51.5%), an unbalanced diet of poor nutritive value, which the birds often rejected. Very large amounts of the meal consumed by these birds were excreted as droppings (232.40 and 222.70 g, especially those fed with 1:1 and 3:1 feed), whereas, the birds fed with ogi powder excreted the least number of droppings (41.20 g). The droppings of the birds depend on the type and quantity of feed consumed. The composite feed consumed by the birds contained probiotics which have an important role in increasing the separation of bile acids. These acids are low in solubility and poorly absorbed in the intestine. Cholesterol is the main material in the manufacture of these acids[55]. Thalinger *et al.*[56] stated that although the number of droppings of a bird in a day loosely correlates to its size smaller birds eliminate more frequently than larger birds." The birds feed mainly on the ogi meal produced two unshelled eggs because they were fed with a poor and unbalanced diet, only fermented maize gruel.

The early laying of eggs by birds on 9:1 feed was due to the fortification of the commercial feed with fermented maize gruel rich in organic acids. While those fed on the commercial feed and the 4:1 composite feed did not produce any egg until after a week. These results are in agreement with Gama *et al.*[57] who reported that organic acid supplementation of feed had positive effects on egg production in laying hens. Similarly, Yesilbag and Colpan[58] observed that dietary organic acid supplementation influenced an increase in egg production.

Birds fed with the commercial feed only gained about 26.64% body weight, whereas, those fed with only the ogi product resulted in weight loss of 13.24%. Engberg *et al.*[59] reported that there was lower feed intake as well as egg yield and body weight gain in birds fed with only fermented feed as compared to conventional mash due to lack of proper adaptation to the fermented feed an observation similar to that obtained in our study. The body weight and feed intake values were also observed to be significantly higher in female quails, especially during the pre-laying period[60]. All these values showed an increasing trend with age. Female quails recorded higher weight percentages of the liver and giblets and lower heart weight percentage than the males[60]. However, the weight gain may be presumed to be a pre-laying weight gain, as the birds on 3:1, 4:1, 9:1 and commercial feed diets produced the highest number of eggs during the experimental periods followed by a notable weight loss in the four groups during and after the laying of eggs.

Generally, the concentration of most of the serum biochemical components in the female 21 days old birds (CFm*) before feeding trials was higher than the male birds (CM*). The biochemical parameters: AST, ALT, glucose, ChE and bilirubin values were observed to be elevated in the male quail birds while in the female birds, higher values were observed in the albumin, total protein, γ-GT, total cholesterol and triglycerides values, respectively thus suggesting sex-related differences[61]. These observed differences may also be as a result of the changes in metabolism in the female birds due to egg-laying because there is an increase in the synthesis of triglycerides, phospholipids and cholesterol in the liver during the laying period which are incorporated into lipoproteins that are secreted into the blood and incorporated into the oocytes of the ovary[62]. Laying hens, therefore, have an extraordinarily high level of triglycerides and cholesterol in their blood in contrast to their male counterparts[62].

The concentrations of some mineral nutrients such as Ca (1.68 mg mL^{-1}), Fe (37.1 mmol L^{-1}), K (7.9 mmol L^{-1}), Mg (1.26 mmol L^{-1}) and Na (147 mmol L^{-1}) in the female birds were higher compared to values obtained in the male birds. In Japanese quails, El-Ghalid[63] observed an increase in calcium content of the serum with the increasing age of the birds. In laying hens, the steroid hormones are involved in the regulation of calcium metabolism via numerous mechanisms of action, resulting in an increased blood concentration of protein-bound calcium[64].

Similarly, the urea (6.2 mmol L^{-1}), total cholesterol (5.1 mg dL^{-1}) and HDL (2.3 mg dL^{-1}) contents were relatively higher due to an increase in the dietary crude protein as reported by Bovera *et al.*[65]. Serum parameters can also be elevated after high protein intake since they are involved in nitrogen metabolism[66]. Meanwhile, the concentration of uric acid (0.16 mmol L^{-1}), PO_4 (4.9), TG (0.75 mg dL^{-1}) and LDL (2.6 mg dL^{-1}) contents in the male birds (CM*) was more than those detected in the female birds. In birds, uric acid is a major product of the catabolism of nitrogen. Age and diet may also influence the concentration of blood uric acid in birds while a high level of uric acid was reported during ovulatory activity[67]. Our results are similar to Zhang *et al.*[68] observations where glucose level in rats was drastically reduced by probiotics in the meal. Perhaps the ability of the probiotic to reduce the blood serum glucose level was due to its antioxidant role[69]. Ooi and Liong[70] reported that the probiotic reduced the level of cholesterol, triglycerides and LDL in the serum but with an increased level of HDL.

Numerous sex-related differences may be demonstrated by the physiological alterations in the metabolic process in the female birds because of egg-laying. However, when the female birds were fed on the composite feed, most of the serum biochemical components examined were higher than the values obtained in the 21 days old birds fed on the commercial feed, except the urea (6.2 mmol L^{-1}) and sodium (147 mmol L^{-1}) contents, with relatively higher values.

The serum uric acid content of the female and male birds fed with group FF (0.87 mmol L^{-1}) and group GM (0.74 mmol L^{-1}) feed, respectively was very high compared to those fed on other composite feed. These results agree with Onyinyechukwu *et al.*[18], who also reported a difference between the uric acid value of the males (5.66 mg dL^{-1}) and the females (24.23 mg dL^{-1}). The increase in the triglyceride content of the female bird can be explained by the physiological changes in metabolism in female birds due to egg-laying. During the laying period, the hepatic synthesis of triglycerides, phospholipids and cholesterol increased[66]. These lipids are incorporated into lipoproteins, secreted into the blood and incorporated into the oocytes of the ovary. König *et al.*[62] reported that laying hens have shown extraordinarily high circulating concentrations of triglycerides and cholesterol in contrast to male birds. In the present study, composite feed formulated was found to be a good alternative to conventional feed.

CONCLUSION

This study has revealed that incorporating Ogi into commercial feeds in 4:1 proportion enhanced egg production as well as carcass yield. Thus, to enhance good quality egg production and provide a cheaper protein source, ogi can form a cheaper component of the dietary feed formulation of Japanese quails.

SIGNIFICANCE STATEMENT

This study discovers the importance of producing low-cost feed alternatives that hold a possibility of supporting quail birds' nutritional requirements and can be beneficial to poultry farmers in their quest for cheap alternatives to conventional feeds. Feed formulation with fermented ogi maize offers a richer, beneficial option for egg yield, higher body weight gain and also help as a probiotic. This study will help researchers in the area of feed formulation and come up with improved feeding regimens for poultry birds given the high demand for animal protein.

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