Egg Production and Quality of Japanese Quails (*Coturnix coturnix japonica*) Fed Diets with Varying Levels of Finger Millet (*Eleusine coracana*) as an Energy Source

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Abstract
*Japanese quails are valued for their rapid growth and prolific egg production. It is critical to optimize their feed with affordable ingredients to ensure health, suitability, and financial viability. This study aimed to evaluate the egg production and quality of Japanese quails (Coturnix **coturnix** japonica) fed diets with different levels of finger millet (Eleusine coracana) as an energy source. Four diet formulations were created with 0% FMM (control), 15% FMM, 30% FMM, and 45% FMM. A total of 160 eight-week-old laying quails were involved in the experiment, which utilized a completely randomized design with four replicates of 10 quails each per treatment. The diets were provided as mash at an average rate of 25 g per bird per day, with water ad libitum. It was noted that total egg production, hen-day egg production (HEDP), egg mass, and feed conversion ratio were significantly ($p<0.05$). Costs per kg of feed, feed consumed per egg, feed for three eggs, and cost of feed for 30 eggs were significantly higher in the control and 15% FMM diets, while 30% FMM and 45% FMM diets had lower costs. Conversely, profit from 30 eggs was greater with the 30% FMM and 45% FMM diets compared to the control and 15% FMM diets. It is concluded that finger millet can effectively replace maize in the diets of laying quails without adversely affecting egg production and quality.*

Keywords: Japanese quails, finger millet, egg production, egg quality, maize

Introduction

Japanese quails (*Coturnix **coturnix** japonica*) are small ground-nesting birds that have become popular in both commercial and backyard agriculture due to their quick growth rates, high egg output, and relatively straightforward care (Widyas *et al*., 2019). With the increasing demand for quail eggs, enhancing the composition of their feed is essential for promoting their health, egg production, and quality. Rising maize prices and the need for sustainable practices push the poultry industry to look for alternative, cost-effective ingredients, despite maize being a traditional energy source. Substituting maize with economical ingredients in poultry diets offers potential benefits in terms of economics, nutrition, and environmental sustainability vital for the industry's future and a more sustainable food system. Finger millet (*Eleusine coracana*), locally known as "tamba," is a drought-resistant cereal crop commonly cultivated in arid and semi-arid regions of Africa and Asia, known for its high drought tolerance and long grain storage life. It contains approximately 11% moisture, 7% protein, 54% carbohydrates, and 2% fat (USFDA, 2024). This study aims to

assess the egg production and quality of Japanese quails (*Coturnix **coturnix** japonica*) when fed diets with varying levels of finger millet.

Materials and Methods

Ethical Considerations

The study complied with ethical standards established by the Ethical Committee of the Federal University, Gashua, Yobe State, Nigeria, regarding animal use in research.

Study Location

The research was conducted at the poultry unit of the teaching and research farms at the Faculty of Agriculture, Federal University, Gashua, Yobe State, Nigeria, situated in the Sahel region characterized by an arid climate with high temperatures, low rainfall, and low humidity (Ovimaps, 2014).

Experimental Diets

Four diets were formulated, consisting of 0% FMM (control), 15% FMM, 30% FMM, and 45% FMM. The composition and ingredients for each diet are detailed in Table 1.

Source and Management of Quails

A total of 160 eight-week-old laying quails were obtained from a farm and acclimatized for one week prior to the experimental trials. Their initial egg mass was recorded at that time, and they were randomly assigned to four dietary treatments, with each treatment comprising four replicates of 10 quails each in a completely randomized design. The birds received the diets in mash form, averaging 25 g per bird daily, while drinking water was available at all times throughout the trial period, which lasted six weeks.

Laying Performance

Egg production metrics, economic indices, and both external and internal egg quality parameters were monitored. Daily records included feed intake, number of eggs produced, egg weight, hen-day production, daily feed consumption per crate of eggs, and feed costs per crate. Ten eggs from each replicate were collected over two consecutive days for evaluation of external and internal quality aspects, which included weighing, measuring using digital vernier calipers, and assessing albumen and yolk height with a tripod micrometer, following Ojediran *et al*. (2018). Eggshells were dried, weighed, and their thickness measured using a micrometer screw gauge.

The weights of the egg components—yolk, albumen, and shell were recorded using an electronic digital scale, following the method outlined by Sudik *et al*. (2024). The yolk's color was assessed using the Roche color fan. The Haugh unit was calculated using the formula: Haugh unit = 100 * log (h + 7.57 1.7w^0.37) (Haugh, 1937),
Where
h represents the height of the egg white in millimeters, and
w is the weight of the egg in grams.
Economic indices were determined as per the methods of Edi and Andri (2023) and Ojediran *et al*. (2022).

Data analysis

For data analysis, a one-way analysis of variance was conducted using SPSS for Windows (SPSS v25), and Duncan's Multiple Range Test identified significant differences between means at a ≤ 5% probability level.

Table 1: Ingredients and composition (%) of experimental diets used in the study

Ingredients (%)	Control	15%FMM	30%FMM	45%FMM
Maize	47.50	40.38	33.25	26.13
finger millet	0.00	7.12	14.25	21.37
Soybean meal	25.00	25.00	25.00	25.00
Wheat offal	8.00	8.00	8.00	8.00
Groundnut cake	9.00	9.00	9.00	9.00
Fish meal	2.00	2.00	2.00	2.00
Bone meal	3.50	3.50	3.50	3.50
Limestone	3.50	3.50	3.50	3.50
Premix	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
Soy oil	0.50	0.50	0.50	0.50
Total	**100.00**	**100.00**	**100.00**	**100.00**
Nutrients (%)				
Crude protein	19.37	19.39	19.40	19.41
Energy (kcal/kg)	2901.51	2901.18	2900.26	2900.09
Lysine	1.04	1.04	1.04	1.03
Methionine	0.39	0.39	0.39	0.38
Calcium	2.90	2.90	2.90	2.90
Phosphorus	0.93	0.93	0.93	0.93
Crude fiber	4.76	4.76	4.77	4.78
Cost kg-1 (₦)	12,145.35	11,894.90	11,644.45	11,394.00

Results and Discussion

Results indicated in Table 2 demonstrate that the egg production of layer quails is influenced by various levels of finger millet meal (FMM). The total egg yield, HEDP, egg mass, and feed conversion ratio showed significant ($p<0.05$) affected by the FMM levels. Table 3 reveals that the only significant external quality parameter was shell percentage, with the 15% FMM diet having a similar percentage to the control, while the 30% and 45% FMM diets recorded lower percentages. Internal quality parameters, shown in Table 4, were not significantly ($p>0.05$) affected by the FMM levels. Table 5 details the economic implications of feeding varying levels of FMM. Cost per kg of feed, feed consumed per egg, and feed consumed for three eggs were all significantly ($p<0.05$) higher in the control and 15% FMM diets and lower in the 30% and 45% FMM diets. Moreover, profits for 30 eggs were greater in the 30% and 45% FMM diets compared to the control

and 15% FMM diets. Table 5 details the economic implications of feeding varying levels of FMM. Cost per kg of feed, feed consumed per egg, and feed consumed for three eggs were all significantly ($p<0.05$) differences due to dietary treatments. Typically, the 30% and 45% FMM diets outperformed the control diet, while the 15% FMM diet was similar to the control. The enhanced performance in total egg production, HEDP, egg mass, and feed conversion ratio in the 30% and 45% FMM diets indicates that these inclusion levels improve the performance of laying quails, with positive effects on shell strength and yolk color. The higher shell percentages might be attributed to the good levels of calcium and phosphorus in finger millet (USFDA, 2024). The similarities observed across most parameters among the treatments suggest that incorporating FMM at levels between 15% and 45% does not negatively impact performance, serving as a viable substitute for maize, even at the lower inclusion levels. This indicates that including FMM in quail diets maintains feed quality. The reduction in feed costs alongside the absence of harmful effects on the birds increases profitability for farmers, as high-quality alternative ingredients provide both cost savings and nutritional adequacy (Edi and Andri, 2023; Ojediran *et al*., 2022; Widyas *et al*., 2019).

Conclusion

In conclusion, this study found that feeding layer quails varying amounts of finger millet meal enhanced egg production and profitability, with 30% and 45% FMM diets improving performance while reducing feed costs compared to the control and 15% FMM diets.

Table 2: Egg production of layer quails fed varying levels of finger millet meal

Parameters	Control	15%FMM	30%FMM	45%FMM	SEM	P-value
Initial weight (g)	140.69	141.45	140.58	141.33	0.44	0.991
Change in weight (g)	175.33	175.96	178.06	182.51	3.25	0.374
Total feed intake (g)	1056.30	1080.24	1054.20	1057.56	12.19	0.419
Daily feed intake (g)	25.15	25.72	25.10	25.18	0.29	0.907
Egg weight (g)	9.23	9.33	10.25	10.55	0.66	0.338
Egg length (cm)	2.89	2.91	3.11	3.31	0.20	0.459
Total egg produced	21.00^{b}	21.00^{b}	23.00^{a}	24.00^{a}	1.50	0.099
HDEP (%)	50.00^{b}	51.00^{b}	55.00^{a}	57.00^{a}	3.30	0.062
Egg mass (g)	197.71^{c}	199.85^{c}	236.78^{b}	252.57^{a}	27.28	0.07
Feed conversion ratio	5.34^{a}	5.41^{a}	4.45^{b}	4.19^{b}	0.62	0.053

Values with different superscripts are significantly different ($p<0.05$).

Table 3: External egg quality parameters of layer quails fed varying levels of finger millet meal

Parameters	Control	15%FMM	30%FMM	45%FMM	SEM	P-value
Egg length (cm)	4.1	4.01	4.15	4.2	0.08	0.611
Egg width (cm)	2.1	2.1	2.1	2.1	0.00	0.999
Shell weight (g)	1.89	1.91	1.93	1.89	0.02	0.412
Shell thickness (mm)	0.55	0.55	0.55	0.55	0.00	0.899
Shell percentage (%)	20.48[a]	20.47[a]	18.83[b]	17.91[b]	1.27	0.018

Values with different superscripts are significantly different ($p<0.05$).

Table 4: Internal egg parameters of layer quails fed varying levels of finger millet meal

Parameters	Control	15%FMM	30%FMM	45%FMM	SEM	P-value
Egg weight (g)	9.23[b]	9.33[b]	10.25[a]	10.55[a]	0.66	0.034
Yolk + albumen weight (g)	8.16	8.19	8.58	8.61	0.24	0.897
Albumen weight (g)	5.45	5.45	5.48	5.49	0.02	0.651
Albumen percentage (%)	59.05	58.41	53.46	52.04	3.51	0.022
Yolk weight (g)	2.71	2.74	3.10	3.12	0.22	0.672
Yolk percentage (%)	29.36	29.37	30.24	29.57	0.42	0.757
Albumen height (cm)	3.88	3.87	3.65	4.02	0.15	0.446
Yolk height (cm)	1.02	1.02	1.02	1.03	0.01	0.228
Yolk length (cm)	3.16	3.15	3.11	3.15	0.02	0.542
Yolk colour	7.00	8.00	8.00	8.00	0.50	0.889
Yolk: albumen	0.50	0.50	0.57	0.57	0.04	0.817
Av Haugh unit	91.53	91.50	91.67	91.67	0.09	0.864

Values with different superscripts are significantly different ($p<0.05$).

Table 5: Economic of production of layer quails fed varying levels of finger millet meal

Parameters	Control	15%	30%	45%	SEM	P-value
Cost/kg feed (₦)	121.45[a]	118.95[a]	116.44[ab]	113.94[b]	3.23	0.035
Feed consumed/egg (g)	50.30[a]	51.44[a]	45.83[b]	44.07[b]	3.52	0.051
Feed consumed/30 eggs (g)	1509.00[a]	1543.20[a]	1375.04[b]	1321.95[b]	105.73	0.068
Cost of feed/ 30 eggs (₦)	183.27[a]	183.56[a]	160.12[ab]	150.62[b]	16.65	0.042
Cost/egg (₦)	110	110	110	110	0.00	0.847
Profit over 30 eggs (₦)	3116.73[b]	3116.44[b]	3139.88[a]	3149.38[a]	16.65	0.771

Values with different superscripts are significantly different ($p<0.05$).

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