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Fish Silage as an Alternative Dietary Protein Source: Effects on Growth and Laying Performance of Japanese Quail (*Coturnix japonica* Lin.)

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Abstract

Rising feed costs and reliance on commercial protein sources such as fish meals and soybean meals have prompted the search for alternative, locally available options. Hence, this study evaluated the potential of fish silage as a partial substitute in Japanese quail diets to reduce feed expenses without compromising growth and laying performance. A 93-day feeding trial was conducted using 160 ten-day-old quails assigned to a completely randomized design with four dietary treatments: T_1 (0% fish silage), T_2 (15%), T_3 (20%), and T_4 (25%), each with four replicates of 10 birds. Growth performance was assessed through weight gain, final weight, average daily gain, feed conversion ratio, and initial weight. No significant differences ($p > 0.05$) were observed among treatments, although birds fed 20% fish silage showed a slight increase in final weight (212.95g) compared to the control (206.25g). Laying performance, evaluated by egg number, size, weight, and production rate, also showed no significant variation. Results indicate that fish silage can be included at 15–25% in quail diets without adversely affecting productivity. A 15–25% inclusion level is recommended as a cost-effective alternative protein source. Further studies should explore its long-term effects on hatchability, egg quality, and overall bird health, supported by proximate analysis to ensure nutritional adequacy.

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Introduction

Quail farming's potential for quick growth and early returns has made it a significant part of small-scale poultry production. Quail meat is a rich source of high-quality protein, low in fat, and is preferred by many consumers due to its delicate texture and flavor (Ahmed *et al.,* 2022). According to Khan *et al.* (2023), quail eggs are also known for their therapeutic qualities in a variety of traditional medicines and are extremely nutrient-dense, containing vital vitamins and minerals. The early sexual maturity of quails, typically between 6 and 8 weeks, is a major benefit of quail farming and makes it a profitable endeavor for smallholder farmers. Furthermore, quails are more disease-resistant, which lowers the need for costly medication and increases farm sustainability (Sengupta *et al.,* 2021).

Despite its potential, raising quail has many difficulties, especially when it comes to feed prices. Smallholder farmers are finding it more challenging to remain profitable due to the rising costs of commercial feed, especially that which contain protein sources like fish meal and soybean meal. Another problem is nutrition; while a balanced diet is essential for healthy growth, egg production, and general well-being, creating economic and efficient feed is still difficult. Quail flocks may experience irregular egg production, disease outbreaks, and poor weight gain due to production problems, such as a lack of awareness about appropriate management techniques. To overcome these obstacles, studies have concentrated on finding locally accessible protein sources that can partially substitute pricey commercial feeds without affecting quail performance.

A potential remedy is to replace traditional protein sources with fish silage, a cheap and nutrient-rich byproduct. According to earlier research, feeding quail silage was beneficial and could lessen feed costs while maintaining growth performance and egg production (Rojas *et al.,* 2023). Fish silage, an affordable and sustainable option, could help smallholder farmers by lowering feed expenses while ensuring the nutrition required for optimal quail performance (Martin & Velasquez, 2022). Several studies, including those by Gomez *et al.* (2023) and Singh & Mehta (2022), have shown that fish silage can be a viable supplement in poultry diets, demonstrating its potential to replace part of the traditional protein sources like fish meal and soybean meal. Nevertheless, fish meals are expensive and compete with human food resources as they are used in animal feeds for protein. Localized fish shortages persist in the Philippines despite this abundance, particularly in inland and upland areas, which puts vulnerable populations at risk for food insecurity and nutritional deficiencies (FAO, 2021). Underutilized fish waste is substantial as a byproduct for protein sources that are low cost and ideal as an alternative component for monogastric animal feed like poultry and quails (Zynudheen *et al.,* 2019).

This idea aims to generate income from waste products and ensure proper disposal, thereby addressing environmental issues and promoting sustainable development through waste management. (FAO, 2020; Martin & Velasquez, 2022). Consequently, this research aligns the sustainable goal for responsible production and consumption of livestock nutrition that supports accessibility to protein and well-being of animals, food security, and the disposal of fish waste.

This is particularly important for small-scale farmers who are looking to enhance profitability without compromising the health of their flocks. Thus, this study was conducted to evaluate the effects of varying levels of fish silage on the growth and laying performance of Japanese quails. Specifically, the study aimed to assess parameters such as initial and final body weight, weight gain, feed intake, feed conversion efficiency, mortality rates during the growing phase, onset of laying, egg production, egg size, and egg weight during the laying period. Furthermore, the study seeks to determine the optimum level of fish silage inclusion in quail diets that balances economic viability and biological efficiency in quail production.

Materials and methods

Study Location, Duration, and Experimental House

The study was carried out at St. Brgy Lamcaliaf, Purok 6, Polomolok , South Cotabato, from October 20, 2024, until January 20, 2025. A week before the arrival of the experimental birds, the brooder and poultry house were disinfected with detergent, chlorine, and water. Old newspapers were used as flooring in the brooding pen during the brooding stage. The housing setup consisted of two wooden cages, each divided into four compartments, with each compartment housing ten quails. Each compartment measured 18" x 12" x 18" and featured a plastic mesh floor for easy cleaning. Individual doors allowed for easy access and management. The design ensured proper ventilation, cleanliness, and comfort for the quails.

Experimental Diets

All feed ingredients, including commercial feeds, were purchased from local agricultural and veterinary supply stores, while the fresh fish used for silage preparation was sourced from the local market. Fresh Bodboron (Bullet Tuna or Bullet Mackerel) was cleaned, descaled, and ground into small pieces using an electric blender. Acetic acid (vinegar) at 5% of the total fish weight was added as an acidifier, and muscovado was mixed in as a carbohydrate source to enhance fermentation, following the methods described by Palkar *et al.* (2017) and Hassan *et al.* (2020). The mixture was fermented in airtight containers for 14 days to produce fish silage. Due to the frequent rainfall and lack of appropriate drying conditions, the fermented silage was cooked after fermentation to prevent spoilage, as recommended by Goddard and Perret (2005) (Figure 1).

Fish silage was added to commercial feed at varying levels to create experimental diets. This resulted in four dietary treatments: T_1 = 1000 g of commercial feed (control diet), T_2 = 850 g of commercial feed + 150 g of fish silage, T_3 = 800 g of commercial feed + 200 g of fish silage, and T_4 = 750 g of commercial feed + 250 g of fish silage. Since no direct laboratory analysis was done for this study, the proximate composition of the fish silage used in the diets was based on standard reference values (Table 3).

Experimental Birds and Experimental Design

The experimental birds were handled following the Good Animal Husbandry Practices in rearing poultry and livestock animals in the Philippines (PNS/BAFPS, 2008). A total of 160 ten-day-old Japanese quails (*Coturnix coturnix japonica*) were purchased from a local quail breeder. The birds were randomly assigned to four dietary treatments with varying levels of fish silage and arranged in a Completely Randomized Design (CRD). Each treatment had four replications with ten birds per replication.

Experimental Bird and Feeding Management

Ten-day-old Japanese quails were placed in brooding cages equipped with two 25-watt light bulbs to provide sufficient lighting and maintain warmth until day 20. During the growing period (Day 21 to Day 34), each quail received 20 grams of feed daily—10 grams at 6:00 AM and 10 grams at 5:00 PM. This feeding schedule was based on the Department of Agriculture's Quail Raising Guide, which recommends 17 grams per bird per day during this stage. A gradual transition to the new feed mixture was implemented by substituting 50% of the daily ration, allowing the quails' digestive systems to adjust gradually. Feed allocation was increased to 25 grams per day—12.5 grams in the morning and 12.5 grams in the afternoon—once the birds reached the laying stage on Day 35. The increase ensured the quails received adequate nutrients for egg production, in line with the 23-gram daily intake suggested for laying birds. Similar to the growing period, the transition to the new laying diet was done gradually, with 50% of the feed mixture replaced to help the birds adjust to the change in both quantity and composition.

Additionally, starting on Day 20, fish silage was added to commercial feed in varying proportions (15% fish silage, 20% fish silage, and 25% fish silage) to enhance their diet. This approach allowed for the assessment of how fish silage affected the quails' capacity for growth and laying. Feed consumption was recorded daily throughout the feeding trial to ensure accurate information on the quails' intake, and any health or mortality issues were closely watched. Water was provided *ad libitum* at all stages to maintain hydration and support overall health.

Lighting Management

Proper lighting is essential for the healthy development and optimal productivity of quails at each growth stage. During the brooding phase (Days 10–20), continuous lighting—typically 24 hours a day—is provided to stimulate feeding, movement, and overall activity. This constant illumination supports early growth and helps chicks acclimate to their environment. As the birds' transition into the growing stage (Days 21–34), light exposure is reduced to a 16-hour light and 8-hour dark cycle (16L:8D), simulating natural daylight patterns. This adjustment ensures adequate rest at night while supporting consistent development. In the laying stage (Day 35 onward), quails require 14 to 16 hours of daily light exposure to maintain high egg production rates.

A stable photoperiod during this stage is critical for sustaining reproductive health and maximizing laying performance. Throughout all stages, moderate light intensity is recommended to enhance productivity while minimizing stress among the birds.

Statistical Analysis

The data were analyzed using a Completely Randomized Design (CRD) using the Statistical Tool for Agricultural Research (STAR) software.

Result and discussion

In the present study, the inclusion of fish silage at varying levels (15%, 20%, and 25%) as a partial replacement for commercial feeds in the diet of Japanese quails was evaluated in terms of growth and laying performance.

Table 1. Growth Performance of Japanese Quail Fed with Varying Levels of Fish Silage as Dietary Supplement

Treatment	Mortality Rate (g)^{ns}	Initial Weight (g)^{ns}	Final Weight (g)^{ns}	Body Weight gain (g)^{ns}	Average Daily gain (g)^{ns}	Feed Conversion Ratio (g)^{ns}
T1-100%CF	0	91.37	206.25	114.88	1.44	3.35
T2-15% FS	0	96.37	203.98	107.60	1.20	3.35
T3-20% FS	0	96.37	212.95	116.58	1.25	3.28
T4-25% FS	0	96.62	209.23	113.10	1.21	3.43
	CV=0%	CV=0.71%	CV=5.03%	CV=7.91%	CV=19.05%	CV=7.82%

CF: Commercial Feeds; FS: Fish Silage ns= not significant; CV = Coefficient of Variance.

The results indicated that the addition of fish silage had no negative effects on the health or growth of quails, as there were no significant differences ($p>0.05$) in mortality, final weight, body weight gain, average daily gain (ADG), or feed conversion ratio (FCR) between treatments. According to Abad *et al.* (2018), poultry diets can incorporate different protein sources without impairing growth performance. This finding is consistent with their findings. Although there was no statistical significance, the birds fed 20% fish silage (T3) had the highest final weight (212.95g), which was numerically greater than the control (206.25g). In line with Jerez *et al.* (2019), who pointed out that substituting protein-rich feed for some of the commercial feed can result in poultry growing at comparable or better rates. Fish silage can support feed efficiency up to a 20% inclusion level and is digestible, according to the comparable FCR values across treatments, with T_3 demonstrating the most effective feed utilization (3.28g) (Table 1). Quails fed 25% fish silage (T_4) demonstrated the highest average number of eggs laid per quail (54.43%) and the highest egg production rate (82.57%) in terms of laying performance. The higher protein bioavailability and amino acid profile in fish silage may be the cause of this increased reproductive output. Essential amino acids, including lysine and methionine, are abundant in fish silage and vital for the development of eggs and reproductive processes (Zynudheen *et al.*, 2019; FAO, 2020). Furthermore, silage production's fermentation process can improve these nutrients' digestibility and absorption, promoting the best possible physiological function during the laying phase.

Table 2. Laying Performance of Japanese Quail Fed with Varying Levels of Fish Silage as Dietary Supplement.

Treatment	Egg Production Rate (%)[ns]	Average Number of Eggs Laid per bird [ns]	Average Egg Size [ns]	Average Egg Weight [ns]
T1-100%CF	71.54	44.08	31.01	10.26
T2-15% FS	75.06	47.90	31.24	10.26
T3-20% FS	70.45	46.58	30.52	10.46
T4-25% FS	82.57	54.43	30.12	11.02
	CV=15.27%	CV=19.00%	CV=2.76%	CV=3.39%

CF: Commercial Feeds; FS: Fish Silage ns= not significant; CV = Coefficient of Variance.

The higher average egg weight (11.02g) despite the slightly smaller egg size (30.12 mm) may be explained by the higher protein intake in T_4, which may have supplied enough building blocks for yolk and albumen synthesis. These results are consistent with earlier research showing enhanced laying efficiency and egg weight when poultry are fed. The findings align with previous studies that demonstrated increased laying effectiveness and egg weight when diets were supplemented with high-protein fish-based ingredients (Zynudheen *et al.*, 2019).

Table 3. Proximate Composition of Fish Silage and Commercial Feeds.

Nutrient Component	Fish Silage (Zynudheen *et al.*,2019)	Commercial Chick Starter Mash	Commercial Laying Mash
Crude Protein (%)	52.30-54.58	19.50	20.00-21.00
Crude Fat (%)	3.54-4.10	3.00	3.50-4.50
Moisture (%)	16.01-17.20	12.00	-
Calcium (%)	-	0.9-1.10	0.90-1.20
Phosphorus (%)	-	0.55	0.55-0.60

The proximate composition of the fish silage used in this study was estimated from literature, with crude protein ranging from 52.30–54.58%—higher than standard commercial feeds, affirming its potential as a high-quality protein source (Zynudheen *et al.,* 2019; FAO, 2020). However, the fish silage used may have been lower in key minerals such as calcium and phosphorus, which are essential for eggshell development (Ajol, 2022). suggesting that the protein density and digestibility of fish silage might have made up for other dietary deficiencies like low levels of calcium, phosphorus, and vitamin D_3 nutrients necessary for the best possible eggshell quality and reproductive success. Although not statistically significant, the trend in results demonstrates that incorporating FS up to 25% in the diet of Japanese quails may enhance laying performance, particularly in terms of egg output and egg weight.

These outcomes emphasize the biological potential of fish silage as a protein-rich supplement capable of supporting the nutritional needs of laying quails. Moreover, the impact of adding different grades of fish silage (FS) on the overall cost, egg production, and net return of Japanese quails is demonstrated by the economic analysis in Table 4. Results revealed that increasing levels of FS in the diet led to a progressive reduction in total feed cost per bird.

Table 4. Total Cost, Egg Production, and Cost-Benefit Analysis of Japanese Quails Fed with Varying Levels of Fish Silage as Dietary Supplement.

Particulars	T1 (100% CF)	T2 (850g CF + 150gFS)	T3 (800g% CF + 200% FS)	T4 (750g% CF + 250g% FS)
FS Level (%)	0%	15%	20%	25%
Feed Cost per Stage				
Booster (₱48/kg)	3.36	3.36	3.36	3.36
Starter (₱44/kg)	22.00	19.80	17.60	15.40
Layer (₱32/kg)	56.76	53.67	55.89	56.78
Total Feed Cost per Bird	93.16	89.22	87.89	86.58
Chick Cost	23.00	23.00	23.00	23.00
Total Cost per Bird	116.16	112.22	110.90	109.58
Egg Production per Bird	44.08	47.9	46.58	54.43
Egg Sales per Bird (₱3/egg)	₱132.24	₱143.70	₱139.74	₱163.29
Net Return per Bird	₱16.08	31.48	28.84	53.71

All costs were shown in PhP/₱ (Philippine peso); 1 USD= 50.30 PhP. *TC – Total Cost; EP – Egg Production; CBA – Cost-Benefit Analysis.

The control group T_1 had the highest total feed cost, at 93.16, while T_4 25% FS had the lowest, at 86.58. After adding the 23.00 cost of the chick, the total cost per bird varied between ₱116.16 T_1 and 109.58 T_4. The higher the FS inclusion level, the higher the egg production per bird (EP). T_4 25% FS produced the most eggs per bird, with an average of 54.43, while T_1 control produced an average of 44.08 eggs.

Fig. 1. Documentation of the preparation of cooked fish silage: (A) materials used in silage preparation, (a) including measuring cup, (b) vinegar, (c) muscovado, (d) weighing scale, and ground fish; (B) mixture of ingredients forming the fish silage before cooking; (C) final product of fermented and cooked fish silage ready for incorporation into the diet.

This shows that quails fed a 25% fish silage diet produced 10.35 more eggs than quails fed only commercial food. With sales per bird rising from 132.24 T_1 to ₱163.29 T_4, this increase resulted in a notable increase in egg income at a selling price of 3 per egg. The same pattern was seen in the Net Return per bird, which is determined by taking the return above feed and chick cost (RAFCC). At 53.71, T_4 had the highest RAFCC, more than three times higher than the control group's 16.08. Although their inclusion levels were lower, treatments T_2 31.48 and T_3 ₱28.84 also demonstrated better returns than T_1. These findings suggest that higher quantities of fish silage increase profitability by boosting egg production and reducing production costs. The numerical trends indicate that, despite statistical analysis showing no significant differences ($p > 0.05$), fish silage has strong potential as a practical and cost-effective alternative protein source in quail diets, particularly at 20–25% inclusion levels.

According to Zynudheen *et al.* (2019), adding fermented fish waste silage to the diet of Japanese quails increased their egg production. These results are in line with their findings. In a similar vein, Somarajan *et al.* (2017) showed that fish waste that has been acid-ensiled could be used in place of fishmeal without affecting the layer quails' health or productivity. Moreover, Kjos *et al.* (2001) confirmed in laying hens that the use of fish silage up to 5% did not affect egg production or quality, supporting its value as a sustainable feed ingredient. Together, these findings and existing research demonstrate the biological potential of fish silage to promote growth and laying performance while lowering production costs. For its long-term nutritional benefits in quail, more research on carcass characteristics, meat quality, reproductive traits, and nutrient profiling is advised.

Conclusion and recommendation

The study demonstrated that incorporating fish silage at graded levels of 15%, 20%, and 25% had no significant impact on the growth performance or egg production of Japanese quails. Despite the lack of statistical differences, birds fed with 25% fish silage showed weight gain and egg production levels comparable to those receiving standard commercial diets. These findings suggest that fish silage can serve as an effective alternative protein source in quail diets without compromising productivity. Based on the results, a fish silage inclusion rate of 15% to 25% is recommended to partially replace conventional protein ingredients. While statistical differences were not observed, the consistent performance across treatments indicates fish silage's biological viability in supporting growth and laying performance. Further studies are warranted to assess its long-term effects on egg quality, hatchability, reproductive parameters, carcass traits, meat composition, and gut development. Conducting a proximate analysis of the fish silage is also advised to verify its nutritional adequacy and compatibility with the dietary requirements of laying quails.

Conflict of interest

The authors declare that they have no conflict of interest.

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