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Feeding value of amino acids and minerals-enriched banana (*Musa sapienta)* peel and spent sweet potato (*Ipomea batatas*) meal-based diets on the laying performance of japanese quail (*Coturnix coturnix Japonica*)

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ABSTRACT: This study evaluated the laying performance of Japanese quail fed with amino acids and minerals-enriched banana peel (BPM) and spent sweet potato (SSPM) meal-based diets over 30 days conducted from September 16, 2024, to October 16, 2024, at Bataan Peninsula State University, Philippines. A total of 120 ready-to-lay Japanese quails were randomly assigned to four treatments with three replications in a Completely Randomized Design (CRD). The treatments included: commercial quail feeds (Control/Treatment 1), 20% amino acids and mineral-enriched BPM (Treatment 2), 20% amino acids and minerals-enriched SSPM (Treatment 3), and 10% amino acids and minerals-enriched BPM plus 10% amino acids and minerals-enriched SSPM (Treatment 4). Data were analysed using variance analysis and LSD for treatment mean comparisons. The results indicated that both BPM and SSPM-based diets significantly improved daily egg production, laying percentage, feed conversion ratio, income over feed cost, and average feed cost per kilogram of eggs ($p<0.05$), with Treatment 4 achieving the highest mean values: 9.8 eggs, 98%, 2.33, Php 42.95, and Php 84.96, respectively. Treatment 1 had the lowest performance. No significant effects on feed consumption and egg quality were observed ($p>0.05$). Consequently, both enriched BPM and SSPM-based diets can effectively substitute traditional feeds due to their substantial impact on the laying performance of Japanese quails.

Keywords: Amino acids, banana peel meal, Japanese quail, mineral-enriched, spent sweet potato meal.

INTRODUCTION

Japanese quails represent a robust avian species that flourish in confined enclosures and are relatively economical to maintain. While they are susceptible to prevalent avian diseases, they exhibit a considerable degree of disease resistance. The maturation process of Japanese quails occurs within approximately six weeks, with individuals typically achieving full ovulatory capacity by 50 days of age. Given adequate management, female quails are expected to produce around 200 eggs during their inaugural year of reproductive activity (Randall and Bolla, 2008). The anticipated lifespan of these birds ranges from two to two and a half years (Dauda, 2014). The quail, commonly referred to as “pugo” in the Philippines, constitutes a diminutive game bird prevalent in both temperate and tropical ecosystems globally and is reared as poultry or commercial livestock in select regions due to

its flesh and vibrant eggs (Del Hoyo, 1994). Quails are classified as very small avian species within the pheasant and partridge families, characterized by a unique morphology that includes a compact body and elongated pointed wings (Lopez-Pedrouso *et al.,* 2019). In spite of their potential as a lucrative source of revenue, the expense associated with feed represents a significant financial burden in the realm of quail production. The provision of high-quality feed is imperative for maintaining the health and productivity of quail; however, such feed can incur substantial costs (Arimado, 2007), which may adversely influence profit margins. Similarly, Nasar *et al*. (2016) highlighted high feed cost as one of the several major challenges in quail farming. In tropical regions like the Philippines, agro-industrial by-products are plentiful and have been utilized as substitutes for traditional poultry feed. These by-products are rich in bioactive compounds like oligosaccharides, phenolic compounds, certain fatty acids, and vitamins. These compounds can act as antimicrobial agents, antioxidants, and immune-modulators for poultry, making these by-products a promising option for functional feeds that enhance the health and well-being of poultry (Sugiharto *et al*., 2018). Therefore, using locally available agro-industrial by-products could help achieve sustainable quail farming.

One potential dietary supplement under consideration is the incorporation of banana peel and spent sweet potato meal. These materials, banana peel and spent sweet potato meal, are abundantly accessible in substantial quantities and at a relatively economical price, serving as a source of energy and providing 1 gram or 2 per cent of the necessary protein content for the nutritional needs of quail. Banana peel contains 10% crude protein and 2932 kcal/kg metabolizable energy (ME) (Blandon *et al*. 2015). According to the studies of Pereira and Maraschin (2015) and Hernández-Alcántara *et al*. (2016), the banana peel is a good source of prebiotics, antioxidants and pro-vitamin A due to its contents of carotenoids, phenolics and amine compounds, while spent sweet potato meal is not only a source of energy but also provides essential nutrients such as vitamins A (beta carotene), B6, C, and E, along with dietary fibre, while being low in fat and cholesterol. It is a crucial protein source for many populations worldwide and offers significant amounts of starch and other carbohydrates, with roots containing 25% to 30% carbohydrates and the remainder being water (58% to 72%). Additionally, sweet potatoes supply important minerals and trace elements like iron, potassium, calcium, zinc, sodium, magnesium, and manganese (Srivastava *et al*., 2012). This research endeavour sought to enhance the laying capabilities of Japanese quail and intended to assess the nutritional efficacy of diets formulated with amino acids and minerals-supplemented banana peel and spent sweet potato meal, with the objective of advancing the exploration of alternative feed resources for quail nutrition. The primary aim of this investigation is to analyze the laying performance of Japanese quail subjected to diets based on amino acids and minerals-enriched banana peel and spent sweet potato meal over a duration of 30 days. Specifically, this study aims to determine the laying performance of quail based on the average daily egg production, average laying percentage, average feed consumption, average feed conversion ratio, average feed cost per kilogram of quail eggs produced, average income over feed cost, average egg weight, average egg shell weight, average eggshell thickness, average egg yolk colour intensity, morbidity rate, mortality rate, and cost and return analysis.

MATERIALS AND METHODS

Experimental birds

A total of 120 heads of 90-day-old Japanese quail were used in the study. It was conducted for 30 days from September 16, 2024, to October 16, 2024, at the Animal Science Department of Bataan Peninsula State University, Philippines. The experimental cage with a 6 ft. x 8 ft. dimension was used in the study. The cage is a battery-type cage for the quail layer which is made up of steel frames, and a polyethylene plastic screen was used for walls, dividers, and flooring. The roof is made from GI sheets, and the feeders and drinkers were made from polyvinyl chloride 75 mm (PVC) which were fixed before the start of the study.

Experimental design and treatments

A total of 120 Japanese quails were randomly allocated in a single-factor experiment using a Completely Randomized Design (CRD). The study treatments consisted of different meal-based diets: Commercial Feeds as Control/Treatment 1 (T1), 20% amino acids and minerals-enriched Banana Peel Meal (BPM) as Treatment 2 (T2), 20% amino acids and minerals-enriched Spent Sweet Potato Meal (SSPM) as Treatment 3 (T3), and a combination of 10% amino acids and minerals-enriched BPM plus 10% amino acids and minerals-enriched SSPM as Treatment 4 (T4). Each treatment was replicated three times with 10 quails per replication.

The experimental quails were given 22 grams of feed per bird divided twice daily every 7:00 am and 5:00 pm, following a restricted feeding schedule. The leftover feed was collected and weighed weekly to track the actual weekly feed consumption for each treatment group's replication. Water was monitored throughout the day, with a constant flow maintained, except during supply issues, when it was replaced daily, and the water containers were thoroughly cleaned with soap and water.

To prevent disease entry, strict biosecurity measures were implemented. This included thorough cleaning and disinfection of the experimental area, housing, cages,

feeders, drinkers, and other equipment. Researchers maintained high standards of personal hygiene and were in good health to avoid transmitting diseases to the Japanese quail. Measures also included banning visitors, keeping out stray animals, and controlling other potential disease vectors. Manure was managed by placing catchers under the cages, and it was regularly removed and replaced with fresh litter every afternoon to prevent ammonia buildup, which could lead to disease in the experimental birds.

Collection and processing of banana peels and spent sweet potatoes

Banana peels and spent sweet potatoes were gathered from production farms. After collection, these were thoroughly washed, shredded, and fermented with an Effective Microorganisms-Activated Solution (EMAS) for seven days. These were then oven-dried until crispy before being milled into crumb-sized particles using a hammer mill.

Preparation of the experimental diets

Mixing of synthetic amino acids and minerals (tricaphos) to banana peel

Enrichment of banana peel meal with synthetic amino acids and minerals (Tricaphos): Banana peel naturally contains 8.30% crude protein (Vali, 2008). To enhance its protein content, the recommended requirements of 1.5% lysine and 0.50% methionine for the quail layer (PhilSAN, 2003) were adhered to. Synthetic amino acids like L-lysine and DL-methionine, along with minerals (Tricaphos), were thoroughly integrated into the banana peel meal.

Enrichment of spent sweet potato meal with synthetic amino acids and minerals (Tricaphos): The crude protein content of spent sweet potato meal is only 3.70% (Vali, 2008). To boost its protein content, the recommended lysine level of 1.5% and methionine level of 0.50% for the quail layer (PhilSAN, 2003) was followed. Synthetic amino acids such as L-lysine and DL-methionine, along with minerals (Tricaphos), were thoroughly mixed into the spent sweet potato meal.

Formulating of the experimental diets

Based on the recommendations and feeding standards of the Philippine Society of Animal Nutritionists (2003) for laying quail, experimental diets were formulated for using varying levels of amino acid and mineral-enriched banana peel and spent sweet potato meal as the primary ingredients as shown in Table 1.

Table 1. Formulating of the experimental diets.

Ingredient	Amount (%)
Treatment 2	
Amino acids and minerals-enriched BPM	20.0
Ground yellow corn	24.0
Soybean oil meal	20.0
Fish meal	11.0
Rice bran (D1)	16.75
Molasses	4.0
Vegetable oil	2.0
Limestone	1.25
Vitamin-mineral premix	1.0
Treatment 3	
Amino acids and minerals-enriched SSPM	20.0
Ground yellow corn	35.0
Soybean oil meal	18.0
Fish meal	10.75
Rice bran (D1)	12.0
Molasses	1.0
Vegetable oil	1.0
Limestone	1.25
Vitamin-mineral premix	1.0
Treatment 4	
Amino acids and minerals-enriched BPM	10.0
Amino acids and minerals-enriched SSPM	10.0
Ground yellow corn	30.0
Soybean oil meal	14.0
Fish meal	15.0
Rice bran (D1)	12.75
Molasses	4.0
Vegetable oil	2.0
Limestone	1.25
Vitamin-mineral premix	1.0

RESULTS AND DISCUSSION

General observations in the study

According to the study's data, all the experimental birds were subjected to a restricted feeding system and consumed an identical amount of average daily feed intake of 22.0 g per quail/day. It was also observed that throughout the experimental period, there were no instances of morbidity or mortality.

Laying performance

Table 2 presents the average daily egg production, laying percentage, and feed conversion ratio of Japanese quails fed with amino acids and minerals-enriched banana peel

Table 2. Average daily egg production, laying percentage, and feed conversion ratio of quail fed with varying levels of BPM and SSPM meal-based diet.

Code	Description	Daily egg production (pc)	Laying percentage (%)	Feed conversion ratio
T1	Control	8.63^{b}	86.33^{b}	2.77^{a}
T2	20 % BPM	9.52^{ab}	95.22^{a}	2.61^{ab}
T3	20% SSPM	9.60^{ab}	96.00^{ab}	2.53^{b}
T4	10% BPM +10% SSPM	9.80^{a}	98.00^{a}	2.33^{c}
F test		**	**	**
CV %		2.29	2.29	4.11

ns- not significant, * - significant, **- highly significant. Means with the same letter are not significantly different.

Table 3. Average feed cost per kilogram of quail egg produced and average income over feed cost

Code	Description	Feed cost per kilogram of quail egg produced (Php)	Income over feed cost (Php)
T1	Control	97.04^{a}	35.62^{b}
T2	20 % BPM	94.36^{a}	40.55^{a}
T3	20% SSPM	85.33^{b}	41.87^{a}
T4	10% BPM +10% SSPM	84.96^{b}	42.95^{a}
F test		*	**
CV %		4.16	3.24

ns- not significant, * - significant, **- highly significant. Means with the same letter are not significantly different.

meal and spent sweet potato meal-based diets. The average daily egg production of quails was calculated by dividing the total number of eggs produced each day by the total number of quails. The average laying percentage was determined by dividing the daily total number of eggs by the total number of quails and then multiplying by one hundred (100). The average feed conversion ratio was obtained by dividing the total kilograms of feed consumed by the average egg production.

Results revealed highly significant differences in the average daily egg production, laying percentage, and feed conversion ratio (FCR) of quails fed with amino acids and minerals-enriched banana peel and spent sweet potato meal-based diets. This indicates that the quails assigned in the amino acid and minerals-enriched treated diets (T2- 20% BPM, T3- 20% SSPM, and T4- 10% BPM plus 10%

SSPM) are significantly higher than the control group (Treatment 1). These findings align with Agbai *et al*. (2024) experiments, which demonstrated that dietary intake of sweet potato peel meal and calcium sources improved egg production and quality. Similarly, these findings align with Padgett and Ivey (1959) research, which showed that varying levels of banana peel meal in the diet enhanced the feed conversion ratio of Japanese quail. However, they contrast with Djulardi *et al*. (2024) study, which found that incorporating fermented banana peel meal in the diet led to significantly lower daily egg production due to low feed consumption that causes the nutrients consumed to produce are not fulfilled, thus reducing egg production.

Financial analysis

Presented in Table 3 are the financial parameters, which include the average feed cost per kilogram of quail-egg produced, and the average income over feed cost of Japanese quail fed with amino acids and minerals-enriched Banana Peel and Spent Sweet Potato Meal-based diet.

The variance analysis showed notable differences in feed costs across the treatment groups, suggesting that diets enriched with amino acids and minerals (BPM and SSPM) significantly impacted the average feed cost per kilogram of quail eggs. These results contrast with Edache *et al.* (2017) findings, which indicated no significant difference in total production costs across diets with varying sweet potato meal content (0%, 25%, 50%, 75%, 100%). Therefore, enhancing the nutrient content of farm by-products like banana peels and spent sweet potatoes through microbial fermentation and the addition of synthetic amino acids could significantly lower production costs.

Average income over feed cost

The analysis of variance revealed notable differences in the treatment groups' average income over feed cost. Quails that were fed diets enriched with amino acids and minerals (BPM and SSPM) had significantly higher income

Table 4. Average egg weight, average eggshell weight, average eggshell thickness, and average egg yolk colour intensity

Code	Description	Egg weight (g)	Eggshell weight (g)	Eggshell thickness (mm)	Egg yolk color intensity (1-15)
T1	Control	9.20	1.13	0.2333	3.07
T2	20 % BPM	8.87	1.07	0.1800	3.47
T3	20% SSPM	9.07	1.00	0.1967	3.93
T4	10% BPM +10% SSPM	9.67	1.20	0.2567	3.80
F test		ns	ns	ns	ns
CV %		4.07	7.42	15.48	15.61

ns- not significant, * - significant, **- highly significant.

over feed cost compared to the control group. These results are consistent with Edache *et al.* (2017) study, which found that a quail diet containing 50% sweet potato meal resulted in a significantly higher gross margin compared to other diets, except for one containing 75% sweet potato meal. This underscores the economic advantage of using locally available farm by-products as feed ingredients over costly imported ones. By incorporating protein-enriched banana peel and spent sweet potato meal, feed costs can be reduced, significantly increasing income.

Egg quality analysis

Presented in Table 4 are the egg quality parameters of Japanese quails fed with amino acids and minerals-enriched BPM and SSPM meal-based diet. The analysis of variance showed no significant differences among the treatment groups in terms of average egg weight, eggshell weight, eggshell thickness, and egg yolk colour intensity in Japanese quails fed diets with protein-enriched banana peel, and spent sweet potato meal. This indicates that the experimental diets did not significantly affect these egg quality parameters. This result contrasts with Djulardi *et al.* (2024) findings, which suggested that supplementing quail diets with fermented banana peel meal had a very significantly different effect on the average egg weight and egg yolk colour intensity. Therefore, egg quality parameters tested in this study were not affected by feeding quails with or without incorporating protein-enriched banana peel and spent sweet potato meal.

Conclusion

The study concluded that diets enriched with amino acids and minerals using banana peel and spent sweet potato meal can effectively serve as substitute feeds for Japanese quail, significantly impacting their laying performance. It is therefore recommended that further research be conducted over a more extended period and with other livestock and poultry species to further explore the potential of these meal-based diets.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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