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# Sweet Potato Peel as Substitute Dietary Energy Source on the Early Laying Performance, Egg Quality Traits and Yolk Biochemical Composition of Japanese Quails (*Coturnix coturnix japonica* Temminck & Schlegel, 1898)

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## ABSTRACT

This study evaluated the potential of sweet potato peels from different varieties as substitute dietary energy in the early laying performance of Japanese quails. A total of 240 heads of ready-to-lay quails were laid out in a Randomized Complete Block Design (RCBD) and were assigned to the following treatments; A-Commercial feeds, B-Home-mixed ration with 10% NISC Sp-35, C- Home-mixed ration with 10% NISC Sp-36, and D- Home-mixed ration with 10% Sp Japonita. The data were analyzed using one-way ANOVA for RCBD, and differences were determined using Tukey's Honestly Significant Difference Test (HSD) at $p<0.05$. The commercial diet improved hen-day egg production, FCR per dozen eggs, FCR per kilogram egg mass, and eggshell thickness. On the other hand, there were no significant differences ($p>0.05$) observed in egg weight, egg shape index, dry shell weight, yolk-albumen ratio and yolk total antioxidant activity. The yolk color score of HMR diets was significantly higher ($p>0.05$) and the yolk cholesterol deposition was lesser than those in the commercial diet. The financial analysis showed that the gross return was highest in the commercial ration. However, HMR diets performed better in terms of net income, return over feed cost, egg-to-feed price ratio, benefit-cost ratio, and return over investment.

*Keywords: early laying performance, NSIC Sp-35, NSIC Sp-36, Sp Japonita Sweet potato peel*

## INTRODUCTION

The increasing density of agro-industrial wastes is among the most concerning problems resulting from man's effort to feed the growing world. One effective way to decrease agro-industrial waste is by utilizing it as animal feed. Studies have shown that crop residues and industrial by-products could be a potential source of raw materials for formulating livestock rations (Meral et al., 2022). Mohamed et al (2021) found that many agro-industrial wastes contain fiber,

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starch, protein, vitamins, and minerals, supporting their potential as livestock feed. Moreover, Abbasi-Parizad et al. (2021) determined that bioactive compounds that act as antimicrobial, antioxidant, anticarcinogenic, and anti-inflammatory are present in these wastes.

## MATERIALS AND METHODS

### *Preparation of the Area*

Twenty-four (24) cages with 0.25 sq ft/ bird and caged floors sloped at 5° (degrees) were constructed for this study. Plastic sheets were provided for the collection of quail excreta. A distance of at least 2.4 meters from floor to ceiling was observed to provide optimum ventilation for quails. Polyvinyl chloride (PVC)-based linear feeders were used with a feeding space requirement of 6-7 cm per bird. A 500 ml round-bubble waterer was placed in individual cages. A week before the quails arrived, cages, feeders, and waterers were cleaned and disinfected. Biosecurity measures were practiced to prevent contamination and infection during the trial.

### *Feed, Water and Layer Management*

A total of 240 ready-to-lay Japanese quails at 7 weeks of age with homogenous weight were acquired from a reliable quail breeder farm. A 7-day adjustment period was observed to acclimatize the ready-to-lay quail pullets in the study site. A 7-day gradual transition from commercial feeds to home-mixed rations (HMR) containing dietary treatments was carried out prior to feeding the HMR. Artificial lighting was provided from 6:00 in the afternoon until 10:00 in the evening using a 40-watt incandescent bulb. During the adjustment period, the same pre-layer feed concentrate was provided to the ready-to lay quail pullets. The feeding of HMR started after the transition period. Feeds were given twice a day, at 7:00 in the morning and 4:00 in the afternoon. Potable water was provided at all times.

### *Chemical Analysis of sweet potato peelings*

A composite sample of sweet potato peel from each variety was taken for proximate analysis. Five (5) grams for each variety were analyzed to determine the chemical composition according to the methods of Goering and Van Soest (1970). A sample for each variety was sent to commercial laboratory for mineral analysis. The results of these assay served as basis in formulating the quail layer ration.

### *Preparation of sweet potato peelings*

The sweet potato peel was sourced from the PRCRTC processing center at the

Visayas State University, Baybay City, Leyte. The peels were approximately 1 to 2 millimeters thick which included the tuber skin and a thin layer of the tuber cortex. The sweet potato peels were oven dried at 60°C until it reached the maximum moisture level of 13% for feed energy sources (PNS BAF, 2015). Each variety was grounded separately using a Rong Tsong Precision Technology Co. Taiwan (2016) Mill.

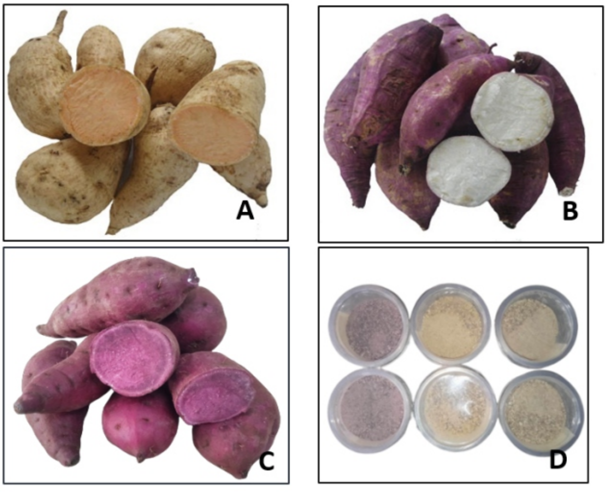


Figure 1. Upper left to right: A-NSIC Sp-35 variety, B-NSIC Sp-36 variety, C-Sp Japonita and D-grounded sweet potato peel (SPP)

### *Experimental Design and Treatments*

A total four (4) treatments, blocked six (6) times with ten (10) birds per treatment were used in this experiment. The quails were laid out in a Randomized Complete Block Design and were randomly assigned to the following treatments: A-Commercial layer feeds (control), B-Home-mixed ration (HMR) with 10 % NISC Sp-35 as substitute energy source, C- Home-mixed ration (HMR) with 10 % NISC Sp-36 as substitute energy source and D- Home-mixed ration (HMR) with 10 % SP Japonita as substitute energy source. The birds were homogenous in weight and age; thus, blocking was made according to cage location inside the quail house since environmental factors such as temperature and humidity inside the quail house were not controlled and could affect the performance of the birds. Sweet potato peels inclusion was fixed at 10% due to its low protein content, fiber, and dustiness. This was based on the recommendations of the Philippine Society of Animal Nutritionists (PHILSAN 2010) on the maximum inclusion rate for root crop feed ingredients in poultry layers.

### *Data collection and Statistical analysis*

The laying performance were collected within ten (10) weeks of the early laying period of quails. The parameters involving weights were measured using a digital laboratory weighing balance. The yolk color was identified using a DSM yolk color fan, and eggshell thickness was measured using an eggshell thickness gauge. Data were analyzed using analysis of variance (ANOVA) for RCBD using SAS (University Edition) software and pairwise comparison using Tukey's Honestly Significant Difference Test (HSD) at P<0.05 was used to determine the differences among treatments.

***Preparation of Dietary Treatments***

Home mixed ration was formulated based on the reference standard for quail layer requirements (PHILSAN 2010).

Table 1. Nutrient recommendation for Japanese quail (Layer)

| NUTRIENTS | LAYER |
|---|---|
| Crude Protein% | 20 |
| Calcium% | 2.50 |
| Available Phosphorus% | 0.35 |
| Salt (NaCl)% | 0.15 |
| Metabolizable Energy, Kcal/kg | 2900 |
| Lysine | 1.00 |
| Methionine | 1.50 |
| Tryptophan | 0.63 |

Table 2. Home Mixed Ration Formula

| INGREDIENTS | A (CONTROL) | B (HMR with 10 % NISC Sp-35) | C (HMR with 10 % NISC Sp-36) | D (HMR with 10 % Sp-Japonita) |
|---|---|---|---|---|
| NSIC Sp-35 | | 10.00 | | |
| NSIC Sp-36 | | | 10.00 | |
| Sp Japonita | | | | 10.00 |
| Yellow corn | | 41.74 | 41.74 | 41.74 |
| Soybean meal | | 32.17 | 32.17 | 32.17 |
| Limestone | | 6.55 | 6.55 | 6.55 |
| Coconut oil | | 5.30 | 5.30 | 5.30 |
| Fish meal Peruvian | | 2.00 | 2.00 | 2.00 |
| Molasses | | 1.00 | 1.00 | 1.00 |
| Monodicalcium phosphate | | 0.85 | 0.85 | 0.85 |
| DL-Methionine | | 0.14 | 0.14 | 0.14 |
| Choline chloride | | 0.12 | 0.12 | 0.12 |
| Vitamin Premix | | 0.10 | 0.10 | 0.10 |
| Multienzyme | | 0.02 | 0.02 | 0.02 |
| Zinc Oxide | | 0.01 | 0.01 | 0.01 |
| TOTAL | | 100.00 | 100.00 | 100.00 |

## RESULTS AND DISCUSSION

### *Chemical Analysis of sweet potato peelings*

The DM, CP, EE, Ash, NDF and GE of NSIC SP 35, NSIC SP36 and SP Japonita SPP is presented in Table 3. The dry matter (DM) of NSIC Sp-35, NSIC Sp-36, and Sp Japonita ranged from 93.56 % to 94.17%. These findings were higher than the DM of SPP in the study of Akinmutimi and Osuagwu (2008). SPP from NSIC Sp-36 had the highest CP at 3.65%, followed by NSIC Sp-35 at 2.18% and Sp Japonita at 1.40%. The CP values obtained in this study was comparable to those of Aboyeji et al (2020), with an average CP of 2.68±0.07. The starch content of SPP were lower than that of the tuber, but the sugar content, which ranged from 6.534% to 11.103% was comparable to that of the tuber, with an average of 9.1% (Heuzé et al, 2020).The gross energy (GE) of SPP NSIC Sp-35, NSIC Sp-36 and Sp Japonita varieties were 3,724.50 kcal/kg, 3,609.50 kcal/kg and 3,657.00 kcal/kg, respectively. The GE values obtained in this study were comparable to the data obtained by Dako et al. (2016) which ranged from 361.86±0.30 to 376.90±0.20 kcal/100g. Furthermore, the ether extract (EE) of SPP in the current study (4.05%-5.28%) was quite similar to the values obtained by Solomon et al. (2015) with an EE of 4.71±0.1%. The ash contents of SPP was lowest in Sp Japonita at 2.89% and highest in NSIC Sp-36 at 5.79%. This ash values were close to the ash value of 4.56% by Omoregie et al. (2009). Moreover, SPP had lower CP as compared to other energy sources with 8.05%, 10.00, and 12.14% for yellow corn(local), rice bran D2 and rice bran D1, respectively (PHILSAN, 2010). However, it is at par with the gross energy of rice bran at 3,650 kcal per kilogram which shows its potential as an energy source (INRAE CIRAD AFZ, 2021).

Mineral analysis for macro and micro elements is presented in Table 4. The NSIC Sp-35 variety was found superior in terms of potassium (K) at 14,201.00 mg/kg, magnesium (Mg) at 731.50 mg/kg, calcium (Ca) at 2,585.00 mg/kg and sodium (Na) at 686.50 mg/kg. Percent total P was highest in NSIC Sp-36 SPP meal at 0.25%, while SP Japonita had the lowest total P, K, Ca, Mg and Na among all SP varieties. The NSIC Sp-35 SPP had the highest iron (Fe) at 380.570 mg/kg and copper (Cu) at 11.065 mg/kg. The NSIC Sp-36, however, contained the highest zinc (Zn).

The NSIC Sp-36 had the highest total free radical scavenging activity in terms of µmol TE/g. The total DPPH free radical scavenging activity recorded in the current study were 677.39 µmol TE/g, 445.32 µmol TE/g, and 318.83 µmol TE/g for NSIC Sp-36, SP Japonita, and NSIC Sp-35, respectively. The darker the tuber skin, the higher the free radical scavenging activity in the peels. Salawu et al. (2015) found higher lipid oxidation inhibition and antioxidant activity in purple SP than in white SP. The high antioxidant activity in dark-pigmented SP is associated with the presence of anthocyanin, while varieties with undetected anthocyanin still contain antioxidants due to other phytochemicals such as phenols and carotenoids (Zhang et al., 2018).

Table 3. Chemical Analysis of NSIC Sp-35, NSIC Sp-36 and SP-Japonita peel

| CHEMICAL COMPOSITION | NSIC Sp -35 | NSIC Sp -36 | Sp-Japonita |
|---|---|---|---|
| DM (%) | 93.56 | 94.08 | 94.17 |
| Crude Protein (%) | 2.18 | 3.65 | 1.40 |
| Ether Extract (%) | 4.88 | 5.28 | 4.05 |
| Crude Ash (%) | 3.11 | 5.79 | 2.89 |
| Neutral Detergent Fiber (%) | 45.50* | 45.50* | 45.50* |
| Sugar (%) | 11.10 | 8.91 | 6.53 |
| Starch (%) | 27.66 | 28.70 | 28.69 |
| Gross Energy kcal/kg | 3,724.50 | 3,609.50 | 3,657.00 |

**NDF was based on the average values of fresh SPP in the data obtained by Heuzé et al (2020)*

Table 4. Mineral analysis and total antioxidants of NSIC SP 35, NSIC SP36 and SP Japonita peel meal

| ITEM | NSIC Sp -35 | NSIC Sp-36 | Sp-Japonita |
|---|---|---|---|
| Total P (%) | 0.23 | 0.25 | 0.11 |
| K(mg/kg) | 14,201.00 | 10,765.63 | 6,837.50 |
| Ca(mg/kg) | 2,585.00 | 2,282.13 | 1,178.75 |
| Mg(mg/kg) | 731.50 | 674.88 | 655.50 |
| Na(mg/kg) | 686.50 | 317.00 | 150.25 |
| Fe(mg/kg) | 380.57 | 200.35 | 136.69 |
| Cu(mg/kg) | 11.07 | 8.20 | 8.19 |
| Zn(mg/kg) | 9.16 | 9.71 | 9.48 |
| Total DPPH FRSA (µmol TE/g) | 318.83 | 677.39 | 445.32 |

***Early laying performance***

The result in Table 5 showed that Diet A with 82.24% HDEP performed better compared to those with SPP. The performance of quails given Diet D was comparable to Diet C and Diet B with 75.93%, 75.14%, and 74.76% HDEP, respectively. Edache et al. (2016), found that HDEP significantly decreased ($p > 0.05$) as the level of SPP meal increased in the quail layer diet, which could be associated with the high fiber content of SPP. Also, the decreased HDEP may be due to differences in the nutrient composition and the amount of anti-nutritional factors present in SPP. In terms of FCR, birds in Diet A were more efficient feed converters with 0.37 FCR per dozen eggs and 3.24 FCR per kilogram of egg mass While FCR in Diet B, Diet C and Diet D had comparable values. Lower feed digestibility of SPP-based HMR with high CF could explain poor FCR per dozen eggs and FCR per kilogram egg mass. Isah et al. (2020) reported that the crude fiber (CF) of SPP was higher than the CF on the SP tuber. Moreover, phytate, oxalate, and tannin are greater in unpeeled sweet potatoes (Dako et al., 2016), which could inhibit the digestion and absorption of feeds in quail layers. Hence, supplementing exogenous enzymes may improve hen productivity and egg quality traits (Bakare et al., 2021).

***Egg quality traits***

Egg weight (EW) is one of the primary factors that determine the egg grade which equates to a specific market price (Travel et al., 2011). The present study revealed that there was no significant difference (p>0.05) among the EW of Japanese quails fed with commercial and HMR diet. The result conforms with Edache et al. (2022) where varying levels of peeled and cooked white SP meal did not significantly affect the EW of Japanese laying quails. Egg shape index (ESI) in this study were somehow similar to the study of Sujana et al. (2020) with a range value of 78.259±2.811. According to Karimi et al. (2022) changes in the source of dietary energy alone could not affect the ESI of Japanese quails. Eggshell thickness (EST) is a vital factor during transportation, storage, and marketing (Chen et al. 2019). The EST in the early laying performance showed that quails in Diet A had the thickest EST (355.16 μm) among the treatments, followed by Diet B (342.22 μm), Diet C (336.88 μm) and Diet D (321.71 μm).The difference in terms of EST of Commercial diet and HMR might be associated with the total calcium content in the diet (Attia et al., 2020). The HMR followed the 2.5% calcium recommendation by PHILSAN (2010), while the commercial quail layer mash contained 2.9-3% calcium. Nascimento et al. (2014) found that eggshell thickness increased linearly when calcium inclusion was increased from 2.85% up to 5.25%.The variation in the eggshell thickness of Japanese quails fed with HMR diets might be due to the disparity in calcium content of the SPP varieties as presented in Table 4.There were no significant differences observed in dry shell weight (DSW ) of quails, moreover the DSW in this study was lighter than the ones cited by Drabik et al. (2022). This might be correlated with the hen's young age during the early laying phase. Zita et al. (2009) and Hanusova et al. (2015) found that most external egg qualities are affected by the hen's age and some genetic factors.

In terms of yolk-albumen ratio (YAR), Diet D had the highest YAR at 0.75; however, there were no significant difference (p=0.0579) among the YAR values of the quails. Physical characteristics of eggs revealed that consumers prefer deeply hued egg yolks compared to light-colored ones (González Ariza et al., 2019). The result of the current study revealed that there were significant differences (p<.0001) between the Commercial ration and the HMR diet. Interestingly, the yolk color score (YCS) of birds fed with the HMR diets did not significantly differ from each other. Higher YCS in Diet D may be due to the anthocyanin in SP Japonita peels. The beta-carotene content in NSIC Sp-36 and NSIC Sp-35 might have also contributed to the darker hues of quail egg yolk in Diet B and Diet C. These observations agree with Tufarelli et al. (2022) found that orange and purple pigments in tomato and grape pomace significantly enhanced YCS. Thus, agricultural waste byproduct pigments could be used as a safe and healthy alternative colorant in commercial products.

Table 5. Early laying performance and egg quality traits of Japanese quails fed with different variety of sweet potato peel

| PARAMETERS | DIET | | | | SEM | P-VALUE |
|---|---|---|---|---|---|---|
| | A | B | C | D | | |
| HDEP(%) | 82.24 a | 74.76 b | 75.14 b | 75.93 b | 0.66 | <0.0001 |
| FCR per dozen of egg | 0.37 a | 0.41 b | 0.40 b | 0.40 b | 0.0040 | <0.0001 |
| FCR per kg egg mass | 3.24 a | 3.58 b | 3.47 b | 3.55 b | 0.05 | 0.0009 |
| Egg weight, g | 9.52 | 9.46 | 9.70 | 9.41 | 0.10 | 0.2279 |
| Egg shape index(%) | 79.93 | 79.67 | 79.21 | 79.89 | 0.31 | 0.3773 |
| Egg shell thickness, µm | 355.16 a | 342.22 b | 336.88 b | 321.71 c | 2.65 | <0.0001 |
| Dry shell weight, g | 0.9100 a | 0.8676 ab | 0.8731 ab | 0.8661 b | 0.01 | 0.0347 |
| Yolk -albumen ratio | 0.69 | 0.72 | 0.73 | 0.75 | 0.01 | 0.0579 |
| Yolk color | 1.61 b | 4.35 a | 4.20 a | 4.44 a | 0.12 | <0.0001 |

***Yolk biochemical characteristics***

The yolk cholesterol level from birds fed HMR diets were lower than those in the commercial diet, as presented in Table 6. Studies have shown that inclusion of high fiber ingredients in the ration could lower yolk cholesterol level. Laudadio et al. (2014) observed that the yolk cholesterol level was lower in diets containing high fiber feed stuff. The same conclusion was drawn by Olgun and Yıldız (2015) with the inclusion of alfalfa which also contains high crude fiber. Medical studies showed that dietary fiber traps and eliminates bile in the stool, forcing the liver to utilize its cholesterol stores to generate more bile, which effectively lowers low-density lipoprotein (LDL) cholesterol (Soliman, 2019). Thus, in this study the fiber in SPP might have reduced the yolk cholesterol deposition among Japanese quail hens.

The 2,2-Diphenyl-1-picrylhydrazyl (DPPH) assay measures a compound's antioxidant properties by acting as hydrogen donors or free radical scavengers (Baliyan et al 2022). A free radical is a by-product of metabolism or exposure to toxic substances. In manufacturing commercial feed, animal nutritionists use toxin binders and synthetic antioxidants as preservatives. However, synthetic antioxidants are harmful to animals over time. Natural antioxidants from plant byproducts are now being studied as an alternative to synthetic antioxidants. In this experiment, the result showed that commercial diet was superior in terms of Trolox equivalent. The total antioxidant activity in the yolk for Diet A was 0.1925 µmol TE/g. This was followed by the Diet D at 0.1678 µmol TE/g, Diet B at 0.1526 µmol TE/g and lastly, Diet C at 0.1435 µmol TE/g. Among the HMR, egg yolk from quails fed Diet D obtained the highest antioxidant capacity in terms of Trolox equivalent. The SPP contains high antioxidant properties, however processing such as drying and milling reduces their antioxidant potency.

Table 6. Yolk biochemical characteristics of Japanese quails fed with different variety of sweet potato peel

| PARAMETERS | DIET | | | | SEM | P-VALUE |
|---|---|---|---|---|---|---|
| | A | B | C | D | | |
| Yolk total DPPH free radical scavenging activity , μmol TE/g | 1,924.65 | 1,525.49 | 1,337.74 | 1,909.44 | 189.34 | 0.1129 |
| Yolk cholesterol , mg/100 grams | 140.00 | 130.00 | 123.00 | 121.00 | | |

Legend: A = Control (Commercial ration), B = HMR with 10% NSIC Sp-35 peelings, C = HMR with 10% NSIC Sp-36 peelings and D = HMR with 10% Sp Japonita peelings. SEM standard error means. Means within a row followed by different superscripts are significantly different ($p \leq 0.05$).

***Financial Analysis***

The financial analysis only included the full productive value of quail in the early laying performance (10 weeks). The result presented in Table 7 showed that Diet A (Commercial Diet) earned the highest gross income with Php 115.00 per quail head. It was observed that Diet A was significantly higher ($p<0.05$) compared to the HMR. However, the net income for Diet A (Php 23.06) was observed to be significantly lower than Diet D (Php 34.34), Diet C (Php 33.24) and Diet B (Php 32.70). The same trend can be observed in the return above feed cost (RAFC). Highest RAFC was observed in Diet D (Php 56.28) followed by Diet C (Php 55.18) and Diet B (Php 54.64) while RAFC of Diet A (Php 45.00) was found significantly lower among the treatment diets. The egg-to-feed price ratio (EFPR) was observed the highest in Diet D with 2.13, followed by Diet C, Diet B, and Diet D at 2.10, 2.09 and 1.64, respectively. The Benefit-Cost Ratio (BCR) was also calculated to determine the benefit (profit) in every unit of investment. The Diet D obtained the highest BCR with 1.48 followed by Diet C (1.46) and Diet B (1.45). Diet A had the lowest BCR at 1.25. The same result was observed in the ROI analysis which was computed by dividing the total cost from the net income, multiplied by 100. The result showed that the HMR were comparable to each other at 47.73%, 46.20% and 45.45% ROI for Diet D, Diet C and Diet B, respectively. However, Diet A (25.09 %) had the lowest ROI among all treatment diets. Thus, despite that Diet A gained the highest gross income due to a higher HDEP performance, the lower feed cost in the HMR led to a favorable economic performance as compared to the commercial ration.

Table 7. Financial analysis of Japanese quail egg production in the early laying period fed with different variety of sweet potato peel (SPP) as substitute dietary energy.

| ECONOMIC PARAMETERS | DIET | | | | SEM | P-VALUE |
|---|---|---|---|---|---|---|
| | A | B | C | D | | |
| RETURNS | | | | | | |
| Eggs produced | 57.50 | 52.33 | 52.60 | 53.15 | | |
| Price/piece, Php | 2.00 | 2.00 | 2.00 | 2.00 | | |
| **Gross Returns** | 115.00 $^{a}$ | 104.67 $^{b}$ | 105.20 $^{b}$ | 106.30 $^{b}$ | 0.8994 | <0.0001 |
| COSTS | | | | | | |
| Cash Cost (Php) | | | | | | |
| Total Feed Cost | 70.00 | 50.02 | 50.02 | 50.02 | | |
| Productive value of quail | 8.44 | 8.44 | 8.44 | 8.44 | | |
| Labor Cost (Php) | 6.29 | 6.29 | 6.29 | 6.29 | | |
| Farm tools | 2.40 | 2.40 | 2.40 | 2.40 | | |
| Overhead Cost | 4.17 | 4.17 | 4.17 | 4.17 | | |
| Sub -Total | 91.30 | 71.32 | 71.32 | 71.32 | | |
| Non -Cash Cost | | | | | | |
| Housing Depreciation | 0.64 | 0.64 | 0.64 | 0.64 | | |
| Total Cost (per head), Php | 91.94 | 71.96 | 71.96 | 71.96 | | |
| **Net Income, Php** | 23.06 $^{b}$ | 32.70 $^{a}$ | 33.24 $^{a}$ | 34.34 $^{a}$ | 0.8994 | <0.0001 |
| **Return Above Feed Cost, Php** | 45.00 $^{b}$ | 54.64 $^{a}$ | 55.18 $^{a}$ | 56.28 $^{a}$ | 0.8994 | <0.0001 |
| **Egg-to-Feed Price Ratio** | 1.64 $^{b}$ | 2.09 $^{a}$ | 2.10 $^{a}$ | 2.13 $^{a}$ | 0.0156 | <0.0001 |
| **Benefit -Cost Ratio** | 1.25 $^{b}$ | 1.45 $^{a}$ | 1.46 $^{a}$ | 1.48 $^{a}$ | 0.0117 | <0.0001 |
| **Return Over Investment** | 25.09 $^{b}$ | 45.45 $^{a}$ | 46.20 $^{a}$ | 47.73 $^{a}$ | 1.1268 | <0.0001 |

Legend: A = Control (Commercial ration), B = HMR with 10% NSIC Sp-35 peelings, C = HMR with 10% NSIC Sp-36 peelings and D = HMR with 10% Sp Japonita peelings. Means within a row followed by different superscripts are significantly different ($p \leq 0.05$)

## CONCLUSION

The 10 % SPP inclusion did not cause any detrimental effects on the overall performance of the birds. Although HDEP, FCR per dozen, and FCR per kilogram egg mass were lower in HMR diets with NSIC Sp-35, NSIC Sp-36 and SP Japonita SPP; it did not affect other egg quality traits. Moreover, it even enhanced the yolk color, increased the yolk-albumen ratio and reduced the cholesterol concentration in the quail egg yolk. In terms of financial analysis, the use of HMR diets containing SPP resulted to a more profitable egg production activity compared to the commercial control. Moreover, the initiative to utilize these agro-industrial byproducts will not only reduce waste production and pollution, but it will also generate new feed materials that are potential alternatives to traditional feed stuffs.

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