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Laying performance of quails (*Coturnix coturnix* Linn.) supplemented with malunggay (*Moringa oleifera*) enhanced ration

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Abstract

The study was conducted at Don Andres Soriano, Toledo City, Cebu from May to July 2024. The researcher aims to investigate the effects of administering *Moringa oleifera* leaf meal on the (1) production performance, (2) laying performance and egg quality, (3) liveability rate, (4) production cost, (5) and sensory evaluation. Results show no significant difference in (1) production parameters such as average feed consumed (AFC), feed efficiency per kg of egg mass, feed efficiency per dozens of eggs, and NFEI. While in (2) laying performance and egg quality, statistical results show no significant difference in hen-day egg production (HDEP), hen-housed egg production (HHEP), egg mass, and egg length and shape index, except in yolk color because of the presence of carotenoids. In (3) liveability rate, varying levels of MOLM do not have a direct effect. In terms of (4) production cost, the cost of treatments and egg: feed price ratio shows a highly significant impact, while the partial economic return is reduced due to MOLM administration. In (5) sensory evaluation, the odor/aroma, off-flavors, flavor, and palatability indicated no significant difference, while color varies significantly. In conclusion, results showed that quails in the T1 to T3 group exhibited similar production, and egg laying performance as well as qualities to the control group, indicating no negative impact on these parameters. However, higher inclusion levels (15% and 20%) resulted in higher costs.

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Introduction

Quail (*Coturnix coturnix*) production is one of the sectors of the Philippines poultry industry. Quails are small-tailed game birds that belong to the families: Phasianidae and Odontophoridae (Britannica, 2024) and are one of the local sources of eggs for consumption.

Rural and urban farmers across the nation are having great success with raising this species of fowl because, quail matures and lays eggs in just 8 to 12 weeks from hatching, unlike the 7 months for chickens and they can lay up to 300 eggs annually (Harlow, 2016; Kalaiselvi, 2019).

In addition, the meat and eggs of quails are also very nutritious. Quail eggs contain vitamins A, B1, and B2, iron, phosphorous, and higher protein than other poultry species. Thus, quail raising can have an important role in contributing to the demand for food, nutrition, and cheap sources of eggs. According to Tridge, (2022), quail egg production has an estimated 50.5K mt produced in 2020 (+1.85% compared to the previous year), and its potential production in the economy is optimistic.

Quail products are abundantly found in almost all areas here in the Philippines. Due to the high demand for quail products, this will be one of the reasons that will encourage farmers to go into quail raising. Quails are hardy animals and are resistant to diseases but they also need additional nutrients and supplements for the improvement of other production parameters such as their laying and growth performance. If fed a poor-quality diet, it can highly affect their production and laying performance (Mnisi *et al.*, 2021). According to Vercese *et al.* (2012); Beyer, (2006) genetics, management, and nutrition are vital variables that play a vital role in egg quality and health. Raharjo *et al.*, (2018) stated that feed and temperature influence egg production.

In feeding livestock, one of the most important nutrients is a high-quality protein that contains adequate amino acid balance. The problem is that these common protein sources have periodic scarcity. Because of this, researchers are encouraged to look for alternative protein feedstuffs that are more readily available in the locality. To answer this, supplementation with *Moringa oleifera* is being looked into.

Moringa oleifera is a fast-growing, drought-resistant tree native to the Indian subcontinent, belonging to the family Moringaceae. It is widely cultivated for its nutritious pods, edible leaves, and flowers, and is used for food, medicine, cosmetic oil, and forage for livestock. The plant is a prominent source of nutrients, containing high levels of protein, iron, vitamin A, and other bioactive compounds. Its leaves have been studied for their potential health benefits, including protection against chronic diseases due to their rich content of flavonoids, vitamins, phenolic acids, and isothiocyanates (Islam *et al.*, 2021). The plant's seeds, flowers, and leaves are edible and have been recognized for their nutritional and antioxidant properties (Ortega and Campos, 2019).

In addition, *Moringa oleifera* has been found to have other animal health benefits, including improving animal health and nutrition (Satish *et al.*, 2007). *Moringa oleifera* is highly nutritious and can be used as a feed supplement for animals, including dogs (Gopalakrishnan *et al.*, 2016). Studies show that malunggay can enhance the egg production of poultry (Garcia *et al.*, 2021).

Scientific research shows that malunggay in poultry diets could enhance their growth and productivity. Additionally, productive outcomes in poultry could be due to the plant's phytochemicals, minerals, and vitamins present in the leaves (Abd El-Hack *et al.*, 2022).

Malunggay can scientifically improve growth and productivity, reduce cholesterol levels, and enhance yolk color in poultry.

Thus, based on the basis above, this study was conducted where; malunggay (*Moringa oleifera*) was added to the quail's diet to determine the effects on the production, laying performance, egg qualities, production cost, liveability rate, and sensory evaluation.

Materials and methods

IACUC protocol

Before the conduct of the study, the proposal was submitted for approval by the Institutional Animal Care and Use Committee (IACUC) of Southwestern University in Cebu City.

Site selection and preparation of experimental house

The study was conducted at Don Andres Soriano, Toledo City, Cebu, Philippines. The layer house was strategically oriented with easy access to water and electricity. DAS, Toledo City is located in the southern part of Cebu, Philippines at a latitude and longitude of: 10.3072° N and 123.7052° E (10° 18` North, 123° 42` East). At these coordinates, the estimated elevation is 271.4 meters (890.4 feet) above sea level (PhilAtlas, 2024). A total of 30 square meters of space was allocated for this study.

Dietary treatments and experimental design

A total of 120 ready-to-lay quail birds were purchased and distributed in a completely randomized design into four (4) treatments replicated three (3) times with ten (10) birds per replicate. The four experimental treatments were the following: T0 (control) were quails fed commercial feeds (basal diet); T1 were quails fed commercial feeds basal diet + 10 grams malunggay leaf meal; T2 were quails commercial feeds basal diet + 15 grams malunggay leaf meal; and T3 consisted of quails fed commercial feeds basal diet + 20 grams malunggay leaf meal. The data gathered were analyzed using Analysis of Variance (ANOVA), and differences were analyzed by STAR (Statistical Tool for Agricultural Research).

Preparation of rearing house

The experimental house was prepared a month before the ready-to-lay quails were purchased and all the facilities and equipment needed for the experimental study were provided. The experimental cages measuring 2.03×2.03 feet were made up of steel wire mesh, 1/2-inch mesh wire was used for the flooring, and 1-inch mesh wire was used in the sidings of the cage for proper ventilation. A galvanized iron sheet was used as the roofing material. Their house was divided into 12 cages representing the four treatments and three (3) replications. Each cage was provided with a PVC type of feed trough.

Selection of experimental birds

A total of 120, 3-week-old RTL (ready-to-lay) quails, apparently healthy and free from any defects were used in the study. The ready-to-lay quail pullets were purchased in Magdugo, Toledo City, Cebu. The birds were grouped according to their treatments. Upon arrival, birds were supplied with water mixed with sugar to lessen the stress from transport, after which birds were randomly distributed to cages where ten (10) birds were placed in each cage, and provided their needs, like water and starter feeds

Feeds and feeding management

Each treatment received the same amount of the recommended feeds. Feeding the experimental birds was done twice a day, at 7 in the morning and 5.30 in the afternoon. This feeding schedule was followed until the end of the study. Quail laying mash was the commercial feed used. From the day the birds were purchased, the birds were fed with starter mash, and laying mash was gradually introduced on the 6th week of the birds as it is the stage when experimental birds started laying. Every day, feeds that were placed in the feed troughs were weighed, as well as the left-over feeds as part of the gathered data.

Health management of the birds

Health care such as implementing biosecurity measures were strictly followed to ward off any possible occurrence of diseases throughout the conduct of the study.

Lighting management

Light management in laying quail was employed for 6 to 17 hours daily (Molino *et al.*, 2015).

Data gathered

Production parameters

Feed intake/consumption

This was obtained by measuring the number of feeds that were given and subtracted by the amount of feed left. Daily feed consumption was recorded.

Leftover feeds

This was obtained by weighing the amount of feed left in the feeding trough before the next feeding was given

AFC= (Total feed given – Total left-over feeds)/ (Total number of birds)

Feed efficiency per kg of egg mass (Feed conversion ratio – FCR)

This takes into consideration the feed intake, egg weight, and egg production. It is the ratio between the feed consumed and the egg mass.

FCR (per kg of egg mass) = (Feed consumed)/ (egg produced)

A value of 2.2 or less is advantageous to the farm.

Feed efficiency per dozen eggs

This takes into consideration the feed intake and egg production. It is the ratio between the feed consumed and the number of eggs produced.

FCR (per dozen of eggs) = (Feed consumed)/ (dozens of eggs produced)

A value of 1.5 or less is advantageous to the farm.

Net feed efficiency index (NFEI)

This is based on egg production, egg weight, feed intake, and body weight gain.

NFEI= ((EM+BW))/FC×100

Where,

EM = Mean egg mass in grams during a specific period

BW = Mean body weight gain or loss in grams during a particular period

FC = Mean Feed consumption/hen in grams during a particular period

NFEI value of 45 and above is desirable.

Egg production performance and egg qualities (Total number of eggs laid per day, week)

Egg production

The egg industry has two principal methods of measuring daily, weekly, and total egg production i.e. the hen-day and hen-housed systems.

Hen-day egg production (HDEP)

For a particular day

〚HDEP〛 day= (Total number of eggs produced on a day)/ (Total number of hens present on that day) ×100

For a long period

This was calculated by first computing the number of hen days in the period by totaling the number of hens alive on each day of the period. Then the calculated number of eggs laid during the same period.

〚HDEP〛 period= (Total number of eggs produced during the period)/ (Total number of hen-days in the same period) ×100

HDEP was usually expressed in percentage. It is mostly used for scientific studies and truly reflects the production capacity of the available birds in the house. A farm average of 85% or more per year is desirable.

Hen-housed egg production (HHEP)

For a particular day

〚HHEP〛 day= (Total number of eggs laid on a day)/ (Total number of hens housed at the beginning of laying period)×100

For a long period

〚HHEP〛 period= (Total number of eggs laid during the period)/ (Total number of hens housed at the beginning of the laying period) ×100

It is usually expressed in numbers. HHEP values of 80% or 295 or higher are desirable.

Egg quality parameters

Egg weight/ Average weight of eggs per week

The average weight of eggs laid per week. At the end of every week, 20 eggs were taken randomly and each weighed by a digital electronic balance.

The eggs were collected manually at 8.00 a.m. each day. The weight and number of eggs laid were recorded daily. The abnormal eggs (broken eggs, shell-less, or soft shells) were excluded when measuring the egg weight. The percentage of broken eggs was calculated by dividing the number of broken and soft-shell eggs by the total number of eggs laid.

AWE = Total weight of eggs laid per week/Treatment.

Egg mass

The use of egg mass rather than egg numbers will lead to better comparisons of flocks or strains of birds. To calculate egg mass, it is first necessary to determine the average weight of eggs by weighing representative samples of the eggs produced.

Average egg mass (Per hen per day) =Percent HDEP × Average egg weight in grams.

Egg length and egg shape index

The egg length (L) and width (W) will be measured using Vernier calipers with the least count of 0.01 mm. The egg shape index (SI) will be determined from the egg length and width described by Dilawar, 2021.

Yolk color (using DSM yolk color fan)

When judging the quality of an egg, another criterion that consumers apply for freshness is the egg yolk color. A simple but subjective method of determining this involves either the BASF Ovo-color Fan or the DSM (formerly Roche) Yolk Color Fan that expresses results on a 1 to 15 scale using visual comparison with calibrated cards in a fan. These fans consist of a range of paper blades colored in fifteen possible outcomes of egg color and numbered accordingly. The blades were held over the yolk and the color of the yolk was compared with the blades to find a corresponding blade of the same color. These numbers was assigned to the egg yolk. Most egg marketing authorities require deep-yellow to orange-yellow yolk colors in the yolk.

Production cost

Cost of the treatments

Cost of Treatment 0 (T0) = total cost of commercial layer feeds consumed + cost of biologics, if any. The price of the nearest registered Agrivet Store was recorded and the cost was determined of commercial layer feed mash (per kilogram).

Cost of treatment = total cost of all ingredients from the formulated feed+ cost of biologics

The labor costs were considered in determining the cost of the formulated feeds by dividing the minimum wage by the estimated labor capacity in kg per day.

Cost of labor= (Minimum wage)/(Labor Capacity in kg.per day).

Partial economic return (PER)

The total number of eggs sold was multiplied by the competitive market price to calculate the partial economic return.

Egg: Feed price ratio (EFPR)

It was used to find out the ratio between the receipts from eggs and expenditure on feed.

EFPR= (Total value of egg produced)/ (Total value of feed consumed).

An EFPR ratio of 1.4 and above is desirable.

Liveability rate

This was obtained by dividing the number of animals that live by the total number of animals raised during the duration of the study.

Sensory evaluation of eggs

Twelve consumer-preference judges (six male members and six female members) aged 20–40 years) from Cebu Technological University were selected for the sensory evaluation of the eggs. The sensory evaluation was performed using a slight modification of the method that was reported by Hayat *et al.* (2018). Six eggs from each treatment were added to a 1.5-quart (approx. 1450 mL) stainless steel pot with a lid, which contains 48 oz. (approx. 1350 mL) of tap water. The gas burner was turned on and kept at a high heat level for 8.5 minutes until the eggs were brought to a low-rolling boil. After turning off the heat, the eggs were kept in the pot with a lid for 20 min. The water was drained, and the eggs were kept under running tap water until the temperature of the egg was cooled to room temperature. The eggs were peeled and cut into quarters (lengthwise) for the sensory evaluation. The sensory attributes tested were the following: (a) odor, aroma/smell of the whole boiled egg; (b) off-flavors, unpleasant or unusual taste or smell of the boiled egg; (c) flavor, the distinctive taste and aroma of the boiled egg; (d) color, overall color of the whole boiled egg; and (e) palatability, an integrated palatable sensation based on the above parameters. The panelists were asked to rate the eggs on a nine-point intensity scale where 0 = extremely bad, 5 = moderately acceptable, and 9 = highly acceptable. The judges will also be provided with cold water in between the sample testing.

Results

Effects of malunggay enhanced ration on the production performance

The results of supplementing *Moringa olefeira* leaf meal (MOLM) in a 60-day feeding period to layer quails in terms of production parameters such as the average feed consumption, feed efficiency per kg of egg mas (FCR), feed efficiency per dozens of eggs, and net feed efficiency index is presented in Table 1.

In terms of the average feed consumption, the administration of MOLM shows no significant effect between the different treatment means ($P<0.9076$). The data showed that T2 (19.11) had the highest feed consumed, followed by T1 (19.09), then T3 (19.07) with T0, or the control group 0 having the lowest feed consumed of 18.85, grams/bird/day. Statistical analysis, however, revealed a non-significant difference among treatment means, indicating a comparable effect of all treatments.

In terms of the feed efficiency per kilogram of egg mass, the results showed that there were no significant differences among treatment means with Treatment 2 having the highest followed by T0, T1 and the least at T3. A value of 2.2 or less is advantageous to the farm.

Since the values in all treatments were greater than 2.2, thus the results suggest a disadvantage effect of all treatments.

In terms of the feed efficiency per dozens of eggs, all values were below 1.5 suggesting a very favorable result. Statistical analysis revealed that there were no significant differences among treatment means; however, T2 stood out as the highest at 1.77, followed by T0 at 1.69, T1, 1.65 and the least is T3 at 1.64.

The net feed efficiency index showed that T2 had the highest among the treatments in the production parameters of 49.42; followed by T0 at 47.97, then T1 at 47.77, with the lowest value at T3 which was at 46.09. A value of 45 and above suggests a very desirable result. Although, statistical analysis revealed a non-significant difference among treatment means indicating the different levels of MOLM supplementation is comparable with pure commercial feeds; but still supplementation with 15% MOLM showed the highest net feed efficiency index.

Effects of malunggay enhanced ration on the laying performance and egg quality

The effects of the Malunggay-Enhanced ration on the laying performance and egg qualities are shown in Table 2. In terms of the hen day and hen housed egg production, the data showed the same trend with T0 having the highest value, followed by T1, T2, and the least at T3. Statistical analysis; however, revealed that there are no significant differences among treatment means; showing a comparable effect with the commercial feeds.

Statistical analysis of the average weight of eggs showed that there were no significant differences among treatment means. However, data revealed that the average weight of eggs was highest at T2 (10.6 g), followed by T1, (10.09 g), T0 (9.98 g) with the least at T3 (9.69 g).

Table 1. Production performance

Treatments	AFC (g)	FE per kg of egg mass – FCR	FE per dozens of eggs	NFEI
T0–commercial feeds	18.85	2.95	1.69	47.97
T1–10% MOLM	19.09	2.48	1.65	47.77
T2–15% MOLM	19.11	2.79	1.77	49.42
T3–20% MOLM	19.07	2.59	1.64	46.09
CV (%)	2.59	32.63	9.57	7.32
p-value	0.9076	0.9094	0.7636	0.7218

Table 2. Egg production

Treatments	HDEP (%)	HHEP (%)	Average weight of eggs (g)	Egg mass (g)	Egg length and shape index	Yolk color
T0–commercial feeds	47.10	48.11	9.98	4.68	80.66	3.60c
T1–10% MOLM	46.28	46.17	10.09	4.67	80.80	5.47b
T2–15% MOLM	43.91	43.90	10.26	4.48	81.33	6.30ab
T3–20% MOLM	41.20	41.00	9.69	4.16	80.13	6.93a
CV (%)	19.44	14.66	3.13	18.34	1.19	10.64
p-value	0.8380	0.6050	0.2350	0.8520	0.5375	0.0007

*Means with the same letter are not significantly different.

Table 3. Production cost

Treatments	Cost of treatments (Php)	PER (Php)	EFPR
T0–commercial feeds	516.12d	283.33	0.3500a
T1–10% MOLM	765.48c	300.67	0.2267b
T2–15% MOLM	889.83b	266.67	0.1667b
T3–20% MOLM	1010.49a	292.00	0.1567b
cv	1.77	24.41	23.62
p Value	0.0000	0.9397	0.0075

*Means with the same letter are not significantly different.

Table 4. Sensory evaluation

Treatments	Odor/aroma	Off-flavors	Flavor	Color	Palatability
T0–commercial feeds	6.22	6.78	7.08	6.47b	7.14
T1–10% MOLM	7.55	6.83	7.19	7.08b	7.45
T2–15% MOLM	6.86	7.11	7.75	7.37ab	7.67
T3–20% MOLM	7.30	5.94	7.86	8.44a	7.75
cv	8.57	9.83	7.40	8.89	7.33
p Value	0.1040	0.2274	0.2868	0.0338	0.5553

*Means with the same letter are not significantly different.

The egg mass was highest in T0 (4.68 g), followed by T1 (4.67 g); T2 (4.48 g); and the least at T3 (4.16 g). Statistical analysis of the average egg mass showed that there were no significant differences among treatment means. Statistical analysis of the egg shape index showed that there were no significant differences among treatment means. However, the data showed that in terms of the egg shape index, T2 had the highest value (81.33) followed by T1(80.80); T0 (80.66) with the least at T3 (80.13). In terms of yolk color, Analysis of Variance (ANOVA) shows a highly significant (P>0.0007) effect when supplemented with different levels of MOLM. The highest color rating was at T3 (6.93) followed by T2 (6.30, then by T1 (5.47) with the least at T0 (3.60). Statistical analysis revealed T2 and T3 are not significantly different from each other; while T1 and TO are significantly different from all the rest of the treatments.

Liveability rate

Results showed that the different levels of MOLM do not have a direct effect on the liveability rate of laying quails in 60 days.

Effects on the Production cost

The Table 3 shows the statistical results of production cost parameters: cost of the treatments, partial economic return (PER), and egg: feed price ratio (EFPR).

Table 3 shows the production costs of the different treatments. Among all treatments, T0 has the lowest cost at 516.12pesos, while the cost of T1, T2, and T3 rises with the administration of MOLM: 765.48, 889.83, 1010.49, respectively. A highly significant differences (P>0.0000) among treatment means was found in terms of the cost of treatment. The incorporation of increasing levels of MOLM increases the overall cost of feeds.

Although statistical analysis showed that the partial economic return shows no significant (P>0.9397) difference but T1 recorded the highest PER with 300.67 T2, followed by T0 at 292.00m, and T2 recorded the lowest PER with 266.67 which indicates a reduction in economic returns due to MOLM administration.

Lastly, in terms of egg feed price ratio, the data showed a highly significant (P>0.0075) difference, with T0 having the highest value with 0.3500, significantly different form the different levels of MOLM. This result also indicated that pure commercial feeding as having the most efficient cost-to-output ratio, compared to the different levels of MOLM supplementation.

Table 4 shows the effects of different levels of *Moringfa olefeira* powder feed supplementation in the sensory parameters such odor/aroma, off-flavors, flavor, palatability, and color of the eggs.

Results showed that in terms of the egg odor/aroma, the data was not statistically significant (P>0.1040). Treatment 0 and T2 have the lowest scores with 6.22 and 6.86, while T3 was a bit higher with 7.30, and T1 has the highest score of 7.55. These values were very near number 5, thus panelists had rated the egg odor/aroma as "moderately acceptable" in all treatments.

Discussion

Increasing feed intake can increase the growth performance of animals. However, several factors must be considered to increase feed consumption. The palatability, texture of feeds, weather conditions, and supplements contribute the greatest impact on feed consumption. Feed conversion ratio or FCR is a measure of an animal's efficiency in converting feed into increased body mass. It indicates how efficient an animal is to convert feed mass to the desired output. The results of AFC and FCR were supported by a study conducted by Ashour *et al.* (2020); Mousa *et al.* (2017), which showed that the administration of MOLM as a dietary treatment shows no significant difference in laying quails. In winding up, a study led by Macambira *et al.* (2018) stated that *Moringa olefeira* has antinutritional compounds including low concentrations of tannins, saponins, and other compounds that can affect the performance, and digestibility of proteins and minerals, and the metabolism of energy of laying quails.

Egg production is influenced by several factors, including good animal health, proper management practices, optimal nutrition, and suitable environmental conditions such as lighting and temperature. These elements work together to support their laying. Another factor on why MOLM administration did not have a significant difference is due to the adaptation period where layers particularly their reproductive system require more time to fully adapt to the changes in diet and need further research (Xin *et al.*, 2022).

The results on the average weight of eggs and egg mass have similar results with the study initiated by Sumiati and Suryati, (2024), evaluating *Moringa olefeira* as a protein substitution for soybean shows no significant difference in egg weight. However, the results were not in agreement with the study investigated for 161 days (23 weeks) by Djitie Kouatcho *et al.* (2020), which showed that extended application of *Moringa olefeira* as dietary treatment shows a significant impact in the (1) laying rate, (2) egg weight, (3) and egg shape index with an average of (1) 81.66±5.02, (2) 11.87±0.74, and (3) 76.87±2.87 of laying quails. In the long run of *Moringa oleifera* application, minerals such as calcium and phosphorus are needed for eggshell formation and are vitamin- and antioxidant-rich which prevents oxidative stress (Masitlha *et al.*, 2024) in quails.

Color is one of the most important sensorial properties that influence consumer's food choices. One of the most important indicators for consumers to determine the quality of eggs is the color of the yolk, which is caused by the presence of carotenoids (Saleh *et al.*, 2021).

Depending on the country, consumers' preferences might vary, but a vast majority prefers eggs with dark orange yolk (Karadas *et al.*, 2006). The differences in the color of the yolk are based on the diet of the animal. The results where diets supplemented with 15% and 20% MOLM showed the most desirable color is supported by the study of Garcia *et al.* (2021), implying that higher levels of moringa treatments upshot a more intense yolk color.

In terms of off-flavors, statistical analysis shows no significant difference (P>0.2274), in which T0 has the lowest score at 5.94, followed by T0 with 6.78, T1 and T2 on the other end, shows the highest panel rating with 6.83 and 7.11. These values were very near number 5, thus panelists had rated the egg odor/aroma as "moderately acceptable" in all treatments. Most of the treatments administered with MOLM, might introduce undesirable flavors that were possibly influenced by tannins and other phytochemicals (du Toit *et al.*, 2020).

Statistical analysis of rating the egg flavors by trained panelists showed, no significant (P>0.2868) difference among treatment means. Treatment 0 has the lowest score of 7.08, T1 score slightly increases to 7.19, while T2 and T3 which were administered with higher levels of MOLM have the highest statistical score of 7.75 and 7.86. These values were intermediate between number 5 and number 9; thus, panelists rated the egg odor/aroma as "moderately acceptable" and "highly acceptable" in all treatments.

In terms of the color of the egg yolk, the color varies significantly (P>0.0338). There were no significant differences among treatments 0, T1, and T2; however, a significant difference was found between T3 and the other treatments. The highest level of MOLM feed supplementation might be due to the effects of the presence of vitamin A in MOLM (Koul and Chase, 2015). T0 has a lower statistical score of 6.47b, while T1 was slightly higher with 7.08b, T2 on the one hand, had a higher rate of 7.37ab, on the other hand, T3 has the highest statistical score of 8.44a.

Conclusion

Results showed that quails in the T1 to T3 group exhibited similar production, and egg laying performance as well as qualities to the control group, indicating no negative impact on these parameters. However, higher inclusion levels (15% and 20%) resulted in higher costs.

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