

ORIGINAL

Productive performance of laying quails fed diets supplemented with *Morinda citrifolia* (noni) leaf meal

Rendimiento productivo de codornices ponedoras alimentadas con dietas suplementadas con harina de hojas de *Morinda citrifolia* (noni)

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ABSTRACT

Introduction: quail production in Latin America has experienced significant growth due to its hardiness, prolificacy, and low maintenance costs, making the rearing of these birds a competitive alternative for egg production. In this context, phytobiotics have gained relevance in the animal feed industry, as they represent a sustainable strategy to improve productive efficiency and reduce dependence on synthetic additives. The objective of the present study was to evaluate the productive performance of laying quails supplemented with *Morinda citrifolia* (noni) leaf meal in their diet.

Method: the study was conducted over 45 days under a completely randomized design (CRD), which included four treatments, five replicates, and a total of 140 laying quails. The treatments consisted of different inclusion levels of *Morinda citrifolia* leaf meal: 0 % (T4), 0,5 % (T1), 1,0 % (T2), and 1,5 % (T3). Productive performance variables were evaluated, mainly laying percentage and economic profitability.

Results: supplementation with *Morinda citrifolia* leaf meal did not exert significant effects on the productive performance of laying quails. No statistical differences were observed in laying percentage among treatments; however, week 6 showed the highest laying rate and persistence, reaching 74,40 %. In economic terms, treatment T2 (1,0 % noni leaf meal) yielded the best results, with a profitability of 45,5 % and a benefit/cost ratio of \$1,45, indicating that for every dollar invested, a net gain of \$0,45 was obtained.

Conclusions: the inclusion of *Morinda citrifolia* leaf meal in the diet of laying quails did not significantly affect productive performance. Nevertheless, supplementation at 1,0 % stood out as the most profitable alternative, highlighting its potential as a phytobiotic feed additive in quail production. These findings contribute to the development of sustainable nutritional strategies in poultry farming, enhancing the competitiveness and profitability of low-cost production systems.

Keywords: Laying Quails; *Morinda Citrifolia*; Phytobiotics; Productive Performance; Economic Profitability.

RESUMEN

Introducción: la producción de codornices en América Latina ha experimentado un crecimiento significativo debido a su rusticidad, prolificidad y bajo costo de mantenimiento, lo que convierte a la crianza de estas aves en una alternativa competitiva para la obtención de huevos. En este contexto, los fitobióticos han adquirido importancia dentro de la industria alimenticia animal, dado que constituyen una estrategia sostenible para mejorar la eficiencia productiva y reducir la dependencia de aditivos sintéticos. Bajo este enfoque, el objetivo de la presente investigación fue evaluar el rendimiento productivo de codornices ponedoras suplementadas con harina de hojas de *Morinda citrifolia* (noni) en la dieta.

Método: el estudio se llevó a cabo durante 45 días bajo un diseño completamente al azar (DCA), que incluyó cuatro tratamientos, cinco repeticiones y un total de 140 codornices ponedoras. Los tratamientos consistieron en diferentes niveles de inclusión de harina de hojas de *Morinda citrifolia*: 0% (T4), 0,5 % (T1), 1,0 % (T2) y 1,5 % (T3). Se evaluaron variables relacionadas con el comportamiento productivo, principalmente porcentaje de postura y rentabilidad económica.

Resultados: la suplementación con harina de *Morinda citrifolia* no presentó efectos significativos sobre el comportamiento productivo de las codornices. No se registraron diferencias estadísticas en el porcentaje de postura entre los tratamientos, aunque la semana 6 evidenció la mayor tasa de puesta y persistencia, alcanzando el 74,40 %. En términos económicos, el tratamiento T2 (1,0 % de harina de noni) obtuvo los mejores resultados, con una rentabilidad del 45,5 % y una relación beneficio/costo de \$1,45, lo que indica que por cada dólar invertido se generó una ganancia de 0,45 centavos.

Conclusiones: la inclusión de harina de hojas de *Morinda citrifolia* en la dieta de codornices ponedoras no modificó significativamente su rendimiento productivo. Sin embargo, la suplementación al 1,0 % se destacó como la alternativa más rentable, evidenciando potencial para su aplicación como aditivo fitobiótico en la producción de codornices. Estos hallazgos contribuyen al desarrollo de estrategias nutricionales sostenibles en la avicultura, favoreciendo la competitividad y rentabilidad de sistemas productivos a bajo costo.

Palabras clave: Codornices Ponedoras; *Morinda Citrifolia*; Fitobióticos; Rendimiento Productivo; Rentabilidad Económica.

INTRODUCTION

Global quail production has experienced remarkable growth, especially in countries such as Brazil, Mexico, and Argentina, where greater advances and experience in zootechnical management have been achieved.

⁽¹⁾ In Ecuador, quail farming is mainly concentrated in the coastal and mountainous regions, as the climatic conditions favor its development. ⁽²⁾ However, its expansion has been limited by cultural factors, the lack of technical information, and the low recognition of the economic and nutritional benefits that this activity offers. ⁽³⁾

Quail farming has established itself as a low-cost production alternative, thanks to the hardiness and prolificacy of this species, which enables greater profitability in egg production. ⁽⁴⁾ However, in modern poultry farming, various additives have been used as growth promoters to improve the health and productivity of the birds. The inappropriate use of these products led to restrictions on their application, creating a need for safer alternatives, such as prebiotics, ⁽⁵⁾ which regulate the intestinal microbiota and strengthen the health of the birds. ⁽⁶⁾ In addition, it has been reported that the use of antibiotics as growth promoters has generated residues in meat and by-products, posing a risk to human health. ⁽⁷⁾

In response to this problem, phytobiotics have emerged as a promising strategy in animal nutrition. These compounds, derived from plants in the form of flours, extracts, or powders, are classified according to their plant origin and bromatological composition, standing out for their medicinal properties and their ability to improve feed efficiency. ⁽⁸⁾ In this context, nutrition is an essential pillar in growth, fattening, and, especially, egg production, while also being the most significant component in production costs, accounting for up to 75 % of the total. ⁽⁹⁾ Therefore, the incorporation of natural phytobiotics into diets is highly relevant, as they improve intestinal health and strengthen the immune system. ⁽¹⁰⁾ According to Yépez ⁽¹¹⁾, medicinal powders in poultry feed promote nutrient digestibility, limit the growth of pathogenic microorganisms in the digestive tract, and improve the quality of the final products (eggs and meat). The present research evaluated the effect of supplementing the diet with *Morinda citrifolia* (noni) leaf meal on the productive performance of laying quails, to reduce feed costs and improve the quality of poultry production.

In this context, *Morinda citrifolia* (noni) leaf meal is considered a phytobiotic of interest due to its high content of vitamins, minerals, and essential fatty acids, which contribute positively to the metabolism and productive performance of birds. ⁽¹²⁾

METHOD

Location

This research was conducted at the “La María” Campus of the Faculty of Animal and Biological Sciences at the Technical State University of Quevedo. In the canton of Mocache, province of Los Ríos. Between the geographical coordinates of 79 ° 29' west longitude, 01°06' south latitude, at an altitude of 73 meters above sea level. ⁽¹³⁾

Experimental design

In this study, a completely randomized design (CRD) was employed, consisting of four treatments with five

replicates each, using seven experimental units (EU) per replicate, resulting in a total of 140 quails. The field evaluation period lasted 45 days.

To determine the existence of statistical differences between the means of the treatments, Tukey's multiple comparison test was used with a significance level of $P \leq 0,05$.⁽¹⁴⁾ The analysis of variance (ANOVA) scheme is presented in table 1.

Table 1. The analysis of variance (ANOVA)		
Source of Variation	Degrees of freedom	
Treatment	t-1	3
Experimental Error	t(r-1)	16
Total	t.r-1	19

Experiment outline

The experimental design is presented in a structured manner in table 2.

Table 2. Experiment outline			
Treatments	Repetitions	UE	Total, quails
T1	5	7	35
T2	5	7	35
T3	5	7	35
T4 (Control)	5	7	35
Total			140

Treatments to be evaluated

Study design

The treatments were based on the inclusion of *Morinda citrifolia* (noni) flour in the birds' diet, with supplementation levels of 0,50 % (T1), 1,00 % (T2), 1,50 % (T3), and a control group with no addition (0 %, T4). The concentrations selected were established based on previous research reporting the effects of this medicinal plant, while the present study sought to evaluate the impact of its flour in different proportions. The characterization of the treatments evaluated is detailed in table 3.

Table 3. Description of treatments	
Treatments	Composition
T1	Balanced + 0,5 % nutraceutical
T2	Balanced + 1,0 % nutraceutical
T3	Balanced + 1,5 % nutraceutical
T4 (Control)	Balanced

Preparation of the nutraceutical

Selection of the medicinal plant

Morinda citrifolia (noni) was used.

Leaf selection

Leaves of different sizes and structures were chosen, ensuring that they were healthy, without mechanical damage or symptoms of pathogens.

Initial preservation

The collected leaves were transferred to the Bromatology Laboratory of the Faculty of Animal and Biological Sciences of the Technical State University of Quevedo, in order to guarantee adequate conditions of preservation and hygiene.

Washing

The samples were carefully washed with distilled water to remove surface impurities.

Dehydration

The dehydration process was carried out over seven days, in the shade, on sheets of aluminum foil, removing the leaves twice a day to ensure uniform drying.

Drying

The leaves were then dried in an air recirculation oven at 60 °C for one hour.

Grinding

The dry plant material was processed in a hammer mill with parallel blades until particles of 1 mm in diameter were obtained.

Flour storage

The resulting flour was stored in amber bottles at room temperature to protect it from light and prevent the degradation of bioactive compounds, following the methodology proposed Foo S et al.⁽¹⁵⁾

The flour obtained was used in the formulation of the experimental diets with the following inclusion levels: 0,5 % for T1, 1,0 % for T2, and 1,5 % for T3.

Bromatological analysis of the nutraceutical

The bromatological analysis of *Morinda citrifolia* flour showed a moisture content of 30,54 % on a wet basis. The ash percentage was 9,27 % on a dry basis and 10,51 % on a wet basis. Crude protein reached 22,44 % on a wet basis. As for crude fiber, values of 18,00 % on a dry basis and 24,43 % on a wet basis were recorded. Finally, the fat content was 5,23 % on a dry basis and 5,01 % on a wet basis. These results are detailed in table 4.

Table 4. Bromatological analysis of the nutraceutical			
Analysis	Unit	Noni flour	
		Dry	Moist
Moisture	%		30,54
Ash	%	9,27	10,51
Crude protein	%		22,44
Crude fiber	%	18	24,43
Fat	%	5,23	5,01

Experimental diets

Table 5. Calculated analysis of the experimental diet of the “Productive behavior of laying quails supplemented with <i>Morinda citrifolia</i> (noni) leaf meal in the diet”				
Raw Material	T1	T2	T3	T4
Domestic corn	0,320	0,320	0,319	0,320
Rice bran	0,050	0,050	0,050	0,05
Soybean meal	0,410	0,410	0,408	0,415
Noni flour	0,005	0,010	0,015	0,000
Palm oil	0,076	0,075	0,073	0,076
Calcium carbonate	0,090	0,090	0,090	0,090
Monocalcium phosphate	0,014	0,010	0,010	0,014
Sodium chloride	0,005	0,005	0,005	0,005
Core	0,0300	0,0300	0,0300	0,0300
Nutritional Nutritional of the feed	1,000	1,000	1,000	1,000

Table 5 presents the analysis of the experimental diets used during the laying phase of the quails. Table 6 shows the bromatological analysis corresponding to these experimental diets applied at this stage of the research.

Table 6. Bromatological analysis of the experimental diet of the “Productive behavior of laying quails supplemented with *Morinda citrifolia* (noni) leaf meal in the diet”

Treatment	Moisture %	Ash %	Fat	Fiber	Protein
1	89,51	12,64	10,34	35,94	10,78
2	90,05	14,88	7,45	33,30	16,64
3	89,54	16,01	9,74	33,93	9,34
4 (control)	88,7	8,48	6,95	30,90	14,30

Variables evaluated

Nutrient consumption: determined using the direct method (food offered - food rejected), adjusted for each treatment.

Dry matter: calculated based on the difference in weight of the samples, applying the formula $DM (\%) = 100 - H$.

Egg production: recorded daily from the second day of the trial, considering number, weight, and characteristics.

Feed conversion: this was established as the ratio between feed consumed and egg yield.

Economic analysis: this included the calculation of total income from egg sales, fixed and variable production costs, net profit, profit/cost ratio, and profitability (%).

Additional production indicators: average egg weight, yolk pigmentation (La Roché Scale, 1-15), mortality (%), and bromatological analysis (moisture, dry matter, ash, and protein) of representative samples per treatment were evaluated.

During the execution of this study, animal welfare principles were strictly observed. The quails were kept in appropriate management, feeding, and health conditions, ensuring their care and avoiding any unnecessary suffering. The experimental protocol complied with international standards established by the *Guide for the Care and Use of Laboratory Animals*, European Directive 2010/63/EU, and the guidelines of the World Organization for Animal Health (OIE), also applying the 3Rs principles (Replacement, Reduction, Refinement). Likewise, the minimum number of experimental units necessary to ensure the statistical validity of the results was used, always seeking a balance between scientific rigor and respect for the integrity of the animals.

RESULTS

Determination of the effect of supplementation with *M. citrifolia* leaf meal on the productive performance of laying quails

Feed consumption (g)

No statistically significant differences were detected between treatments in relation to the feed consumption variable. During the first week, treatment T2 and the control recorded the highest values, with an average consumption of 200,77 g, while T3 (1,5 % inclusion of noni meal) had the lowest consumption, with 199,11 g. In the second and third weeks, T1 and the control achieved the highest consumption, with 203,29 g and 199,48 g, respectively. In the fourth, fifth, and sixth weeks, the highest consumption was observed in T1 and T2, with values of 198,69 g and 195,29 g, while T3 maintained the lowest averages, reaching 201,64 g in these evaluations. Consistently, the treatment with the highest level of supplementation (T3) had the lowest intake in the last week of the study. The detailed results are shown in table 7.

Table 7. Feed consumption in laying quails (g)

Weeks	Treatments				CV (%)
	T1 (0,5 %)	T2 (1,0 %)	T3 (1,5 %)	T4 (control)	
1	199,66 to	200,77 a	199,11 a	200,77 a	1,50
2	203,29 to	201,60 to	199,74 to	201,86 a	1,69
3	198,23 to	197,37 a	196,81 to	199,48 a	1,01
4	198,69 a	197,97 a	197,94 to	197,62 a	0,63
5	195,00 to	195,29 to	193,35 to	194,01 to	0,99
6	201,64 to	200,40 to	197,18 to	198,90 a	1,49
Average	199,41	198,90	197,35	198,77	

Note: identical superscript letters in the same row indicate no statistical differences between treatments, while different letters indicate significant differences according to Tukey's test ($P \leq 0,05$).

Feed conversion ratio

Table 8 shows the results for the feed conversion ratio. No statistically significant differences were observed between the means of the treatments. In the first week, the highest value corresponded to T1 (8,18). During the second week, the treatments with 0,5 % and 1,5 % noni flour showed similar values (7,78). In the third week, T1 again recorded the highest index (7,26). In the fourth and fifth weeks, T3 achieved the highest results with 5,91 and 6,00, respectively. Finally, in the sixth week, the highest index corresponded to T1 with 4,81. These findings indicate that supplementation with *Morinda citrifolia* leaf meal as a nutraceutical in the diet of quails did not have a significant effect on the feed conversion ratio.

Table 8. Feed conversion ratio					
Weeks	Treatments				CV (%)
	T1 (0,5 %)	T2 (1,0 %)	T3 (1,5 %)	T4 (control)	
1	8,18 to	5,85 a	7,47 a	6,48 a	23,29
2	7,78 a	6,93 a	7,78 to	7,08 a	15,37
3	7,26 a	6,28 a	6,58 to	5,99 a	15,93
4	5,81 a	4,89 to	5,91 to	5,41 a	15,93
5	5,89 a	5,33 a	6,00 to	5,63 a	23,55
6	4,82 to	4,55 to	4,66 to	4,81 a	17,70
Average	6,62	5,63	6,40	5,90	
Note: identical superscript letters in the same row indicate no statistical differences between treatments, while different letters indicate significant differences according to Tukey's test ($P \leq 0,05$)					

Mortality (%)

Table 9 shows the mortality results, which show a similarity in the rate obtained for treatments T1, T2, and T4, with a value of 2,86 % in each case. In contrast, treatment T3, with 1,5 % inclusion of noni flour, recorded no mortality (0 %). Considering the total of 140 birds evaluated, the overall mortality rate was 2,14 %. When analyzing only the 105 birds that received diets supplemented with nutraceuticals, mortality reached 1,9 % during the experimental period.

Table 9. Mortality (%)			
Treatments	No. of Birds Initial	No. of birds dead	% Mortality
T1	35	1	2,86
T2	35	1	2,86
Q3	35	0	0
Q4	35	1	2,86
Total	140	3	2,14
	105	2	1,9

Analysis of the effect of supplementation with *M. citrifolia* leaf meal on the laying rate of quails

Egg production (%)

No statistically significant differences ($P < 0,05$) were observed between treatments in terms of egg production percentage in any of the weeks evaluated. However, in the first week, treatment T2 achieved the highest value with 27,60 %. During the second week, although no statistical differences were detected, T2 recorded the highest production (32,80 %), while T4 had the lowest value (20,00 %). In the third and fourth weeks, there were still no statistical differences, with T2 again standing out with the highest production percentages (34,20 % and 29,40 %, respectively). In the fifth week, T1 reached the highest level of egg laying with 30,00 %, while in the sixth week, T2 recorded the highest production with 34,00 %. The detailed results are presented in table 10, while graph 1 shows the egg-laying curve.

Table 10. Egg production (%)

Weeks	Treatments				CV (%)
	T1 (0,5 %)	T2 (1,0 %)	T3 (1,5 %)	T4 (control)	
1	21,80 to	27,60 a	21,80 to	17,00 to	39,91
2	26,80 to	32,80 to	21,80 to	20,00 to	30,33
3	30,20 to	34,20 to	22,60 to	23,80 to	33,94
4	29,20 to	29,40 to	23,40 to	20,20 to	31,76
5	30,00 to	27,20 to	21,60 to	20,40 to	38,98
6	27,00 to	34,00 to	22,60 to	26,60 to	24,92
Average	27,5	31,00	22,30	21,0	

Note: identical superscript letters in the same row indicate no statistical differences between treatments, while different letters indicate significant differences according to Tukey's test ($P \leq 0,05$)

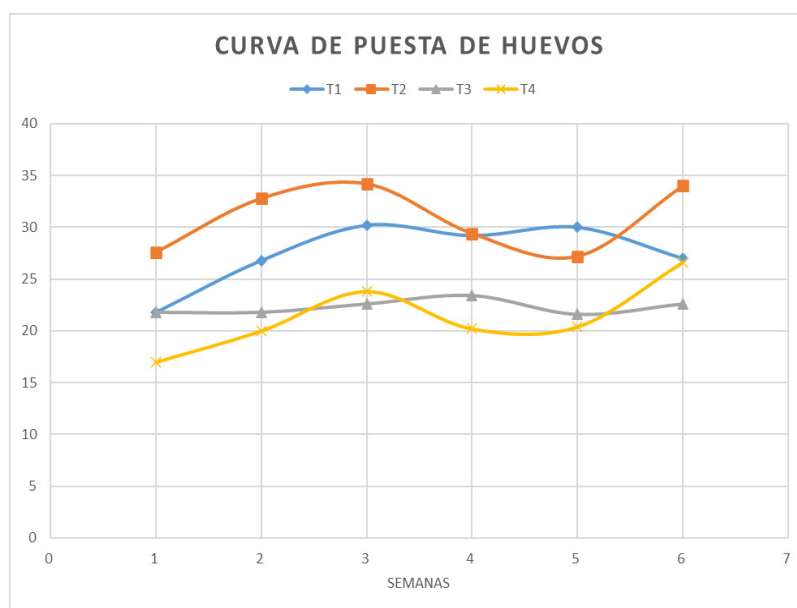


Figure 1. Egg-laying curve

Average egg weight (g)

Table 11. Average egg weight (g)

Weeks	Treatments				CV (%)
	T1 (0,5 %)	T2 (1,0 %)	T3 (1,5 %)	T4 (control)	
1	12,40 to	12,80 to	13,60 to	13,00 to	7,05
2	13,00 to	12,80 to	13,40 to	12,80 to	5,79
3	13,00 to	13,00 to	13,00 to	13,00 to	7,85
4	12,80 to	12,80 to	13,00 to	12,60 to	4,84
5	12,80 to	12,80 to	12,60 to	13,20	3,41
6	13,60 to	13,20 to	13,40 to	13,40 a	6,13
Average	13,10	12,90	13,16	13,00	

Note: identical superscript letters in the same row indicate no statistical differences between treatments, while different letters indicate significant differences according to Tukey's test ($P \leq 0,05$)

Table 11 shows the results of the average weight of quail eggs during the laying phase. No statistically significant differences were found between the means of the treatments. In the first week, the highest weight corresponded to T3 (1,5 % inclusion of noni flour) with 13,60 g, while the lowest value was recorded in T1 with 12,40 g. In the second week, T3 maintained the highest values (13,40 g), while treatments T2 and T4 showed similar results, both with 12,80 g. During the third week, no differences were observed between treatments,

with a uniform average of 13,00 g. In the fourth and fifth weeks, T3 and the control predominated, with averages of 13,00 g and 13,20 g, respectively. Finally, in the sixth week, T1 reached the highest average weight with 13,60 g, followed by T3 and T4 with 13,40 g, while the lowest value corresponded to T2 (1,0 % inclusion of noni flour) with 13,20 g.

Egg mass (g)

In the variable corresponding to quail egg mass during the laying phase, the results for the first week showed that the highest value was recorded in treatment T2 with 7,18 g, while T4 obtained the lowest average with 4,50 g. In the second and third weeks, T2 maintained the highest values with 8,65 g and 8,97 g, respectively. For the fourth week, treatment T2 (1,0 % inclusion of noni flour) again achieved the highest value with 7,70 g, while T4 had the lowest average with 5,25 g. In the last two weeks, the treatments with the highest averages were T1 (8,23 g) in the fifth week and T2 (9,83 g) in the sixth week. In the overall analysis, no statistically significant differences were detected between treatments ($P > 0,05$), indicating that supplementation with *Morinda citrifolia* leaf meal in the balanced diet of quails did not significantly influence this variable. The detailed results are presented in table 12.

Table 12. Egg mass in laying quails (g)					
Weeks	Treatments				CV (%)
	T1 (0,5 %)	T2 (1,0 %)	T3 (1,5 %)	T4 (Control)	
1	5,54 to	7,18 a	5,92 a	4,50 a	40,59
2	7,10 a	8,65 to	6,00 to	5,35 a	33,91
3	8,15 to	8,97 to	6,10 to	6,38 a	34,58
4	7,61 to	7,70 to	6,20 to	5,25 a	32,10
5	8,23 to	7,73 to	5,84 to	5,86 a	37,96
6	7,94 a	9,83 a	6,53 to	7,75 a	27,79
Average	7,42	8,34	6,09	5,84	
Note: identical superscript letters in the same row indicate no statistical differences between treatments, while different letters indicate significant differences according to Tukey's test ($P \leq 0,05$)					

Yolk pigmentation

In the evaluation of the pigmentation of quail egg yolks, the control treatment (T4) recorded the highest value with 12 points on the La Roché Scale, reflecting the greatest color intensity. In contrast, treatments with noni flour inclusion had lower values: T1 with 6, T2 with 9, and T3 with 10 points, showing lower pigmentation intensity compared to the control. Specific results are detailed in table 13.

Table 13. Yolk pigmentation														
Treatments	Pigmentation													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Q1						X								
Q2									X					
T3										X				
T4												X		

Percentage of laying (%)

No statistically significant differences were observed between treatments in the variable corresponding to the percentage of laying. During the first week, the highest value was recorded in T2 with 56,20 %, while the control reached the lowest percentage with 34,80 %. In the following weeks (2, 3, and 4), T2 remained the treatment with the highest average laying rates (66,80 %, 69,80 %, and 60,00 %, respectively). In the fifth week, T1 had the highest percentage with 64,20 %, while the control had the lowest value with 44,40 %. In the sixth week, T2 again stood out with the highest percentage (74,40 %), while treatments T1 and T4 recorded similar

results of 57,60 %. Finally, the lowest percentage corresponded to T3 (1,5 % inclusion of noni flour) with 48,80 %. The detailed results are presented in table 14.

Table 14. Laying rate in quails (%)					
Weeks	Treatments				CV (%)
	T1 (0,5 %)	T2 (1,0 %)	T3 (1,5 %)	T4 (control)	
1	44,40 to	56,20 to	44,40 a	34,80 to	39,75
2	54,60 to	66,80 to	44,60 to	41,00 to	29,98
3	61,80 to	69,80 to	46,20 to	48,60 to	33,79
4	59,80 to	60,00 to	47,80 to	41,40 to	31,60
5	64,20 to	59,20 to	46,00 to	44,40	38,48
6	57,60 to	74,40 to	48,80 to	57,60 to	25,20
Average	57,00	64,40	46,30	44,60	
Note: identical superscript letters in the same row indicate no statistical differences between treatments, while different letters indicate significant differences according to Tukey's test ($P \leq 0,05$)					

Bromatological analysis of eggs

In the bromatological analysis of the eggs, with regard to moisture content, it was observed that on day 0, treatment T3 reached the highest value with 28,55 %, while T1 had the lowest percentage with 17,94 %. At the end of the trial (day 45), the control treatment (T4) recorded the highest value with 45,19 %, in contrast to T2, which showed the lowest percentage (26,42 %). In the case of ash, the initial values were similar for T1 and T2 (1,39 %), lower than the highest percentage obtained by T3 (1,75 %); this trend continued on day 45, when T3 again had the highest value (1,75 %).

In terms of fat content, on day 0, the control treatment (T4) had the highest percentage at 36,47 %, while T3 had the lowest value at 31,89 %. On day 45, T4 maintained the highest level (40,37 %), compared to the lowest value observed again in T3 (35,30 %). Regarding fiber, the highest results were recorded on day 0 (16 %), while on day 45, T1 stood out with 19,37 %. Finally, in the protein analysis, T3 reached 20,41 % at the start (day 0) and 20,42 % on day 45, maintaining the highest percentages in this variable. The complete results are presented in table 15.

Table 15. Bromatological analysis of eggs										
Treatments	Moisture		Ash		Fat		Fiber		Protein	
	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
	DAY 0	DAY 45	DAY 0	DAY 45	DAY 0	DAY 45	DAY 0	DAY 45	DAY 0	DAY 45
Q1	17,94	36,99	1,39	1,30	32,97	36,22	9,12	19,37	20,13	19,56
Q2	21,41	26,42	1,39	1,13	34,89	36,38	13,49	10,83	18,08	20,12
Q3	28,55	30,52	1,75	1,25	31,89	35,30	15,58	13,29	20,41	20,42
Q4 (control)	28,06	45,19	1,47	1,20	36,47	40,37	16,00	16,81	19,55	13,71

Evaluation of the economic viability of including *M. citrifolia* leaf meal in the diet of laying quails

Table 16 shows the results of the economic analysis. Treatment T2, with 1,0 % inclusion of noni flour as a nutraceutical, recorded the highest profitability with 45,50 % and a benefit/cost ratio of 1,45, indicating that for every dollar invested, a profit of \$0,45 was obtained. This was followed by T1 with a benefit/cost ratio of 1,30 and a profitability of 29,63 %, and T3 with 1,05 and 5,12 %, respectively. The lowest profit corresponded to the control treatment (T4), with a benefit/cost ratio of 1,01 and a profitability of 0,56 %. Despite these differences, all the values obtained are considered acceptable within the parameters of poultry production.

Table 16. Economic analysis in the research on laying quails

Items	0,5 % nutraceutical flour nutraceutical	1,0 % nutraceutical meal	1,5 % nutraceutical meal nutraceutical	0 % nutraceutical flour nutraceutical
Revenue	Q1	Q2	Q3	Q4
Total Eggs Produced	825,00	926	669	640
Price per egg, USD	0,07	0,07	0,07	0,07
Total income, USD	57,75	64,82	46,83	44,80
COSTS				
Quail 35 (\$1,20 each)	42,00	42	42	42
Labor	1,45	1,45	1,45	1,45
Food	1,1	1,1	1,1	1,1
Total of Costs, USD	44,55	44,55	44,55	44,55
Net Profit	13,20	20,27	2,28	0,25
Profit / Cost	1,30	1,45	1,05	1,01
Profitability	29,63	45,50	5,12	0,56

DISCUSSION

The results obtained in this study showed that the inclusion of the evaluated treatments did not generate statistically significant differences ($P > 0,05$) in productive variables such as feed consumption, daily weight gain, final weight, and egg laying. This finding suggests that supplemented diets maintain stable productive behavior in laying quails without compromising their performance. From a practical perspective, the absence of adverse effects is a significant aspect, as it supports the feasibility of incorporating alternative ingredients into balanced diets as a sustainable nutritional strategy.

In terms of interpretation, the stability of the responses could be explained by the quails' adequate physiological capacity to assimilate nutrients from diets, maintaining a metabolic balance that prevents significant variations in productive performance. This behavior coincides with the principle of dietary homeostasis, where the bird regulates its intake to meet energy and nutritional requirements, even when the components of the diet are modified.

The results have significant implications for science, economics, and society. Scientifically, they provide evidence on the safety of incorporating plant-based supplements into quail diets, thereby contributing to the expansion of the knowledge base in avian nutrition. From an economic perspective, it raises the possibility of reducing feed costs by partially replacing conventional inputs with readily available alternative ingredients. Socially, this strategy can promote the sustainability of small- and medium-scale production systems, improving the availability of high-quality animal protein for human consumption.

The findings obtained in this research are similar to those reported by Degalloda⁽¹⁶⁾, who evaluated the addition of moringa leaf meal at levels of 0,5 and 10 % in quail diets to analyze nutrient utilization, egg lay, and egg quality. In that study, statistical analyses revealed no significant differences ($P > 0,05$) in variables such as feed intake, daily weight gain, final weight, and egg production. Similarly, Ibarra⁽¹⁷⁾ evaluated the effect of including inulin in diets for 10-week-old quails and also found no statistical differences in feed intake between treatments.

Similar results were described by Ibarra⁽¹⁷⁾ in his study on productive behavior, shell quality, and internal quality of eggs in quails fed diets supplemented with inulin under conditions of normal or reduced calcium levels. In this case, the feed conversion ratio also showed no significant differences between treatments. Similarly, Degalloda⁽¹⁶⁾ reported similar results when evaluating supplementation with moringa leaf meal, as no statistical differences ($P > 0,05$) were detected in egg production. Likewise, the results of the present investigation are consistent with those described by Salazar⁽¹⁸⁾, who also found no significant variations between treatments ($P > 0,05$).

In contrast, Degalloda⁽¹⁶⁾ reported different results, observing that in his trial with moringa meal, the average egg weight was higher in treatment T1 compared to T2 and T3 ($P > 0,05$). Similarly, Salazar⁽¹⁸⁾, in their research titled "Phytobiotic effect of *Jatropha curcas* leaf powder on the productivity, egg quality, and blood biochemistry of laying quails," obtained results showing that the indicators of egg quality and weight did not exhibit statistically significant differences ($P > 0,05$). These authors suggest supplementing laying quail diets with 0,5 % *J. curcas* leaf powder as a viable alternative.

On the other hand, Degalloda⁽¹⁶⁾ also reported divergent results when evaluating the inclusion of moringa leaf meal in the balanced diet of quails. Levels of up to 10 % favored yolk pigmentation without compromising egg production or quality, with the highest coloration values observed in treatments T2 and T3. Finally, Salazar⁽¹⁸⁾

found significant differences between treatments in his research on continuous and rotational mating with two feeding systems in breeding quails, highlighting that the seven-day rotational system, combined with the diet used, generated a higher percentage of egg laying.

The present study was conducted under controlled experimental conditions, ensuring data reliability and minimizing environmental variability. However, this approach limits the direct extrapolation of results to large-scale commercial systems. Likewise, the 45-day evaluation period provided sufficient information to identify initial trends in productive performance, but did not cover the potential effects on prolonged production cycles.

Similarly, physiological or biochemical variables that would have allowed for a more in-depth interpretation of the internal mechanisms associated with the birds' response were not incorporated.

Nevertheless, the findings provide a solid and reliable basis for understanding the effect of supplemented diets on quail, constituting a valuable starting point for future studies that integrate longer-term evaluations, physiological analyses, and validations under real production conditions.

CONCLUSIONS

Supplementing the diets of laying quails with *Morinda citrifolia* (noni) leaf meal is a viable and promising nutritional strategy, as it does not negatively affect production parameters and provides bioactive compounds with potential benefits for bird performance. These results confirm that the use of alternative plant-based ingredients can be integrated into feeding programs without compromising zootechnical efficiency.

Beyond the stability observed in productivity, the inclusion of noni flour represents an alternative with practical, economic, and social implications. Its incorporation into balanced diets opens up the possibility of reducing production costs, diversifying raw material sources, and leveraging easily accessible local resources, which contribute to the sustainability of poultry systems and food security.

Ultimately, this study serves as a foundation for future research investigating the physiological and biochemical mechanisms underlying the effects of noni on poultry, as well as its long-term impact on productivity, egg quality, and profitability indicators. The validation of these findings under commercial conditions will consolidate the use of this plant resource as an innovative tool for the development of more sustainable and competitive poultry farming.

BIBLIOGRAPHIC REFERENCES

1. González P, Robustillo P, Caravaca F. Effects of long-term storage on hatchability and incubation length of game farmed quail eggs. *Animals*. 2023;13(13):1-13. <https://www.mdpi.com/2223-7747/11/5/697#B93-plants-11-00697>
2. Nakaguchi V, Ahamed T. Development of an early embryo detection methodology for quail eggs using a thermal micro camera and the yolo Deep learning algorithm. *Sensors*. 2022;22(15):1-22.
3. Gallo M, Huamán O. Effect of *Coturnix japonica* (quail) egg yolk in ethanol damage-induced mice. *Nutr Clin y Diet Hosp*. 2023;43(4):91-7.
4. Lobato H, Viera M, Rezende R, Ferreira F, Lara L. Japanese quail production in Brazil: historic, challenges and opportunities. *Worlds Poult Sci J*. 2025;1(20):1-10.
5. Arunrao K, Kannan D, Amutha R, Kannan A, Yakububu A. Production performance of four lines of Japanese quail reared under tropical climatic conditions of Tamil Nadu, India. *Front Genet*. 2023;14:1-13.
6. Gomes A, Santos R, Albuquerque D, Arantes L, Perazzo F. Heat Stress in Japanese quails (*Coturnix japonica*): benefits of phytase supplementation. *Animals*. 2024;14(24):1-25.
7. Owusu B, Appaw W, Abe V. Antibiotic residues in poultry eggs and its implications on public health: A review. *Sci African*. 2023;19:1-9.
8. Zambrano S, Suárez G, Vázquez L, Alvarado K, Vera J, Intriago F, et al. Freeing Big- American turkeys with a balanced diet plus turnip (*Brassica rapa* L.). *Rev Vet y Zootec Amaz*. 2023;3(2):1-13. <https://revistas.unsm.edu.pe/index.php/revza/article/view/544>
9. Yeppez P, Arévalo W, Vázquez L, Alvarado KB alimentados con balanceado U+ N en fase engorde para mejorar las características organolépticas de la carne. Pavos BIG6 alimentados con balanceado UTEQ + NABO en fase engorde para mejorar las características organolépticas de la carne. *J Sci Res*. 2022;7(2):1-10. <https://revistas.utb.edu.ec/index.php/sr/article/view/2737>

10. Yépez P, Vásquez L, Alvarado K, Intriago F, Estrada R, Vera J. Organoleptic characteristics of chicken meat *pio pio* Campero with balanced diets UTEQ and *saccharomyces cerevisiae*, in the experimental farm “La Maria.” *Rev Investig Agroempresariales*. 2023;10:9-18. <https://revistas.sena.edu.co/index.php/riag/article/view/5492>
11. Yépez P, Vásquez L, Vera F, Rodríguez S, Romero D, Alvaro P. Effect of different levels of breeder's yeast (*Saccharomyces cerevisiae*) application on productive parameters and economic analysis. *Rev la Fac Agron y Vet - UNRC*. 2024;7(14):1-25.
12. Adriani L, Indrayati N, Rusmana D, Hernawan E, Rochana A. Effect of noni (*Morinda citrifolia*) fruit flour on antioxidant status and hematological indices of laying Japanese quail. *Int J Poult Sci*. 2017;16(3):93-7.
13. Vásquez L, Vera J, Erazo C, Intriago F. Induction of *rhizobium japonicum* in the fermentative mass of two varieties of cacao (*Theobroma Cacao* L.) as a strategy for the decrease of cadmium. *Int J Health Sci (Qassim)*. 2022;3(April):11354-71. <https://sciencescholar.us/journal/index.php/ijhs/article/view/8672/5762>
14. Vasquez L, Alvarado K, Intriago F, Vera J, Raju N, Prasad R. Banana and apple extracts with efficient microorganisms and their effect on cadmium reduction in cocoa beans (*Theobroma cacao* L.). *Discov Food*. 2024;4(1):1-13. <https://link.springer.com/article/10.1007/s44187-024-00205-5>
15. Foo S, Yusoff F, Khong N. Storage and degradation kinetics of physicochemical and bioactive attributes in microalgal-derived fucoxanthin-rich microcapsules. *J Agric Food Res*. 2024;15:1-14.
16. Degalloda K, Bernal H, Olivares E, Vásquez N, Cervantes M, Morales A, et al. Efecto de la inclusión de *Moringa oleifera* Lam. en dietas de cordoniz, sobre posturas, utilización de energía, proteína metabolizable y calidad de huevo. *Sci Agric Vita*. 2024;1(3):1-12.
17. Ibarra A, Vilchez C, Mendoza O. Comportamiento productivo, calidad de cáscara y calidad interna del huevo de codornices (*Coturnix coturnix*) alimentadas con insulina en dietas normales o bajas en calcio. *Rev Investig Vet del Peru*. 2023;34(1):1-13.
18. Salazar I, Rodríguez R, Aroche R, Valdivié M, Martínez Y. Phytobiotic effect of *Jatropha curcas* leaf powder on productivity, egg quality. *Cuba J Agric Sci*. 2021;55(3):315-26. http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S2079-34802021000300315

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The authors declare that there is no conflict of interest.

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