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Productive parameters and carcass composition of *Coturnix coturnix japonica* (Quail) fed *Leucaena leucocephala* (leucaena) and *Moringa oleifera* (moringa)

Parámetros productivos y composición de la canal de *Coturnix coturnix japonica* alimentados con *Leucaena leucocephala* y *Moringa oleifera*

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Grains and concentrates are the basis of poultry feed, currently the use of multipurpose forage plants is encouraged to maintain productive efficiency. The study was conducted to determine the feed intake, daily and final weight gain, feed conversion ratio and carcass composition of Japanese quails supplemented with foliage meal of *Moringa oleifera* and *Leucaena leucocephala*, for which 270 quail chicks with average body weight of 19 ± 0.5 g were used. Chicks were randomly divided into three groups: Control (ACOM), Moringa (MO) and Leucaena (LEU), with six repetitions of 15 individuals per group. Individuals in each group had *ad libitum* water. Final body weight, daily weight gain, feed intake, feed conversion ratio and carcass quality were evaluated. The data were analyzed using the Statistic v7.1 software under a completely randomized design and comparison of Tukey's means. The heaviest final body weight and highest feed consumption were observed in the ACOM group, followed by MO. The heaviest carcass and the lightest viscera corresponded to ACOM; But, the weight of the meat was similar in all treatments. Protein content, ether extract, ash, and pH were not modified by the diets containing foliage meal. Up to 50 % of foliage meal can be included in quail diets, reducing the consumption of concentrate feed, maintaining meat quality and increasing carcass yield.

Keywords: *carcass quality, forage plants, quail production*

Aunque los granos y concentrados son la base del alimento para aves, actualmente se está fomentando el uso de plantas forrajeras multipropósito para mantener la eficiencia productiva. El presente estudio se realizó para determinar la ingesta de alimento, ganancia diaria y final de peso, conversión alimenticia y composición de la canal de codornices japonesas suplementadas con harina de follaje de *Moringa oleifera* y *Leucaena leucocephala*. Para esto, se utilizaron 270 pollitos de codorniz con peso corporal promedio de 19 ± 0.5 g. Los pollitos se dividieron aleatoriamente en tres grupos: Control (ACOM), Moringa (MO) y Leucaena (LEU), con seis repeticiones de 15 individuos por grupo, y recibieron agua *ad libitum*. Se evaluaron el peso corporal final, ganancia diaria de peso, consumo de alimento, relación de conversión alimenticia y calidad de la canal. Los datos se analizaron con el software Statistic v7.1 con un diseño completamente al azar y la comparación de medias mediante Tukey. El mayor peso corporal final y el mayor consumo de alimento se observó en el grupo ACOM, seguido por MO. La canal con mayor peso y las vísceras más ligeras correspondieron a ACOM. Sin embargo, el peso de la carne fue similar en todos los tratamientos. El contenido de proteína, extracto etéreo, cenizas y pH no se modificaron por las dietas que contenían harina de follaje. Se puede incluir hasta un 50 % de harina de follaje en las dietas de codorniz, con una reducción del consumo de alimento concentrado, manteniendo la calidad de la carne y aumentando el rendimiento de la canal.

Palabras clave: *calidad de la canal, plantas forrajeras, producción de codornices*

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Introduction

In Mexico, poultry production in 2024 was 4,013,215.817 tons (SIAP 2024), the state of Campeche contributing 0.6 % to productivity, and increased in the last five years from 22,761.903 to 24,031.919 tons. Of the poultry species most raised and consumed in Campeche, the hen (*Gallus gallus*) is recorded, followed by the turkey (*Meleagris gallopavo*), mainly in backyards, because they contribute to the family economy through sales (Portillo-Salgado *et al.* 2018). Regarding the consumption of these birds, the values range between 65 and 1.2 kg per year per capita, increasing in the December season (Magaña *et al.* 2022). Both the chicken and the turkey are species of great commercial interest, but in rural communities, a fast-growing, prolific species is required to meet the requirements of families in a short time. Therefore, quail (*C. coturnix japonica*) is a viable option, due to its early egg production, high nutritional value in proteins, vitamins and minerals, and low cholesterol content, as well as rapid growth for the supply of meat (Saeed *et al.* 2025).

Feeding practices for commercial poultry birds are limited to consumption of grains and concentrates (Getahun *et al.* 2025). To reduce the dependence on these products, there are various strategies that maintain or increase the production efficiency, such as the use of probiotics (Mulyono 2025), *Vicia faba* L., *Pisum sativum*, *Cicer arietinum* L., Copra Meal and Palm kernel meal (Babatunde *et al.* 2021). In recent years it has been reported that the inclusion of forage plants improves the nutritional quality in the diet of birds (Barbarosa *et al.* 2022). Among tropical forage species, Valdivié-Navarro *et al.* (2020) and Faustin-Evaris *et al.* (2022) mention that it is favorable to include *M. oleifera* in bird diets, because it increases the rate of feed conversion and digestibility of the holistic diet (Egbu *et al*. 2024). In addition, this incorporation of foliage could improve the content of polyunsaturated fatty acids, oxidative stability, the colour of the breast muscle and abdominal fat (Cui *et al.* 2018). Similarly, improvements are reported in egg quality and antistress activity (Gayathri *et al.* 2020). In this sense, the inclusion of foliage shrub species such as *L. leucocephala* at low levels in the diet of laying hens has shown promising results in weight gain, body weight and feed intake (Utami and Akbar 2025).

Regarding the supply of forage species in bird diets, it has been shown that the transformation of foliage to meal causes positive effects on health, survival, growth rate, feed use efficiency and improves egg production, leading to a positive economic impact, by significantly reducing feed and production costs (Valdivié-Navarro *et al.* 2020). These benefits were observed in commercial laying hens fed inclusions of up to 6 % *M. oleifera* (da Silva *et al.* 2024) and fermented *L. leucocephala* meal (Utami and Akbar 2025), without causing negative effects on performance or egg quality. Despite the encouraging results that have been obtained in birds, there are few studies on the productive performance of *C. coturnix* including these foliage species in the diet. Therefore, the objective of this research was to evaluate the productive parameters and carcass composition of *Coturnix coturnix japonica* fed *L. leucocephala* and *M. oleifera.*

Material and Methods

Study area: The work was carried out at the poultry facilities of Colegio de Postgraduados Campeche Campus, located at 19 ° 29'51.79 "N and 90 ° 32'45.01"W, in Sihochac, Champotón, México (INEGI 2017), with an annual temperature of 26 °C and at 24 masl (García 2004).

Animal handling and treatment design: A total of 270 quails aged 18 days with an average body weight of 19 g were randomly distributed into three treatments, with three repetitions (cages) per treatment and 30 birds per cage. Treatments were classified as ACOM=Commercial Feed (600 g d^{-1} $replicate^{-1}$ = 1800 g d^{-1}), MO: ground *M. oleifera* (300 g d^{-1} $repetition^{-1}$ = 900 g d^{-1}) + ACOM (300 g d^{-1} $repetition^{-1}$ = 900 g d^{-1}) and LEU: ground *L. leucocephala* (300 g d^{-1} $repetition^{-1}$ = 900 g d^{-1}) + ACOM (300 g $d^{-1}$$replicate^{-1}$ = 900 g d^{-1}).

The experimental period lasted 84 days, plus a five-day adaptation period. The birds were housed in cages with an area of 0.67 m^2 per quail, which included cup-type drinkers for water and PVC feeders. The animals were treated in accordance with guidelines and regulations for animal experimentation of the Colegio de Postgraduados (COLPOS 2019), with official approval CCACC2017-069 and following animal management and well-being guidelines of the NRC (2010).

Foliage collection and chemical composition: The leaves of *M. oleifera* were collected from a five-year-old orchard located at the Faculty of Veterinary Medicine and Animal Science of the Universidad Autónoma de Yucatán, México. The leaves of *L. leucocephala* were collected from a four-year-old orchard at Colegio de Postgraduados. The foliage was sun-dried for a period of 48 h, crushed using a Bomeri® Model PD65RM mincer with two hoppers and a sieve size 3 mm; the foliage was subsequently chopped and sieved using a mesh size 7 until a flour-like texture was achieved.

Crude protein (CP) content was calculated according to the Kjeldahl method, the ether extract (EE) was quantified by the Soxhlet method, ash content was determined by the combustion method, acid detergent fiber (ADF) and neutral detergent fiber (NDF) were determined using the method (AOAC 2019). For gross energy (GE) it was used by an adiabatic pump calorimeter (Parr-328, Parr Instruments Co., IL, USA) (AOAC 2019). The diets met the nutritional requirements of quails aged at 19 days old (NRC 1994) (table 1).

Table 1. Chemical composition (%) of the feed used in the experiment

Nutritional content	ACOM	MO	LEU
Dry material (%)	88.00	88.05	88.15
Crude protein (%)	21.00	23.15	22.35
ADF (%)	26.09	27.11	25.69
NDF (%)	39.12	44.42	40.38
EE (%)	2.20	2.70	3.30
Ash (%)	8.00	6.80	8.18
GE (kJ/kg)	77.61	77.69	82.42

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Feed consumption, daily weight gain, final weight gain and feed conversion: Feed consumption (dry mater: DM) of each treatment was measured daily by weighing the feed offered and subtracting the rejected amount on a Torrey® digital scale of 20 kg. To assess body weight gain and final body weight, all birds in each treatment were weighed every seven days for 12 weeks, with previous fasting period. Feed conversion ratio (CA) was calculated using the average feed intake, divided by the average body weight gain for each treatment.

Composition of the quail carcass: At the end of the experiment, 30 birds were randomly chosen per treatment, they were fasted for 12 hours to minimize the interference of the intestinal content with the weight of the animals. They were humanely slaughtered according to the Animal Welfare guidelines of Colegio de Postgraduados (COLPOS 2019), with official approval CCACC2017-069 which are based on the Official Mexican Norm NOM-033-SAG/ZOO-2014. After removing the inedible parts (feathers, legs, head), the carcass, skin, meat, bones, and viscera were weighed, on an analytical balance (260g x 0.0001g) model ADVENTURER PRO AV264C O' HAUS. The carcass yield and yield percentages were calculated by the following formula:

$$Yield = \frac{Carcass\ weight}{(Live\ weigth)} x100$$

Chemical composition of meat: After the animals were slaughtered, meat samples from each treatment were homogenized to determine pH using an Oakton EcoTestr pH® pH meter, CP was evaluated using the Kjendahl method, and ash and EE were measured following the methodology established by the AOAC (2019).

Statistical analysis: The feed consumption, daily weight gain, final weight gain, feed conversion ratio, composition of the quail carcass (carcass, skin, meat, bones, and viscera) and chemical composition of meat (pH, CP, ash and EE) were analyzed under a completely randomized design. The comparison of means was carried out through a multiple Tukey test using the Statistica v7.1 software (StatSoft 2005). The variability in the data was expressed as the standard error (SE) and a significance level of $p \leq 0.05$ was considered statistically significant.

Results and Discussion

Total feed consumption, daily weight gain, final weight gain, and feed conversion ratio: Consumption of foliage meal ($p \leq 0.05$) and the final weight gain ($p \leq 0.05$) of *C. coturnix*, were higher in the group that consumed commercial feed (ACOM) than in the groups fed MO and LEU. Daily body weight gains ($p \leq 0.05$) were higher in treatments fed ACOM and MO diets compared to LEU. The feed conversion ratio was higher in the birds fed the LEU diet ($p \leq 0.05$), but this parameter was similar in both the ACOM and MO groups of birds (table 2).

The final body weights recorded in the MO and LEU treatments are similar those reported by Perdomo *et al*. (2019) reaching final body weights of 147 g on average, in one-day quails with initial weight of 7.3 g and supplements with foliage of *Morus alba*, and Cassava leaf meal, quails improve weight gain and feed conversion with 176.4 and 3.04 g,

Table 2. Feed consumption, body weight gain and feed conversion ratio of *C. coturnix* japonica fed *M. oleifera* and *L. leucocephala*

Variables	ACOM±SE	MO±SE	LEU±SE	P Value
Initial body weight (g)	19 ± 0.24	19 ± 0.21	19 ± 0.31	0.882433
Final body weight (g)	183.50 ± 0.89[a]	160.37 ± 2.35[b]	141.75 ± 3.09[c]	0.000001
Daily weight gain (g/bird/day)	1.95 ± 0.07[a]	1.67 ± 0.001[ab]	1.45 ± 0.001[b]	0.000001
Daily foliage meal consumption (g/bird/day)	0	639.24 ± 3.29[a]	608.82 ± 0.14[b]	0.000001
Total consumption (g/bird/day)	1800 ±42.53[a]	1539.24 ± 12.71[b]	1508.82 ±1.87[c]	0.000001
CA	9.23 ± 0.02[b]	9.21 ± 0.05[b]	10.40 ± 0.18[a]	0.000001

ACOM: commercial feed, MO: *M. oleifera,* LEU: *L. leucocephala,* SE: indicates standard error, CA: feed conversion ratio (g feed consumed/g weight gain per treatment). [a,b,c]: Different letters in the same row indicate significant differences ($p \leq 0.05$)

respectively (Silva *et al.* 2017). Likewise, when 14 % de *M. oleifera* is offered in the diet of *C. coturnix*, they increase the yield of the carcass by 61 % (Castillo *et al.* 2018), improving nutrient utilization and productive performance (Manju and Bidhan 2025a).

Regarding the diet containing *L. leucocephala*, it was the least consumed foliage, possibly because of the presence of mimosine or another metabolite that may cause adverse effects (Bageel *et al.* 2020). For example, in broilers fed diets supplemented with leaf meal of the legume *Acacia angustisima*, a quadratic decrease in final body weight, consumption of feed and daily weight gain was observed (Gudiso *et al.* 2019) and, in quails, the inclusion of 4 to 8 % of fermented leucaena meal improves nutrient intake, feed conversion ratio and egg production (Utami and Akbar 2025). Therefore, the incorporation of Leucaena meal up to 10 % of diet may be a viable option for quail feeding, compared to that of a strictly commercial diet.

Carcass composition: It was observed that the birds in the ACOM group obtained the highest carcass weight (p≤0.05) and bone weight (p≤0.05), and the lowest viscera weight (p≤0.05) compared to the rest of the treatments. The viscera and carcass weights in birds from MO and LEU treatments were similar, whereas the LEU showed the lowest bone weight. No differences were observed in meat and skin weight among treatments (table 3).

When using other supplements in quails such as *Tenebrio molitor*, *Zophobas morio* at a proportion of 1 to 2 g/kg or aqueous cinnamon extract (1.5 mL/L) a carcass weight of 128-133 g was obtained (Khan *et al.* 2022, Al-Khalaifah *et al.* 2025 and Isam *et al.* 2025) similar to the value found in this study.

A high carcass and bone weight gain in ACOM treatment can reveal high fat or collagen content, which is usually affected by factors such as species, age, and nutritional plan. In this research, the low weight of bones in the LEU treatment, is attributed to the inclusion of 50 % of Leucaena foliage meal, which provides greater amount of fiber, poor digestibility in the digestive tract, increasing the excretion of nutrients, including calcium. Also, the carcasses of birds supplemented with Moringa and Leucaena foliage meal had the highest carcass yield, with 80 and 90 % respectively. In this sense, Castillo *et al.* (2018) recorded an increase in weight of *C. coturnix* carcasses, recording up to 61 % of the carcass yield, with diets supplemented with 14 % of *M. oleifera* powder whereas, while the incorporation of lower values such as: 1, 3, 5, 7 and 9 % of Moringa leaf meal in the diet of *C. coturnix* japonica did not affect the weight of the carcass, viscera, neck, back, wing, thigh, drumstick and breast; however, 3 % of the meal improved the meat-bone ratio (Manju and Bidhan 2025b). Some studies indicate that increasing the inclusion of legumes such as *Tylosema esculentum* in quail diets decreases body weight gain (Fatoki *et al.* 2023).

Chemical composition of meat: No effect of feeding was found on the chemical composition of the meat for any of the treatments (table 4).

The pH values obtained in the present investigation are similar to those reported in quails fed diets with *Brassica napus* added at levels of 2.5 to 17.5 %, with pH values of 6.38 to 6.56 (Mnisi and Mlambo 2018), as well as in broiler chicken meat fed with *M. oleifera* leaf meal with values of 5.45 to 6.40 (Cui *et al*. 2018). However, in quails supplemented with black cumin meal and noni leaf meal,

Table 3. Carcass composition of *C. coturnix japonica* fed *M. oleifera* and *L. leucocephala*

Treatment	N	Carcass (g) ±SE	Viscera (g) ±SE	Meat (g) ±SE	Bone (g) ±SE	Skin (g) ±SE
ACOM	30	143 ± 6.34[a]	13 ± 2.32[a]	68 ± 1.83	47 ± 1.71[a]	9 ± 0.92
MO	30	129 ± 1.76[b]	21 ± 2.17[b]	72 ± 1.33	17 ± 1.72[b]	8 ± 0.56
LEU	30	127 ± 2.55[b]	21 ± 2.39[b]	73 ± 1.59	9 ± 0.87[c]	9 ± 0.39
Value P		0.004114	0.047571	0.147567	0.000001	0.097529

ACOM: Commercial feed, MO: *M. oleifera,* LEU: *L. leucocephala,* SE: indicates standard error. [a,b,c] Different letters in the same column indicate significant differences p≤0.05.

Table 4. Chemical composition of meat in *C. coturnix japonica* fed *M. oleifera* and *L. leucocephala*

Treatment	n	pH ±SE	Ash (%) ±SE	EE (%) ±SE	Protein (%) ±SE
ACOM	30	6.33±0.002	5.00±0.026	7.80±0.359	14.75±0.03
MO	30	6.21±0.002	4.97±0.023	7.51±0.238	14.31±0.048
LEU	30	6.17±0.002	4.92±0.017	7.78±0.059	13.99±0.135
Value P		0.127587	0.087659	0.780673	0.427412

ACOM: commercial feed, MO: *Moringa oleifera,* LEU: *Leucaena leucocephala.* SE: indicates standard error of mean.

the pH in the meat is more acidic (5.80 and 5.90) (Dengan and Kombinasi 2024). The Ash content in the study ranged between 4.92 and 5.0 %, being higher than those reported in different lines of quail and pigeons, with amounts of 1.29 to 2.26 % (Lukanov *et al*. 2023 and Muraduzzaman *et al*. 2023).

In relation to protein, the values observed in the present work are lower than those reported by Sabow (2020), where the average was 22.52 g/100 g in three species of quail fed with commercial diets, as well as specialized, dual-purpose and European-type quail lines with averages of 21.24, 21.65 and 20.08 % (Lukanov *et al*. 2023), and in pigeons and fattening quails with 19.18 and 24.40 % (Muraduzzaman *et al.* 2023). Finally, the percentage of ether extract was higher than those recorded in different quail lines with ranges from 1.86 to 6.06 (Lukanov *et al*. 2023 and Muraduzzaman *et al*. 2023).

Conclusions

Supplementing *Coturnix coturnix japonica* with 300 g d^{-1} of *L. leucocephala* or *M. oleifera* foliage meal maintains productive parameters and carcass composition. Carcass yield improves by 80 %, without modifying protein, ash, pH, or ether extract, resulting in a viable alternative for feed.

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