MEDICINAL PLANT LEAF MEAL AS A PHYTOBIOTIC ADDITIVE IN DIETS FOR FATTENING QUAIL

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ABSTRACT

The present investigation was carried out in the Rio Verde parish, in Ecuador's Santo Domingo de los Tsáchilas province. The study aimed to evaluate the productive behaviour of quail (Coturnix coturnix japonica) using a mixed meal of medicinal plant leaves as a phytobiotic additive to reduce antibiotic drugs and improve animal production. These diets were included at supplementation levels in different treatments (T): 0 (T1); 0.50 (T2); 1.00 (T3); 1.50 (T4) % of a mixed powder of medicinal plant leaves of Morinda citrifolia L. (noni), Psidium guajava L. (guava), Annona muricata L. (soursop) and Jatropha curcas L. (piñon de tempate), in a ratio of 40:20:20:20, respectively. A completely randomized design (DCA) was applied with four treatments and five repetitions, including eight birds per repetition (160 quails in total with eight days of age). The research project lasted six weeks, in which feed intake (g), weight gain (g), feed conversion, carcass yield (%), morphometric measurements, mortality and economic analysis were evaluated. The results obtained reflect that the productive parameters were not affected by this meal. However, statistical differences were found in weight gain, registering 146.18 g for T1. Regarding feed conversion, the lowest value was obtained by T1 (6.72), and the highest value was T2 (9.00). On the other hand, the gastrointestinal tract of the quail was not affected by the addition of this phytobiotic in terms of its size. In the economic return, T2 obtained 17.77% with a cost–benefit ratio of USD 1.18, referring to the fact that we will earn 17 cents for every dollar invested. It is concluded that no effect was found in production parameters and morphometric measurements since adding medicinal plant leaf meal to the diet do not affect production parameters and measurements.
Keywords: probiotic, productive performance, profitability, phytobiotic additive.

1 INTRODUCTION

The increase in meat consumption worldwide has caused the expansion in the production of poultry meat and derived products. Given this scenario, antibiotic growth promoters (AGP) are common to increase performance in poultry production. In recent years, the use of AGP in food production for livestock animals has been questioned, leaving the vast majority of residues affecting the organoleptic characteristics of meat and by-products [1]. Several studies have shown that AGPs contribute to the development of bacteria resistant to antibiotics [2]. For this reason, many countries have banned its use to avoid health and environmental problems [3]. On the other hand, it is necessary to ensure animal performance and its resistance to diseases, finding alternatives that solve this type of problem [4].

Some of the alternatives to AGP proposed to date include probiotics and phytobiotics, which benefit bird performance and health [5], [6]. Currently, phytobiotics or phytogenetic feed additives have gained importance in poultry performance and health [7]. These additives are characterized by their pungent odour and taste, usually added to human food [8]. Phytobiotics also allow to inhibit pathogenic bacteria [7], improve antioxidant status [9], and improve the immune and digestive system of birds [10], improving growth performance [11].

Since ancient times, medicinal plants have been a tool for curing or improving diseases in humans and animals [12]. Herbs are a phytobiotic subject of studies on poultry performance

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and health with positive results [13], [14]. Some examples of herbs used as phytobiotics are Persicaria odorata [15], Piper beetle [16], Cinnamon [17].

Quail meat has qualities that make it better than other meats, such as tenderness, juiciness, good flavour and low-fat content; these birds show early growth, which shortens the fattening period and reach adult live weight earlier poultry species (such as chicken or turkey). In addition, they also have the peculiarity of being sexually precocious; as polygamous species, there are evident morphological differences between their sexes. The male has reddish-brown feathers on his chest, while the females' feathers are greyish-beige with black specks, a difference that is discovered at 15 days of life [18].

One factor that restricts poultry farming is the growing concern about the potential problems associated with the inappropriate use of antibiotics (application time and excessive dosage) [19]. A viable alternative is the development of a balanced feed based on grains and phytobiotics, which would imply a reduction in production costs. In addition, this type of non-traditional raw material allows for meeting current needs without compromising the capacity of future generations [20].

For this reason, the present investigative work exposes the effect of fattening quails, using mixed flour of medicinal plant leaves in different amounts, which will help reduce costs and, at the same time, find a new alternative to their diet.

2 MATERIALS AND METHODS

The present investigation was carried out in the Rio Verde parish, located in the Santo Domingo canton in Ecuador. The study is of an exploratory type and observation–experimental method, which was developed in three phases: (i) elaboration of meal as a phytobiotic and determination of treatments, (ii) formulation of experimental diets, and (iii) experimental evaluation through variables.

2.1 Stage I: Meal preparation as a phytobiotic and determination of treatments

The mixed meal proposed in this study is composed of Morinda citrifolia L. (noni), Psidium guajava L. (guava), Annona muricata L. (soursop), and Jatropha curcas L. (piñon tempate). For the elaboration of the additive, the fresh leaves of the medicinal plants under study were collected without injuries induced mechanically or by pathogens. The leaves were identified in the department of bromatology of the Facultad de Ciencias Pecuarias de la Universidad Técnica Estatal de Quevedo. The diversity of the size and structure of the leaves were considered in the collection.

Following the collection, washing was carried out, which was carried out three times with distilled water in order to eliminate as many impurities as possible. Next, the leaves were dehydrated for seven days in the shade, on mesh and plastic plates, and were removed twice a day. It was then placed in an oven with air recirculation for one h at 60°C.

They were then ground in a parallel blade hammer mill to 1–2 mm particle size. Finally, the samples were kept at room temperature in amber bottles to prevent the decomposition of the active substances by the action of light.

There were 160 eight-day-old quails; their feeding was according to the treatments to be evaluated. The experimental diets were supplied daily, and the experimental units were weighed every seven days to observe the studied variables.

Statistical analysis was performed using the ANOVA variance analysis, with its respective test using free software. In addition, Tukey's multiple range test was used at 5% probability to determine the differences between treatment means. Table 1 shows the scheme of the analysis of variance.

Table 1: ANOVA variance analysis.

Variation source		Degrees of freedom
Treatment	t−1	3
Experimental error	t(r−1)	16
Total	t.r−1	19

Note: t = treatment or fixed variable and r: repetition.

A completely randomized design (CRD) was used, with four treatments (T), five repetitions, and eight experimental units (EU) per repetition, giving a total of 160 quail (Table 2).

Table 2: Scheme of the experiment.

Treatments	Repetitions	EU	Total quail
T0			40
T1			40
T2	5	8	40
T3			40
Total			160

Treatments consisted of inclusion in the diet at supplementation levels of 0 (T1); 0.50 (T2); 1.00 (T3); 1.50 (T4) % of a mixed powder of medicinal plant leaves of Morinda citrifolia L. (noni), Psidium guajava L. (guava), Annona muricata L. (soursop) and Jatropha curcas L. (piñon tempate), in a ratio of 40:20:20:20, respectively. The percentages were used by previous research where they analyzed the influence of these medicinal plants separately, that is, one by one. This study proposes to analyse the effect of the four medicinal plants together (Table 3).

Table 3: Treatment description.

Treatments	Composition
T1	Balanced feed
T2	Balanced feed + 0.5% of medicinal plant leaf meal
T3	Balanced feed + 1% of medicinal plant leaf meal
T4	Balanced feed + 1.5% of medicinal plant leaf meal

2.2 Stage II: Formulation of experimental diets

For the formulation of the experimental diets, a bromatological analysis of the mixed meal of medicinal plant leaves elaborated carried out, in which percentages of moisture, protein, fat, ash, and fibre were determined on a wet and dry basis (Table 4).

Subsequently, according to the bromatological analysis of the meal and the nutritional requirements of the animal species studied (quail), the quantities to be used in the composition of the diet (balanced) in the initial physiological stage (Table 5) and final were determined. (Table 6).

Table 4: Bromatological analysis of mixed meal.

Bromatological composition (%)	Wet (%)	Dry (%)
Humidity	10.5	
Protein	15.41	17.13
Fat	1.15	1.28
Ash	8.82	9.81
Fibre	19.70	21.90
Nitrogen free extracts (NFE)	44.87	49.88

Table 5: Calculated analysis of the experimental diet at the initial stage.

Raw materials	T1	T2	T3	T4
National corn	0.390	0.380	0.377	0.373
Soybean meal 44	0.571	0.571	0.569	0.568
Soursop foliage meal (20%)	0.000	0.001	0.002	0.003
Noni foliage meal (40%)	0.000	0.002	0.004	0.006
Piñon foliage meal (20%)	0.000	0.001	0.002	0.003
Guava foliage meal (20%)	0.000	0.001	0.002	0.003
Palm oil	0.020	0.020	0.020	0.020
Calcium carbonate	0.010	0.010	0.010	0.010
Dicalcium phosphate anh.	0.013	0.013	0.014	0.014
Marine sodium chloride 98	0.0003	0.0003	0.0003	0.0003

Table 6: Calculated analysis of the experimental diet at the final stage.

Raw materials	T1	T2	T3	T4
National corn	0.458	0.458	0.451	0.444
Soybean meal 44	0.492	0.492	0.494	0.496
Soursop foliage meal (20%)	0.000	0.001	0.002	0.003
Noni foliage meal (40%)	0.000	0.002	0.004	0.006
Piñon foliage meal (20%)	0.000	0.001	0.002	0.003
Guava foliage meal (20%)	0.000	0.001	0.002	0.003
Palm oil	0.020	0.020	0.020	0.020
Calcium carbonate	0.010	0.010	0.010	0.010
Dicalcium phosphate anh.	0.013	0.015	0.015	0.015
Marine sodium chloride 98	0.0003	0.0003	0.0003	0.0003

2.3 Stage III: Experimental evaluation through zootechnical variables

The experimental evaluation contemplates the recording of the consumption of the food supplied in grams and the rejection (eqn (1)) and weight gain (eqn (2)) every seven days:

$$Food\ consumption\ (g) = Accumulated\ ration - Accumulated\ residue, \quad (1)$$

$$Weight\ gain\ (g) = Final\ weight - Initial\ weight. \quad (2)$$

Likewise, the feed conversion was calculated based on the feed consumed and the weight increase at the end of the experimental stage (eqn (3)).

$$Food\ conversion = \frac{Food\ consumed}{Weight\ gain}. \quad (3)$$

Another variable to analyse is carcass yield (CY) (%), for which the birds under study were slaughtered, evaluating their live weight (LW) and carcass weight (CW) (eqn (4)). This variable allows for determining the real weight of the animal.

$$CY = \frac{CW}{LW} x100. \quad (4)$$

Subsequently, the percentage of mortality due to treatment in the stages of the investigation is evaluated based on the number of initial birds (NIB) and number of dead birds (NDB) (eqn (5)).

$$M = \frac{NDB}{NIB} x100. \quad (5)$$

In addition, morphometric measurements of the GIT (Gastro-Intestinal Tract) are taken, selecting it in the gizzard, proventriculus, ceca (left and right), intestines (thin and large). Each one of the measurements is carried out with a calibrator (cm), and the purpose was to evaluate, through the measurements of the different sections of the TGI, if the inclusion of mixed meal of medicinal plant leaves as a phytobiotic additive in the birds studied, causes size changes in it.

Finally, the economic analysis was carried out, including the total income from the sale of quail, the total cost of the treatments, the net benefit of the treatments, and the benefit/cost ratio.

For the total income (TI), the income from the sale of quail was calculated based on the price (P) and the price of the product (PP) (eqn (6)).

$$TI = PxPP. \quad (6)$$

On the other hand, the total cost (TC) of the treatments was evaluated through the fixed costs (FC) that include baby quail, health, labour, among others; and variable costs (VC) based on feed (eqn (7)).

$$TC = FC + VC. \quad (7)$$

For the analysis of the net benefit (NB) of the treatments provided and the relationship of the benefit/cost of the project, the income and expenses were evaluated (eqns (8) and (9)).

$$NP = GI - TC, \quad (8)$$

where NP = net profit; GI = gross income; TC = total cost.

$$RBC = \frac{Total\ income}{Total\ expenses}. \quad (9)$$

3 RESULTS

3.1 Food consumption

There was no statistical difference ($P>0.05$) in the food consumption variable between the applied treatments. The results obtained reflect a maximum consumption of 1024.30 g for T2, while T4, with the highest meal content (1.5%), obtained the lowest consumption with 969.68 g (Table 7). This difference in consumption could refer to several factors, for example, lower consumption of animals and facilities with conditions that harm the feeding of birds, among others.

Table 7: Total food consumption (g) in the productive performance of quail.

Treatments	Food consumption (g)
T1	977.63 a
T2	1,024.30 a
T3	1,001.78 a
T4	969.68 a
Variation coefficient (VC) (%)	5.31

* Means with a common letter are not significantly different (P ≤ 0.05).

3.2 Weight gain

In total weight gain, it was observed through the ANOVA that there were significant differences (P ≤ 0.05) regarding the treatments. Treatment T1 with 146.18 g represents the highest weight gain in the study. On the other hand, T2 was the lowest weight with 113.85 g (Table 8). Considering that the feed consumption in T2 was the highest (Table 7), the leading cause of this decrease in weight gain is the waste of feed-in facilities by feeders or the animal itself.

Table 8: Total weight gain (g) in the productive performance of quails.

Treatments	Weight gain (g)
T1	146.18 b*
T2	113.85 a
T3	115.80 a
T4	114.80 a
VC (%)	7.83

* Means with a common letter are not significantly different (P ≤ 0.05).

The results obtained for feed conversion show a statistical difference (P>0.05) between the means of the treatments that were evaluated throughout the investigation, where values of T2 (9.00) were reported, followed by T3 (8.77) and T4 (8.49), leaving T1 with the lowest value (6.72) for food conversion (Table 9).

Table 9: Food conversion in the productive performance of quail.

Treatments	Food conversion (g)
T1	6.72 a
T2	9.00 b
T3	8.77 b
T4	8.49 b
CV(%)	10.06

* Means with a common letter are not significantly different (P ≤ 0.05).

3.3 Carcass yield

In the carcass yield variable, no statistical differences were observed (P>0.05) in the means of the treatments, reporting values from highest to lowest. T2 obtained the maximum value, followed by T4, T3, and T1 (Table 10).

Table 10: Carcass yield (%) in the productive performance of quail.

Treatments	Carcass yield (%)
T1	64.01 a
T2	77.55 a
T3	71.50 a
T4	72.72 a
CV (%)	17.02

* Means with a common letter are not significantly different (P ≤ 0.05).

3.4 Morphometric measurements

For the variable of the morphometric measurements where data from the gizzard, proventriculus, ceca (left and right), and intestines (left and right) were taken, no statistical difference was observed, so it is determined that the gastrointestinal tract (GIT) was not altered) from quail fed on medicinal plant leaf meal. However, T2 registers values of 4.05 cm for the gizzard and T4, while the data for proventriculus has 5.05 cm, resembling T3. Likewise, T2 obtained a high value for the left and right cecum with 4.20 cm and small intestine measurements of 23.80 cm, while T3 reports 32.20 cm for the large intestine (Table 11).

Table 11: Morphometric measurements of the gastrointestinal tract of quail.

Data	Treatments								CV (%)
	1		2		3		4		
Gizzard (cm)	3.80	a	4.05	a	3.80	a	4.05	a	23.12
Proventricle (cm)	4.55	a	5.05	a	5.05	a	4.55	a	17.67
Blind: left and right (cm)	3.10	a	4.20	a	3.85	a	3.45	a	30.37
Small intestine (cm)	23.90	a	23.80	a	24.10	a	23.60	a	33.48
Large intestine (cm)	29.50	a	31.90	a	32.20	a	29.20	a	15.61

* Means with a common letter are not significantly different (P ≤ 0.05).

3.5 Mortality

The mortality variable was recorded daily for each treatment with its respective repetition; T1 obtained 5% mortality, this being the only one with that percentage and obtaining a total of 1.5% mortality throughout the investigation (Table 12).

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Table 12: Mortality percentage of the phytobiotic additive in diets for fattening quail.

Treatments	Number of quail at the start	Number of dead quail	Mortality percentage (%)
T1	40	2	5
T2	40	0	0
T3	40	0	0
T4	40	0	0

* Means with a common letter are not significantly different ($P \leq 0.05$).

3.6 Treatment profitability

Regarding the economic analysis, it can be seen in Table 13 that T2 obtained the highest profitability with 17.74% and a cost–benefit ratio of 1.18, which represents a profit of 17 cents for each dollar invested. With a similar result, the T3 obtained a return of 17.17% and a cost–benefit ratio of 1.17. On the other hand, the lowest profitability was recorded by Treatment 1 with 5.23% and a net benefit ratio of 1.05, which tells us that for every dollar invested, we will obtain 5 cents of profit (Table 13).

Table 13: Economic analysis of fattening quail fed with medicinal plant leaf meal.

Items	0% Mixed meal	0.5% Mixed meal	1.0% Mixed meal	1.5% Mixed meal
	T1	T2	T3	T4
Income				
Total of kilograms (kg)	5.58	4.91	4.88	4.78
Price per kilogram, USD	5.00	5.00	5.00	5.00
Total income, USD	27.89	24.53	24.41	23.91
Costs				
Baby quail (40 birds)	10.00	10.00	10.00	10.00
Labour	1.25	1.25	1.25	1.25
Sanitation	1.25	1.25	1.25	1.25
Food	14.00	8.33	8.33	8.33
Total costs, USD	26.50	20.83	20.83	20.83
Net Income	1.39	3.70	3.58	3.08
Benefit/cost	1.05	1.18	1.17	1.15
Profitability (%)	5.23	17.74	17.17	14.77

* Means with a common letter are not significantly different ($P \leq 0.05$).

4 DISCUSSION OF RESULTS

The productive parameters of these birds in studies were not affected by health and nutritional processes when supplying the proposed phytobiotic meal. In addition, the production of this type of additive contemplates low costs in its elaboration, increases animal production, and improves economic profitability. Based on the results, T2 presents the best increase in production parameters. For example, in food consumption, the T2 obtained a higher consumption with 1024.30g, a maximum feed conversion (9.00), carcass yield of 77.55%, and an economic return of 17.77% with a cost–benefit ratio of $1, 18 referring to the fact that we will earn 17 cents for every dollar invested. As an alternative to improve poultry

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production, the implementation of this type of additive is validated with the statistical differences recorded in the control treatment (T1). This treatment records a weight gain of 146.18 g, with a minimum feed conversion of 6.72 and a mortality of 5% (which was not recorded in the other treatments).

The benefits of the proposed phytobiotic additive in poultry to improve intestinal quality, increase nutrient absorption, and prevent diseases have been widely applied. For example, garlic and oregano phytopharmaceuticals have been used [21], lemon verbena infusion treatments in water [22], rosemary meal [19], and fodder peanut meal (Arachis pintoi) [23]. Likewise, at an international level, we can find a broad application of this type of additive (e.g. [12], [24]–[28]).

In general, this study presents as main limitations: (i) vegetative material scarcity (mainly guava, noni, and piñon), (ii) adequate space for the elaboration process of the additive, and (iii) establishing a means of adaptation that prepares the animal's target for consumption. Previous studies of microbiological and metabolic analyses before and after the experiment for the animals under study are recommended to resolve this limitation. In the case of the additive, it is recommended to carry out a bromatological analysis for all weather stations and analyse secondary and microbiological metabolites. For the raw material scarcity (leaves of medicinal plants), a viable alternative is the addition of species such as moringa, oregano, and coriander, which benefit from the proposed additive.

5 CONCLUSIONS

The phytobiotic additive based on leaves of medicinal plants proposed in diets for fattening quail did not negatively affect the productive parameters for food consumption and weight gain. On the contrary, this meal improved the ability to absorb nutrients in birds, improved animal production, and represented an economically viable alternative to quail production.

Regarding the morphometric measurements, it was determined that the addition of medicinal plant leaf meal to the diet did not alter the size of the gastrointestinal tract of the quail. Of the treatments applied, T2 was the one that reflected a higher carcass yield (77.55%), and profitability of 17.77%, with a cost–benefit ratio of USD 1.18.

In particular, the application of this type of additive demonstrates its effectiveness in reducing diseases, eliminating the application of antibiotics, and reducing bird mortality, which translates into more significant economic benefits.

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