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Research Article

Effects of *Faidherbia Albida* (Del.) Chev. Torrefied Pods on the Zootechnical Performances of Laying Chickens

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ABSTRACT

Introduction: The cost of poultry feed directly impacts production yield. The search for feed formulations based on less expensive products is, therefore, an alternative to improve the profits of producers. This study was conducted in Maradi at the Regional Center for Agronomic Research of the National Institute of Agronomic Research of Niger to assess the effect of roasted *Faidherbia albida* pods on the zootechnical performance of Isa Brown laying chickens.

Materials and methods: A total of 200 Isa Brown laying chickens, aged 21 weeks, were randomly assigned to four feeding groups with five replicates each. The chickens were housed in a 5 m × 10 m building, with 10 chickens per replicate in blocks of 1.71 m^2. The building featured ventilation, natural lighting, and bedding made from peanut shells. Apart from the control feed (F0), the experimental feeds contained 5% (F5), 10% (F10), and 15% (F15) crushed pods of *Faidherbia albida* roasted at 110°C. Millet and wheat bran were the main energy sources, while fishmeal and groundnut cake provided protein. Water was provided *ad libitum* to all chickens. The feed was distributed over 2 months.

Results: The results showed that feed ingestion increased significantly with F10 compared to the control, while consumption remained comparable among the control, F15, and F5 groups. The incorporation of roasted *Faidherbia albida* pods led to a significant decrease in the feed conversion ratio, with a significant difference among the treatments. The best feed conversion ratio was obtained with the F5, followed by the control.

Conclusion: The inclusion of *Faidherbia albida* in the chicken diet is beneficial for egg production. The optimal incorporation rate for roasted pods of *Faidherbia albida* was determined to be 10%.

1. Introduction

In Africa, poultry holds a prominent position in household menus due to its affordability, lack of religious prohibitions, and nutritional benefits[1].

In Niger, livestock farming, including poultry, plays a significant role, contributing 12% to the agricultural Gross Domestic Product (GDP)[2]. Thus, poultry farming, like other forms of livestock farming, can actively participate in local development. At the national level, poultry farming serves as a means of expanding agricultural activities and allows saving the foreign currencies spent on importing poultry products[3]. This income-generating activity is practiced in a very traditional way in most cases. In Niger, the poultry sector is predominated by traditional poultry farming[4].

The advancement of modern poultry farming faces several impediments. Food crises have led to an increase in the cost and scarcity of cereals crucial for food production, making them challenging for poultry farmers to acquire on both national and subregional markets. Furthermore, the low average income of the population, standing at $550 per person per year, aggravates the situation[5]. The issue of supplying feed inputs has become more critical as there is a notable rise in the cost of basic raw materials like corn, as well as essential protein-rich materials such as soybean meal and fish meal on the international market[6].

The importance given to poultry feed has resulted in the development of several feed formulas. Despite all these

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efforts, the problem is far from being definitively resolved. While the provided formulas may meet economic criteria for breeders, they often fall short in terms of the nutritional quality of the resulting feed products[7]. In this context, it is necessary to look for alternative feeds to available and nutritious cereals, aligning poultry farming development with local realities. For many specialists, one of the solutions would lie in the incorporation of a local plant resource rich in protein and inexpensive in the poultry ration[8].

Faidherbia albida (Del) A. chev (*Acacia albida*, Del.) is a tree of the family *Leguminoseae*, subfamily *Mimosoideae*. *Faidherbia albida* is a species widely distributed in arid and semi-arid areas of Africa. It is distributed from Central and Eastern Africa to the South African part[9]. This species is found in Niger throughout the southern strip and in some basins or oases. Brah et al.[10] reported that *Faidherbia albida* pods have a chemical composition of 91% dry matter, 10% crude protein, 25% fiber, and 5% mineral matter. Pod seeds contain an average of 20.6% crude protein and provide 1682 KJ of gross energy per 100g of dry matter, while the pulps contain 19.5% crude protein and 1363 KJ of energy per 100g of material dry[11]. The pods can be used in laying hen feed to reduce the amount of energy and protein from conventional resources and thus reduce the cost of producing the feed. However, their crude fiber content and tannin could influence the zootechnical performance of laying chicken[11, 12]. This study aimed to evaluate the optimal threshold for incorporating roasted *Faidherbia albida* pods into the feed of laying chickens in Niger.

2. Materials and Methods

2.1. Ethical approval

All applicable international, national, and/or institutional guidelines for the care and use of animals were followed.

2.2. Experimental design

The experiment was carried out at the poultry farm of the Regional Agricultural Research Center of the National Institute of Agricultural Research of Maradi, Niger, for 2 months in a 5 m × 10 m building with ventilation and natural lighting. The biological material was composed of 200 Isa Brown laying chickens aged 21 weeks with an average weight of 1379 ± 37 g. The chickens were housed on the ground in a litter made from peanut shells. They were randomly distributed into four groups, and each group had five replicates with 10 chickens in each replicate. The experiment occurred in a building with natural ventilation and lighting with a wind speed of 1.49 ± 0.07 m/s in the morning, 1.49 ± 0.12 m/s at noon, and in the evening. The chickens were located in blocks of 1.71 m2. The temperature was 24.91 ± 1.73°C in the morning, 33.85 ± 3.02°C at midday, and 34.26 ± 3.36°C in the evening. The maximum and minimum humidity averages were 85% and 47%, respectively. One week adaption period was observed before data collection.

2.3. Dietary groups and evaluation of zootechnical performances

Whole *Faidherbia albida* pods were purchased from Maradi-Niger city market. Before their incorporation, they were sorted to eliminate impurities and pods containing mycotoxins. The pods were then roasted and crushed with a Hammer Mill-type grinder. The dietary groups of control (F0), F5, F10, and F15 containing 0, 5, 10, and 15% pods, respectively, were formulated. The percentage composition of the four feeds tested and their nutritional values are given in Table 1. During the experiment, the distribution of feeds was performed twice a day, with 700 g in the morning and

Table 1. Ingredient and nutrient composition of feed for Isa Brown laying chicken (from 21 to 30 weeks) containing different levels of *Faidherbia albida* pods per 100 kg.

Ingredients (%)	F0 (control)*	F5*	F10*	F15*
Millet	69.00	66.00	61.50	57.50
Wheat Bran	8.00	6.10	5.50	4.00
Peanut meal	7.50	6.50	6.25	6.50
Fishmeal	7.00	7.00	6.50	6.50
Calcined bone	8.00	8.00	8.00	8.00
Salt	0.30	0.30	0.30	0.30
Premix[1]	0.20	0.20	0.20	0.20
Peanut oil[2]	0.00	0.50	1.25	1.50
D-L Methionine	0.00	0.20	0.25	0.25
Lysine HCl	0.00	0.20	0.25	0.25
Roasted pods of *Faidherbia Albida*	0.00	5.00	10.00	15.00
TOTAL	100	100	100	100
Calculated nutritional composition				
ME (Kcal/KgMS)[3]	2812	2798	2766	2719
Crude Protein (%)	19.25	18.89	18.24	17.97
Crude Fiber (%)	2.96	4.26	5.90	7.39
Calcium (%)	2.31	2.30	2.27	2.26
PNP[4] (%)	1.19	1.18	1.16	1.15
Calcium/PNP[4]	1.93	1.94	1.95	1.95

* Feeds that contain *Faidherbia albida* pods are incorporated at 0% (F0), 5% (F5), 10% (F10) and 15% (F15).
[1]Premix containing per kg: Vitamins: A 4000000 IU, D3 800000 IU, E 2000 mg; K 800 mg, B1 600 mg; niacin 3600 mg, B6 1200 mg B12 4 mg, choline chloride 80000 mg; minerals: Cu 8000 mg, Mn 64000 mg; Zn 40,000 mg, Fe 32000 mg, Se 160 mg
[2]Unrefined peanut oil, [3]Metabolizable energy in kilocalories per kilogram of dry matter, [4]PNP: Nonphytic phosphorus.

400 g in the evening for each repetition for 2 months. Feed intake was calculated daily. According to the formula used by Brah[8], feed consumption was calculated using Formula 1.

$$\text{Feed intake} = \frac{\text{Quantity of food distributed (g)/day} - \text{Quantity of food refused (g)/day}}{\text{Duration of the period x Number of subjects}}$$

(Formula 1)

The feed conversion ratio (FCR) was calculated to determine the relationship between feed intake and the number of eggs produced (g feed/egg).

2.4. Statistical analysis

All the variables were analyzed with R software version 4.2.2 using a multivariate analysis of variances (ANOVA, one-way). The mean values of the variables are presented in tables with the standard errors (SE) and the probabilities (P) resulting from the comparison of the means with the Tukey test. The effect of incorporating *Faidherbia albida* roasted pods in the feed is significant if $p < 0.05$.

3. Results

3.1. Feed ingestion

The incorporation of *Faidherbia albida* roasted pods into the feed of laying chickens at different rates had a very highly significant effect on ingestion during the 2 months of testing ($p < 0.001$; Table 2). The lowest feed consumption was recorded at F5 (87.34 ± 10.15 g/day) and F15 (90.23 ± 11.95 g/day). The highest feed ingestion rates were observed with F10 (97.51 ± 9.23 g/day) and F0 (93.51 ± 7.77 g/day). The average values of feeds ingested per treatment and feed consumed by the chickens are presented in Table 2.

3.2. Laying rate

During the first and second months of the experiment, the average laying rates experienced a highly significant difference between the groups of hens treated with 5%, 10%, and 15% *Faidherbia albida* pods and the control group ($p < 0.001$; Table 3). At the first month, chickens fed the control feed laid the greatest number of eggs, with an average rate of 52.35%. In the second month, the layers fed with control also had the highest laying rates. It is decreased with increasing roasted *Faidherbia albida* pods in a layer diet. After 60 days of testing, it was still the layers fed with control that lay the most, with an average of 54.35% (Figure 1). Treatment F5 (53.52%), F10 (51.38%) and F15 (43.84%) had the lowest laying rates, with highly significant differences ($p < 0.001$).

3.3. Feed conversion ratio

Table 4 presents the average values of the layers' feed

Table 2. Feed intake (g/d) of laying chicken with different amounts of incorporated roasted *Faidherbia albida* pods into their feed.

Month	F0 (control)*	F5*	F10*	F15*	P value
1	93.51 ± 7.77^{b}	92.26 ± 9.77^{b}	97.51 ± 9.23^{a}	92.29 ± 8.83^{b}	<0.001***
2	88.72 ± 8.31^{b}	87.34 ± 10.15^{b}	95.91 ± 8.99^{a}	90.23 ± 11.95^{b}	<0.001***
Mean	91.12 ± 8.38^{b}	89.80 ± 10.24^{b}	96.71 ± 9.13^{a}	91.26 ± 10.54^{b}	<0.001***

$^{a, b}$: on the same line, the same letter is assigned to values presenting no statistically significant difference between them p = 0.05; ***: very highly significant.
* Feeds that contain *Faidherbia albida* pods are incorporated at 0% (F0), 5% (F5), 10% (F10), and 15% (F15).

Table 3. Effect of incorporating roasted *Faidherbia albida* pods on the laying rate (%) of laying chickens

Month	F0 (control)*	F5*	F10*	F15*	P value
1	52.35 ± 27.60^{a}	49.62 ± 25.10^{a}	49.60 ± 26.31^{a}	40.38 ± 23.87^{b}	<0.001***
2	64.97 ± 16.67^{a}	62.70 ± 19.25^{a}	61.73 ± 19.13^{a}	55.12 ± 16.26^{b}	<0.001***
Mean	54.35 ± 25.72^{a}	53.52 ± 24.42^{a}	51.38 ± 24.82^{a}	43.84 ± 22.15^{b}	<0.001***

$^{a, b}$: on the same line, the same letter is assigned to values presenting no statistically significant difference between them p = 0.05; ***: very highly significant.
* Feeds that contain *Faidherbia albida* pods incorporated at 0% (F0), 5% (F5), 10% (F10) and 15% (F15).

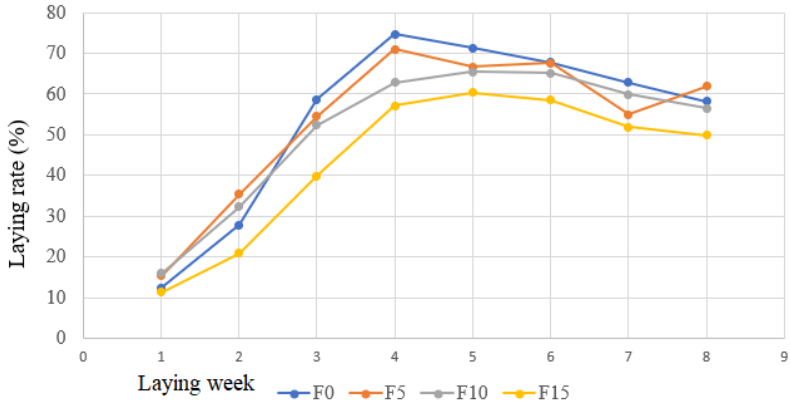

Figure 1. Effect of roasted *Faidherbia albida* pods in food on the laying rate (%) of Isa Brown laying chickens

Table 4. Average values of feed conversion ratio in laying hens fed with different amounts of incorporated roasted *Faidherbia albida* pods

Month	F0 (control)*	F5*	F10*	F15*	P value
1	412.39 ± 349.34^{ab}	352.73 ± 302.18^{b}	397.90 ± 315.20^{ab}	486.83 ± 350.63^{a}	<0.01**
2	152.24 ± 85.88^{b}	153.25 ± 53.65^{b}	185.21 ± 130.64^{ab}	187.37 ± 105.88^{a}	<0.001***
Mean	282.32 ± 285.43^{ab}	252.99 ± 238.58^{b}	291.55 ± 263.36^{ab}	337.10 ± 298.91^{a}	<0.01**

$^{a, b}$: on the same line, the same letter is assigned to values presenting no statistically significant difference between them p = 0.05; **: highly significant; ***: Very highly significant. * Feeds that contain *Faidherbia albida* pods incorporated at 0% (F0), 5% (F5), 10% (F10), and 15% (F15).

conversion ratio (FCR) for producing an egg. At the end of the analysis FCR, there was a highly significant difference between the treatments overall over the two cumulative months of the trial ($p < 0.01$). The chickens receiving F5 had the best FCR (252.99 g of feed/egg), followed by those receiving the F0 feed (282.32 g feed/egg), F10 (291.55 g of feed/egg), and F15 (337.10 g of food/egg).

4. Discussion

4.1. Feed intake and age

Dietary supplementation of *Faidherbia albida* pods significantly increased the overall feed consumption of laying chickens, particularly in the F10 treatment, compared to the F0. The increased consumption of feeds containing roasted *Faidherbia albida* pods may be attributed to the decreased levels of antitrypsin factors and condensed tannin found in the seeds of the pods, a result of the roasting process at 110°C. The mechanical and physical treatments can eliminate undesirable factors (cellulose, tannins, antitrypsin factors) and increase the accessibility of certain nutrients[13]. According to Dahouda, trypsin inhibitors are heat labile[14]. The results found by Iyayi and Taiwo showed that feed ingestion by broilers and layers decreases with the incorporation of raw *Mucuna pruriens* seeds, while those that have undergone heat treatment in an autoclave and seeds that were toasted were similar in all treatments[15].

4.2. Laying rate and age

The laying rates gradually decreased with the incorporation of *Faidherbia albida* pods into the layers' feed, and the best rate was obtained with the control (F0). The results of the current study corroborate those of Houndonougbo et al.[16], who fed Isa Brown laying chickens dried cassava leaves. Girma et al.[17] observed the same trend by the incorporation of *Prosopis juliflora* pods into the diet of Bovans Brown laying chickens. However, the laying data of the present study was lower than those observed by Houndonougbo et al.[16], who obtained 84.7%, 75.4%, and 71.7% for the control and diets containing 5% and 10% dried cassava leaves in the second month of testing, respectively, and those of Effiong et al.[18], who incorporated processed bean flour into the layer rations. This inferiority could be linked to the ambient temperature during the experiment. Layers of the current study were subjected to very strong temperature variations ranging from 24.91 ± 1.73°C on average in the morning to 34.26 ± 3.36°C in the evening, unlike these authors who conducted their tests at relatively low temperatures. This is how Banga-Mboko et al.[19] observed a drop in laying rates at a temperature of 31°C in two lines of laying chickens. A high temperature leads to a drop in consumption and production, which cannot be compensated by feed and is more detrimental to short-cycle production (chicken)[20]. More precisely, above 27°C, the temperature negatively influences the laying rate[21].

4.3. Feed conversion ratio and age

The results of the current study indicate that the average values of the feed conversion ratio increase as *Faidherbia albida* pods are incorporated. This means that as the quantity of pods in the layers' diet increases, their feed consumption rises while their egg production decreases. This decline in egg production relative to feed consumption may be attributed to variations in the energy levels of the feeds, which progressively increase from F15 to the control; F15 (2719 Kcal F10 (2766 Kcal), F5 (2798 Kcal), F0 (2812 Kcal). The energy level of a feed has a possible influence on the feed conversion ratio[22]. In other studies, the type of feed has a significant effect on the feed conversion ratio[23].

The results in this trial are contrary to those found by Khaled et al.[24], who observed a low consumption index compared to the control with Rhode Island red hens having received supplementation with fresh *Moringa oleifera* leaves.

5. Conclusion

At the end of this study, it turned out that the incorporation of roasted *Faidherbia albida* pods into the diet of laying chickens had no negative effect on the zootechnical parameters throughout the experiment. All analyses were significant. The control diet showed better performance on the majority of the variables studied. Therefore, considering the feed conversion ratio, the best rate to use in the feed formula would be 10%. An in-depth study on the chemical composition and/or a separate diet is necessary to understand the determining factors for optimizing the incorporation of unconventional feeds.

Declarations

Competing interest

The authors declare that they have no competing interests.

Authors' contribution

Brah Nouri supervised this study. He has played a pivotal role from the project conceptualization to the manuscript redaction. Amadou Gado Boubacar has done the data collection. Moussa Hassan Ousseini played a significant role

in data analysis and manuscript redaction. In terms of methodology, all authors have contributed. Regarding the draft preparation and subsequent revision, the authorship team worked together to ensure the quality and coherence of the manuscript. All authors checked and approved the final version of this manuscript.

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Availability of data and materials

The manuscript contains all datasets generated and/or analyzed in the current study, which are available from the corresponding author upon reasonable request.

Ethical considerations

Ethical issues (including plagiarism, consent to publish, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy) have been checked by all the authors.

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