Full Length Research Paper

Comparative effects of *Moringa oleifera* powder and soybean meal on the zootechnical parameters of the ISA Brown pullet

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Poultry farming is an important sector of the Beninese agriculture. But this sector is facing economic difficulties. The aim of this study is to evaluate the effects of *Moringa oleifera* powder and soybean meal on zootechnical parameters in the ISA Brown pullet. For this purpose, the experiment was carried out on a total of 250 day-old chicks with an initial average weight of 40 ± 1 g. Among these chicks, 25 subjects were used for the digestibility test and the rest were grouped into cinq (05) batches of 45 chicks fed with different rations. The test lasted 56 days. The apparent digestibility of the dry matter varied significantly from 50.0 ± 9.18 to 50.42 ± 16.11 at the 5% threshold between the different batches. Feed consumption of chicks of the different experimental batches did not show any significant variation, while for the feed conversion rate, weight gain and average daily gain, most averages vary significantly between batches and weeks. It brings out that *M. oleifera* powder improves the feed conversion and growth rates of ISA Brown pullets fed with a feed containing *M. oleifera* powder at different incorporation rates.

**Key words:** *Moringa oleifera*, soybean, ISA Brown laying hens, zootechnical parameters.

INTRODUCTION

Benin's agriculture, which employs 70% of the working population, is one of the vital sectors of the economy. It contributes nearly 40% to GDP (INSAE, 2008). However, it does not significantly reduce poverty. The consequences of this are undernourishment and more particularly a lack of animal protein (FAO, 2010). Indeed, the animal protein coverage rate is very low in developing countries (Omole, 2006). Thus, in order to ensure food security for rural and urban populations, the new livestock development programs are oriented towards the promotion of short-cycle animal species in general and poultry in particular (FAO, 2000). In this dynamic, poultry farming is a major component of farmers in animal production. It is a sector that represents a complementary source of income in which to draw in emergency case. However, it must be noted that this farming is subject

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to multifactorial constraints leading to a high mortality rate (65 to 70%) between 0 and 2 months and a drop in zootechnical performance (Laurensen, 2002). Among these constraints, those related to food occupy a prominent place, characterized by the high cost of certain raw materials, in particular soybean meal, which represents a raw material used in conventional food resources. But it should be noted that access to these resources is limited for many farmers due to their ever-increasing costs (FAO, 2010). The use of non-conventional local foods in the feeding of herbivorous monogastric animals appears to be a reasonable alternative to conventional commercial foods (Aboh et al., 2002). *Moringa oleifera* is a legume that is increasingly used in animal feed, especially for laying hens and broilers (Raphaël et al., 2015; Mufwaya and Kiatoko, 2016). In addition to the nutritional role, it is shown that the ethanolic extract of *M. oleifera* leaves has antibacterial activity against *Staphylococcus aureus* strains (Dougnon et al., 2011). The extracts of *M. oleifera* leaves have antioxidant and anticancer activities (Charoensin, 2014; Pamok et al., 2012). It is therefore urgent to propose endogenous alternatives to make poultry production in Benin competitive. An endogenous solution must be sought to reduce the cost of production in laying hens. The main aim of the study is to evaluate the effect of *M. oleifera* powder on the zootechnical parameters of the ISA Brown pullet.

**MATERIALS AND METHODS**

**Study area**

Part of the experiment took place at the Centre Cunicole de Recherche et d’Information (CECURI) located next to the EPAC Department of Animal Production and Health (D/PSA) on the Abomey-Calavi University Campus (UAC), and the other part on a farm located in Togoudo not far from the Catholic Church of Togoudo.

**Animal material**

The experiment was carried out on two hundred and fifty ISA Brown pullets imported from France and divided into five batches of fifty subjects each, including four experimental batches and a control batch. The average body weight of the chicks was 40 ± 1 g at reception.

**Plant material**

The plant material consisted of the whole leaves of *M. oleifera*.

**Experimental ration**

To obtain *M. oleifera* flour, the leaves were harvested and dried on sheets metal in the open air at a laboratory temperature away from the sun until completely dry leaves were obtained. These dry leaves were then ground to powder by the LFJ-40B grinding device at the EPAC feed mill. For the experiment, five types of experimental diets were used. The first is the control feed (Batch 1), the second is composed of 5% *M. oleifera* in substitution for soybean meal (Batch 2), the third is composed of 10% *M. oleifera* in substitution for soybean meal (Batch 3), the fourth is composed of 15% *M. oleifera* in substitution for soybean meal (Batch 4), and the fifth is composed of 20% *M. oleifera* in substitution for soybean meal. Different raw materials were used for this composition. The feed is mainly based on corn, roasted soya, bran, flesh concentrate 5% (Belgian origin), fish meal, cooking salt and oyster shell (Table 1).

**Evaluation of zootechnical parameters**

Twenty-five ISA Brown chicks divided into 5 batches of five were used for the digestibility test of *M. oleifera*. The chicks were raised for 8 weeks in rabbit cages of 80 cm × 50 cm and 30 cm, each equipped with water trough and feeding trough. Tarpaulins are placed under the individual cages to collect droppings from each batch.

(i) 250 chicks were reared up to laying in variable size fence pens at each phase, meaning 1 m² for 50 subjects during the chick phase; 1 m² for 10 subjects during the pullet phase and 1 m² for 5 subjects during the laying phase. Each pen is equipped with water trough and feeding trough.

The batches constituted for the test are in numbers of five: Batch 1; Batch 2; Batch 3; Batch 4 and Batch 5. The details of the constitution of each batch are described in Table 2. The amount of feed refused was weighed daily, the amount of feed consumed weekly was determined by making the difference between the total amount served per week and the sum of the daily refusals. The sum of the weekly consumptions allowed us to obtain the total quantity of feed consumed. Individual weight gain of the chickens was performed every 7 days. The chickens were vaccinated against Newcastle disease, Gumboro disease and infectious bronchitis. They have also been treated against coccidiosis and helminths. They received vitamin (anti-stress) to fight stress. The data collected made it possible to calculate the following zootechnical parameters:

(i) **Feed consumption (CA)**

It is obtained by the formula:

\[
CA = \frac{\text{Amount of feed distributed (g)} - \text{Amount of feed refused (g)}}{\text{Number of animals}}
\]

(ii) **Average daily gain (ADG)**

The ADG was calculated according to the formula: \(ADG = (W_f - W_i)/d\) with \(W_f\) = final average weight, \(W_i\) = initial average weight and \(d\) = duration in days.

(iii) **Feed conversion ratio (FCR)**

It was obtained by the formula:

\[
FCR = \frac{\text{amount of feed consumed during a given period (g)}}{\text{weight gain during this period (g)}}
\]

**Digestibility test**

It was carried out on a total of twenty-five chickens from the 14th to the 21st day. The chickens were placed in cages measuring 45 cm × 37.5 cm × 33 cm. These cages are each equipped with two
### Table 1. Gross composition of experimental diets.

| Ingredients (kg) | R0  | R5  | R10 | R15 | R20 |
|------------------|-----|-----|-----|-----|-----|
| Maize grain      | 58.98 | 58.98 | 58.98 | 58.98 | 58.98 |
| Wheat bran       | 10  | 10  | 10  | 10  | 10  |
| Soybean meal     | 18  | 17.1 | 16.2 | 15.3 | 14.4 |
| Fish meal        | 7   | 7   | 7   | 7   | 7   |
| Concentrated broilers | 5 | 5 | 5 | 5 | 5 |
| Iodized salt     | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| Oyster shell     | 1   | 1   | 1   | 1   | 1   |
| Moringa oleifera | 0  | 0.9 | 1.8 | 2.7 | 3.6 |
| Total            | 100 | 100 | 100 | 100 | 100 |

| Chemical composition | R0  | R5  | R10 | R15 | R20 |
|----------------------|-----|-----|-----|-----|-----|
| Dry matter (%)       | 87  | 87  | 87  | 87  | 87  |
| Crude fiber (%)      | 2.88 | 2.90 | 2.92 | 2.94 | 2.97 |
| Metabolisable energy (kcal/kg) | 2945.10 | 2953.33 | 2961.56 | 2969.78 | 2978.01 |
| Crude protein (%)    | 18.09 | 17.95 | 17.82 | 17.62 | 17.55 |
| Lysine(%)            | 1.6  | 1.03 | 1.01 | 0.99 | 0.96 |
| Methionine(%)        | 0.39 | 0.38 | 0.38 | 0.37 | 0.37 |
| Calcium(%)           | 1.20 | 1.21 | 1.22 | 1.23 | 1.24 |
| Total phosphorus (%) | 0.43 | 0.42 | 0.42 | 0.42 | 0.42 |

1Concentrated broilers composition per kg: Vitamins: A 200000 UI; D3 40000 UI; E 600 mg; K3 40 mg; B1 30 mg; B2 100 mg; B3 (calpan) 200 mg; niacinine 800 mg; B6 40 mg; B12 0.5 mg; Folic acid 20 mg; Biotin 2 mg; choline chloride 10000 mg, Minerals: Cu 180 mg; Mn 1200 mg; Zn 1000 mg; Fe 800 mg; Se 3 mg; Ca 2.5 mg; P 2.5 mg; available P 3.85 mg; Na 2.3 mg; methionine 4.10 mg; cysteine methionine 4.80 mg; lysine 5.4 mg; 8phytase FYT/kg 30769; metabolisable energy Kcal/kg 1810.

### Table 2. Batch composition.

| Batches | Description       | Dosage       |
|---------|-------------------|--------------|
| 1       | M. oleifera powder| 5% substitution |
| 2       | M. oleifera powder| 10% substitution |
| 3       | M. oleifera powder| 15% substitution |
| 4       | M. oleifera powder| 20% substitution |
| 5       | Without M. oleifera | No substitution 100% soy |

(i) Batch 1: the chicks received 5% substitution of soybean meal by *M. oleifera* powder.

(ii) Batch 2: the chicks received 10% substitution of soybean meal by *M. oleifera* powder.

(iii) Batch 3: the chicks received 15% substitution of soybean meal by *M. oleifera* powder.

(iv) Batch 4: the chicks received 20% substitution of soybean meal by *M. oleifera* powder.

(v) Batch 5: the chicks did not receive *M. oleifera* powder.

To determine the dry matter of each batch of feed, we sampled 150 g of each batch then dried in an oven at 70°C for 24 h; The droppings were weighed before and after drying in the oven at 70°C for 24 h using a Weiheng® precision balance with a capacity of 7 kg, d = 1 g

### Statistical analysis

Data on growth parameters and digestibility were subjected to a...
one-way analysis of variance (ANOVA). In case of a difference between the treatments at 5% probability, the means were separated using the Student (t) test. The R software was used for the analyses. The statistical model used was as follows:

\[ N = \text{number} \]
\[ \text{ES} = \text{Error Standard} \]
\[ X = \text{average} \]

RESULTS

In general, the level of incorporation of *M. oleifera* flour into the ration significantly affected all production parameters. Figure 1 shows the diagram of the apparent digestibility utilization coefficient. From Figure 1, it is noted that the amount of dry matter ingested was 125.28 ± 18.78 g.MS for chickens in Batch 1 that received 5% substitution for *M. oleifera* powder; 130.57 ± 17.84 g.MS for chickens in Batch 2 that received 10% of *M. oleifera*; 146.57 ± 23.25 g.MS for Batch 3 (15% of *M. oleifera*); 165.57 ± 29.53 g.MS for Batch 4 (20% of *M. oleifera*); 154.22 ± 16.25 g.MS for batch 5 (100% Soybean). The amount droppings produced was 59.14 ± 17.59 g.MS (Batch 1); 50.0 ± 9.18 g.MS (Batch 2); 50.42 ± 16.11 g.MS (Batch 3); 43.28 ± 10.57 g.MS for Batch 4 and 49.41 ± 11.24 g.MS (Batch 5). Statistical analyses did not reveal a significant difference for these different parameters regardless of the batch (p>0.05).

Weight gain, average daily gain (ADG) and feed conversion ratio (FCR) in ISA Brown pullets fed with *M. oleifera* powder

Feed consumption in chickens from the different experimental batches showed no significant variation between the experimental batches. Weight gain is the amount of meat deposited by a chicken after ingesting a certain amount of feed. For the different experimental batches, there was a significant increase (p<0.05) in weight gain at the first and second week as the amount of *M. oleifera* incorporated into the feed increases. During weeks 1, 2 and 3, there was no significant variation between the weight gains recorded. In addition, the data recorded in the various batches showed significant variations at the 5% threshold from the 4th to the 8th week. Finally, the incorporation of *M. oleifera* powder improves weight gain until the 7th week of chicken production (Table 3).

As regards the average daily gain, large significant variations (p<0.05) were recorded in chickens from the different batches during weeks 1, 2, 4, 5, 6, 7 and 8. With the exception of the second and eighth weeks where there was no significant difference in any batch. The highest average daily gains were recorded in chickens in batches 3 and 4 fed a feed containing 15% and 20% *M. oleifera* respectively (Table 4).

During weeks 4, 5, 6, and 7, the feed conversion ratio

Figure 1. Diagram of the apparent digestibility utilization coefficient. CUaD1: Apparent digestibility utilization coefficient of Batch 1; CUaD 2: Apparent digestibility utilization coefficient of batch 2; CUaD 3: Apparent digestibility utilization coefficient of Batch 3, CUaD 4: Apparent digestibility utilization coefficient of batch 4; CUaD 5: Apparent digestibility utilization coefficient of Batch 5.
(FCR) varied significantly. Chickens fed with a feed containing M. oleifera powder had the lowest feed conversion ratio between different batches. For the other weeks, no significant differences were observed between the different batches. During weeks 1, 2, 3, and 8, the lowest feed consumption indices were observed in chickens in the control batch (Figure 2).

**DISCUSSION**

Apparent digestibility of the dry matter of ISA Brown pullets fed with M. oleifera powder

The results obtained for the apparent digestibility test indicate that chickens fed feed containing different proportions of M. oleifera powder have presented a different digestibility compared to the control batch. This suggests that the different incorporation rates of M. oleifera powder have significantly influenced the apparent digestibility of dry matter in pullets. However, chickens that received 15% M. oleifera had a slightly higher digestibility than the batch that received 20% M. oleifera. This is related to the incorporation of M. oleifera into the feed. Indeed, M. oleifera has properties that facilitate digestibility (Fuglie, 2001). These authors explain that the antioxidant properties of M. oleifera leaves are mainly due to the reducing power of β-carotene. Diphenyl-1-picrylhydrazyl (DPPH)/superoxide/hydroxyl trapping, ferrous ion chelation and lipid peroxidation. This may therefore explain the results obtained for digestibility.

**Weight gain, average daily gain, feed conversion ratio of ISA Brown pullets fed with Moringa oleifera powder**

**Weight gain**

The weight gains of chickens in batches that ingested the feed containing M. oleifera powder are greater than those in the control batch at weeks 1, 3, 4, 5, 6, 7, and 8. In addition, chickens that received 15% M. oleifera showed a strictly higher weight gain than chickens in the batches that received 20, 10 and 5% M. oleifera respectively. This difference is related to the incorporation of M. oleifera into the feed.

**Average daily gain**

The large variations in experimental batch chickens for mean daily gain (ADG) during weeks 1, 2, 4, 5, 6, 7, and 8 are due to the antioxidant properties of M. oleifera (Charoensin, 2014). Apart from week 3 when the ADG is high in the control batch chickens, the highest daily average gains were recorded in chickens in batches 3 and 4 that were fed a feed containing 15 and 20% of the M. oleifera powder respectively, which corroborates the antioxidant property of M. oleifera. This confirms the results of Kakengi et al. (2007) in Tanzania on laying hens that the performance obtained with M. oleifera leaves is among the best compared to other leaves.

**Feed conversion ratio**

During weeks 4, 5, 6 and 7, the feed conversion
Figure 2. Evolution of the feed conversion ratio for pullets. Batch 1: Chicks received 5% substitution of soybean meal by *M. oleifera* powder; Batch 2: Chicks received 10% substitution of soybean meal by *M. oleifera* powder; Batch 3: Chicks received 15% substitution of soybean meal by *M. oleifera* powder; Batch 4: Chicks received 5% substitution of soybean meal by *M. oleifera* powder; Batch 5: Chicks did not receive *M. oleifera* powder.

ratio (FCR) varied significantly between the different batches. Chickens fed a feed containing *M. oleifera* powder had the lowest consumption indices. This confirms the results of Leclercq and Beaumont (2000) who concluded that as the protein content of the feed increases, the feed conversion ratio decreases while weight gain increases. It is the feed conversion ratio that reflects the consumption of the feed during the breeding cycle, as Jaovelo (2007) pointed out. This justifies our results because feeds containing *M. oleifera* powder are also rich in protein as the standard feed. Ndong et al. (2007) pointed out that *M. oleifera* is rich in protein. The different FCRs obtained are much lower than those obtained by Jaovelo (2007) who proposes the value of 1.9 to 42 days of age; this confirms that *Moringa oleifera* powder improves the growth rate of pullets and therefore the feed conversion rate.

**Average daily gain and feed conversion ratio**

*M. oleifera* leaves are a vegetable of good nutritional quality and are part of one of the best tropical vegetables. They are an excellent source of protein with average levels ranging from 19-35% MS (Olugbemi et al., 2010). These authors found that mature leaves contain less protein than young leaves because of their high fibre content, especially crude fibre ranging from 9.13-28.2% MS. These proteins contribute to the zootechnical performance of both broilers and laying hens. These nutritional properties or qualities of *M. oleifera* bring it closer to soybean meal. The leaves of this plant, which are more available and less expensive, thus offer the possibility of its substitution at different rates (5, 10, 15 and 20%) in this study. With a relatively high content of metabolizable energy, 2273 and 2978 kcal/kg MS (Olugbemi, 2010), *M. oleifera* leaves contain a very high concentration of vitamins (A, B, C, E, etc.), minerals (iron, calcium, zinc, selenium, etc.) and are rich in ß-carotene (Fuglie, 2002; Mbora et al., 2004). Minerals occupy a modest share of the dry matter of *M. oleifera* leaves with contents of 0.6 to 11.42% MS. The fat content of *M. oleifera* leaves varies from 2.3 to 10% MS (Ndong et al., 2007). Due to its exceptional nutritional qualities, *M. oleifera* leaves have been used in both feed and feed (Price, 2007). Many authors have focused on the use of the flour from these leaves in animal feed. A study by Tedonkeng et al. (2008) showed that the incorporation of up to 6% *M. oleifera* leaf flour in the finishing ration of broilers as a substitute for soybean meal had no negative effect on the ADG, consumption and feed conversion ratio. The same is true of Kaijage et al. (2003) and Kakengi et al. (2007), who, with high rates (20 and 15% respectively), found a significant improvement in productivity and feed conversion among laying hens. However, at 20% incorporation of the flour from these leaves, Kakengi et al. (2007) observed a depreciation of the feed conversion ratio. Indeed, total phenols, tannins, saponins and phytates detected in *M. oleifera* leaves may possibly limit their use in feed. Total phenols (0.67-3.4%) and tannins (0.5-1.4%) are known to reduce the bioavailability of proteins, carbohydrates and minerals in the intestine of animals (Tchiégang and Aissatou, 2004). Phytates (2.3 to 3.1%) and oxalates (4.1%) present in legumes at a rate of 1 to 5% reduce the bioavailability of minerals, particularly phosphorus (Richter et al., 2003).
Trypsin inhibitors have not been detected in *M. oleifera* leaves while other anti-nutritional factors are at low levels (Kavitha et al., 2012).

In short, *M. oleifera* is characterized by a high content of nutrients, antioxidants, glucosinolates, phytochemicals and organoleptic qualities. However, given the results obtained in this study, it would be better not to exceed the incorporation rate of 20% at the risk of not affecting productivity in chickens because of the inhibitory effect of the anti-nutritional factors present in the leaves of *M. oleifera*.

**Conclusion**

The incorporation of *M. oleifera* powder into the staple feed did not have a noticeable negative effect on the zootechnical parameters of ISA Brown laying hens, but improved growth and feed conversion ratio. In this case, *M. oleifera* leaf flour can be considered as a possible alternative in the feeding of laying hens for economic purposes. This study opens the way for prospecting medicinal plants to strengthen the immune system, particularly in vulnerable and genetically weakened avian strains, in this case laying hens.

**CONFLICT OF INTERESTS**

The authors have not declared any conflict of interests.

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**Table 4. Average Daily Gain.**

| Weeks | BATCH 1 |       | BATCH 2 |       | BATCH 3 |       | BATCH 4 |       | BATCH 5 |       | ANOVA |
|-------|---------|-------|---------|-------|---------|-------|---------|-------|---------|-------|-------|
|       | Average | ES    | Average | ES    | Average | ES    | Average | ES    | Average | ES    |       |
| 1     | 3.857<sup>ab</sup> | 7.6365 | 3.936<sup>a</sup> | 7.8875 | 3.990<sup>a</sup> | 8.15789 | 4.029<sup>a</sup> | 7.8683 | 3.308<sup>ab</sup> | 7.40947 | ** |
| 2     | 6.149<sup>ab</sup> | 12.816 | 6.478<sup>ab</sup> | 14.022 | 6.509<sup>a</sup> | 14.4395 | 6.062<sup>b</sup> | 13.912 | 7.438<sup>a</sup> | 2.06538 | * |
| 3     | 9.251<sup>a</sup> | 20.419 | 9.293<sup>a</sup> | 23.037 | 9.467<sup>a</sup> | 22.9427 | 9.749<sup>a</sup> | 22.357 | 7.981<sup>a</sup> | 21.9654 | NS |
| 4     | 11.59<sup>a</sup> | 30.011 | 9.905<sup>ab</sup> | 32.048 | 12.29<sup>a</sup> | 32.8697 | 10.94<sup>ab</sup> | 31.038 | 8.931<sup>b</sup> | 30.4486 | * |
| 5     | 11.347<sup>ab</sup> | 39.995 | 12.130<sup>ab</sup> | 41.442 | 14.788<sup>a</sup> | 41.1722 | 13.26<sup>a</sup> | 40.42 | 9.439<sup>b</sup> | 37.2273 | ** |
| 6     | 12.72<sup>ab</sup> | 39.995 | 15.31<sup>a</sup> | 48.586 | 15.579<sup>a</sup> | 53.878 | 15.706<sup>a</sup> | 47.564 | 11.15<sup>b</sup> | 46.332 | * |
| 7     | 12.72<sup>ab</sup> | 61.629 | 15.31<sup>a</sup> | 41.442 | 15.579<sup>a</sup> | 67.6889 | 15.706<sup>a</sup> | 59.563 | 11.15<sup>b</sup> | 57.3356 | * |
| 8     | 17.657<sup>c</sup> | 72.969 | 12.87<sup>a</sup> | 69.179 | 23.29<sup>a</sup> | 72.8119 | 19.857<sup>ab</sup> | 73.852 | 15.96<sup>c</sup> | 65.9122 | *** |

NS: Not significant; ANOVA: Analysis of Variance; ES: Standard Error; *: Significant difference at 5% threshold; **: Significant difference at 1% threshold; ***: Significant difference at 1% threshold. The averages assigned to different letters are significantly different at the 5% threshold.
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