Effects of Incorporating Moringa Oleifera Leaf Powder on the Zootechnical Performance of Broilers in Karakoro (Northern Côte d'Ivoire)

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Abstract— The present study was conducted in the commune of Karakoro to evaluate the effects of incorporating *Moringa Oleifera* leaf powder on the zootechnical performance of broiler chickens. A sample of 200 broiler chicks was divided into 4 batches of 50 birds. Batch 1 was fed feed without *Moringa Oleifera*. The other batches (batch 2, batch 3, and batch 4) received three experimental feeds containing different levels of the powder of 1%, 2%, and 4% respectively. The results showed a decrease in feed intake with an increasing rate of incorporation of *Moringa Oleifera* leaf powder without significant difference ($p>0.05$). At 49 days of age, the mean weights of the animals were 1860.85 ± 30.49 g; 1879.45 ± 30.79 g; 1916.98 ± 31.41 g; 2010.96 ± 44 g for batch 1, batch 2, batch 3, and batch 4 respectively. However, there is no significant difference ($p>0.05$) between the average weights of the different batches. In addition, the incorporation of *Moringa Oleifera* leaf powder improved carcass weight, skin color, abdominal fat, legs, and beak. The best results were obtained with an incorporation rate of 4%. Ultimately, farmers should incorporate *Moringa oleifera* leaf powder into broiler feeds to improve growth performance and carcass characteristics

Index Terms— *Moringa oleifera*, broilers, zootechnical performance, Karakoro

1 Introduction

THE shortage of animal protein due to population growth and urbanization has led West African countries such as Côte d'Ivoire to turn to the production of short-cycle species such as poultry and small ruminants [1]. In Côte d'Ivoire, the poultry sector plays a major role, with national poultry meat production of 47,000 Tonne Carcass Equivalent (TCE) in 2011 compared to 56,500 Tonne Carcass Equivalent (TCE) in 2016 [2]. Poultry farming is the most widespread form of animal husbandry, with more than 62,000,000 head in 2014, and represents 30,000 direct and indirect jobs for a turnover of more than 40 billion CFA francs [3]. This poultry farming sector includes modern broiler and layer chicken farming as well as traditional village farming. It is dominated by traditional extensive farming with 60% of the workforce against 40% of modern intensive farming [4]. Modern livestock farming generally involves the production of broilers for meat and laying hens for eggs. This intensive production of broiler chickens makes it possible to have good meat available to the population in record time thanks to quality feed. Indeed, feed is a determining factor in the development of both modern and traditional poultry farming and represents 2/3 of production costs [5]. However, in Côte d'Ivoire, few farms use *Moringa Oleifera* in broiler feed. However, several scientific studies have shown that this plant is very rich in proteins, minerals, and vitamins [6,7,8]. The general objective of this study is to assess the impact of using *Moringa Oleifera* on the zootechnical performance of broilers.

2 Materials and Methods

2.1 Geographic location and climate

Korhogo is the fourth largest city in Côte d'Ivoire in terms of population and economy. It is located in the north of the country (Figure 1) with a surface area of 12 500 km², i.e., 3.9% of the national territory, for a population of 536 851 inhabitants, of which 286 071 inhabitants live in the commune of Korhogo. The climate of Karakoro is characterized by a tropical Sudanese-Guinean climate, marked by two main seasons, a rainy one from May to October and a dry one from October to April. The dry season is marked by the harmattan from December to February, as well as by heat peaks in March and April. Average annual temperatures during the harmattan season are around 29°C, and 25°C in the rainy season. The average annual temperature is then 26.7°C and annual rainfall varies between 1,200 mm and 1,400 mm [3].

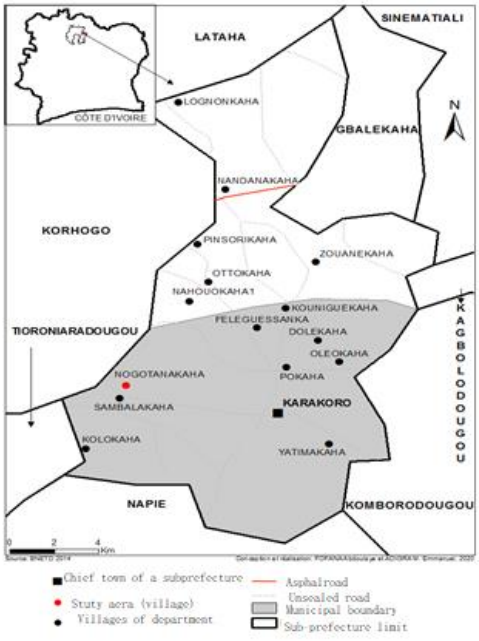

Figure 1: Map of sub-prefecture of Karakoro [9].

2.2 Biological material

The biological material consisted of Cobb 500 broilers and *Moringa Oleifera* leaves collected from the farm field. The trial involved 200 broiler chicks of the Cobb 500 strain divided into four batches of 50 birds each.

2.3 Experimental Device

During the start-up phase from day 1 to day 21 of age, a commercial feed was used to feed the different batches. From the 4th week of age, which marks the growth phase, the experimental diets used were formulated using industrial growth feed and dried *Moringa Oleifera* leaf meal in differentiated contents of 0; 1; 2, and 4% respectively to the four feed rations. The mixing of these feed rations was done manually until a homogeneous compound was obtained. These feeds were packed in bags and stored on pallets in the well-ventilated and dry farm shop.

Before the chicks arrived, troughs and feeders were installed in the different boxes. Rice husk bedding was spread in each box before the chicks were placed in their flocks. Upon arrival, the 200 chicks, with an average weight of 40 g/subject, were physically examined to ensure their physical fitness. These chicks were randomly divided into four batches of approximately equal weight, each containing 50 chicks and corresponding to the four feed treatments of batch 1, batch 2, batch 3, and batch 4, occupying pens 1, 2, 3, and 4 respectively. The feeding trial was started at 22 days of age with a density of 10 birds/m².

The formulated feed was weighed and distributed to each batch twice a day, in the morning at 8 am and in the evening at 4 pm. Water is permanently available in the troughs in each house and the birds in each house drink as much as they want. The broilers were vaccinated against Newcastle disease and Infectious Bronchitis on day 5 and the booster was given on day 28. Vaccination against Gomboro disease and the booster was carried out on days 14 and 21 respectively.

2.4 Preparation of *Moringa Oleifera* Leaf Powder and Feed Formulation

Fresh *Moringa oleifera* leaves harvested each weekend are dried in the shade in a well-ventilated and protected building for 2 days. The leaves are turned over to allow even drying and exposed to the sun the following day for 15 minutes before grinding. The dried leaves are placed in a 4 mm mesh sieve. Pressing the palm of the hand on the leaves in the sieve yields the *Moringa oleifera (M. oliefera)* powder collected in a container.

The formulation of the test feed was carried out in proportion to the percentage of M. oleifera powder to be included in the basic industrial feed. The control feed is made up of industrial feed only for the control batch, the batch 1 feed is made up of 99 % industrial feed and 1 % M. oliefera, the batch 2 feed is made up of 2 % *M. oliefera* and 98 % industrial feed. For batch 3, 4 g of *M. oliefera* powder is integrated into 96 g of industrial feed

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2.5. Equations of the studied parameters

2.5.1. Feed consumption (FC)

The daily feed consumption per bird is determined by dividing the amount of feed distributed per batch by the number of chickens present [8].

$$FC = \frac{quantity\ of\ food\ distributed}{number\ of\ subjects\ present} \quad (1)$$

2.5.2. Average Weight (AW)

The average weight of the hens is determined by dividing the sum of the weights of the individuals in the same batch by their number according to the following formula.

$$AW(g) = \frac{sum\ of\ masses\ of\ weighed\ individuals}{total\ number\ of\ weighed\ individuals} \quad (2)$$

2.5.3. Average Daily Gain (ADG)

This parameter represents the daily weight gain of a subject. It is used to monitor the growth rate of the subjects.

$$ADG\ (g/d) = \frac{final\ weight\ -\ initial\ weight}{number\ of\ days} \quad (3)$$

2.5.4. Consumption index (CI)

The Consumption index is the quantity of feed consumed to obtain 1 kg of live weight. It is calculated as the average quantity of feed consumed during a period over the average weight during the same period.

$$CI = \frac{quantity\ of\ food\ consumed\ (g)}{average\ weight\ during\ the\ same\ period\ (g)} \quad (4)$$

2.5.5. Mortality rate (MR)

The mortality rate is an important factor in profitability as it influences both the feed conversion ratio and the cost of production of chickens. It is calculated according to the following formula.

$$MR = \frac{number\ of\ dead\ chickens}{initial\ number}\ X\ 100 \quad (5)$$

2.5.6. Carcass yield (CY)

The Carcass Yield is a measure of the quality of the carcass. It is the ratio, expressed as a percentage (%), of the carcass weight to the live weight of the animal at slaughter.

$$CY = \frac{Carcass\ weight}{live\ weight\ at\ slaughter}\ X\ 100 \quad (6)$$

2.6. Assessment of Carcass Extremity Colouration

The assessment of the color of the carcass extremities (beak and legs), skin, and abdominal fat was based on the intensity

of the yellow color [6]. A score ranging from 1 to 4 was assigned according to the intensity of coloration:

- ✓ no yellow staining
- ✓ low yellow coloration
- ✓ medium yellow coloring
- ✓ strong or dark coloration.

2.7. Data treating

The data collected were entered using Microsoft Excel. The data underwent basic descriptive analyses such as means, standard deviations, and proportions of the variables studied. The Khi-square test was used to compare the results. These different analyses were carried out using XlStat software version 2018.

3 RESULTS

3.1. Food consumption

The food consumption of the subjects of the different batches and food treatments is shown in table I. From week 1 to week 3, the food consumption of the different batches evolved in an identical manner. As soon as *Moringa Oleifera* leaf meal was added to the ration from the 4th to the 7th week of age, the feed consumption decreased. It was respectively in batch 2 (2803.66 g/d), batch 3 (2755.83 g/d) and batch 4 (2719.66 g/d) compared to batch 1 control (2835.83 g/d) at week 4 and in batch 2 (5088 g), batch 3 (5053 g) and batch 4 (5031.83 g) compared to batch 1 (5145 g) at week 7. The highest food consumption was observed in batch 1 (5145 g) and the lowest was recorded in batch 4 (5031.83 g). However, statistical analysis revealed no significant difference (p>0.05) in feed intake between the different batches.

Table 1: Feed consumption of chickens

Age (Week)	Batch 1 Control	Batch 2	Batch 3	Batch 4	P-value
S1	565.5±14.66	569±14.86	566.33±15.15	568.5±15	0.089
S2	1294.5±19.25	1289.33±19.85	1106.33±19.72	1285.83±20.33	0.076
S3	2095.66±15.06	2093.50±14.08	2093.83±14.93	2091.16±13.86	0.772
S4	2835.83±25.67	2803.66±23.29	2755.83±25.24	2719.66±26.06	0.923
S5	3556.66±19.46	3535.00±19.43	3494.33±18.26	3493.00±17.20	0.998
S6	4402.00±22.02	4368.83±21.04	4343.66±18.31	4319.83±18.52	0.999
S7	5145.00±27.64	5088.00±25.00	5053.66±22.26	5031.83±19.26	0.998

3.2. Average weight

The evolution of the live weight of the chickens fed with the different feeds is presented in figure 2. An improvement in the average live weight was observed immediately after the introduction of *Moringa oleifera* leaf meal in the chickens' ration, depending on the incorporation rate.

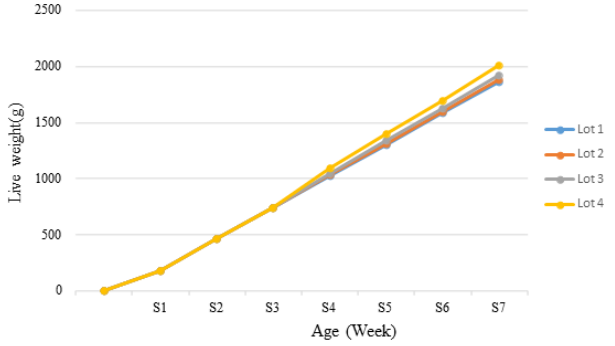

Figure 2: Evolution of the average live weight of chickens per treatment

At seven weeks of age (49 days), the weights were respectively 1860.85 ± 30.49 g; 1879.45 ± 30.79 g; 1916.98 ± 31.41 g; 2010.96 ± 44 g for the treatments of batch 1, batch 2, batch 3 and batch 4. Comparison of these mean weights revealed no significant difference (p>0.05) between the weights of the chickens in the different batches. However, the average weights recorded for the birds in batches 3 and 4 were slightly higher than those in batches 1 and 2.

3.3. Average Daily Gain

The results relating to the Average Daily Gain (ADG) of the subjects subjected to the different feed treatments are presented in Table 2. From the 1st to the 3rd week of age, the ADG of the different batches evolved in an identical way. The incorporation of *Moringa Oleifera* leaf meal into the broiler ration from the beginning of the 4th week of age resulted in an improvement in the ADG of the broilers in batch 2 (40.53 g/d), batch 3 (41.33 g/d), and batch 4 (45.26 g/d) compared to the control batch (40.12 g/d). From week 4 to week 7, chickens in lot 1 and lot 2 had approximately the same ADG with 39.64 g and 40.90 g for week 4 and 40.12 g and 40.53 g for week 7 respectively. For the chickens in batch 3 and batch 4, the ADG s were close with an average difference of 4 g/d. The ADGs for batch 3 and batch 4 were 43.73 g and 49.66 g respectively at week 4 and 41.33g and 45.26 g at week 7. At week 7, the highest ADG has recorded with the batch 4 subjects (45.26 g) and the lowest was observed in the control batch (40.12 g). There was no significant difference (p>0.05) between the ADG of the different batches.

Table 2 : Average Daily Gain (ADG) of chickens

Age (Week)	Batch 1 Control	Batch 2	Batch 3	Batch 4	P-value
S1	25.56±4.28	25.66±4.45	25.59±4.36	25.66±4.44	1
S2	40.32±0.004	40.35±0.011	40.40±0.014	40.32±0.052	1
S3	40.02±0.017	40.08±0.091	40.40±0.014	40.03±0.024	0.887
S4	39.64±0.034	40.90±0.072	43.73±0.197	49.66±0.365	0.962
S5	40.19±0.031	40.61±0.014	41.60±0.077	43.34±0.054	1
S6	39.96±0.027	40.34±0.011	41.21±0.037	42.98±0.128	0.998
S7	40.12±0.022	40.53±0.027	41.33±0.027	45.26±1.47	0.995

3.4. Consumption Index

The Consumption indexes of the different batches of broilers were 2.76, 2.70, 2.63 and 2.5 for batch 1, batch 2, batch 3 and batch 4 respectively (Table 3). As the incorporation rate of *Moringa Oleifera* in the diet increased, the feed conversion ratio decreased. No significant difference (p>0.05) between the feed conversion ratios of the different batches was observed.

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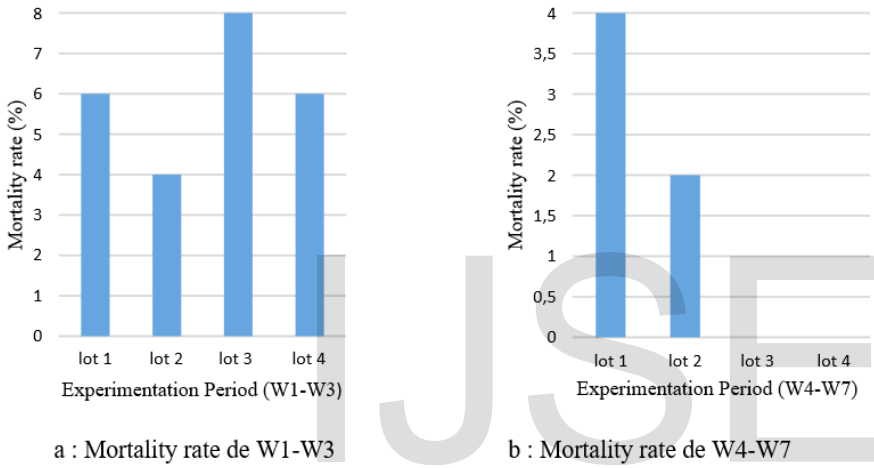
3.5. Mortality Rate

During the start-up phase from the 1st to the 3rd week of age, the mortality rate recorded was 6 %; 8 %; 4 % and 6 %

respectively for broilers in batch 1, batch 2, batch 3 and batch 4 (Figure 3). For the growth and finishing phases, from the 4th to the 7th week of age, batch 3 and batch 4 did not record any mortality. On the other hand, batches 1 and 2 recorded mortalities of 4% and 2% respectively.

Table 3: Consumption Index of chickens

Age (Week)	Batch 1 Control	Batch 2	Batch 3	Batch 4	P-value
S1	3.16±0.47	3.17±0.47	3.16±0.49	3.16±0.48	0.998
S2	2.80±0.62	2.78±0.63	2.39±0.64	2.78±0.66	0.999
S3	2.82±0.49	2.81±0.46	2.82±0.48	2.81±0.45	1
S4	2.78±0.83	2.72±0.75	2.62±0.79	2.49±0.78	1
S5	2.73±0.63	2.69±0.62	2.60±0.58	2.50±0.52	1
S6	2.78±0.71	2.73±0.67	2.66±0.57	2.54±0.55	0.998
S7	2.76±0.90	2.70±0.81	2.63±0.70	2.50±0.43	1



a : Mortality rate de W1-W3 b : Mortality rate de W4-W7

Figure 3 : Mortality rates during the experimental period

3.6. Carcass Characteristics

The incorporation of Moringa leaf meal led to an improvement in carcass weight at 7 weeks of age in the broilers of batches 2, 3 and 4 compared to batch 1 control. In addition, the incorporation had no adverse effect on the carcass yield of the broilers fed with the Moringa leaf meal supplement and on organ weights (Table IV). The highest carcass yield was recorded in batch 4 (79.96%) and the lowest in batch 2 (77.37). However, the coloration of the skin and abdominal fat of the carcasses was more visible in the chickens fed 4% *Moringa Oleifera* leaf meal compared to the controls. The yellow coloration of the legs, beak and skin was more pronounced in broilers fed a diet containing *Moringa Oleifera* leaf meal compared to controls that did not undergo any changes (Table IV). The numbers 1, 2, 3 and 4 indicate no yellow coloration, slight yellow coloration, medium yellow coloration, and dark yellow coloration, respectively.

Table 4: Carcass and organ characteristics

Characteristics	Batch 1 Control	Batch 2	Batch 3	Batch 4
PV (g)	1727.32	1761.17	1793.87	1887.92
PC (g)	1346.57	1362.69	1409.03	1502.88
RC (%)	77.95	77.37	78.54	79.96
Skin Color	1	2	3	3
Abdominal fat color	1	2	2	3
Legs	2	2	4	4
Beak	1	2	3	4

4. DISCUSSION

The incorporation of Moringa Oleifera leaf meal into the broiler ration reduced feed consumption (FC) non-significantly, especially in subjects receiving the respective rations of batch 2, batch 3 and batch 4 compared to batch 1 control. The decrease in feed intake was more pronounced the higher the incorporation rate of *Moringa Oleifera* meal. This result is similar to those of Mukhtar [10] and Loukou *et al*. [11], who observed that incorporation of bissap seeds at an inclusion rate ranging from 0 to 22 % resulted in a sharp decrease of 13 to 66 % in individual food consumption. Similar decreases observed in subjects fed with *Moringa leaf meal* could be explained by the lack of palatability of the leaves. Foidl *et al.* [12] and Pamo *et al.* [13] noted that chickens do not voluntarily consume fresh or dried *Moringa Oleifera* leaves. However, when mixed with other ingredients, these leaves are consumed by the birds, while their high content in rations decreases their feed intake. This could be due to the presence of tannin, which gives the Moringa leaf a bitter taste [14].

The incorporation of Moringa oleifera leaf flour resulted in a non-significant improvement in live weight. This can be explained by the fact that the supplemented feed is well processed and assimilated by the chickens. It seems to be of better quality and better used by the broilers to increase growth. This result is similar to those obtained by Tendonkeng *et al.* [15] who showed that low levels (5-10%) of *Leucaena leucocephala* leaf meal in the feed of laying hens resulted in an improvement in live weight compared to the control. *Moringa Oleifera* leaf powder in the chicken feed resulted in an overall non-significant improvement in the ADG of the birds in the different feed treatments compared to the control. In addition, the incorporation of *Moringa Oleifera* leaves had no negative effect on the ADG. This result is in line with those of Ndong *et al.* [16] who showed that the incorporation of up to 6% of Moringa Oleifera leaf meal in the broiler finishing ration as a substitute for soybean meal had no negative effect on the ADG.

The incorporation of *M. oleifera* leaf meal into chicken feed also improved consumption index. These results are similar to those of Bello [6] who showed that the inclusion of *M. oleifera* leaves in the feed of local chickens improved the consumption index up to 24% of incorporation, compared to the control. They corroborate those of Olugbemi *et al.* [17], Brou *et al.* [18]) and Adouko *et al.* [8], who observed improved consumption index in broiler chicks and laying hens when incorporating these leaves at a low rate. The results of the present study reveal that increasing incorporation of Moringa Oleifera leaf meal had no significant adverse effect on carcass performance. However, it did promote a light to pure yellow colouration of the skin, leg and beak. These results are like those of Bello [6] who reported that a respective inclusion rate of 0; 5; 10 and 20% in the ration, resulted in a significant improvement in yolk colouration. Furthermore, the attribution of this yolk colouration is due to the existence of pigments (ß-carotenes) in

the leaves of *Moringa oleifera* [7].

The highest mortality rate is recorded during the start-up phase (8%). This could be explained by the stress of transporting and handling the chicks at the facility. During the experimental phase, mortality was only observed in the chicks of batches 1 and 2, i.e. 1.5%. Overall, the incorporation of M. oleifera leaf meal favoured a decrease in the mortality rate of the chicks. This could be explained by the effect of the vitamins present in these leaves on the strengthening of the immune system [19].

5. CONCLUSION

The incorporation of *Moringa oleifera* leaf meal in the broiler feed resulted in a non-significant improvement in average live weight, average daily gain and consumption index. Furthermore, carcass characteristics of broilers were not affected with the incorporation of M. oleifera leaf meal up to 4% in the ration. It induced a non-significant increase in carcass and organ weights, with the highest values in the batch 4 treatments and the lowest in the controls. In addition, the yellow colouration of the skin and abdominal fat was more pronounced with the incorporation of *M. oleifera* leaf meal into the chickens' diet, especially at 4% inclusion. This incorporation of *Moringa oleifera* leaf meal resulted in a non-significant decrease in feed intake in batches 2, 3 and 4 compared to the control batch 1 during the 4-week trial. *M. oleifera* leaf powder could be used as an alternative to the substitution of protein of oleaginous origin in the ration of broilers at a moderate dose because it favors a good consumption rate, a good daily weight gain, a better-quality weight yield and a considerable decrease in mortality rate.

CONFLICT OF INTEREST

No conflict of interest exists between the different authors.

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