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Evaluation of the Nutritional Effect of *Moringa oleifera* Leaf Powder on the Growth of Traditional Chickens in Northern Côte d'Ivoire

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Abstract The search for better zootechnical performance is a major stake in the strategy for the development of animal resources in Côte d'Ivoire. The present study aims at improving the nutritional status of traditionally reared poultry using feedstuffs containing *Moringa oleifera* leaf powder, a plant with appreciable levels of micronutrients. The study was carried out on traditional chicks reared in a total confinement farm from March to June 2019 in the municipality of Korhogo in northern Côte d'Ivoire. Ninety 14-day-old traditional chicks were equitably divided into 3 lots and then fed for 12 weeks on diets based on single maize bran (lot 0 or control) or supplemented with *M. oleifera* leaf powder at 5% (lot 1) and 10% (lot 2) incorporation rates. The study showed that the incorporation of *M. oleifera* powder in the ration significantly ($p<0.05$) improved the live weight of the chickens, with means of 699.81 ± 31.28 g and 633.43 ± 135.44 g for the individuals in lots 1 and 2, respectively, compared to 557.40 ± 100.24 g for the control lot. *M. oleifera* also improved the average daily gains (ADG) of chickens in lot 1 (7.23 g/d) and lot 2 (6.34 g/d) compared to the control lot (5.80 g/d). This supplementation was beneficial on the feed conversion of the chickens, estimated at 9.55 and 10.82 for 5% and 10% of *M. oleifera* compared to 11.14 for the feed without the supplement. The incorporation of *Moringa oleifera* leaf powder in growth-type feeds, especially at the 5 % level, could therefore be recommended in local traditional chicken farming.

Keywords: *Moringa oleifera, animal nutrition, local poultry, zootechnical performance, Côte d'Ivoire*

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1. Introduction

Despite the remarkable progress made by modern poultry farming, traditional poultry farming accounts for more than 65% of egg and chicken production in West Africa [1,2]. In Côte d'Ivoire, as elsewhere in tropical Africa, extensive traditional chicken farming is a widespread activity, particularly in rural areas where it is practiced in each family [3,4]. Traditional poultry farming accounts for 70% of the total national poultry population [5]. However, its productivity remains low due to the lack of improvement in its management [6]. Strengthening the production of this important local animal resource is therefore necessary for food security in terms of animal protein in Côte d'Ivoire, where dependence on hinterland countries remains a concern [7]. Indeed, in addition to the quantitative preponderance of traditional poultry farming, traditional chickens from this form of farming have organoleptic qualities that better meet consumer expectations than broilers from modern farms [8,9].

In the municipality of Korhogo, traditional poultry farming is carried out with little quality feed, but with acquisition costs representing 60% to 70% of the total production cost [10,11]. In this traditional system, chickens are generally fed on bran or maize grain, feeds with low levels of protein, minerals and vitamins [10,11,12]. As a result, the expression of the genetic potential for growth and maintenance of traditional chickens is significantly affected, reducing their productivity and profitability.

A diet rich in growth nutrients that is available and accessible at low cost to local rural poultry producers can significantly support the traditional Ivorian poultry industry. For this reason, the incorporation of local products, such as *Moringa oleifera* leaf powder, in the feed rations of traditionally reared poultry is conceivable given the multiple nutritional and therapeutic potential of this plant [13]. *M. oleifera* is one of the best tropical vegetables. It is an excellent source of vegetable protein,

with levels ranging from 19% to 35% dry matter depending on the plant organ and the region of production [14,15]. Its leaves contain considerable concentrations of minerals (Fe, Ca, Zn, Se, etc.), vitamins (A, B, C, E, etc.) and are rich in β-carotene [16,17]. Fortification of human food with *M. oleifera* leaves has been found successful by some authors [18]. However, the use of *M. oleifera* leaves in feed fortification of traditionally raised poultry is still poorly documented. The present study is a contribution to the valorization of local plant products in traditional poultry farming. It consists in determining the effect of *M. oleifera* leaf powder on feed intake and weight gain of traditional chickens in total confinement.

2. Materiel and Methods

2.1. Study Site

The study took place in a traditional poultry farm in Premafolo, a district on the outskirts of the city of Korhogo (Figure 1) located in the north of Côte d'Ivoire, between 5°16 and 16°16 west longitude and between 8°32 and 10°20 north latitude. This area has a tropical climate of the Sudano-Guinean type with two seasons characterized by a dry period and a rainy period. The dry season extends from November to April and is marked by a hot, dry wind between December and January (harmattan); while the rainy season extends from May to October, with rainfall estimated at between 1300 mm and 1400 mm and evenly distributed. This region is consisted mainly of savannah formations [19].

2.2. Biological Material

The biological material used consists essentially of 90 local reared chicks acquired one day after hatching of eggs in an incubator and from a traditional rearing in the municipality of Korhogo.

2.3. Experimental System

A well-ventilated 27 m^2 building at the end of the farm was used for the study. Prior to the test, a crawl space in the building was created using disinfectants to eliminate parasites (mites, bacteria and viruses) from the farm. The building was then subdivided into 3 boxes of 9 m^2 each with a height of 2 m in order to provide the same rearing conditions for the fowl. Each lodge was equipped with litter (rice husks), watering and feeding troughs. Then, the 90 chicks were divided into three homogeneous lots of 30 chicks and placed in the boxes. Thus, one lot was considered control and scored as lot 0, while the other two test lots were scored as lot 1 and lot 2.

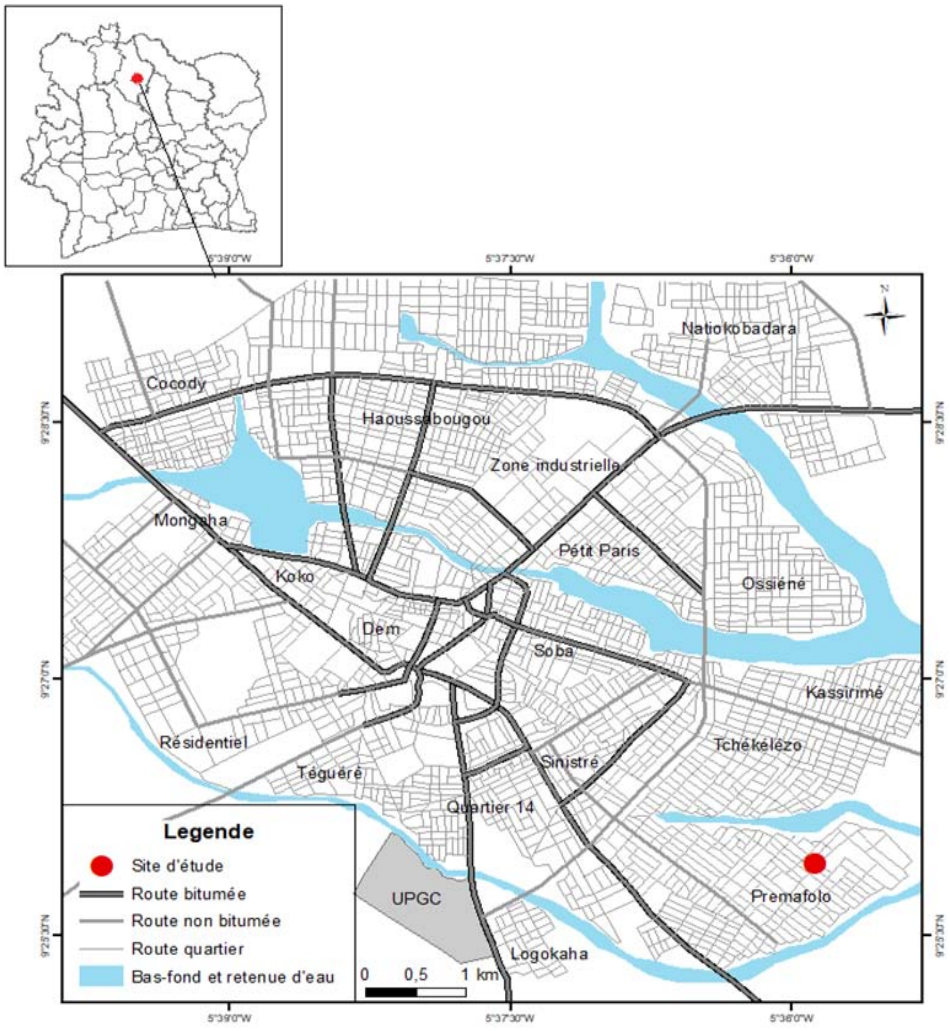

Figure 1. Geographic location of the study site in the city of Korhogo

Table 1. Food ration for subjects according to age and average weight

Age (week)	1	2	4	6	8	10	12
Food (g/suject/d)	15	25	25	30	50	50	50
Average weight (g)	70-100	110-145	190-210	260-290	340-370	430-460	560-700

2.4. Management of Rearing

The trial was conducted in total confinement where subjects were raised in a semi-intensive system.

The staple food for rearing was corn bran from the local mills in the municipality. For enrichment, the staple food was supplemented with *M. oleifera* powder obtained locally by grinding young leaves of the plant in mortar and drying them in the shade. The powder obtained is packaged in dry plastic bags with a one-month shelf life. Three (3) types of feed have been formulated according to the incorporation rate of the *M. oleifera* powder (*M. oleifera* mass / total mass) and the lot of chicks to be reared. Thus, the incorporation rates of 0%; 5% and 10% *M. oleifera* were set for the chicks of lots 0, 1 and 2 respectively. These feeds were formulated by weighing with the help of scales and then distributed in equal quantities to the different lots at the rate of two intakes per day (07:00 and 12:00) following the standard rationing model [20] in force in Côte d'Ivoire (Table 1). The chicks of each lot received daily drinking water at will in the drinking troughs. In addition, the rearing equipment was regularly disinfected and the standard prophylactic calendar for chickens was followed during the trial to prevent various avian diseases such as Newcastle and Gomboro.

2.5. Data Collection on the Rearing Dynamics

After food intake, leftover (uneaten) food as well as subjects from each lot were weighed daily and weekly, respectively. The individual weightings were performed using an electronic scale with a capacity of 1500 g and an accuracy of 0.01 g. The number of dead subjects per lot per day was recorded regularly. From this data, various zootechnical parameters were determined.

2.5.1. Determination of the quantity of feed ingested

The individual daily feed intake was assessed over the entire duration of the rearing trial. The amount of feed ingested (IAQ or QAI) is determined by the ratio of the total amount of feed ingested by a subject from each lot (in g) to the duration of the trial (in days).

$$QAI\left(g/suject/d\right) = \frac{Total\ individual\ consumption\left(g\right)}{Total\ duration\left(day\right)}.$$

Or:

$$QAI\left(g/suject/d\right) = \frac{\Sigma\left[\frac{QAf\ i - QAr\ i}{Number\ of\ subjects\ in\ period\ i}\right]}{Time\left(day\right)}$$

Where: QAf i = amount of feed supplied at the beginning of period i; QAr i = amount of feed remaining at the end of period i

2.5.2. Determination of Average Daily Gain

The Average Daily Gain (ADG) indicates the average rate of weight growth of the subject per unit of time per day. It was calculated for each lot by the ratio of the weight gain (difference between the average weight at the end of the period and the average weight at the beginning of the period) to the number of days in that period.

$$GMQ\left(g/d\right) = \frac{Pmf - Pmi}{Time} = \frac{Weight\ gain}{Time}$$

Where: Pmi = average weight at the start or beginning of the period in g; Pmf = average weight at the end of the period in g, Time = period length in days.

2.5.3. Determination of the Consumption Index

The Consumption index (CI) is the ratio that measures the conversion of the amount of food consumed to body live weight. It is calculated as the ratio of the amount of food ingested over a given period of time to weight gain over the same period of time.

$$CI = \frac{Quantity\ of\ food\ consumed\left(g\right)}{Weight\ gain\left(g\right)}.$$

2.5.4. Determination of the Death Rate

The death rate (DR) of subjects in each lot was calculated by age group and expressed as a percentage, taking into account the initial number of subjects and deaths during a follow-up period.

$$DR\left(\%\right) = \frac{Number\ of\ dead\ subjects\ x\,100}{Initial\ number\ of\ subjects}.$$

2.6. Statistical Analysis

The data of the various zootechnical parameters collected were subjected to statistical processing with the STATISTICA 7.1 software. Elementary descriptive analyses (average, frequency and standard deviation) were carried out. Subsequently, comparison tests were carried out for each rearing parameter with a statistical probability of 5% by means of a one-factor analysis of variance (enrichment rate) followed by classification with the Tukey HSD model.

3. Results

3.1. Effects of Feed Type on the Zootechnical Performance of Traditional Chickens

3.1.1. Food Intake

Over the duration of the trial, the average amounts of food ingested per subject per day in the different lots were similar regardless of the rate of incorporation of *M. oleifera* into the staple food (Figure 2). No significant

differences were found. These subjects consumed an average of 43.12 g/day.

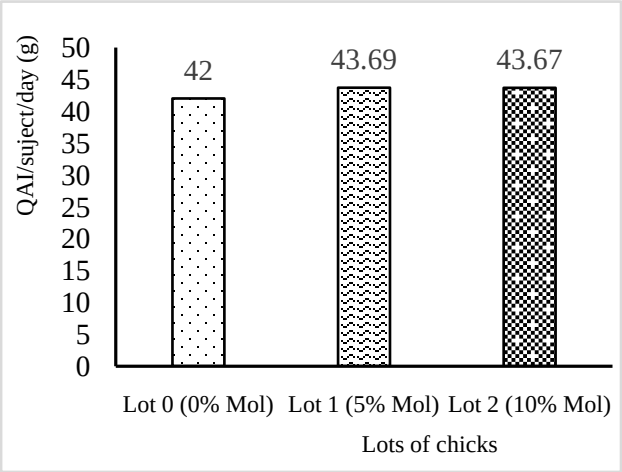

Figure 2. Average feed intake per subject per day according to the incorporation rate of *Moringa oleifera* (Mol) for rearing chicks in total confinement.

3.1.2. Average Live Weight and Average Daily Weight Gain of Chickens

The evolution of live weight of traditional chickens showed a slow growth of chicks from each lot from the 1st week to the 7th week of rearing (Figure 3). During this period, all three lots of chicks had similar growth. However, from the 8th week onwards, a rapid weight change was observed in the subjects of the different lots. The results show that the weights of the lot 1 chicks' fed with maize bran supplemented with 5% M. oleifera were higher than those of 0% and 10% after 7 until 12 weeks.

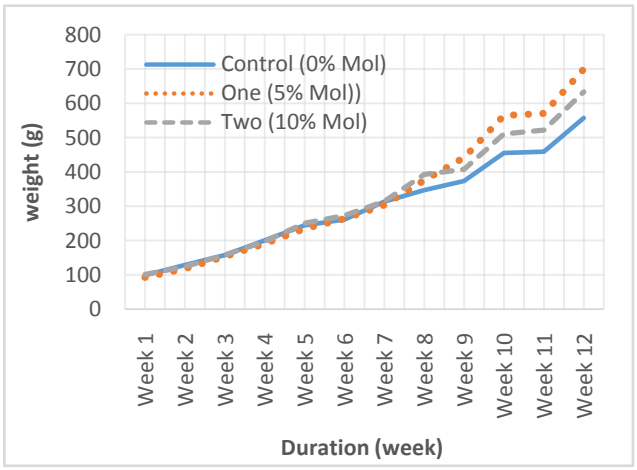

Figure 3. Growth curves of the three lots of traditional chicken during 12 weeks

The average weights recorded during the experiment were shown in Table 2. One can see that in each lot, there is no significant difference from week 1 to week 7. However, the average weights of the chicks in each lot increased significantly from week 8 to week 12 ($P < 0.05$). The data also showed that lot 1 had the highest average weight in this second period of the trial.

Table 2. Comparison of average weights of the three traditional chicken lots

	average weights (g)					
Lots	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Control (0% *Mol*)	98,57^{a} ±32,30	128,63^{a} ±33,90	157,53^{a} ±37,80	200,47^{a} ±45,70	244,07^{a} ±56,11	261,13^{a} ±61,34
One (5% *Mol*))	92,89^{a} ±30,26	118^{a} ±33,21	153,59^{a} ±39,40	190,81^{a} ±50,77	234,81^{a} ±65,44	263,59^{a} ±75,87
Two (10% *Mol*)	100,93^{a} ±32,24	123,75^{a} ±39,79	158,04^{a} ±46,12	197,04^{a} ±51,81	250,39^{a} ±60,29	272,50^{a} ±69,54
Lots	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12
Control (0% Mol)	313,27^{a} ±62,43	346,87^{a} ±72,09	373,63^{a} ±76,39	455,07^{a} ±91,37	458,83^{a} ±94,64	557,40^{a} ±100,24
One (5% *Mol*)	303,78^{a} ±82,72	375,70^{ab} ±86,98	441,89^{b} ±105,37	564,74^{b}±106,57	570,37^{b} ±110	699,81^{c} ±131,28
Two (10% *Mol*)	314,32^{a} ±75,42	392,82^{b} ±81,07	407,68^{ab} ±79,97	510,79^{b} ±110,31	521,82^{b} ±107,35	633,43^{b} ±135,44

The values assigned to different letters are significantly different at the 5% threshold.

Table 3. Comparison of average weights of the three traditional chicken lots

Age (week)	GMQ (g/d)		
	Lot 0 (Control, 0 % *Mol)*	Lot 1 (5 % *Mol*)	Lot 2 (10 % *Mol*)
1st	4,29	3,59	3,26
2nd	4,13	5,08	4,90
3rd	6,13	5,32	5,57
4th	6,23	6,29	7,62
5th	2,44	4,11	3,16
6th	7,45	5,74	5,97
7th	4,8	10,27	11,21
8th	3,82	9,46	2,12
9th	11,63	17,55	14,73
10th	1,97	2,23	1,58
11th	12,65	15,67	13,60
12th	4,08	1,40	2,35
Average	5,80^{a}	7,23^{a}	6,34^{a}

The values assigned to different letters are significantly different at the 5% threshold.
The values affected by the same letter are not significantly different at the 5% threshold.
Moringa oleifera (Mol)

The daily weight gain of traditional chickens in this experiment was estimated per lot for each week (Table 3). Weekly values of GMQs ranged from 1.97 g/d to 12.65 g/d for the control lot; from 1.40 g/d to 17.55 g/d for the subjects fed with 5% *M. oleifera* incorporation and from 1.58 g/d to 14.73 g/d for the lot with 10% *M. oleifera*, without showing any particular clear trend. Thus, Table 3 shows that the overall average daily average gain of the subjects up the 12 weeks of the rearing trial is estimated to be 5.80 g/d, 7.23 g/d and 6.34 g/d for the control, lot 1 and lot 2, respectively, with no significant difference between treatments (P>0.05).

3.1.3 Consumption index

The consumption index (CI) of traditional chickens obtained in the control, lot 1 and lot 2 during the experiment were 11.14, 9.55 and 10.82, respectively. Comparison of these indices show no significant difference. However, the subjects in lot 1 provided the highest number (Figure 4).

3.2 Effect of the Incorporation of *Moringa oleifera* on the Death of Chickens

At the end of the experiment, the number of dead subjects record was up to 18, with a death rate of 20%. When comparing the death rates between the different lots of the trial no significant differences were observed. However, a high death rate (33.43%) was observed in subjects from lot 2 (Figure 5).

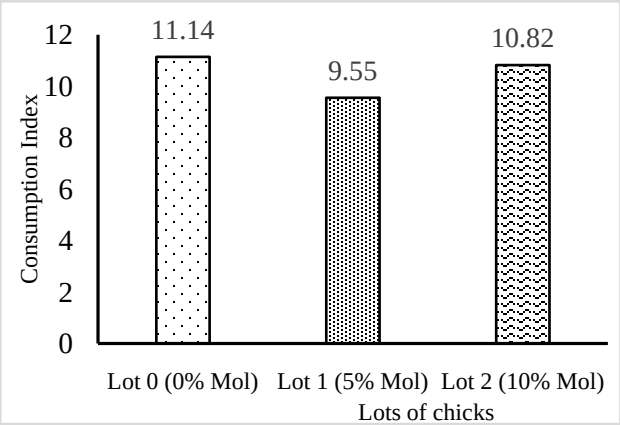

Figure 4. Average consumption index of different lots of traditional chickens *Moringa oleifera* (Mol)

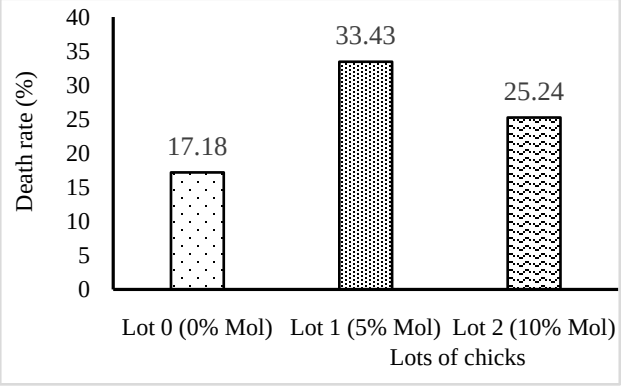

Figure 5. Average death rate per lot during 12 weeks *Moringa oleifera* (Mol)

4. Discussion

The addition of *M. oleifera* leaf powder (5% or 10%) to the maize bran did not significantly change the quantity of feed ingested by the local chickens. Depending on the method of incorporation used in the study, this feed additive therefore had no influence on the feed attraction of the local chickens. This observation could be justified by the fact that incorporation rates of 10% or less are not able to generate a significant change in the appearance of the feed presented to the reared subjects.

During the rearing of traditional chickens for 7 weeks, a slow growth was observed, in spite of the presence of M. oleifera in their feed, suggesting that is primary due to the young age of the chickens and secondly to the difficult processing of the feed ingested by the chicks. The average weights of the various lots were not significantly different during this first period, suggesting an adaptative phase of growth. On the other hand, from the 8th week which marks the beginning of the second period, the growth of the subjects was rapid and sustained until the end of the trial. Subjects at this age assimilated the feed more efficiently, with better results in lots 1 and 2 fed with 5% and 10% *Moringa oleifera* incorporation respectively. In this case it is plausible that *M. oleifera* powder had a significant effect on the growth of these subjects compared to the control lot. These results are similar to those of Mutayoba *et al.*, [21] who, by incorporating Leucaena leucocephala powder in the feed of laying hens at low levels (5-10%) observed an improvement in the live weight of the subjects compared to the control. The best growth was observed in subjects from lot 1 where the incorporation rate of *M. oleifera* was low (5%). The same observation was made by Tendonkeng *et al., [22]* who by incorporating 6% *M. oleifera* leaf powder in the finishing ration of broilers observed an improvement in the live weight of the chickens.

M. oleifera leaf powder in the feed ration of conventional chickens improved daily weight gain (DWG) during the same period (8 to 12 weeks of age) compared to the control lot. In addition, the low incorporation rate of *M. oleifera* (5%) resulted in a greater increase in weight gain in the chickens compared to the 10% incorporation of. The 5% *M. oleifera* incorporation rate would therefore be more advantageous for the flock than the 10% incorporation rate. Several authors have reported the positive effect of introducing low levels (5-6%) of *M. oleifera* leaf powder on QGMF in broilers [15,22,23]. On the other hand, by increasing the incorporation rate to 10%, *M. oleifera* powder has a depressant effect on daily weight gain, as observed by Buldgen *et al.*, [24] and Ali [25] in broiler feed ration studies. Similarly, Satyanarayana *et al.*, [26], Hussain *et al.*, [27] and Vohra *et al.*, [28] found a decrease in QGW by incorporating higher levels (12-20%) of Leucaena leucocephala powder in the broiler ration.

The best consumption index was obtained with a low level (5%) of *M. oleifera* in the feed ration of local chickens, although the difference between the indexes of 11.14, 9.55 and 10.82 with respectively 0%, 5% and 10% incorporation was not significant at the 5% threshold. These data are consistent with the work of Limcangco-Lopez [23], Tendonkeng *et al [22]* and Olougbemi *et al*,

[15] who showed that incorporation of *M. oleifera* at a low rate (5-6%) in the diet of broiler and layer chicks improved their consumption index.

The death rate observed in subjects fed *M. oleifera*-enriched diets ranged from 20-35% over the 12-week trial period. This rate is explained by the rearing system used (total confinement), which is a system for controlling the feeding and health of the subjects. This death rate is lower than the one observed in the natural condition of local chickens. Moreover, reports by Laurenson [29] stipulate that traditional chicks feeding on food waste and residues in total confinement in the wild (extensive system) are subject to a greater risk of death (65% to 70%) between 0 and 2 months of age.

5. Conclusion

The use of *Moringa oleifera* leaf powder in the feed ration of traditional chickens significantly improved their growth especially during the period from the 8th to the 12th week of age, especially in the reared subjects rationed with 5% (699.81 g) and 10% (633.43 g) of Moringa compared to the control lot (557.40 g). Moringa incorporation also improved the GMQs in the subjects (7.23 g/d and 6.34 g/d) compared to the control lot (5.80 g/d). Furthermore, this incorporation had a greater positive effect on the consumption index when performed at low levels (5%).

The incorporation of a low rate (5%) of *Moringa oleifera* leaf powder in the feed ration had a positive effect on growth performance in traditional chickens. This technology could therefore be extended to traditional chicken farming systems.

Statement of Competing Interests

The authors have no competing interests.

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