

## Impact of the addition of grasshopper meal (*Tettigonia viridissima*) to the diet of young Broiler chickens in Mahagi, Democratic Republic of Congo

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**Abstract:** Improvement of poultry farming by providing nutritional quality based on local ingredients. We closely examined the zootechnical performance induced by this inclusion, as well as the ration losses resulting from different feed formulations. The 12-day-old chicks placed in pens were gradually accustomed to local food and then divided into groups according to diets. The growth of the chicks was monitored by weekly measurements carried out on a sample of 15 chickens randomly selected from a batch of 20 chicks per test.

63 days later, an average weight gain of 2591g was noticed. The initial hypotheses are confirmed. It should be noted that feeds with 15% grasshopper meal gave the best zootechnical performance, with a higher live weight than other formulations. The exception was ration losses in tests where grasshopper meal was present at a lower rate (5%) or absent. These results prove the effectiveness of integrating grasshopper meal into the *Broiler* diet, both in terms of performance and reduction of ration losses, thus paving the way for new feeding practices in local livestock farming.

**Keywords:** Impacts, flour, grasshopper (*Tettigonia viridissima*), food, Broiler Mahagi, DRC.

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## 1. Introduction

Chicken farming has been the subject of numerous studies, demonstrating that it is not the first to undertake research in this field. Among these seminal works, we can mention Bessa (2019) who studied the poultry sector in the Tizi-Ouzou region, revealing a variation in slaughter weight due to the age of the animals and the breeding conditions. Kenzi and Mahaj. (2015) examined the maize-based feeding of chickens, concluding that supplementation with 25% maize reduces rearing costs and improves slaughter weight. Fwarwinyo (2021) analysed the constraints of chicken farming in Mahagi, highlighting deficient breeding practices and major constraints such as diseases and lack of technical supervision.

Faced with these findings, our research is part of the perspective of contributing to the improvement of local livestock farming by examining the effect of incorporating grasshopper meal into the diet of young Broiler chicks in Mahagi, Democratic Republic of Congo. This approach aims to respond to the challenges of undernourishment and malnutrition, which are widely present in developing countries, particularly in the DRC. The expected results should provide answers to the following questions: Does the incorporation of grasshopper meal improve the zootechnical performance of broiler chicks in Mahagi? Do diets containing this flour lead to less ration loss? Are these formulated diets effective in improving the performance of young birds?

## 2. Materials and Methods

### 2.1. Study environment



The research took place at the University of Lake Albert in Mahagi, located on Paley Hill about 2 kilometers from the center of Mahagi commune. The institution's chicken coop is located at a latitude between 1°54' and 2°54' North, and a longitude between 30°6' and 31°18' East, with an average altitude of 1663 meters. The ecological conditions of this area largely correspond to those of the commune of Mahagi.

As for the commune of Mahagi, it is the capital of the Territory of the same name, one of the five Territories making up the province of Ituri, located in the north-east of the Democratic Republic of Congo, about 180 km from the city of Bunia, and covers an average area of 20 km<sup>2</sup>. Administratively, the commune is delimited as follows: to the east, up to 4 km in the Djupamamba group; to the west, over a distance of 4 km in the Gossi grouping; to the north, 4 km away in the Palara group; and to the south, 5 km away in the Pakwong'a grouping.

It comprises 14 districts and 54 avenues, administered respectively by the district chiefs and the heads of avenues, under the direction of the Mayor of the Commune. The latter was created by the Presidential Ordinance by Order No. 15/013 of 22 July 2015 on the appointment of Mayors and their deputies in the province of Ituri on a provisional basis. To date, the Commune of Mahagi has fourteen districts, subdivided into avenues, the number of which has increased from 15 in 2006 to 54 in 2020 according to the annual report of the Commune of Mahagi

Mahagi Commune enjoys a humid tropical climate characterized by two distinct seasons: a dry season from November to March and

a rainy season from April to October, with an annual rainfall of about 1500 mm. In terms of flora, the vegetation is mainly made up of planted trees such as Eucalyptus, Grevilia, Cyprus, as well as fruit trees such as *Mangifera indica* and *Persea americana*, as well as grassy savannah areas. This plant diversity is influenced by climatic and topographical variations and human activities.

As far as fauna is concerned, the commune is mainly home to domestic species such as goats, sheep, pigs and poultry. However, increasing urbanization and the expansion of human activities have reduced the space available for livestock. Hydrographically, the commune is crossed by several rivers, the main ones being the Ridha River to the northwest, the Aturuba River to the southeast, and the Angiraju and Acana streams, contributing to a diverse hydrographic landscape. Regarding the population, Mahagi is a cosmopolitan entity, mainly populated by the Alur tribe, but also inhabited by various other tribes of the region and the country. This ethnic diversity is reflected in the use of several languages, including Alur, Lingala, Swahili, French and English, contributing to a rich cultural mix.

### 2.2. Material

The biological material consists of 100 12-day-old Broiler chicks, as well as the feed ingredients and technical equipment needed for the furnishing of the barn and other aspects of the experiment.

### 2.3. Methodology

The methodology of this study includes several preparatory steps. First of all, we developed the experimental protocol, studied the site where the chicken coop would be installed, and gathered the necessary equipment for its construction as well as the purchase of the chicks. We also collected relevant information on the rearing of broiler chicks, in particular concerning their environment and the layout of the experimental set-up, as well as on the different feed ingredients.

#### 2.3.1. The experimental setup

Consists of five batches of chicks, each given a different diet. Each batch is represented by a specific combination of grasshopper flour in the feed, ranging from 0% to 20%. The henhouse consists of five lodges, equipped with bedding, feeders, waterers and perches for the well-being of the chicks. Heat sources are also installed in each dressing room to maintain a constant temperature. Local feed ingredients were chosen based on their availability and nutritional benefits for the chicks, then processed according to specific processes before being incorporated into the different diets administered to the chicks.

Table 1: Formulated and rationed diets for reared chicks

| IA                     | RO  | PB%   | R1  | PB%   | R2   | PB%   | R3   | PB%   | R4  | PB%   |
|------------------------|-----|-------|-----|-------|------|-------|------|-------|-----|-------|
| Corn flour             | 49  | 3,92  | 36  | 2,88  | 45,5 | 3,64  | 52,7 | 4,22  | 60  | 4,8   |
| Soybean flour          | 33  | 11,55 | 44  | 15,40 | 34,5 | 12,08 | 24,8 | 8,68  | 15  | 5,25  |
| Cassava cossetes flour | 2,5 | 0,8   | 2,5 | 0,8   | 4,5  | 0,14  | 2    | -     | 1,5 | 0,05  |
| Farine fretins         | 10  | 6     | -   | -     | -    | -     | -    | -     | -   | -     |
| Grasshopper flour      |     |       | 5   | 3     | 10   | 6     | 15   | 9     | 20  | 12    |
| Rice bran              | 3   | 0,04  | 5   | 0,04  | 3    | 0,24  | 3    | 0,24  | 1   | 0,08  |
| Premix (vitamines)     | 1   | 0     | 1   | 0     | 1    | 0     | 1    | 0     | 1   | 0     |
| NaCl                   | 0,5 | 0     | 1   | 0     | 1    | 0     | 1    | 0     | 1   | 0     |
| F. of Bone             |     | 0     | 0,5 | 0     | 0,5  | 0     | 0,5  | 0     | 0,5 | 0     |
| <b>Total</b>           |     | 22,31 |     | 22,12 |      | 22,10 |      | 22,14 |     | 22,18 |

**Source :** Feed formula used

Legend:

1. AI: Food ingredients;
2. RO: Control diet, containing 10% fishmeal in the feed, with a crude protein (CP) content of 22.31%;
3. R1: Diet consisting of 0% fishmeal and 5% grasshopper meal in the feed, with a crude protein content of 22.12%;
4. R2: Diet containing no fishmeal and including 10% grasshopper meal in the feed, with a crude protein content of 22.10%;
5. R3: Diet without fishmeal but with 15% grasshopper meal in the feed, with a crude protein content of 22.14%;
6. R4: Diet free of fishmeal and including 20% grasshopper meal in the feed, with a crude protein content of 22.18%.

### 2.3.2. Parameters to be observed

Parameters evaluated included body weight, average weight, weekly body weight gain, loss of donated ration, waste, refusals or leftovers of diet administered, and ration consumption index.

To measure these parameters, we followed the following steps:

1. The individual live weight of the chickens was recorded weekly during the experiment using an electronic scale.
2. Weekly live weight gain was calculated by differentiating the current week's weight from the previous week's weight.

3. Ration loss, wastage and refusals were assessed by subtracting the amount of ration remaining in the feeder from the initially offered ration, as well as the amount ejected by the chicks.
4. The feed conversion ratio was calculated by dividing the intake by the weekly live weight gain of the chicks.

### 2.3.3. Data processing and analysis of results

The data collected were grouped according to their nature and analyzed for validity using appropriate tests. The resulting findings were examined and discussed. Measurements were made on a sample of 15 young chicks randomly selected from each batch. The data collected on these 15 subjects were presented in a tabular format, where the calculation of arithmetic mean, variance, standard deviation and coefficient of variance was essential to assess the amount of ration distributed, consumed, refused or lost, as well as the feed conversion ratio.

## 3. RESULTS AND DISCUSSION

The results of this study are presented in the following tables and are interpreted and discussed below.

**Result 1:** Evaluation of weekly rationing of chicks from 5 batches examined

The weekly rationing of chicks from 5 breeding lots is recorded in the table below, including a control lot incorporating fry meal into their diet (To) and 4 test lots including grasshopper meal in their feed.

**Table 1 :** Results of weekly rationing of breeding chicks of 5 batches (in Kg)

| Weeks              | Amount of feed administered in Kg |        |        |        |        |
|--------------------|-----------------------------------|--------|--------|--------|--------|
|                    | L0                                | L1     | L2     | L3     | L4     |
| Σ0                 | 3.65                              | 3.5    | 3.5    | 3.6    | 3.65   |
| Σ1                 | 5.35                              | 4.4    | 4.6    | 4.6    | 5.35   |
| Σ2                 | 6.45                              | 5.6    | 5.7    | 5.7    | 5.7    |
| Σ3                 | 7.6                               | 7      | 7      | 6.7    | 7      |
| Σ4                 | 9.3                               | 9.2    | 8.5    | 9.1    | 9.2    |
| Σ5                 | 10.4                              | 10.4   | 10     | 10     | 10     |
| Σ6                 | 10.6                              | 11     | 10.7   | 11.2   | 11     |
| Σ7                 | 11.6                              | 12.5   | 11.9   | 12.2   | 12.1   |
| Σ8                 | 13.1                              | 14     | 13.4   | 12.5   | 12.5   |
| Are                | 78.05                             | 77.6   | 75.3   | 75.6   | 76.5   |
| Average            | 8.672                             | 8.622  | 8.367  | 8.4    | 8.5    |
| Standard deviation | 3.115                             | 3.690  | 3.405  | 3.350  | 3.191  |
| Variance           | 9.703                             | 13.617 | 11.6   | 11.225 | 10.186 |
| CV                 | 35.92                             | 42.798 | 40.708 | 39.885 | 37.547 |

Table 9 shows that the chicks in the control lot received on average a higher amount of ration than the test lots. The analysis of variance reveals a significant difference between the weekly rationing averages of the 5 batches, with a probability threshold of 0.05. However, the weekly rationing of the test batches is more heterogeneous than that of the control batch.

**Table 2:** Summary of ANOVA rationing of chicks from 5 lots observed

| Source    | DF | Adj SS  | Adj MS  | F-Value | F-tab.<br>5 % | P-Value |
|-----------|----|---------|---------|---------|---------------|---------|
| L         | 4  | 0.64467 | 0.16117 | 0.01431 | 2.60597       | 0.99958 |
| ΣSemaines | 40 | 450.641 | 11.266  | -       | -             | -       |
| Total     | 44 | 451.286 | -       | -       | -             | -       |

The data in Table 2 show that chicks in the control lot received an average ration of 78.05, which is higher than the test lots as a whole. The analysis of variance confirms a significant difference between the five means of weekly rationing, with a probability threshold of 0.05. However, it should be noted that the weekly rationing of the test batches is more heterogeneous than that of the control batch. In addition, it can be observed that the rationing of test batches generally increases over time, as shown in the table.

**Result 2: Weekly evaluation of the feed consumption of 5 batches of chicks examined**

Table 3: The weekly consumption of farmed birds from 5 batches examined during the trial is shown in the table below.

| Weeks              | Amount of ration consumed in Kg |        |        |        |        |
|--------------------|---------------------------------|--------|--------|--------|--------|
|                    | L0                              | L1     | L2     | L3     | L4     |
| Σ0                 | 2.805                           | 2.875  | 2.96   | 3.25   | 2.905  |
| Σ1                 | 4.195                           | 3.97   | 4.42   | 4.32   | 4.195  |
| Σ2                 | 5.655                           | 4.75   | 5.15   | 5.36   | 4.905  |
| Σ3                 | 6.85                            | 5.625  | 6.04   | 6.41   | 5.765  |
| Σ4                 | 8.595                           | 8.445  | 8.175  | 8.505  | 8.445  |
| Σ5                 | 9.86                            | 9.645  | 9.545  | 9.795  | 9.75   |
| Σ6                 | 10.165                          | 10.625 | 10.225 | 11.005 | 10.785 |
| Σ7                 | 11.265                          | 12.18  | 11.6   | 12.055 | 11.8   |
| Σ8                 | 12.545                          | 13.745 | 13.085 | 12.15  | 12.3   |
| Are                | 71.935                          | 71.86  | 71.2   | 72.85  | 70.85  |
| Average            | 7.993                           | 7.984  | 7.911  | 8.094  | 7.872  |
| Standard deviation | 3.319                           | 3.856  | 3.469  | 3.385  | 3.514  |
| Variance           | 11.013                          | 14.872 | 12.037 | 11.462 | 12.351 |
| CV                 | 41.52                           | 48.299 | 43.855 | 41.825 | 44.643 |

**Table 4:** Summary of the analysis of variance (ANOVA) of the weekly chick consumption observed in the five lots.

| Source    | DF | Adj SS  | Adj MS  | F-Value | F-tab.<br>5 % | P-Value |
|-----------|----|---------|---------|---------|---------------|---------|
| L         | 4  | 0.26314 | 0.06578 | 0.00533 | 2.60597       | 0.99994 |
| ΣSemaines | 40 | 493.887 | 12.3472 | -       | -             | -       |
| Total     | 44 | 494.15  | -       | -       | -             | -       |

The table above shows that, in general, chicks in the test batches consumed less feed than those in the control batch, with an average of 7.993 with the exception of test batch 3, which had an average intake during the test of 8.094. In addition, the analysis of variance, shown in Table 10b, confirms a significant difference between the consumption averages of the five batches of chicks examined.

**Outcome 3: Evaluation of rations refused weekly throughout the trial period**

Evaluation of the weekly refusals throughout the trial period reveals the results of the feed loss offered to the chicks throughout the rearing period. The data is presented in the following table :

**Table 5:** Averages of refused rations

| Semaines                  | Quantité d'aliment refusée en Kg |        |        |        |        |
|---------------------------|----------------------------------|--------|--------|--------|--------|
|                           | L0                               | L1     | L2     | L3     | L4     |
| $\Sigma 0$                | 0.745                            | 0.625  | 0.540  | 0.350  | 0.745  |
| $\Sigma 1$                | 1.155                            | 0.430  | 0.220  | 0.720  | 1.155  |
| $\Sigma 2$                | 0.795                            | 0.850  | 0.550  | 0.340  | 0.795  |
| $\Sigma 3$                | 0.750                            | 1.305  | 0.360  | 0.280  | 1.230  |
| $\Sigma 4$                | 0.705                            | 0.755  | 0.425  | 0.595  | 0.755  |
| $\Sigma 5$                | 0.540                            | 0.755  | 0.455  | 0.705  | 0.560  |
| $\Sigma 6$                | 0.435                            | 0.375  | 0.475  | 0.375  | 0.215  |
| $\Sigma 7$                | 0.335                            | 0.320  | 0.420  | 0.195  | 0.375  |
| $\Sigma 8$                | 0.555                            | 0.255  | 0.415  | 0.395  | 0.320  |
| <b>Are</b>                | 6.015                            | 5.67   | 3.86   | 3.955  | 6.15   |
| <b>Average</b>            | 0.668                            | 0.63   | 0.429  | 0.4394 | 0.683  |
| <b>Standard deviation</b> | 0.240                            | 0.331  | 0.099  | 0.188  | 0.354  |
| <b>Variance</b>           | 0.058                            | 0.111  | 0.010  | 0.0353 | 0.126  |
| <b>CV</b>                 | 35.943                           | 52.556 | 23.095 | 42.772 | 51.852 |

The table presents the values of several series ( $\Sigma 0$  to  $\Sigma 8$ ) on five dimensions or variables (columns), followed by **sums, means, standard deviations, variances and coefficients of variation (CV)**. The aim is to identify the strengths, i.e. the most efficient and stable dimensions. Variable 3 is the **most stable** (lowest CV, 23.1%), but its mean is the lowest (0.429). On the other hand, **variable 1** combines a **high average (0.668)** and a **moderate dispersion (CV = 35.9%)**, which makes it a **solid strength**.

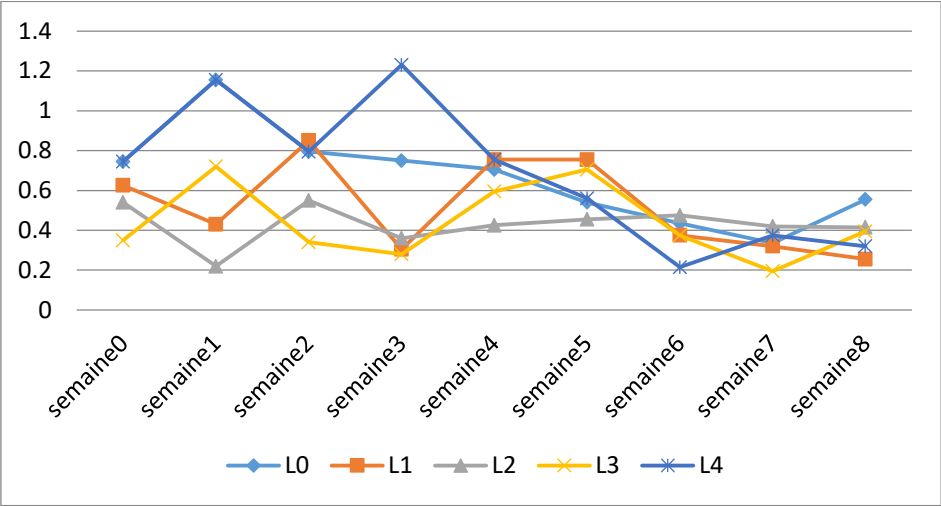
The table shows a **good overall performance on variables 1 and 5, with a decent stability for the former**. To reinforce the strengths:

1. **Maintain the quality** observed on variable 1.
2. **Stabilize the results** of variable 5.
3. **Value the consistency** of variable 3, while seeking to improve its average level.

**Table 6:** Summary of ANOVA of Weekly Ration Refusals to 5-Lot Chicks

| Source            | DF | Adj SS  | Adj MS  | F-Value | F-tab.<br>5 % | P-Value |
|-------------------|----|---------|---------|---------|---------------|---------|
| L                 | 4  | 0.56764 | 0.14191 | 2.09913 | 2.60597       | 0.0989  |
| $\Sigma$ Semaines | 40 | 2.70416 | 0.0676  | -       | -             | -       |
| Total             | 44 | 3.2718  | -       | -       | -             | -       |

A review of the weekly rejection data for chick rations, as presented in Table 11a, shows that birds in the four test batches generally consumed less feed than the control batch, with an average of 0.668 kg, or 240 g, as shown in the figure below. It should be noted, however, that test batch 4 had a slightly higher average, at 0.683 kg, equivalent to 354 g.



**Figure 1:** Evolution of refusal of rations administered to chicks from 5 batches observed throughout the trial period.

**Result 4:** The evolution of the weekly weight of chicks in the five batches

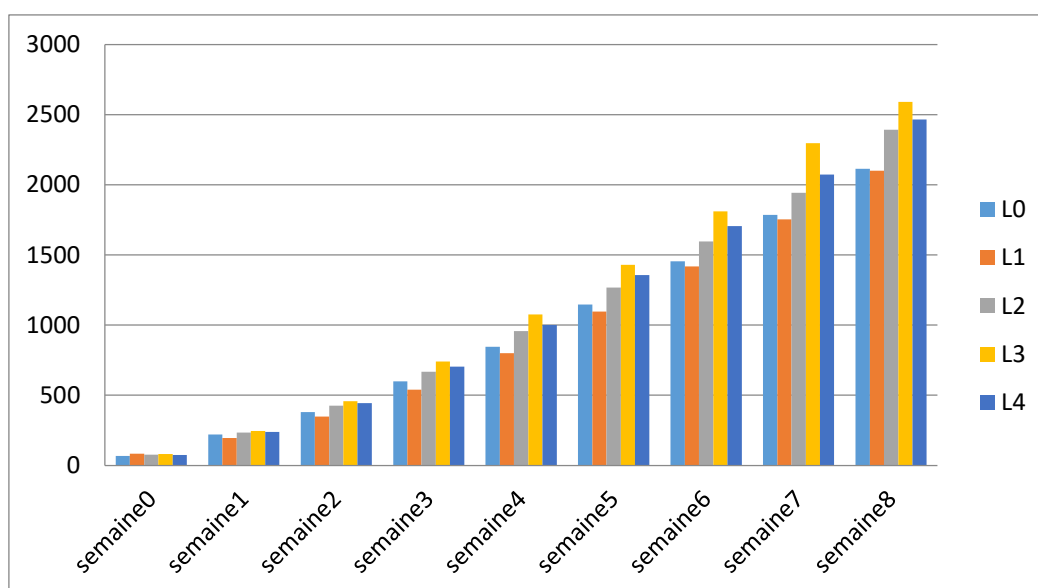
The evolution of the weekly weight of chicks in the five batches examined during the trial is presented in the table below, along with their analysis of variance. The evolution of the weekly weight of chicks from the five batches examined during the trial is shown in the table below:

**Table 7:** Weekly Chick Weights of the 5 Lots Examined (in grams)

| Weeks              | Average weekly chick weight in grams |         |          |          |          |
|--------------------|--------------------------------------|---------|----------|----------|----------|
|                    | L0                                   | L1      | L2       | L3       | L4       |
| Σ0                 | 68.66                                | 83.33   | 76.66    | 81       | 74       |
| Σ1                 | 219.66                               | 196     | 234      | 244.86   | 239.66   |
| Σ2                 | 379                                  | 347.66  | 426      | 457      | 443.33   |
| Σ3                 | 598.33                               | 539.66  | 667.33   | 740.33   | 704.33   |
| Σ4                 | 845.66                               | 798.66  | 957.33   | 1076.33  | 1001     |
| Σ5                 | 1145.66                              | 1097    | 1267     | 1429.33  | 1356     |
| Σ6                 | 1455.33                              | 1417    | 1597     | 1811     | 1704.66  |
| Σ7                 | 1784.66                              | 1752.66 | 1942     | 2296     | 2072.66  |
| Σ8                 | 2114.33                              | 2100    | 2392     | 2591     | 2465.33  |
| Are                | 8611.29                              | 8331.97 | 9559.32  | 10726.85 | 10060.97 |
| Average            | 956.81                               | 925.774 | 1062.147 | 1191.872 | 1117.886 |
| Standard deviation | 717.313                              | 713.697 | 798.377  | 901.7    | 838.816  |
| Variance           | 514538                               | 509364  | 637406   | 813064   | 703612   |
| CV                 | 74.97                                | 77.092  | 75.17    | 75.65    | 75.04    |

**Table 8:** Summary of the Analysis of Variance (ANOVA)

The following is the summary of the analysis of variance (ANOVA) of the live weight of the chicks of the five experimental batches:



A careful analysis of the live weight results, as presented in Table 12a above, reveals that chicks in the test batches generally experienced an increase in weight at the beginning, peaking around the second week, and then a noticeable acceleration from the third week until the end of the trial, compared to the chicks in the control batch. This trend is clearly illustrated in the figure below, which represents the weekly evolution of the average live weight curves of the chicks of the five batches examined.

In addition, the analysis of variance performed with a probability threshold of 0.05 according to Fisher's Table F confirmed that there is a significant difference between the five means of the endpoint examined.

In terms of discussion, it should be noted that the average weight of chickens, standing at 2591g on the third test, varies between 2235g and 3655g after 63 days. The analysis of variance, with a probability threshold of 0.05, shows a significant difference between the five means of the endpoint examined, a result similar to that of Bessa (2019) in the Tizi-Ouzou region. The average weekly intake of chickens in test batch 3 was 8.094 kg of feed during the 63-day trial, with generally lower intake in the other test batches at 7.993 kg, with the exception of test batch 3. These results are consistent with those of Shoko et al. (2016), who note a gradual consumption of 60g to 90g per day in Broiler chickens.

The birds in the test batches generally left few rations, unlike the control batch, thus illustrating a variable feed preference. Weekly live weight gains vary significantly between the five batches, with a peak of 163.86g at the third week, contrasting with the observations of Katunga (2016). The feed conversion ratio, estimated at 1.667 kg, reflects the feed efficiency of chickens raised with local feed formulated with grasshopper meal, consistent with the results of Officine (2005) and the statements of Langrenez and Messier (2017) on the nutritional quality of insects. In sum, the growth and feeding of chickens raised with local feed show significant variations depending on the feed formula used, as shown in Tables 9, 10, 12 and 13.

## Conclusion

The conclusion of this study on the effect of incorporating grasshopper meal into the diet of broiler chicks aims to promote local gall farming and improve poultry feed. Zootechnical performance showed an average weight of 2591g of chickens after 63 days, confirming the effectiveness of the grasshopper meal feed. Analysis of ration losses revealed that formulas with no or less grasshopper meal resulted in more losses, partially confirming a hypothesis. Suggestions include encouraging the use of 15% grasshopper meal in broiler feed, future studies with larger samples, and exploring other alternative food sources, such as maggots and locusts, to reduce reliance on conventional feed.

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