

Effects of *Tetracarpidium conophorum* Oil Cake in a Cafeteria Feeding System on Growth Performance of Broiler Chicken

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Abstract

Original Research Article

The useful of unconventional resources such as *Tetracarpidium conophorum* oil cake in improving poultry production is a challenge for developing countries where crude protein sources are scarce and expensive. The present study evaluated the effect of separate feeding of *Tetracarpidium conophorum* cake on the growth performance of broiler chickens under Congolese tropical conditions. A sample of 120 healthy broiler chickens (Hubbard strain), three weeks old and weighing an average of 500 g, were randomly divided into two groups (control group: n = 60; treatment group n = 60). Each group (control and treatment) was divided in four replicates of 15 chickens per group. The control group received daily ad-libitum a complete diet mixed with *T. conophorum* oil cake. While the treatment group received ad-libitum the basal diet and the oil cake offered separately in an additional feeder. Both diets were isoenergetic and isonitrogenous. The experiment lasted from day 21 to day 42. The two groups and replicate were compared on body live weight, feed intake, feed efficiency and average body weight gain. Compared to the control group the treatment improved significantly final body weight, average daily gain, feed conversion ratio, voluntary feed intake, and water consumption, while moderating cake intake. These results support the potential domestication and valorization of *Tetracarpidium conophorum* as a sustainable local protein source for poultry in tropical areas.

Keywords: African walnut, Average daily gain, Feed consumption, Hubbard strain, Separate feeding.

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INTRODUCTION

Poultry production is one of the sectors that holds a strategic place in the world's food and economy. Indeed, broiler chicken meat ranks second in global meat consumption after pork, with a worldwide production estimated at 118 million tons in 2020 (FAO, 2019). In Africa, it represents only 8% of global production, while demand continues to increase due to its availability, relatively affordable price, and nutritional value (FAO, 2019). In the Republic of Congo, poultry is an important source of animal protein in the population's diet. However, more than 90% of the poultry meat consumed in the country comes from abroad (Adzona, 2019; FAO, 2019), revealing a high external dependence and low local production. Among the major constraints to poultry production in Congo, feed remains the most determining factor. It accounts for nearly 70% of production costs and directly determines the growth performance of poultry (Banga-Mboko *et al.*, 2007; Mantsanga *et al.*, 2016;

François, *et al.*, 2020). Broiler chickens' diets are based on balanced rations that provide energy, proteins and minerals. The most commonly used energy sources are cereals, while proteins come from either animal sources (fish meal, blood meal, etc.) or vegetable source oilcake (Ntsoumou, 2024). soya bean, widely used as a protein source worldwide, remains difficult to access for Congolese producers due to its high cost and limited availability (Adzona, 2019). This is why various alternatives are being considered, such as partial or total replacement with a local and less expensive source like *Dacryodes edulis* oil cake (Saboukoulou 2024) and *Tetracarpidium conophorum* oil cake (Ntsoumou, 2024; Untea *et al.*, 2025). Indeed, *Tetracarpidium conophorum* is a perennial oil seed liana widely cultivated in tropical Africa. *Tetracarpidium conophorum* trees cover Sierra Leone and Nigeria in West Africa, and Democratic Republic of Congo and republic of Congo in Central Africa (Mezajoug, 2010; Sianard, 2010). In Congo, this plant is commonly cultivated in the Department of

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Plateaux and Cuvette, where it is known by the local names “Nkâ” and “Mbenza” respectively (Sianard, 2010; Ntsoumou, 2024). The seeds are consumed by local populations and processed for oil extraction, leaving behind a cake that is particularly rich in proteins (37-52%) and essential amino acids such as lysine (2.7%) and methionine (0.62%) (Mezajoug, 2010; Sianard, 2010; Uchechukwu and Nkeiruk, 2017). Studies have shown that this cake can partially replace soybean meal in the diets of broilers and laying hens, with promising performances when its inclusion does not exceed 17 to 17.5% (Ntsoumou *et al.*, 2021; Ndoulou, 2022). In addition, in poultry farming, it has been shown that separate feeding, which consists of offering an ingredient apart from the rest of the ration, is a nutritional strategy that has shown positive effects in several studies (Fanatico *et al.*, 2016). This approach allows poultry to self-regulate their consumption according to their nutritional needs, which can provide significant advantages both from a nutritional perspective and in terms of resilience to unfavorable climatic conditions (Maalheiros *et al.*, 2003; Fanatico *et al.*, 2016). In Congo, positive results have already been obtained with separate feeding of calcium (Mantsanga *et al.*, 2016), sesame cake (Adzona, 2019) and pumpkin oil cake (Adzona *et al.*, 2025). However, no study had previously evaluated the performance of broiler chickens fed with *Tetracarpidium conophorum* oil cake under a separate feeding system. It is within this context, aiming to fill this gap, that the present study was conducted. The aim of the study was to evaluate the effects of separate feeding based on *Tetracarpidium conophorum* oil cake on the growth parameters of broiler chickens.

MATERIALS AND METHODS

Ethical Approval

The experimental design was approved by the national ethical scientific comity of the ministry of scientific research and innovated technology under the controllers of the Delegation Generale de la Recherche Scientifique et Technologique (DGRST). The experiment was also approved by the scientific comity of the Faculty of Sciences and Techniques of Marien Ngouabi University, Brazzaville, Republic of Congo

Study Area

This study was conducted at the farm of the national Institute of Agronomic Research (IRA) in Brazzaville, Republic of Congo (latitude 4°05'58" S; longitude 15°16'59" E). The climate is humid tropical, with two seasons (a rainy season and a dry season), an annual rainfall ranging between 1,400 and 1,600 mm, and an average temperature of 25°C that can reach a maximum of 38°C (Samba-Kimbata and Mpounza, 2001).

Plant Material

As indicated in Figure 1, pods were collected from wild shrubs in Lekana forests District located at 450 km of Brazzaville. Pods were manually opened in Lekana, in order to remove the shell nuts. Nut shells were transported to national Institute of Agronomic Research in Brazzaville. They were then cooked in boiler water during 6 hours at 100°C. Shells nuts were then discarded showing the shells in one part and kernel other part. Kernels were finally were subjected to oil cake production as described in Figure 2.

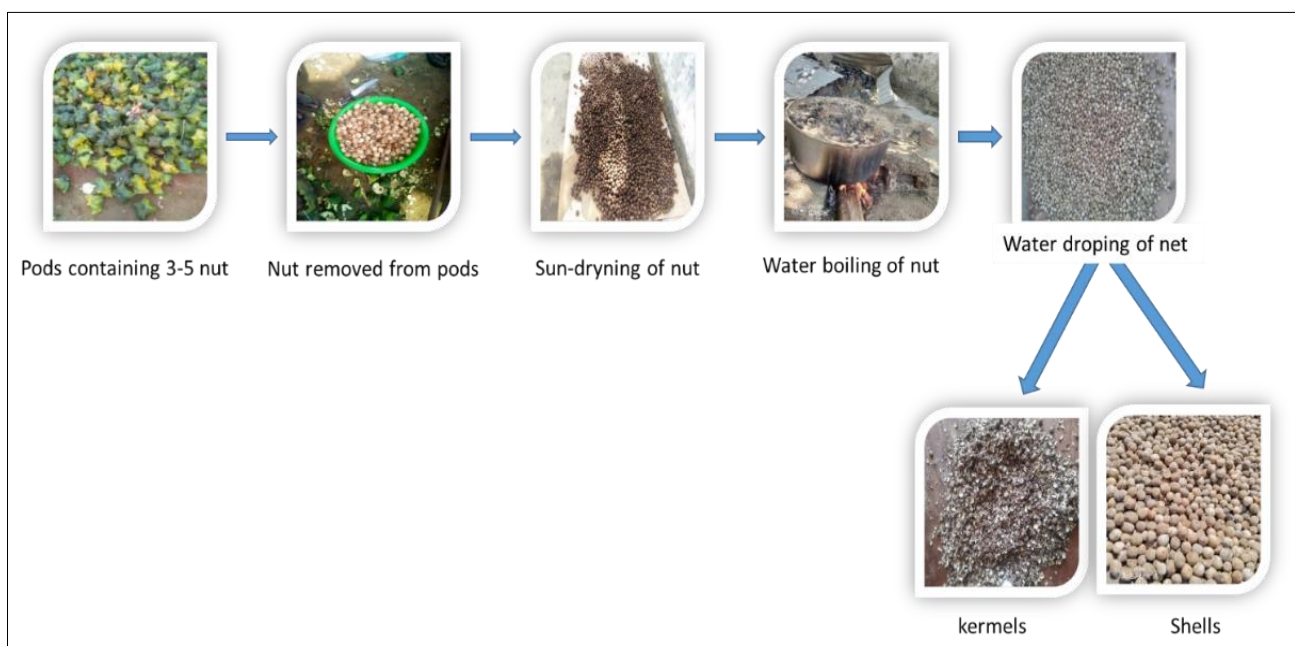


Figure 1: Process of kernel extraction



Figure 2: *Tetracarpidium conophorum* oil cake processing

Study Design

The study involved 120 broiler chickens (Hubbard strain), three 3 weeks old, with an initial average body weight of approximately 500 g. The animals were divided into two groups of 60 subjects each, further subdivided into four replicates of 15 chickens. The chickens were reared on deep litter, in buildings with natural ventilation. The temperature reached 2°C in the morning and 30°C in the afternoon. Water and feed were distributed *ad libitum* as well. During the starter and grower stage, chickens were vaccinated against a Newcastle by using Hitchner HB1 vaccine (Novovet laboratory, Morocco) and Gumboro (NSD Animal health, South Africa) diseases. Also, they were controlled against coccidiosis and infective diseases by using anti coccidial drugs in water and anti-

infectious. No vaccination program was implemented during the trial from day 21 to day 42.

Feeding System

The trial lasted from day 21 to day 42. Two isoenergetic (about 3,050 kcal ME/kg) and isoprotein (about 17% crude protein) diets were formulated in accordance with the recommendations of the NRC (1994; Table 1). The control group (T0) receives a complete ration in the form of flour, containing 6% *Tetracarpidium conophorum* oil cake incorporated, the treatment group (T1) receives a basic ration without *Tetracarpidium conophorum* cake, that was distributed separately in a second feeder. The diets were distributed twice daily (morning and afternoon), simultaneously with the *Tetracarpidium conophorum* oil cake in the case of treatment T1.

Table 2: Diets composition of Hubbard broiler chickens

Items	Control group (%)	Treatment group (%)
Ingredients (%)		
Corn	40	40
Wheat bran	13	14
Cassava flour	12	11
Palm oil	5	5
Cowpea flour	3.5	6
Fish meal	10	10
<i>Tetracarpidium conophorum</i> oil cake	6	0 (given separately)
Soybean meal	8	11.5
Limestone	2	2
Salt	0.5	0.5
Total	100	100
Metabolizable energy (kcal)	3,070.5	3,042.4
Crude proteins (%)	17.4	17.2
Energy/crude protein ratio	176.06	176.88

Parameters measured

All the broiler chickens were weighted at the beginning of the trial and then weekly till the age of 12 weeks. The feed intake in grams/broiler/d was recorded each day in order to evaluate growth performance Feed conversion ratio was calculated weekly.

Voluntary Feed Consumption (VFC) of *T.conophorum* oil cake in a complete diet was the product of voluntary food consumption and the rate of *T.conophorum* incorporation of squash, all divided by one hundred (100), which is the total percentage of the food formulation.

$$VFC (g) = \frac{VFI \times 6}{100}$$

Voluntary consumption of oil cake in separate feeding (VSC) was the product of the voluntary feed consumption of the crude protein fraction with the incorporation rate of the *T. conophorum* oil cake, divided by 33.6% as the total percentage of the feed formulation of the crude protein fraction.

$$VSC (g) = \frac{VFI \times 6}{33.6}$$

Classical data such as Average daily gain (ADG), live body weight and feed conversion ratio

(FCR) were calculated from the weekly records of the live body weight and daily feed intake as previously described by Adzona *et al.*, (2025).

$$\text{ADG (g/day)} = \frac{\text{Final body weight} - \text{initial body weight}}{7 \text{ weeks}}$$

Death, if present, was recorded daily

Statistical analysis

The data obtained in this experiment were entered into the Excel, then transferred to Statistical Analysis System (SAS, 2013). The Meal application mode (R1TM and R2TS) in finishing was the only factor

for one-way ANOVA. Fisher's F test was used to determine the significance of the effect of the treatment factor, and Student's t was used for mean comparison. The significance threshold was $p < 0.05$. Results are presented as a mean $\pm$ standard deviation (SD).

RESULTS AND DISCUSSION

Effect of *Tetracarpidium conophorum* on growing performance of broiler chickens

The results of the weekly monitoring of live body weight, ADG, and FCR throughout the study are presented in Table 2.

Table 2: Effect of *Tetracarpidium conophorum* oil cake on growing performance of Hubbard broiler chickens at finisher stage (21-42 days)

Parameters	Control (Mean $\pm$ SD)	Treatment group (Mean $\pm$ SD)
Live body weight (g)	1,498 $\pm$ 384.42 ^a	1,717 $\pm$ 464.97 ^b
ADG (g/day)	38.9 $\pm$ 8.01 ^a	45 $\pm$ 9.92 ^b
Feed conversion ratio	3.9 ^a $\pm$ 0.20 ^a	3.2 ^b $\pm$ 0.09 ^a

^{ab}Different superscript letters on the same row indicate a significant difference at $p < 0.05$

Analysis of Table 2 shows a significant improvement in the live weight of broiler chickens fed with *Tetracarpidium conophorum* cake offered separately (treatment), compared to the control group ($p < 0.05$). These results indicate that chickens in the treatment group the efficiency of the nutrients consumed was improved. Unlike a single fixed diet, where the broiler chickens is subjected to an imposed composition, the separate provision of an ingredient allows chickens to modulate their consumption according to the energy and protein needed for growth (Maalheiros *et al.*, 2003). Such result on body live weight, ADG and feed conversion ratio has been reported in Guinea fowls (Adzona and Banga-Mboko, 2017). The results on live body weight are in agreement with previous study on the substitution of soybean meal (1,729g) with *T. conophorum* oil cake in broiler chickens fed (hubbard strain; Ndoulou, 2022; Ntsoumou, 2024). On the other hand, the data from the present study (1,717g) are higher to those reported by Adzona *et al.* (2019), who evaluated the effect of sesame meal under fractionated, separate, and sequential feeding systems in cobb 500.

Compared to the control group with regard to ADG, the treatment increased the ADG significantly ($p < 0.05$) by 15.68%. This result is higher than that achieved by Ndoulou (2022) who tested soybean meal in broiler chickens fed and obtained an ADG of 32g/day. Adzona *et al.*, (2025), who also studied on *Dacryodes*

edulis pull cake in a basal diet for common Guinea fowl, obtained similar results, with a ADG of 32g/day in the finishing phase.

Concerning the feed conversion rate, the treatment improved this parameter by 17.94%. The improvement in the feed conversion ratio indicates better nutrient utilization. One possible explanation is that when fed separately, *T. conophorum* meal is consumed in smaller quantities (3.8 g/day vs. 7 g/day) but is better assimilated. The chickens therefore consume just the right amount, avoiding an overload of fiber or antinutrients that could occur when the meal is heavily incorporated into a mixed ration. This observation is consistent with the results of Fanatico *et al.* (2016), when working on broiler chickens show that split feeding improves feed conversion by reducing energy and crude protein (12%) waste. These better growth in live body weights and ADG obtained in this study in broiler fed *T. conophorum* meal separately could be explained by a higher voluntary feed intake, which is known for its high crude proteins level (over 44%) and essential amino acids (Mezajoug, 2010; Petraru *et al.*, 2025).

Effect of *Tetracarpidium conophorum* oil cake on water and food consumption parameters of broiler chickens

The results of feed and water intake (mean and SD) are presented in Table 3.

Table 3: Effect of *T. conophorum* oil cake on feed and water intakes of Hubbard broiler chickens at finisher stage (21-42 days)

Parameters	Control (Mean $\pm$ SD)	Treatment group (Mean $\pm$ SD)
Voluntary feed consumption (g/day/chicken)	116 $\pm$ 20.45 ^a	150 $\pm$ 36.10 ^b
Voluntary consumption of oil cake (g/day)	7 $\pm$ 1.23 ^a	3.8 $\pm$ 1.42 ^b
Voluntary water consumption (ml/ /day/chicken)	369 $\pm$ 85.82 ^a	424 $\pm$ 95.98 ^b

^{ab}Different superscript letters on the same row indicate a significant difference at $p < 0.05$

The data indicates the treatment increase significantly ($p < 0.05$) voluntary feed intake by 29.31%. These results are higher than 88.57g obtained by Ntsoumou (2024) who evaluated the effect of the substitution of soybean meal with *Tetracarpidium conophorum* oil cake on the performance of broiler chickens and testify to the better palatability of *T. conophorum* oil cake.

With regard to the voluntary intake of *T. conophorum* oil cake, was reduced (45%) in the treatment group. On the other hand, the experiment showed that *T. conophorum* oil cake presented separately from the other ingredients, was consumed moderately. This reduction can be explained by the physiological stage of the animal, which needs to consume more energy-rich foods to promote fat tissue formation, hence the need to switch to feed containing energy-rich ingredients. According in previous studies in separate feeding the control group overconsumes the mixed feed to meet its energy needs. Similar results have been reported in laying hens fed in separate calcium diet (Banga Mboko *et al.*, 2007; Ntsoumou, 2024). In these previous studies the calcium had been reported to be overconsumed in control group

Finally, water consumption was significantly ($p < 0.05$) higher in the treatment group versus to the control group. This higher water consumption in the treated group can be interpreted as a physiological response to a large feed intake. This finding is consistent with most of previous studies on separate-mode diets, which induce increased water consumption in poultry (Banga-Mboko *et al.*, 2007; Mantsanga *et al.*, 2016; Adzona *et al.* Banga-Mboko, 2017).

CONCLUSION

The results obtained indicate that separate feeding has significantly improved growth performance (final live body weight, ADG and FCR) and voluntary feed and water consumption. The feed intake of oil cake was moderated. Given the observed improvement in parameters, *T. conophorum* oil cake can be recommended as a dietary supplement for broiler chickens in the finishing phase. However, economic studies must be conducted to assess the profitability of this approach.

DECLARATIONS

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Authors' contribution

This experiment was the result of the efforts of a team of researchers who contributed in various ways to the experiment, from its design to the drafting of this document. Dr. Adzona and Ir. Soki Kimpala carried out the experiment; both wrote the first version of the

manuscript. Dr. Ntsoumou and Dr Bati collected *Tetracarpidium conophorum* nuts from Lekana wild forest to Brazzaville, where the experiment took place. They also participated with Ir. Kikabou in oil cake production and the formulation of diet. All the experiment and the manuscript writing were under the supervision of Pr. Banga Mboko. All authors have read and approved the final version of the manuscript before publication in the present journal

Competing interests

The authors declared that there are no competing interests.

Ethical Considerations

The authors affirm that all ethical issues have been addressed, including plagiarism, consent to publish, misconduct, double publication and/or submission, and redundancy. The authors also declare that no Generative artificial intelligence was used in the creation of this manuscript.

Availability of data and materials

The data obtained in this study can be obtained from the corresponding author upon reasonable request.

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