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Effects of the inclusion rate of cassava flour in the diet of broilers (Cobb 500) on digestibility parameters

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Abstract

This study evaluated the apparent digestibility of nutrients as a function of the inclusion rate of cassava flour in broiler feed (Cobb 500). Thirty-six (36) animals and six (6) growth starters coded Rt1, Rt2, R25, R50, R75 and R100 were used. Digestive assessments were carried out on five consecutive days for each feed. CUDa values varied from one feed to another. The CUDa MS, CUDa MO and CUDa EM were high for all six feeds, ranging respectively from 74.12 to 81.83%, 80.33 to 89.05% MS and 80.26 to 88% MS. However, the MS, MO and EM of the control feeds were the most digested, followed by the R25 and R50 feeds. The animals digested the MG and PB of the control, R25 and R50 feeds better (80% DM and 72% DM). On the other hand, they did not digest the MG and PB of diets R75 and R100 (>70% DM). The CUDa CB of the control and R25 diets were statistically similar and the best digested. On the other hand, the CB of the R50, R75 and R100 diets were the least digestible. The CUDa of minerals such as calcium and phosphorus were less influenced by the feed. Above 50% inclusion of cassava flour in the feed, chickens digest less certain nutrients such as MG, BC and PB. But they digest minerals, DM, OM and EM well.

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Introduction

In Côte d'Ivoire, one of the main factors limiting the development of broiler production remains the high cost of feed and its availability to breeders. Poultry feed for broiler production represents around 60 to 70% of production costs (Kouadio *et al.*, 2020 ; Bouvarel *et al.,* 2010). This high cost is due to difficulties in supplying feed mills with raw materials, and to the high cost of inputs such as soybean meal, fishmeal and especially corn (Kouadio *et al.*, 2020).

Maize is the main source of energy and the most important by volume in chicken feed, occupying an important part in the formulation of their feed rations (50 and 70%) (Coulibaly, 2014; Teguia *et al.*, 2004).

The metabolizable energy value of grain maize varies between 3635 and 4093 kcal/kg dry matter (Lessire *et al.*, 2003). In recent years, demand for maize has risen steadily, given that its production is greatly influenced by climatic hazards and crises around the world. As a result, the price of maize is constantly on the rise. As a result, the cost of producing poultry feed has risen, and poultry production revenues have fallen steadily (Kouadio *et al.*, 2020).

Under these conditions, in order to find ways of reducing the cost of poultry feed production, research efforts must focus on assessing the quality and potential of other locally available products (Silue *et al.*, 202 0). Cassava figures prominently among these available food resources. For example, in Côte d'Ivoire, the third largest producer of cassava in West Africa (FAOSTAT, 2019), cassava could be an interesting alternative to maize in poultry feed (*Dahouda et al.*, 2009). Its tubers are rich in energy (390.05 Kcal/100 g), minerals and vitamins (Randrianatoandro, 2004). Some authors have already used cassava leaves and peelings as an energy source in broiler chicken feed (Dahouda, 2009; N'Guessan *et al.*, 2020; Ngueda Djeuta and Tona, 2022). However, there is very little data available on the use of cassava tuber flour in general and the digestibility of nutrients in particular for broilers in Côte d'Ivoire.

One of the most important steps to be taken in animal nutrition is to gain a better understanding of the actual digestibility of feeds in livestock farming (Vilariño *et al.,* 2017). This will also make it possible to reduce waste, gaseous emissions and their consequences on animal health (Vilariño *et al.,* 2017).

The present study focuses on determining the apparent digestibility of nutrients in broilers (Cobb 500) fed diets with different levels of substitution of cassava flour for maize.

Equipment and method

Animals and diets

A total of 36 Cobb 500 broilers were used for this digestibility study. The experimental feeds were of two types, depending on the rearing phase: a starter feed and a growth feed. For each rearing phase, six feeds were formulated according to the inclusion rate of cassava flour. The feeds were coded as Rt1 and Rt2 for 100% maize feeds and R25, R50, R75 and R100 according to the percentage of cassava flour in the experimental feed. Chickens were fed the feeds in the form of meal.

Cobb 500 broilers were placed in the conditions of good practice on experimental animals. The experiments were carried out at the experimental farm of the University of Nangui ABROGOUA. These animals had free access to water and standard feed for broilers (Ivograin®). The chickens were submitted to a 12-h dark/light photoperiodic cycle. The chickens were treated according to good laboratory practices (OECD, 1998). The different experimental protocols were followed in accordance with the protocols for the protection of experimental animals of the European Council on legislation 2012/707 (European Union, 2012).

digestibility test set-up

Chickens were placed in a 3-replicate randomized complete block design (metabolism cages), with two chickens per experimental unit, i.e. six groups of chickens. For dietary digestive assessments, two chickens were housed in a metal cage measuring 40 cm x 35 cm x 40 cm, equipped with a feeder, a drinker and a device for collecting total droppings. The cages are wire-mesh at the front and hermetically sealed at the sides and rear. The cage opens to the side, and the lower part of the cage has a tray for collecting droppings.

Methods

Collection method and method for determining fecal digestibility of nutrients

The digestive balance method using total excreta collection has been used to determine the digestibility of dietary constituents (Métayer *et al.*, 2013).

Digestive assessments were carried out between days D9-J13 and D18-J22, i.e. for five consecutive days for each diet and for each rearing phase (start-up and growth), preceded by five days of adaptation of the chickens to the experimental feed. During these five days, the total consumption of each batch was measured. Water and feed were served ad libitum. Excreta were also collected during this period, then weighed, dried and ground to 0.5 mm. The excreta were then stored at +4°C until analysis. At the beginning and end of the assessment, the chicks were fasted for 12 hours (the total transit time being considered less than 12 hours in chickens), in order to recover the entire undigested fraction and measure it. The study took place in one of the poultry buildings of the experimental farm of the Nangui ABROGOUA University. Figure 1 shows a diagram of the digestibility test protocol used in this experiment.

Chemical analysis

Chemical analyses were performed on feed samples and chicken excreta. These samples were analyzed according to the methods used by Atchade *et al,* (2019) and approved by AOAC (2000).

These methods were used to determine the contents of Dry Matter (DM), Organic Matter (OM), Total Nitrogenous Matter (TNM), Mineral Matter (MM), Fat Matter (FM), Crude Protein (CP), Crude Cellulose (CC), Total Ash (TC) and Metabolisable Energy (ME). These methods are summarized in Table 1.

Determining metabolizable energy

The Metabolisable Energy (ME) (Kcal/Kg DM) of each feed and excreta sample was calculated using the regression equation described by Sibbald (1980) and repeated by Kenfack *et al.*, (2006) and Kouakou and Brou (2016). This method takes into account, on the one hand, lipid (MG), crude fiber (CB) and total ash (CT) contents and, on the other hand, energy coefficients relating to co-products according to the following formula:

$$EM\ \left(\frac{Kcal}{1000\,gMS}\right) = 3951 + 54{,}4 \times MG - 88{,}7 \times CB - 40{,}8 \times CE$$

Hence EM: metabolizable energy

MG: fatty matter

CB: raw fiber

TC: total ash.

Calculation of the apparent digestive utilization coefficient

The data from these chemical analyses of the samples were used to calculate the apparent Digestive Utilization Coefficient (UDa) of the various nutrients according to the following formula:

$$CUDa\ nutriments\ \% = \frac{Ingérée - Excrétée}{Ingérée} \times 100$$

Statistical analysis

Statistical analyses were performed using GraphPad Prism 8.0.1 software. Comparison of the means of the Apparent Digestive Utilization Coefficients (ADUC) was carried out by analysis of variance (ANOVA 2), with food as the main factor of variation. Two means are significantly different if the probability derived from the statistical tests is less than or equal to 0.05 ($P \leq 0.05$).

Results and discussion

Results

Chemical composition of different foods

Tables 2 and 3 show the chemical composition of the six feeds for each rearing phase, in particular the starter and growth phases. For starter feeds, dry matter content was statistically identical for all feeds, with an average of 85% DM. Crude protein contents were statistically identical, but significantly higher for the Rt1 and Rt2 control feeds (21.40%). In terms of fat content, R75 and R100 recorded the highest levels, with values (3.8 and 3.21%) that were significantly higher ($p < 0.05$) than those of the two control feeds (Rt1 and Rt2), which were identical with an average of 1.5 ± 0.01% ($p > 0.05$). Crude cellulose, calcium and phosphorus contents were statistically identical in all feeds. For growth feeds, dry matter contents were statistically identical for R75 and R100 feeds (88% DM), but different from other feeds (average 85% DM). Crude protein levels are statistically identical, but significantly higher for feed R25 (19.36%).

In terms of fat content, feeds R25, R50, R75 and R100 recorded the highest levels, with values (3.12, 3.84, 3.59 and 3.08%) that were significantly higher ($p < 0.05$) than those of the two control feeds (Rt1 and Rt2), which were identical with an average of 1.8 ± 0.01% ($p > 0.05$). With regard to mineral matter, no major differences were recorded.

Table 1. Analysis methods.

Components	Analysis methods
Dry matter	Oven-dried at 105°C to constant weight
Organic matter	In contrast to the formula, MO (%) = 100 - CT (%)
Gross Protein	Nitrogen determination by Kjeldahl method. The nitrogen measured is multiplied by 6.25 to find the PB content.
Grass material	Soxhlet extraction with petroleum ether (40-60°C) for 6 h
Gross cellulose	Weende method: two acid hydrolyses and one alkaline hydrolysis separated by filtration and hot-water rinsing
Total ash	Calcination in an electronic oven at 550°C for 7 h

Study of the metabolic digestibility of nutrients in formulated feeds

Starter feed

Metabolic results of starter feeds in broilers evaluated in this study are summarized in Table 4. These results show that the metabolic digestibilities of DM, OM, PB, MG, EM and BC were significantly different ($P < 0.05$) for the R75 and R100 starter feeds compared with the others. Indeed, the DM, OM and ME of the control feeds were the most digested by the chickens ($P < 0.05$), followed by the R25 and R50 feeds.

However, overall, the CUDa MS, CUDa MO and CUDa EM were high for all six feeds, ranging from 74.12 to 81.83%, 80.33 to 89.05% MS and 80.26 to 88% MS respectively.

Table 2. Chemical composition of starter diets.

Biochemical composition	Food rations Start-up					
	Rt1	Rt2	R25	R50	R75	R100
Dry matter (DM) in	85	85	85	85	85	85
Crude protein (% DM)	21,40	21,40	21,28	21,37	21,34	21,35
Fat (% DM)	1,05	1,05	1,33	0,45	0,58	0,21
Gross cellulose (% DM)	2,65	2,65	3,95	6,12	10,15	10,37
Calcium (% DM)	0,79	0,71	0,74	0,75	0,80	0,85
Phosphorus (% DM)	0,70	0,62	0,63	0,60	0,70	0,70
Lysine (%)	1,20	1,20	1,28	1,25	1,29	1,31
Methionine (%)	0,62	0,53	0,36	0,23	0,21	0,17
Ca/P	1,13	1,20	1,20	1,25	1,15	1,22
Metabolizable energy (kcal/kg DM)	2948	2 985	2982	2965	2944	2923

Legend: Rt1 : Commercial industrial control feed; Rt2: Control feed containing 100% maize and 0% cassava; R25: Feed containing 75% maize and 25% cassava R50: Feed containing 50% maize and 50% cassava; R75: Feed containing 25% maize and 75% cassava; R100: Feed containing 0% maize and 100% cassava.

PB, MG and BC of the six starter feeds were similarly digested by the chickens (P > 0.05). Statistical analyses revealed that the metabolic digestibilities of MG and PB were significantly different between feeds. Indeed, the CUDa of PB and MG of the six starter feeds decreased concomitantly with the rate of inclusion of cassava flour in the feed. Compared with the other feeds, the chickens had better digested the MG and PB contained in the control feeds, R25 and R50, with MG and PB CUDa of around 80% DM and 72% DM respectively. On the other hand, they did not digest the MG and PB of R75 and R100, with a digestibility rate below 70% DM. As for fiber, the chickens digested less (P = 0.001) of the CB of the six feeds. The results show that the CUDa CB of the control and R25 feeds were statistically similar, and were the best digested at 51.20% DM, 51.23% DM and 50.15% DM respectively. In contrast, the BC of R50, R75 and R100 feeds were the least digestible. In short, Rt1, Rt2 and R25 appeared to be the starters with the most digestible nutritional compounds in chickens.

Table 3. Chemical composition of growth diets.

Biochemical composition	Food rations Growth					
	Rt1	Rt2	R25	R50	R75	R100
Dry matter (DM) in	85	85	85	85	88	88
Crude protein (%)	19,14	19,14	19,36	19,26	19,14	19,21
Fat content (%)	1,8	1,8	1,12	0,84	0,59	0,48
Gross cellulose (%)	2,37	2,35	3,95	6,53	10,30	11,30
Calcium (%)	0,85	0,75	0,85	0,85	0,73	0,77
Phosphorus (%)	0,68	0,66	0,69	0,59	0,65	0,61
Lysine (%)	0,98	0,98	0,30	0,28	0,26	0,26
Methionine (%)	0,57	0,57	0,25	0,15	0,14	0,16
Ca/P	1,25	1,20	1,24	1,44	1,13	1,27
Metabolizable energy (kcal/kg)	3004	3102	3015	3125	3226	3018

Legend: Rt1 : Commercial industrial control feed; Rt2: Control feed containing 100% maize and 0% cassava; R25: Feed containing 75% maize and 25% cassava R50: Feed containing 50% maize and 50% cassava; R75: Feed containing 25% maize and 75% cassava; R100: Feed containing 0% maize and 100% cassava.

The CUDa of Ca and P were statistically similar for all starter feeds. In fact, statistical analysis revealed that the metabolic digestibilities of Ca and P did not differ significantly (P> 0.05) between feeds. They are around 80% MS for all feeds.

Growth feed

The metabolic results of the growth feeds in broilers evaluated in this study are summarized in Table 5. These results show that the metabolic digestibilities of DM, OM, PB, MG, CB and EM were significantly different (P < 0.05) for the R75 and R100 growth feeds compared with the others. Indeed, the DM and OM of the control feeds were the most digested by the chickens (P < 0.05), followed by the R25 and R50 feeds. Overall, however, CUDa DM and CUDa OM were high for all six feeds, ranging from 77.12 to 80.55% and 79.55 to 85.25% DM respectively.

PB, MG and CB from the six growth feeds were similarly digested by the chickens (P > 0.05). Statistical analyses revealed that the metabolic digestibilities of MG and PB were significantly different between feeds. Indeed, the CUDa of PB and MG of the six growth feeds decreased concomitantly with the rate of inclusion of cassava flour in the feed. Compared with the other feeds, the chickens digested the MG and PB contained in the control, R25 and R50 feeds better, ranging from 65.12% to 9% and 87% to 91.2% MS CUDa MG respectively. CUDa PB varied from 68.15 to 73.54% DM respectively. On the other hand, the chickens did not digest the MG and PB of R75 and R100 feeds well, with a digestibility rate of less than 70% MS. As for EM CUDa, there was a significant difference between the growth feeds. EM CUDa values are around 65-71% DM. The EM CUDa of the control (100% corn), R25 and R50 growth feeds are more or less identical to those of R75 and R100. R75 and R100 have the lowest values, at 65.56 and 65.85% DM.

Table 4. Apparent digestive utilization coefficients (ADUC) of nutrients (%) in starter diets.

CUDa (%)	Starter Diets (Average ± SE)						P Value
	Rt1	Rt2	R25	R50	R75	R100	
MS	81,83± 0,50 ᵃ	80,65± 0,12 ᵃ	79,55 ± 0,11 ᵃ	79,33 ± 0,85 ᵃ	74,21± 0,34ᶜ	74,12 ± 0,56ᶜ	<0,001
MO	89,05 ± 0,62ᵃ	89,72± 0,23 ᵃ	84,54 ± 0,86 ᵇ	80,33 ± 0,69 ᶜ	81,73± 0,59 ᶜ	80,34 ±0,46 ᶜ	<0,001
PB	80,33± 0,14 ᵃ	80,46 ± 0,14 ᵃ	80,01 ± 0,72 ᵃ	77,71 ± 0,35 ᵇ	65,90± 0,25 ᶜ	60,15 ± 0,48ᶜ	<0,001
MG	72,15± 0,26 ᵃ	72,45± 0,60 ᵃ	71,46 ± 0,18 ᵃ	70,53 ± 0,25 ᵇ	60,63 ± 0,62ᶜ	65,75 ± 0,85ᶜ	<0,001
CB	51,20± 0,35 ᵃ	51,23 ± 0,56 ᵃ	50,15 ± 0,33 ᵃ	46,77± 0,26 ᵇ	40,88 ± 0,26ᶜ	38,65± 0,45 ᶜ	0,001
Ca	80,2 ± 0,68 ᵃ	80,1± 0,88 ᵃ	80,21 ± 0,54 ᵃ	80,1 ± 0,46 ᵃ	80,1 ± 0,96 ᵃ	80,1± 0,56 ᵃ	0,16
P	80,15± 0,31 ᵃ	80,18± 0,92 ᵃ	80,15 ± 0,45 ᵃ	80,11 ± 0,92 ᵃ	80,12 ± 0,34 ᵃ	80,13± 0,98 ᵃ	0,09
EM	87,35 ± 0,70ᵃ	88± 0,42 ᵃ	86,25 ± 0,63 ᵃ	85,55± 0,63 ᵃ	79,30 ± 0,37ᵇ	80,26 ± 0,54ᵇ	0,001

Rt1 : Commercial industrial control feed; Rt2: Control feed containing 100% maize and 0% cassava; R25: Feed containing 75% maize and 25% cassava R50: Feed containing 50% maize and 50% cassava; R75: Feed containing 25% maize and 75% cassava; R100: Feed containing 0% maize and 100% cassava. SE = Residual standard error; CUDa = Coefficients of apparent digestive utilization; MS = Dry matter; MO= Organic matter; MG= Fat; PB= Crude protein; Ca= Calcium; CB: Crude cellulose, CT: P= Phosphorus; EM= Metabolic energy; P value = Probability value of significance level; Values followed by different letters on the same line (a, b, c) are significantly different (P < 0.05).

The CUDa CB of the control and R25 diets are statistically similar and were the best digested at 49.36% DM, 48.18% DM and 45.25% DM respectively. In contrast, the BCs of R50, R75 and R100 diets were the least digestible. In short, Rt1, Rt2 and R25 appeared to be the starters with the most digestible nutritional compounds in chickens.

The CUDa of Ca and P were statistically similar for all starter feeds. In fact, statistical analyses revealed that the metabolic digestibilities of Ca and P showed no significant difference (P> 0.05) within the feeds. They were also around 80% DM for all feeds.

Discussion

In nutrition, a feed only fulfils its role if the animal eats and digests it (Maertens *et al.*, 2002). This is why in vivo digestibility studies are carried out to gain a better understanding of the percentage of nutrients (organic matter, amino acids, fat and metabolizable energy) absorbed in the digestive tract and which constitute the fraction usable by the animal's metabolism (INRA, 1989). Digestibility is therefore a quantitative concept, expressed in terms of the digestive utilization coefficient (DUC) or digestibility coefficient (DC) (INRA, 1989). In poultry in general, this is a metabolic process, as faeces and urine are evacuated together in the droppings through the same orifice, the cloaca. The CUDa of DM varies from one feed to another, despite the fact that it comes from the same animal species. High DM CUDa values (79 - 81%) were recorded for the control feeds R25 and R50 at start-up and during growth, while the lowest values were recorded for feeds R75 and R100 (74-77%), which is no doubt linked to the crude cellulose content of the feeds. In fact, the crude cellulose content of R75 and R100 feeds (start-up and growth) is the highest (<10% DM), as shown in Tables 2 and 3. This plays a very important role in the digestive transit of the diets, notwithstanding other physiological factors. Foods with high cellulose content have low digestibility, which corroborates the observations of Missohou *et al*, (1995). But also those of Cissé *et al.*, (1997).

The low CUDa MO values obtained with the R75 and R100 feeds could be explained by the poverty of cassava flour in these nutrients. In general, the digestibility of a feed's OM gives an overall picture of its value, which needs to be further assessed by evaluating the digestibility of its various components, such as PB, MG and BC. The PB CUDa of the six starter and grower feeds decreases proportionally with the rate of inclusion of cassava flour in the feed. CUDa PB at start-up and during growth ranged from 70 to 80% DM for the control, R25 and R50 feeds, and statistical analysis showed that the PBs of the feeds tested are digested in a similar way by the chickens. Feeds R75 and R100 had the lowest values (60-68% DM). Digestibility is highly dependent on feed type and varies according to the degree of inclusion of cassava flour. Crude protein digestibility does not necessarily depend on the nutrient content of the feed, which explains our results.

For example, the R75 and R100 feeds which, despite having crude protein contents statistically identical to those of the other feeds, nonetheless showed high digestibility, but with low levels compared to the control feeds, R25 and R50.

Table 5. Apparent digestive utilization coefficients (ADUC) of nutrients (%) for growth diets.

CUDa (%)	Growth Diets (Mean ± SE)						P Value
	Rt1	Rt2	R25	R50	R75	R100	
MS	80,40± 0,18 a	80,11± 0,22 a	80,55 ± 0,92 a	78,11 ± 0,42 b	77,11± 0,87 b	77,52± 0,12 b	<0,001
MO	85,25 ± 0,58a	84,35± 0,66 a	84,00 ± 0,46 b	80,15± 0,21 b	79,95± 0,48 b	79,55 ±0,52 b	<0,001
PB	73,54± 0,55 a	72,85 ± 0,74 a	73,01 ± 0,65 a	70,45 ± 0,12 b	70,05± 0,15 b	68,15 ± 0,17b	<0,001
MG	68,75± 0,65 a	68,85± 0,66 a	65,12 ± 0,42 b	65,65 ± 0,45 b	64,80 ± 0,15b	64,65 ± 0,51b	0,015
CB	49,36± 0,62 a	48,18 ± 0,69 a	45,25 ± 0,46 b	45,75± 0,51 b	43,95 ± 0,84c	42,45± 0,41 c	0,018
Ca	63,56± 0,75 a	64,45± 0,12 a	65,65 ± 0,59 a	65,23 ± 0,84 a	65,20 ± 0,21a	64,28± 0,51 a	0,256
P	45,25± 0,92 a	46,36± 0,61 a	43,40 ± 0,92 a	44,45 ± 0,15 a	43,85 ± 0,12 a	44,18± 0,91 a	0,126
EM	70,45 ± 0,88a	71,14± 0,20 a	70,05± 0,94 a	69,95± 0,48 a	65,56 ± 0,44b	65,85 ± 0,12b	0,076

Rt1 : Commercial industrial control feed; Rt2: Control feed containing 100% maize and 0% cassava; R25: Feed containing 75% maize and 25% cassava R50: Feed containing 50% maize and 50% cassava; R75: Feed containing 25% maize and 75% cassava; R100: Feed containing 0% maize and 100% cassava. SE = Residual standard error; CUDa = Coefficients of apparent digestive utilization; MS = Dry matter; MO= Organic matter; MG= Fat; PB= Crude protein; Ca= Calcium; CB: Crude cellulose, P= Phosphorus; EM= Metabolic energy; P value = Probability value of significance threshold; Values followed by different letters on the same line (a, b, c) are significantly different ($P < 0.05$).

This is probably due to the high crude cellulose content of R75 and R100, which means that the proteins are not absorbed as well as they could be by the digestive mucosa. This shows that the protein content of the diet modifies protein metabolism through its own effects due to the quantities of protein ingested, as well as through effects linked to variations in these intake levels. The best protein efficiency was obtained with the control feed (100% maize). Our results corroborate those of Ayssiwede *et al.*, (2010) who evaluated the metabolic digestibility and nutritional value of *Cassia tora (Linn.)* leaf meal in the feed ration of indigenous chickens in Senegal. Also, the low protein digestibility recorded in chickens on R75 and R100 feeds could be explained by the presence of anti-nutritional factors (phytase, tannin, enzyme inhibitors, etc.) that reduce protein digestibility in poultry, as shown by the work of (Gilani *et al.*, 2005). The results obtained indicate that the digestibility of MG (60-75% DM) in chickens varied considerably according to starter and grower feed. The low MG CUDa values obtained with the R50, R75 and R100 feeds show that the fats contained in cassava meal are the least digested by chickens.

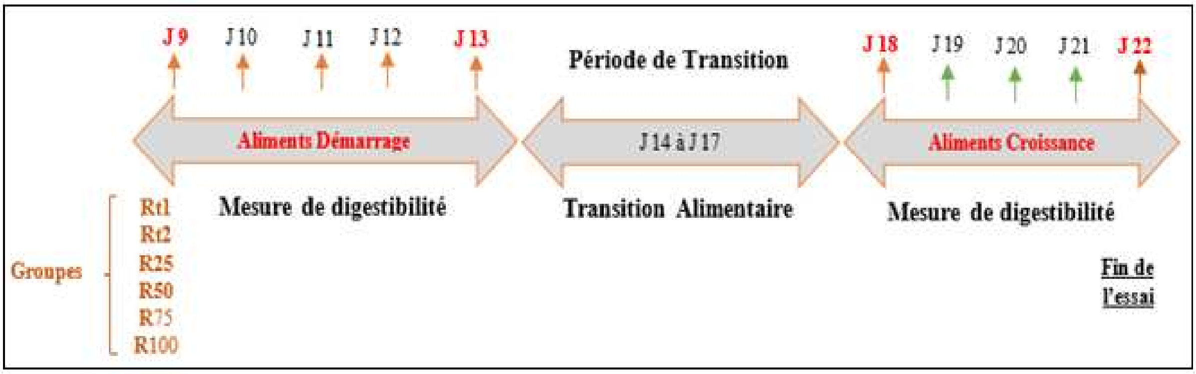

Fig. 1. Schematic diagram of metabolic digestibility test protocol.

This difference in the apparent MG digestibility of the feeds tested could be explained by the nature of the lipids contained in cassava flour. Indeed, the work of (Metayer *et al.*, 2015) has shown that the richer the feed in fatty acids, the better it is digested by the chicken. Yet cassava flour contains relatively very low levels of polyunsaturated (highly digestible) fatty acids (Vernier *et al.*, 2018). The results of this study are very low compared with the CUDa MG of 91% DM and 94% DM reported by (FAS *et al.*, 2015) and (Aguihe *et al.*, 2013), who used compound feeds containing 56% and 59% maize respectively to feed growing chickens. On the other hand, the lower CUDa MG recorded with R75 and R100 feeds (60-64% DM) would probably be due to the low MG contents of starter feeds as growth (0.20-0.60% DM), since the results of (Metayer *et al.*, 2015) show that MG digestibility deteriorates for feeds with lower MG contents. The level of fat in the feed, in addition to influencing digestibility, has an influence on the amount of lipids deposited (Walugembe *et al.,* 2015).

With regard to feed BC digestibility, this corresponds to that of fiber, as cellulose makes up the bulk of dietary fiber (Aguihe *et al.*, 2013). The BC digestibility of the control and R25 starter diets tested was 51.20, 51.23 and 50.15% DM respectively, and that of the R50, R75 and R100 diets was 46.77, 40.88 and 38.65% DM. These results show that the chickens were able to digest a fairly good proportion of the crude fiber contained in the control and R25 starter diets, in contrast to the R50, R75 and R100 diets. These results for the R50, R75 and R100 diets may be due to the high BC content of these feeds (9.12, 10.15 and 10.37% DM). Poultry are unable to digest high-fiber feeds, as the fibers are not hydrolyzed by chickens for lack of specific digestive enzymes (Wiseman *et al.*, 2000). The work of (Tijani *et al.*, 2016) indicated a CUDa CB of 22.15% DM, very low compared with the values obtained in the present study. In contrast, other authors (Lawal *et al.*, 2016 and Ndelekwute *et al.*, 2019) had CB digestibility values of feeds containing 54% cereals close to those obtained with the R25 and control feeds tested. The BC digestibility of the control diets (100% maize) (51% DM) was found to be higher than that of the other experimental diets. This result could be due to the nature of the fibers making up the experimental feeds, particularly in cassava flour.

CUDa CB results for growth feeds showed the same trends as for starter feeds. Average CUDa values for metabolizable energy differed between starter and grower feeds. It is highly dependent on the feed formulated, and varies according to the rate of incorporation of cassava flour. EM's CUDa for the control (100% maize), R25 and R50 starter and grower feeds are more or less identical, and different from those for the R75 and R100 feeds. It is highly dependent on the feed formulated, and varies according to the rate of inclusion of cassava flour in the feed. Generally speaking, the lower the digestibility coefficient of this nutrient, the higher the raw energy intake. However, this intake is not necessarily linked to the nutrient content of the food in question. Generally speaking, analysis of the digestibility coefficient of each food for most nutrients is important for a number of reasons.

Conclusion

At the end of this study, it should be noted that the average values of digestibility coefficients vary from one feed to another and according to the rate of inclusion of cassava flour in both starter and grower feeds. Those for fat, crude cellulose and crude protein fall with the rate of inclusion of cassava flour in the feed. Minerals such as calcium and phosphorus, on the other hand, were not influenced by the feed. Above 50% inclusion of cassava flour in both starter and grower feeds, chickens are unable to digest certain nutrients such as fat, crude cellulose and crude protein. But they do digest minerals, organic matter, dry matter and metabolizable energy.

This work will be continued by evaluating enzyme supplementation to improve digestibility. Studies of the impact of cassava flour on the nutritional characteristics of meat will also be carried out.

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