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Ingestion and *in vivo* Digestibility of a Compound Feed Containing *Adansonia digitata* Seeds in Guinea Pigs

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Abstract: For a better use of the *Adansonia digitata* (baobab) seeds as source of protein in feeding guinea pig, experimental trials were done at the research unit for animal production and nutrition of the University of Dschang. Baobab seeds that were harvested in the North region in Cameroon were submitted to three processing methods: firstly, we had untreated baobab seeds; secondly, baobab soaked in cold water for 24 hours; and thirdly, toasted baobab seeds. Seeds belonging to these three treatments were analysed in order to determine the chemical composition before being incorporated into the following rations: control ration without baobab (R_0), ration including untreated baobab seeds (R_1), ration comprising toasted baobab seeds (R_2), and a ration containing baobab soaked for 24h (R_3). 48 British breeds' guinea pigs having an average weight of 350 ± 50 g, were used for the evaluation of the ingestion and the digestibility of each ration. During the digestibility trial which lasted for 17 days (10 days for adaptation and 7 for data collection), each ration was repeated on 12 guinea pigs. The main results showed that the total grades of tannin and phenol have been considerably reduced ($p < 0.05$) in baobab seeds soaked for 24 hours (0.05% DM; 0.5 mg/100gDM) and in toasted (0.03% DM; 0.3 mg/100g DM). Whatever the sex, the daily ingestion, compound feed (CF), dry matter (DM), organic matter (OM), crude protein (CP) and crude fiber (CF) increase with the incorporation of the baobab seeds powder into the experimental rations of guinea pigs. Likewise, the digestion of nutriments registered has been significantly higher (80.01; 82.14; 83.16; 64.63% respectively for DM, OM, CP and CF) with a ration containing the powder of baobab seeds toasted at a threshold of 5%. Sex did not influence the ingestion and the digestive utilization of nutrients of the various rations at the threshold of 5%. This study shows that the toasted baobab seeds can be used as an alternative protein source in the feeding of guinea pigs.

Keywords: Chemical Composition, Ingestion, Digestibility

1. Introduction

In most African countries where people suffer from malnutrition, food security remains a great challenge [1]. To fight this, the evolvement and vulgarization of mini farming such as guinea pig breeding offers an alternative source of proteins contributing globally to the country's economy through the promotion of jobs, exchanges and the preservation of biodiversity [2]. Despite its importance in the informal economical circuit in rural areas, guinea pig production in Cameroon is mainly done using traditional systems [1, 3]. A great part of its feeding comes from domestic wastes and from harvest residues which, qualitatively and quantitatively, are very poor in essential nutrients. However, it has been underlined that if a strategic breeding follow-up such as an adequate diet program is put in

place, this could improve the productivity of this animal [4].

Unfortunately, the scarcity and high cost of conventional protein sources (soya beans), necessary for a good growth, are responsible for nutritional deficit. On another note, it is imperative to search for non-conventional protein ingredients in order to produce balanced foodstuffs of low cost so as to improve guinea pigs productivity [5, 6]. Amongst these non-conventional protein ingredients, grains of the African baobab (*Adansonia digitata*) may appear as an absolute resource. In Cameroon and in many countries where it grows, leaves from this tropical tree are used in human diet [7] and in feeding animals [8]. The grains, on their part, have a usage which is still sidelined. They are being pressed in order to extract oil, and the deposit dregs are used in the diet of ruminant [9] and poultry [10]. However, the *Adansonia digitata* grains show some toxic and antinutritional factors which require some detoxification methods. Physical and chemical processings have been put to place to control negative effects of those antinutritional factors at a threshold harmless to humans as well as to animals which consume them. Thus, Udensi and collaborators have shown that there is a decrease in tannin content in leguminous grains when soaked in water [11]. According to Dahouda and collaborators, toasting equally decreases by one third phytate contents and almost by half autoclaving [12]. Gbenou and collaborators have revealed a reduction of the high rate of those antinutritional factors (tannin, phytate, flavonoid) present in the *Adansonia digitata* grain when submitted to treatments such as boiling, fermentation and soaking [13].

Nevertheless, till date, very few studies on ingestion and digestibility rations linked to African baobab grains (*Adansonia digitata*) which have undergone the various processing methods, have been carried out on guinea pigs. It is in this line that came to light this work which main goal is to portray the effect of treated *Adansonia digitata* grains on the ingestion and digestibility of guinea pigs.

2. Material and Methods

2.1. Area of the Study

This work was carried out at the Animal Nutrition and Production Research Unit (URPRONAN) of the Faculty of Agronomy and Agricultural Sciences in the University of Dschang. The city of Dschang is located at the 15th Eastern meridian, latitude 5° 36'- 5° 44' North and longitude 09° 85'- 10° 06' East. The area has an equatorial climate modified by altitude. In the locality, precipitations vary between 1500 mm and 2000 mm per year. The average annual temperature turns around 20°, a total annual insolation of 1800 hours, and an average humidity ranging between 40 and 90%.

2.2. Vegetal Material

The vegetal material consisted *Pennisetum purpureum* and seeds of *Adansonia digitata* (untreated, soaked and toasted). The seeds were bought in North region in Cameroon. *Pennisetum purpureum,* harvested at the IRAD farm of Dschang, was cut, dried and ground before being added to the rations.

2.3. Animal Material and Stalls

Forty-eight guinea pigs of English race (24 males and 24 females) aged between 4 and 5 months and of an average weight of 350±50 g were used to evaluate the ingestion and digestibility. The animals were placed in individual wire cages of 10.6 dm^3 (7.6 dm x 4.65 dm x 3.0 dm) having each a plastic feeder and plastic drinker with an intake of 100 g.

2.4. Evaluation of the Chemical Composition of Adansonia digitata Seeds and Preparation of Experimental Rations

The methods described by AOAC show that the chemical composition of *Adansonia digitata* grains was done in order to determine the contents in dry matter, ashes, organic matter, crude cellulose, crude protein, fatty material, condensed tannin, and total phenols [14]. The chemical composition of baobab seeds was figured out at the Animal Production and Nutrition Unit (UPROMAN) of the Faculty of Agronomy and Agricultural Sciences, and at the Biochemistry Nutrition Laboratory of the Faculty of Sciences. Four rations (Table 1), with one in light and three containing 10% of *Adansonia digitata* seeds powder treated or not were constituted according to the different treatments applied on the seeds.

Table 1. *Centesimal composition of experimental rations.*

Ingredients	R0	R1	R2	R3
Maize	28.5	21.0	21.0	21.0
Sharps	45.0	42.5	42.5	42.5
Cotton cake	3.0	3.0	3.0	3.0
Soybean meal 49	3.5	3.5	3.5	3.5
Palm kernel cake	3.0	3.0	3	3.0
Fish meal 60	5.0	5.0	5	5.0
Oyster shell	0.5	0.5	0.5	0.5
Untreated Baobab	0.0	10.0	0.0	0.0
Toasted Baobab	0.0	0.0	10.0	0.0
soaked Baobab	0.0	0.0	0.0	10.0
Pennesetum P	10.0	10.0	10.0	10.0
Oil	1.0	1.0	1.0	1.0
Premix	0.5	0.5	0.5	0.5
Total	100	100	100	100
Chemical Composition (% MS)				
DM	92.47	92.29	95.25	93.18
OM	86.06	85.81	85.97	86.27
CP	23.85	23.73	23.27	23.67
CF	13.32	13.84	13.48	13.14
FM	3.67	03.81	03.73	03.34
Ashes	6.41	6.47	6.28	6.91
Digestible energy (Kcal)	4406.24	4374.12	4356.46	4382.7

DM = dry matter; OM = organic matter; CP = crude protein; CF = crude fiber; FM = fatty matter; R0 = control ration; R1 =ration containing untreated baobab seeds R2 = ration containing toasted baobab seeds R3= ration containing soaked baobab seeds for 24h.

2.5. Evaluation of in vivo Ingestion and Digestibility Rations

For each treatment, 12 animals (6 males and 6 females) aged between 4 to 5 months, weighing averagely 450 ± 50 g, were used per ration. Those animals were randomly zoned in individual digestibility cages, and were fed once a day between 8 and 9 am. As for ingestion evaluation, each animal was being served 40 g of feed and those that refused to eat were collected daily and weighed before any other distribution. Those that did not eat were quantified so as to determine the amount of food ingested. The feed ingestion was calculated following the formula below:

Food ingestion = Daily amount of food served – Amount not consumed (refusal)

The digestibility trial was preceded by an adaptation period which lasted for 10 days with the aim to familiarise the animals to digestibility cage and to granulated compound feed. During this period, the quantities of granulated compound feed served were adjusted to the animal's consumption estimated at 40 g/animal/day. During the data collection period which lasted for 7 days, every morning before sharing the feed, faeces were collected, weighed and dried at 60°C in the laboratory in a ventilated oven. Subsequently, the analysing of their content in dry matter (DM), in organic matter (OM), in crude protein (CP), and in crude fiber (CF), following the method described by AOAC (2000). The formula of Roberge and collaborators was used to calculate the apparent digestive utilization coefficients of Dry Matter (CUDaDM), Organic Matter (CUDaOM), Crude Protein (CUDaCP), and Crude Fiber (CUDaCF) [15]:

$$CUDaDM\ (\%) = (DM\ ingested - fecal\ DM)/(DM\ ingested) \times 100$$

$$CUDaOM\ (\%) = (OM\ ingested - OM\ fecal)/(OM\ ingested) \times 100\ CUDaCP\ (\%) = (CP\ ingested - CP\ fecal)/(CP\ ingested) \times 100$$

$$CUDaCF\ (\%) = (CF\ ingested - CF\ fecal)/(CF\ ingested) \times 100$$

2.6. Statistical Analysis

Data on the ingestion of feed and digestibility of nutriments were propounded to variance analysis (ANOVA) at two factors (treatment and sex) following general linear model (GLM). When great differences were observed between the processing, the averages separation was done by Waller Duncan's test at a significant threshold of 1% [16]. The SPSS 21.0 analysis software was used for the purpose.

Table 2. *Chemical composition of Adansonia digitata grains submitted to different treatments.*

Chemical composition	Baobab seeds				
	Untreated	Soaked	Toasted	SEA	P
DM (%)	92.29^{c}	93.24^{b}	95.25^{a}	0.437	0.001
OM	85.81^{c}	88.33^{b}	89.97^{a}	0.604	0.001
ASH	6.47^{a}	4.91^{c}	5.28^{b}	0.238	0.001
CP	23.72^{b}	19.67^{c}	26.27^{a}	0.993	0.001
Lipids	20.81^{a}	15.34^{c}	16.73^{b}	0.841	0.001
CF	13.84^{c}	20.14^{a}	18.48^{b}	0.941	0.001
Tannin (mg/gDM)	0.10^{a}	0.05^{b}	0.03^{b}	0.011	0.001
Total phenols (mg/gDM)	0.70^{a}	0.50^{a}	0.30^{a}	0.020	0.102

DM = dry matter; OM = organic matter; CP = crude protein; CF = crude fiber, FM = fatty matter; SEA= Standard Error on average; p = Probability, ($p<0.01$).

3. Results

3.1. Effects of Various Treatments on the Chemical Composition of Adansonia digitata Grains

In a flexible manner, the different treatments applied on *Adansonia digitata* grains have influenced its chemical composition (Table 2). The DM content, organic and protein matter of toasted *Adansonia digitata* grains have been significantly ($p<0.05$) higher than that of untreated grains and grains soaked for 24 hours. Content in raw cellulose has been meaningfully ($p<0.05$) lower in untreated grains. Content in condensed tannin has been comparable ($p>0.05$) and noticeably ($p<0.05$) lower in the treated *Adansonia digitata* grains. In contrast, irrespective of the treatment the content in total phenols has been comparable to a 1% threshold.

Table 3. *Average ingestion of granulated compound feed of dry matter (DM), of organic matter (OM), of crude proteins (CP), and of crude fiber (CF) per animal according to experimental processings and sex.*

Ingestions (g DM/D/animal)	Sex	Treatments				SEA	P
		R0	R1	R2	R3		
granulated compound feed (GCF)	♂(5)	22.57^{c}	30.41^{b}	34.07^{a}	31.35^{b}	1.30	0.01
	♀(5)	22.16^{c}	32.86^{a}	27.29^{b}	26.52^{b}	1.16	0.01
	♂♀(10)	22.36^{c}	31.63^{a}	30.68^{a}	28.93^{b}	1.21	0.01

Ingestions (g DM/D/animal)	Sex	Treatments				SEA	P
		R0	R1	R2	R3		
Nutriments							
	♂(5)	20.05^{c}	27.12^{b}	30.60^{a}	28.16^{b}	1.19	0.01
Total dry Matter (DM)	♀(5)	19.69^{c}	29.30^{a}	24.52^{b}	23.91^{b}	1.04	0.01
	♂♀(10)	19.87 ^{b}	28.21^{a}	27.56^{a}	26.03^{a}	1.11	0.01
	♂(5)	20.19^{c}	27.06^{b}	30.55^{a}	27.89^{b}	1.16	0.01
Organic matter (OM)	♀(5)	19.83^{c}	29.23^{a}	24.47^{b}	23.60^{b}	1.02	0.01
	♂♀(10)	20.01^{c}	28.14^{a}	27.5^{a}	25.74^{b}	1.09	0.01
	♂(5)	2.57^{c}	3.65^{b}	4.16^{a}	3.50^{b}	0.17	0.01
Crude protein (CP)	♀(5)	2.53^{d}	3.95^{a}	3.33^{b}	2.96^{c}	0.15	0.01
	♂♀(10)	2.55^{c}	3.80^{a}	3.74^{a}	3.23^{b}	0.16	0.01
	♂(5)	2.15^{d}	3.44^{c}	4.05^{a}	3.60^{b}	0.21	0.01
Crude Fiber (CF)	♀(5)	2.53^{d}	3.95^{a}	3.33^{b}	2.96^{c}	0.19	0.01
	♂♀(10)	2.34^{c}	3.69^{a}	3.69^{a}	3.28^{b}	0.20	0.01

$^{a, b, c, d}$: averages carrying the same letters on the same line are not significantly different from the threshold of 5%; SEA: Standard Error on average; p: Probability; (p<0.01): enrolment; ♂: male; ♀: female; ♂♀: male and female mixed; R_0: ration without baobab grain; R_1: ration containing untreated baobab grain powder R_2: ration containing toasted baobab grains R_3: ration containing baobab grains soaked for 24h.

3.2. Effects of the Treatment of Adansonia digitata Grains on the Ingestion and Digestive Usage of Nutriments on Guinea Pigs

The average dietary ingestion of dry matter (DM), of organic matter (OM), of crude proteins (CP), and of crude fiber (CF) per animal according to experimental processings and sex (Table 3) reveals that no matter the sex, average values of daily ingestion, compound feed, dry matter, organic matter, crude proteins, and crude fiber have increased with the use of *Adansonia digitata* grains in experimental rations. In male guinea pigs, average ingestion of nutriments of animals fed with ration R2 containing toasted baobab grain powder have been significantly (p<0.01) higher than those registered on animals in the other batches. In female guinea pigs, the ingestion of compound feed, of DM, and of OM of rations R2 and R3 have been comparable to a 1% threshold and significantly (p<0.01) lesser than that of ration R1 and higher than that of witness ration. On the contrary, the ingestion of CP and CF of ration R1 have been meaningfully (p<0.01) higher than those of rations R2 and R3 and lesser than the ingestion of R0. Irrespective of sex, the average consumption of compound feed, of DM, of OM, of CP, and of CF have been significantly (p<0.05) higher and comparable to rations R1 and R2 at a threshold of 1%.

3.3. Effects of the Treatment of Adansonia digitata Grains on Digestive Use of Nutriments on Guinea Pigs

Apparent digestive usage coefficients of dry matter (DM), of organic matter (OM), of crude protein (CP), and of crude fiber (CF) in accordance with the treatment of *Adansonia digitata* grains in experimental rations and sex presented in Table 4 reveals that the digestibility of nutriments has increased with the presence of grains. Irrespective of sex, digestion of nutriments registered has been significantly (p<0.05) higher with ration R2 at a 1% threshold. However, with the male, no significant difference (p>0.01) has been noted between the values of DM, of OM in animals taking rations R1 and R3. On the female, digestibility values of DM, OM and CF, obtained from animals submitted to ration R1 have been considerably (P < 0.01) lower than those registered in other packs; on the contrary the CP value found in this same ration was as comparable to that of witness rations and R3 at a 1% threshold.

Table 4. *Apparent digestive use coefficient (CUDa) on guinea pig according to experimental treatments and sex.*

CUDa (%)	sex	Treatments				*SEA*	p
		R0	R1	R2	R3		
	♂(5)	59.85^{c}	63.94^{b}	80.37^{a}	64.82^{b}	2.38	0.01
DM	♀(5)	60.04^{b}	56.71^{c}	79.66^{a}	61.10^{b}	2.72	0.01
	♂♀(10)	59.94^{b}	60.32^{b}	80.01^{a}	62.96^{b}	2.55	0.01
	♂(5)	65.95^{c}	68.49^{b}	82.11^{a}	69.30^{b}	1.91	0.01
OM	♀(5)	65.86^{b}	62.36^{c}	82.18^{a}	66.56^{b}	2.31	0.01
	♂♀(10)	65.90 ^{a}	65.42 ^{b}	82.14^{a}	67.93^{b}	2.11	0.01
	♂(5)	65.88^{d}	72.66^{b}	84.04^{a}	69.09^{c}	2.09	0.01
RP	♀(5)	64.02^{c}	65.25^{bc}	82.28^{a}	66.59^{b}	2.25	0.01
	♂♀(10)	64.95^{c}	68.95^{b}	83.16^{a}	67.84^{b}	2.17	0.01
	♂(5)	15.89^{d}	32.40^{c}	64.89^{a}	38.17^{b}	5.31	0.01
RC	♀(5)	49.53^{a}	20.61^{c}	64.37^{a}	32.33^{b}	5.01	0.01
	♂♀(10)	32.71^{c}	26.50^{d}	64.63^{a}	35.25^{b}	5.16	0.01

$^{a, b, c, d}$: averages carrying the same letters on the same line are not significantly different at a 5% threshold; SEA: Standard Error on average; p: Probability, (p<0.01): enrolment; ♂: male; ♀: female; ♂♀: male and female joined. R_0: ration without baobab; R_1: ration containing untreated baobab grains R_2: ration containing toasted baobab grains R_3: ration containing baobab grains soaked for 24h.

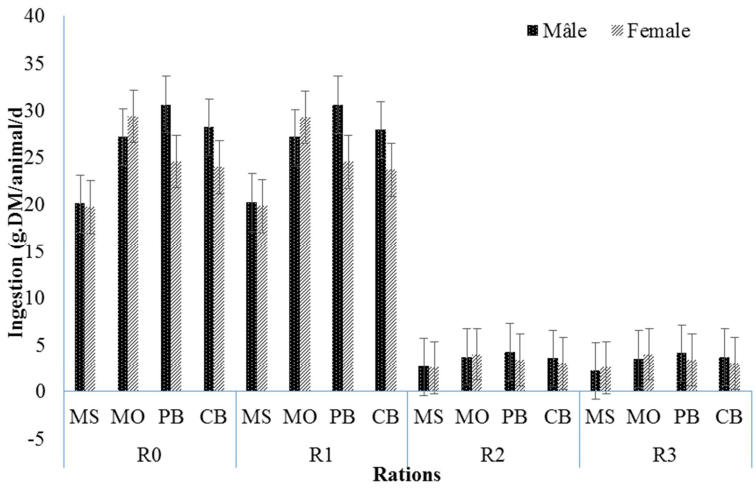

Figure 1. *Effect of sex on the ingestion of DM, OM, RP, and RC in guinea pigs fed with rations containing various treatments of Adansonia digitata grain.*

R0: ration without baobab; R1: ration containing untreated baobab grain powder; R2: ration containing toasted baobab grain powder; R3: ration containing baobab grain powder soaked for 24h.

3.4. Effects of Sex on the Ingestion and Digestive Use of Nutriments on Guinea Pigs Submitted to Various Treatments of Adansonia digitata Grains

The comparison of various rations of nutriments ingestion according to sex of guinea pigs fed with rations containing *Adansonia digitata* treated or not (Figure 1) shows that sex has no major influence ($p>0.01$) on nutriments ingestion of different rations. Nevertheless, this ingestion has been significantly ($p>0.01$) poor with rations R2 and R3.

3.5. The Effect of Sex on the Digestibility of Adansonia digitata Grains Which Have Undergone Several Treatments, in Guinea Pigs

The sex did not significantly ($p>0.05$) influence the digestive usage of nutriments on guinea pigs nurtured with rations R0, R1 and R2 (Figure 2). In contrast, the digestive usage coefficient of DM and RC has been much more ($p<0.05$) lower on females with ration R3. Nonetheless, the coefficient of nutriments digestive usage has greatly ($p<0.05$) been higher in animals nourished with ration R2.

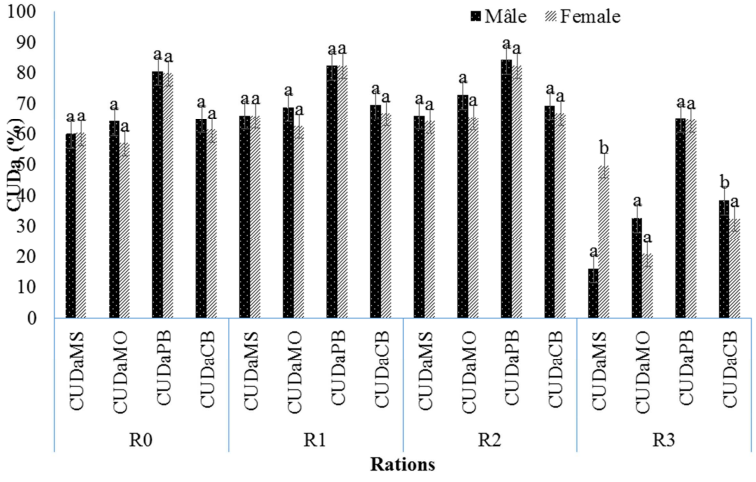

Figure 2. *Effect of sex on the apparent digestive utilization coefficients of Adansonia digitata grains submitted to different treatments, on guinea pigs.*

[a, b]: Averages having the same letters for the same parameter are not significantly different at a 1% threshold for the same treatment; R0: ration without baobab; R1: ration containing untreated baobab grain powder; R2: ration containing toasted baobab seed powder; R3: ration containing baobab seed powder soaked for 24h.

4. Discussion

The content in fatty matter of non-treated *Adansonia digitata* grains has been significantly ($p<0.05$) greater than that of grains toasted and soaked for 24hours; the opposite effect has been noticed with the content in raw cellulose significantly ($p<0.05$) very poor in non-treated grains. The content in protein of toasted *Adansonia digitata* grains has been significantly greater than that of non-treated grains

and grains soaked. On the one hand, this could be explained by the fact that the 24 hours treatment would have help reduce the condensed tanin and phenol in order to make available proteins of the beforehand precipitated ration. This result matches with work of Lawan and collaborators quoted by Gbénou and collaborators who showed that soaking and roasting reduce contents in tannins, in alkaloids, in flavonoids, in phytates [17, 13]. Furthermore, Udensi and collaborators reported a decrease of content in tannin, phenol, and phytate in leguminous grains after soaking for 24h in water [11]. However, fatty matter and available proteins will have been denatured and diminished, adding thus the content in cellulose when drying the soaked grain.

The daily ingestion of dry matter (DM), organic matter (OM), crude protein (CP), and of crude fiber (CF) has increased with treatments brought to *Adansonia digitata* grains in experimental rations. This result goes on the same line with observations done by many authors [5, 18, 4]. According to these authors, the presence of protein sources, with required proportions, boosts the ingestion and digestion of rations. The highest ingestion level of DM obtained from this trial (31.63 g DM/d/animal), has been greater to the values 21.20 ± 12.9 g DM/day/animal as reported by Niba and collaborators, but lesser to 56.8 et 63.22 g DM/d/animal as reported respectively by Nguedia and collaborators and Egena and collaborators [19, 21, 22]. It could be explained by the content in digestible energy of the rations used. In fact, Egena and collaborators like Nguedia and collaborators have shown that when the amount of energy of the ration is poor the animal consumes more and vice versa [22, 21]. Thus, animals regulate their ingestion depending on the content in energy of the ration. On other note, rations containing untreated and toasted grains were the most consumed, this could be explained by the fact that, as compared to others, it had a greater level of content in crude fiber. These results support those of Meyer and collaborators who underlined that an excess quantity of fibre in the ration has as effect the increase of voluntary ingestion [23]. The highest digestibility values (80.01; 82.14; 83.16 and 64.63% respectively for that of DM, OM, CP, and CF) are greater than (31.7; 23.1; 6.5 and 4.1% respectively for that of DM, OM, CP, and CF) those reported by Fokom and collaborators in guinea pigs fed with ration containing *Moringa oleifera* grains [24]. The cause of this difference could be the chemical composition of grains, notably the type of processing to which the grains were submitted to. On another note, these values are close (78.72; 82.41; 69.34 and 86.72% respectively), reported by Zougou and collaborators, with granulated feed containing conventional proteins [4]. However, these results have been greater (52.22%, 53.02%, 37.37% and 59.06% respectively) to those reported by Noumbissi and collaborators [25]. This is clarified by the protein source used.

The digestibility of raw cellulose has increased after the treatment (soaking or toasting of grain). However, fibres act as a physical barrier to microbial attack, and thus a depressive role on digestibility [26]. Toasting may have a positive effect on the shells of the grains in that constituents of its cellular wall were attacked during the treatment, what may have led to their weakening. In fact, even a low use of nitrogen in a ration poor in protein ameliorates digestibility of cellulose [27]. The bioavailability of proteins following the treatment may have improved the digestive use of cellulose. Actually, protein complementation of impoverished fodders assures the digestive tube of favourable conditions to cellulolytic microflora proliferation, thus speeding fermentation and therefore cellulose digestibility [28].

5. Conclusion

It results from this study that:

1) The different treatments done on *Adansonia digitata* seeds have greatly reduced its condensed tannin and total phenols contents.
2) Toasted *Adansonia digitata* seeds have upgraded the ingestion of rations as compare to soaked and untreated seeds.
3) The digestive use of proteins has been increased when the seeds were toasted before being incorporated in the ration.
4) Sex did not influence the ingestion and the digestive utilization of nutrients of the various rations.

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