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Research article

Digestibility of Cereal Grains and Biochemical Assimilation of their Nutrients in Rabbits

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Abstract

In order to evaluate the nutritional value of cereal grains (CG) used in rabbits feed, an *in vivo* digestibility and metabolism test were conducted over five days on forty adult rabbits with an average weight of 1921.65±5 g. An experimental fisher block with five treatments and eight replicates of rabbits was used. Rabbits were fed with each single CG: White Maize EVDT-W (WM), Yellow Maize SAMAZ-40 (YM), White Sorghum (WS), Red Sorghum (RS) and Millet (MI). The composition of CG was determined through chemical analyzes. The apparent digestibility of Dry Matter (DM), Organic Matter (OM), Ether Extract (EE), Crude Fiber (CF), Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF) and Ash were evaluated. Similarly, concentrations of Glucose, Total Proteins, Total Cholesterol and Triglycerides were determined in rabbits blood through biochemical analyzes. The results showed that rabbits similarly digested (P> 0.05) DM (85 to 93%), OM (86 to 93% DM), EE (97 to 99% DM), NDF (93 to 96% DM) and ADF (47 to 61% DM) of the five CG. However, apparent digestibility of CF and Ash of the five CG was low (36 to 57% DM and 25 to 64% DM, respectively). Millet grains appeared to be the grain that nutritive compound were more digestible by rabbits. Moreover, CG had no significant influence (P>0.05) on blood glucose, Total Protein, Total Cholesterol, and Triglycerides levels in rabbits. However, in all the dietary treated, blood total protein of rabbits increased significantly (P<0.05) after feeding with the cereal grains. The good digestive use of cereal grains nutrients indicates that all the tested grains are suitable in rabbit's balanced feed.

Keywords: Cereal grains, Apparent Digestibility, Metabolism, Rabbit, Bénin.

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Introduction

Rabbit, a short-cycle animal, has great potentials to increase meat production and thereby reduce protein deficiency in the poorest regions. The rabbit is characterized by its high legendary prolificity, its rapid growth (Etchu et al. 2013) and its high efficiency in high-quality animal protein production (Aboh et al. 2013).

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Rabbit meat is low calorie, very good quality of protein, rich in omega-3 fatty acid and excellent source of vitamins (B3 and B12), minerals (phosphorus, potassium) and trace elements (selenium) (Afssa, 2007). This gives a renewed interest to rabbits, that nutritional qualities meet the expectations of consumers (Combes, 2004).

In commercial farm, rabbit is fed with balanced feed, containing Concentrated Feed Resources (CFR), including mainly cereal grains. In West Africa, the most common cereal grains used to feed animals are maize, millet, and sorghum (Archimède et al. 2011).

The challenge for feed formulator is to obtain diets that are cost-effective and fully meet the needs of the animals (Maertens et al. 2002). So, an accurate knowledge of the feed nutritional value of available feed resources is fundamentally important. The nutritional value of feed or feedstuff is characterized by its concentration in different nutrients (Dimi, 1990) and its digestibility by animals. Often, in each country the feed value of feedstuffs is listed in national nutritional composition tables (INRA, NRC, EGRAN, FEEDBASE, etc.). These tables are very useful for both farmers and scientists in balanced feed formulation (Maertens et al. 2002). It is therefore appropriate, to develop a national table of the nutritional value of the CFR including cereal grains used in rabbits feeding in Benin.

Akinmutimi (2004) reported that blood biochemical components are generally influenced by the quantity and quality of food. Thus, the serum biochemical parameters allows on the one hand, to determine the quality of the feed by which the animals have been fed and the quality of their meat; on the other hand, to evaluate the biochemical assimilation of the feed by the animals' organism (Thrall et al. 2012; Hochleithner et al. 2013). Therefore, the determination of cereal grains nutritional value and the serum biochemical parameters they induced in rabbits would contribute to the valorization of these grains in rabbit's diet.

In that perspective, this study aims to contribute to the development of a national table of feedstuffs for in Bénin.

Materials and Methods

Experimental animals and housing

Forty adult rabbits, having an average weight of 1921.65 ± 55 g were randomly divided into five groups of eight rabbit each. Each rabbit was housed individually in a digestibility cage, 40 cm x 35 cm x 40 cm equipped with feeder, drinker and a device for total faeces collection. The rabbits were previously dewormed against helminthiases and coccidiosis.

Feed and experimental design

Concentrated Feed Resource (CFR) used in this study is five types of cereal grains (CG) available in Benin. They are: White Maize EVDT-W (WM); Yellow Maize SAMAZ-40 (YM); White Sorghum (WS); Red Sorghum (RS) and Millet (MI). These were ground into meal. Table I shows their chemical composition.

The experimental design used was a Fisher block with five dietary treatments of CG (WM; YM; WS; RS; MI) with eight replicates of one rabbit each. Each group of eight rabbit has been therefore randomly assigned to a CG.

Evaluation of cereal grains digestibility in rabbits

To assess the apparent digestibility of CG in rabbits, an *in vivo* digestibility experiment of five-day was conducted. Five groups of eight rabbits were fed *ad libiditum* with the corresponding single CG for five days and fasted for 12 hours. Then, rabbits were fed *ad libiditum* for five consecutive days during which total faeces were collected daily at the same time in the morning per rabbit. During this period, each rabbit was watered *ad libitum*.

The quantities of feed served and refused were weighed per rabbit. Samples of faeces, CG served and refused were refrigerated at + 4°C for chemical analyzes.

Chemical analyzes data were used to estimate the Apparent Digestibility (AD) of different nutrients (DM, OM, CP, EE, CF, NDF, ADF and TA) and of Energy of each CG, as follows:

Apparent digestibility = [(Nutrients Content in feed x FI) – (Nutrients Content in faeces x FO)] x100/ Nutrients Content in feed x FI with,
FI = Feed Intake and FO = Faecal Output.

Chemical analyzes

Chemical analyzes were performed on samples of the five CG and rabbits faeces. These samples were analyzed by using official methods approved by AOAC (2000) to evaluate the Dry Matter (DM), the Organic Matter (OM), the Crude Protein (CP) or the total nitrogen (TN), the Ether Extract (EE), the Crude Fiber (CF), the Neutral Detergent Fiber (NDF), the Acid Detergent Fiber (ADF) and the total ash (TA).

Contents of CG nutrients: Non-Nitrogen Extract (NNE); hemicellulose (HEM); Gross Energy (GE) and Digestible Energy were estimated using various formulae (Table I).

Evaluation of some hepatic biochemical parameters in rabbits

At the beginning of the adaptation period and at the end of the five consecutive days of digestibility experiment, four rabbits randomly selected by tested CG, was collected on a fasting basis early in the morning for the hepatic biochemical study. The blood was collected from the marginal vein of the ear in dry

tubes and tubes with anticoagulant (Sodium Fluoride). After two hours, blood was centrifuged at 3500 towers for ten minutes. Serum and plasma collected were kept at -20°C for biochemical analyzes. The conventional procedures were used to measured Blood glucose (Biolabo Glucose, Ref: LP80209), Total Protein (Biolabo Total Proteins, Ref: 80103), Total Cholesterol (Biolabo Cholesterol Chod-Pap, Ref 80106) and Triglycerides (Biolabo Triglycerides, Ref: 80019). Glucose was measured within 24 h and the other parameters within 72 h.

Statistical Analyzes

Statistical analyzes were performed in R version 3.6.0 software environment (R Core Team, 2019). In order to determine the relationships between CG (WM, YM, WS, RS, and MI) and the Apparent Digestibility (AD), a Principal Component Analysis (PCA) was performed. A linear mixed model (fixed factor - CG and random factor-block) was performed to assess the effects of the CG on the AD of their nutrients and on hepatic biochemical parameters in rabbits respectively. The conditions of application of the linear model mixed effects (residuals normality, average invalidity and homogeneity of residue variance: Pinheiro and Bates (2000) have been previously verified. In case of non-compliance with these application conditions, a Kruskal Wallis test (Crawley, 2013) was preferred. When the probability is significant ($p<0.05$), a structuring of averages was realized with the *posthoc.kruskal. dunn.test* function of the package "PMCMR" (Pohlert, 2014).

In addition, in order to compare the initial and the final biochemical parameters of the rabbits, a two-sample paired Student test was performed. The application conditions of this test (data normality and variances homogeneity) were previously verified. The values are presented as average ± Standard Error in Tables II and III.

Results

Chemical and energetic values of cereal grains in rabbits

Table I shows chemical composition of different CG used to feed the experimental rabbits. The proportions of DM (90%) and OM (98% DM) in five CG were very high. EVDT-W white maize was the richest CG in CP (more than 13% of DM), while Millet grains were the poorest one. Thus, Yellow maize SAMAZ-40 was poorer in CP than White maize EVDT-W. Red sorghum was richer than the White in CP. Millet grains were richer in EE, CF, and TA than other CG. Both maize varieties contained approximately the same proportion of EE (3.9% DM), while EE content was higher in White sorghum than in Red sorghum.

The CF and TA content of the two maize varieties were similar. Red sorghum was richer in CF than White sorghum. White maize grains were the richest in ADF, while Millet grains were the poorest in NDF. However, millet grains were found to be the richest in Hemicellulose. The NNE proportion exceeded 80% in all the CG, except in white maize where it was lower.

The maize grains were the richest CG in Gross Energy (approximately 4540 Kcal/kg DM) while the richest in Digestible Energy was Millet (4166 Kcal/kg DM). Apart from the Yellow maize (3949 Kcal/kg DM), the Digestible Energy of CG in rabbits exceeds 4000 Kcal/kg DM.

Apparent digestibility of cereal grains in rabbits

Apparent Digestibility (AD) of cereal grains in rabbits are summarized in Table II. The results showed that DM, OM, EE, CF, NDF, and ADF in CG were similarly digested by rabbits ($P>0.05$). In general, AD of DM; OM; NDF and EE contents were high in all the five CG and varied respectively from 84% to 93%; 86% to 93% DM; 93% to 96% DM and 97% to 98% DM. The CF of all the CG was poorly digested by rabbits with an AD between 36 and 51% DM. ADF was moderately digested by rabbits (47 to 64% DM). The lowest AD of CF and ADF in rabbits were respectively obtained with the white maize and the white sorghum.

Apparent digestibilities of CP and TA were significantly different between the CG ($P<0.005$). In fact, AD of CP and TA of the five CG varied respectively from 54% DM to 93% DM and from 25% DM to 64% DM respectively. Compared to other CG, rabbits digested better the CP in Millet ($P=0.000$). In contrary, Yellow maize CP was the less digested (55% DM). Rabbits similarly digested the CP in White sorghum, Red sorghum, and Millet grains. Also, they used in a similar way (87 to 93%), the Gross Energy of the five CG.

The digestibility of CG minerals was low in rabbits. The results show that TA of Millet grains was the most digestible (64% DM), ($P=0.011$); while that of White maize (25% DM) was the less digested by rabbits.

The results of the Principal Components Analysis (PCA) carried out to describe the relationships between the Apparent Digestibility of nutrients in rabbits and the CG show that the first two axes concentrate 83.8% of the initial information (Figure 1) which is sufficient to guarantee an accurate interpretation. The projection of CG and AD nutrients (Figure 1) reveals that millet grains induce high digestibility in DM, NDF, OM, CP, CF, and TA (Dim 1). Red Sorghum and white maize induced a high AD to ADF, whereas yellow maize and millet (in addition to above characteristics) induced a high digestibility in EE.

On the whole, comparatively to the other CG, the Millet grains appeared to be the most digestible cereal.

Table I: Nutritive value of cereal grains (CG)

Composition	WM	YM	WS	RS	MI
DM	86.91	90.41	87.42	89.61	87.59
OM (% DM)	98.31	98.56	98.16	98.09	97.86
CP (% DM)	13.58	10.36	9.38	11.90	8.82
EE (% DM)	3.81	3.99	3.56	2.3	4.06
CF (% DM)	2.25	2.56	1.89	2.05	2.80
ADF (% DM)	4.24	3.45	3.91	4.01	3.83
NDF (% DM)	12.5	12.3	11.1	10.91	17.2
HEM (% DM) ¥	8.26	8.85	7.19	6.90	13.37
TA (% DM)	1.68	1.43	1.83	1.90	2.13
NNE (% DM) §	78.67	81.65	83.33	81.84	82.18
GE (Kcal/Kg DM) *	4554.52	4530.54	4469.54	4439.00	4482.52
DE (Kcal/Kg DM) µ	4070	3949	4075	4022	4166

DM= Dry Matter; OM= Organic Matter; CP= Crude Protein; EE= Ether Extract; CF= Crude Fiber; ADF= Acid Detergent Fiber; NDF= Neutral Detergent Fiber; HEM= Hemicellulose; TA= Total Ash; NNE= Non-Nitrogen Extract; WM= White Maize; YM= Yellow Maize; WS= White Sorghum; RS= Red Sorghum; MI = Millet: ¥ Calculated according to the formula given by Maertens et al. (2002): HEM (%) = NDF – ADF: § Calculated using the INRA formula (1989): NNE (%) = 100 – (EE+CP+TA+CF): * Estimated with INRA (2004) predictive equation: GE (Kcal/Kg DM) = 4134 + 14.73 CP + 52.39 EE + 9.25 CF – 44.60 TA + Δ= 75: µ Calculated using formula: DE (Kcal/Kg DM) = GE (Cereal grain) – GE (Faeces).

Table II: Effects of Cereal Grains (CG) on Apparent Digestibility (AD) in rabbits

Apparent Digestibility (%)	CG (Mean ± SE)					Pr (>F)
	WM	YM	WS	RS	MI	
Dry Matter	88.64±1.33	84.46±2.75	91.00±1.84	90.44±2.00	92.74±1.87	0.064
Organic matter	89.83±1.19	85.78±2.51	91.98±1.64	91.28±1.83	93.36±1.71	0.058
Crude Protein	76.47±2.76^{b}	74.31±8.08^{b}	91.00±1.84^{ab}	90.44±2.00^{ab}	92.74±1.87^{a}	0.000[1]
Ether Extract	97.20±0.33	97.55±0.43	97.02±0.61	96.59±0.71	98.55±0.37	0.106
Crude Fiber	36.00±6.24	41.70±7.49	46.31±4.46	42.12±8.00	51.19±11.01	0.353
NDF	94.01±0.70	92.73±1.29	94.05±1.21	94.51±1.15	95.68±1.11	0.467
ADF	61.22±4.55	49.60±7.44	46.82±10.85	63.95±7.55	57.80±10.85	0.569
Total Ash	24.68±7.34^{b}	43.80±7.22^{ab}	53.20±7.91^{ab}	55.90±6.60^{ab}	64.12±9.23^{a}	0.011[1]
Energy	89.37±1.25	87.17±2.04	91.18±1.80	90.61±1.97	92.93±1.82	0.244

SE= Standard Error; WM= White Maize; YM= Yellow Maize; WS= White Sorghum; RS= Red Sorghum; MI = Millet; Pr (>F): 5% significance probability; [1] =Kruskal Wallis test. For an AD, the mean followed by different letters on the same line are significantly different

Tableau III: Blood biochemical parameters of rabbits fed with Cereal Grains (CG)

Parameters	Sampling time	Cereal Grains (Mean ± SE)					Prob
		WM	YM	WS	RS	MI	
Blood Glucose (g/L)	BeT	0.94±0.04	0.91±0.05	1.02±0.04	0.94±0.03	1.00±0.03	0.6026
	AfT	1.00±0.02	0.91±0.07	1.01± 0.07	0.97±0.06	1.10±0.09	0.4411
	Prob	0.325	0.648	0.821	0.800	0.180	
Total Protein (g/L)	BeT	60.05^{b}±0.86	62.32^{b}±2.23	54.57^{b}±2.36	57.30^{b}±1.03	58.50^{b}±2.72	0.1265
	AfT	72.50^{a}±1.79	70.18^{a}±1.98	67.00^{a}±2.42	70.40^{a}±2.59	66.48^{a}±2.95	0.3842
	Prob	0.001	0.043	0.008	0.010	0.022	
Total Cholesterol (g/L)	BeT	0.47±0.10	0.74±0.13	0.68±0.14	0.75±0.11	0.50±0.05	0.2944
	AfT	1.34±0.40	1.01±0.11	1.40±0.48	0.90±0.24	0.93±0.08	0.6822
	Prob	0.072	0.055	0.139	0.511	0.400	
Triglycerides (g/L)	BeT	0.32±0.06	0.54±0.08	0.63±0.27	0.39±0.09	0.36±0.09	0.5120
	AfT	0.99±0.22	0.68±0.13	0.75±0.06	0.58±0.02	0.69±0.16	0.3799
	Prob	0.082	0.574	0.740	0.170	0.123	

SE= Standard Error; WM= White Maize; YM= Yellow Maize; WS= White Sorghum; RS= Red Sorghum; MI = Millet: Values followed by different letters in the same column (a, b) are significantly different; Prob: 5% significance probability; BeT= Before Treatment; AfT= After Treatment.

Hepatic biochemical parameters in rabbits fed with cereal grains

The results of the serum biochemical parameters recorded in rabbits fed exclusively with different types of cereal grains are in Table III. Prior to the CG feeding, rabbit blood Glucose, Total Protein, Total Cholesterol, and Triglycerides were similar (P>0.05) and varied respectively from 0.91 to 1.02 g/L; 54.57 to 62.32 g/L; 0.47 to 0.74 g/L; and 0.32 to 0.63 g/L. After exclusive feeding with CG, maize, sorghum, and millet

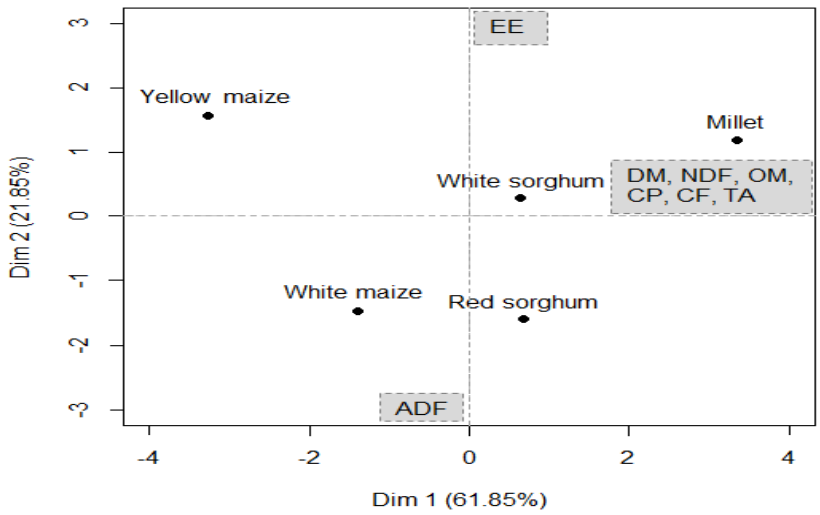

Fig. 1: Projection of cereal grain and their nutrients apparent digestibility in rabbits.
DM= Dry Matter; OM= Organic Matter; CP= Crude Protein; EE= Ether Extract; CF= Crude Fiber; ADF= Acid Detergent Fiber; NDF= Neutral Detergent Fiber; TA= Total Ash

grains had no significant (P>0.05) influence on rabbit blood Glucose, Total Protein, Total Cholesterol, and Triglycerides. Concentrations of these biochemical parameters varied respectively from 0.91 to 1.10 g/L; 66.48 to 72.50 g/L; 0.90 to 1.40 g/L and 0.58 to 0.99 g/L. Rabbits fed with white maize synthesized more proteins (72.50 g/L) than other rabbits.

Additionally, the two-sample paired student test revealed that for each CG, Total Protein of rabbits before and after feeding were significantly different (P<0.05). Thus, Total Protein in rabbits increased respectively by about 18%, 17% and 12% by using White and Red sorghum, White maize, Yellow maize and millet (Table III).

Discussion

This study gives an overview of the chemical profile of cereal grains used in balanced feed for monogastric animals in Benin. The high DM content of the five experimental CG proves their easy preservation. These values are close to 92% found by Salissou et al. (2016) in Niger. CP content of the evaluated CG is close to 8 to 11% (Nago, 1997; Smith, 1997; Cothenet and Bastianelli, 1999). The CP content in yellow maize grains is similar to 10.20% reported by Larbier and Leclercq (1992), but higher than the 9.9% DM found by Aysiwèdé et al. (2010). Furthermore, CP content in white maize grains is higher than 11.8% DM reported by Houndonougbo et al. (2009). EVDT-W white maize contained therefore more CP than SAMAZ-40 yellow maize. This justifies the low NNE content (78.67% DM) in the White maize. The difference may be explained by the used of nitrogen fertilizer to grow EVDT-W white maize. In fact, Toléba et al. (2007) reports that in Benin, white maize is the most cultivated maize and farmers are increasingly using nitrogen fertilizer to maximize their harvest. Sometimes, this fertilization is also the after-effects of cotton production. Cereal grains used in this experimentation had a low EE content, which is similar to Favier's (1989) results indicating a low fat content in cereals. The CF rate of the CG is also low. These values are relatively close to those reported by some authors (INRA, 1989; Houndonougbo et al. 2009; Aysiwèdé et al. 2010). However, CF in the current cereal grains remained very low compared to the recommended rate of 14% in rabbit's balanced feed (Lebas et al. 2007). Parietal constituents NDF and ADF contents in maize, millet and sorghum grains are in agreement with those given by Feedtable (2019). The cereal grains evaluated are rich in digestible energy (3950 to 4170 Kcal/kg DM). This is due to the high gross energy content of GC and the high digestibility of their OM and Energy by rabbits. Indeed, INRA (2004) reports that the digestible energy content can be calculated with gross energy values and the digestibility of gross energy.

Apart from the studies of the National Institute of Agronomic Research (INRA) and the European Group on Rabbit Nutrition (EGRAN), very few studies have been carried out on *in vivo* digestibility experimentations based on exclusive Concentrated Feed Resources (CFR). In addition, there are fewer references on feedstuffs digestibility in rabbits. Consequently, this discussion is based on references focused on the Apparent Digestibility (AD) of balanced feed components.

The high AD values of DM and OM recorded for the CG may be explained by the low CF content of these grains and certainly their poverty in anti-

nutritional factors. In fact, according to Anselme (1987), cereals are generally well digested by all animals, except in the case of disturbance by an anti-nutritional factor. The low fiber content of CG may also explain the high digestibility of their dry and organic matters, because Gidenne et al. (1991) report that digestive use of DM, OM and energy are higher when the fiber content in diet is lower.

In general, digestibility of OM in feed provides a global overview of its valorization. But, this needs to be further investigated by assessing the digestibility of its various components such as CP, EE and CF (Atchadé et al. 2019). Statistical analysis showed that the CP of the CG was digested differently by rabbits. The AD of maize grains CP were the lowest compared to that of sorghum and millet grains that exceeded 90% DM. These results show that the high content of CP in maize grains are not very well digested by rabbits compared with the CP in sorghum and millet. This could be due to the quality of the protein in the maize. As Gidenne et al. (2015) reported that rabbit has a better use of "true" proteins that are balanced in essential amino acids. This is not the case with maize since their proteins are deficient in essential amino acids (lysine and tryptophan in particular) according to Nuss and Tanumihardjo (2011). The apparent digestibilities of CP are lower than 93.34 to 97.14% DM recorded by Tchibozo et al. (2017) when they fed rabbit with balanced feed containing respectively 5.5% and 16.5% of maize grain and bran to feed rabbits. In contrary, they are higher than 53 to 60,57% DM reported in rabbit by Kpomassè et al. (2015) when evaluating the digestibility of balanced feed containing cowpea pods (0 to 15%) and maize grains (22 to 34%).

The results obtained indicate that EE digestibility was significantly high in rabbits and did not depend on the type of CG. The fat in cereal grains would therefore be well assimilated by rabbits that according to Gidenne et al. (2015) are animals with a specific requirement for essential fatty acids (linoleic and linolenic acids) that can be covered with diet containing 3 to 4% of EE fat ration. However, the AD of EE obtained in this study remain low compared to 71 to 76% DM recorded by some authors (Oladele-Oso et al. 2010; Ogunsipe et al. 2014; Oké et al. 2016; Ozung et al. 2017; Wafar et al. 2017) when testing in rabbits, balanced feed containing 30 to 58% of grain maize.

The apparent digestibility of CF by rabbits is similar in this study. However, it was lower in rabbits fed with white maize grains, with a value approximates 38% DM reported by Igwebuike et al. (2013) with a balanced feed containing 17% of maize grain and 17% of "Chakalere" sorghum. In contrast, the better digestive use of CF in the other four CG remains below the AD of CF reported by Oladele-Oso et al. (2010) (63.52% DM) and Oke et al. (2016) (65% DM) when testing balanced feed containing respectively 45% and 40% of maize grain in rabbits. The digestibility of CF is also lower than value varying from 59.5 to 67% reported by Koura et al. (2015) with diets based on 10% cowpea pod shell, 10% soybean pod shell and 22 to 31% maize grains. However, the results are in accordance with those of Maertens and Groote (1987) who indicated that the digestion of cellulosic constituents is generally weak in rabbits, since the main function of fibers in this animal is a "ballast" function than a nutritional one.

The high digestibilities of CG parietal components NDF and ADF recorded could be due to their high content (8 to 13%) of hemicellulose, which belongs to the category of digestible fibers. In fact, digestible fibers such as hemicellulose and pectin are more digested by rabbits and are sources of safe energy for them; this because by degrading the digestible fibers, fibrolytic bacterium will release Volatile Fatty Acids (VFA), an energy source for rabbits (Lebas, 2008). The apparent digestibility of NDF and ADF of CG are significantly higher than 76 to 83% reported by Karikari et al. (2011) in millet residue meal, as well as those found by Muhammad et al. (2017) when testing feed based on 25% of peanut shell and 12% of maize grains.

The high Total Ash content of millet grains could explain the significantly high AD of TA recorded in rabbits fed millet. This result is also justified by the content of minerals in CG. Indeed, millet contains higher contents of potassium, sodium, manganese, zinc and iron (FeedTable, 2019).

Nevertheless, the AD of TA recorded remain below 75.46% DM (Oladele-Oso et al. 2010) and 78.22% DM (Oke et al. 2016). Similarly, the TA AD (84.17% DM) found by Wafar et al. (2017) by testing a balanced feed containing 50% of grain maize in rabbits was significantly higher than the values in this study.

The Gross Energy in the CG was digested by rabbits at 87 to 92%. This high digestibility of the energy might be linked to the good digestibility of OM in relation with the low proportion of NDF in CG. Indeed, there is a strong positive correlation between the digestibility of energy and the proportion of the parietal constituents of feed resources in ruminants, rabbits and horses (INRA, 2004). Thus, the higher the NDF content of feed resource, the higher the digestibility of energy in rabbits (INRA, 2004). Digestibility of energy in maize, sorghum and millet of this study exceeds 79 to 83% indicated in Feedipedia (2019).

On the whole, the nutritional components of yellow maize, white maize, red sorghum, white sorghum, and millet were well digestible in rabbits. However, millet appeared as the most digestible CG. Millet grains could therefore be an alternative to maize in the production of rabbit’s balanced feed.

Although the difference in the digestibility of some nutritional components of the five CG, the blood Glucose, Total Protein, Total Cholesterol, and Triglycerides, that reflects the biochemical metabolism and absorption of nutrients, were not significantly affected by the type of cereal grain used to feed the rabbits.

Thus, the concentration of glucose in rabbit's blood varied from 0.91 to 1.10 g/L during the experiment and is close to that obtained by Ogunsipe et al. (2014), Oladele-Oso et al. (2010) and Atchadé (2012), who fed rabbits with balanced feed. The rabbit's serum concentrations in Total Proteins, varied from 66.48 to 72.50 g/L and showed that rabbits fed single CG synthesized less Total Proteins than 80.9 to 82.3 g/L produced by rabbits fed with sorghum by-product (Ogunsipe et al. 2014). However, the results are similar to the 71 g/L of Total Protein recorded by Saad et al. (2017) with a commercial pelleted feed. Total Cholesterol content varying from 0.90 to 1.40 g/L in rabbits fed with CG. These values are similar to 0.9 to 1.15 g/L reported by Osho et al. (2013) when testing diet at different fiber levels; but it is still higher than 0.28 to 0.32 g/L reported by Atchadé (2012) with balanced feed containing 0; 10 and 20% of *Pachyrizus erosus*. Triglycerides contents (0.58 to 0.99 g/L) recorded are lower than 2.31 to 2.52 g/L reported by Atchadé (2012).

These variations in serum biochemical parameters recorded in different studies confirm the close link between the feed of an animal and its biochemical profile (Akinmutimi, 2004). Otherwise, the increase in Total Protein in rabbits fed with single CG proves that the nutrients contained in maize, sorghum and millet have promoted the synthesis of total plasmatic proteins, which according to Piotrowska et al. (2011) is a commonly used parameter for judging animal health status. Nevertheless, the present study shows that the consumption of white maize grain allowed rabbits to synthesize more Total Protein (72.50 g/L); due to a good intake of that CG having the highest CP content. While the Millet nutrients were well digested by rabbits, this do not induced a high Total Protein in their blood, certainly because of the low CP content of this CG.

The glucose, Total Protein, Total Cholesterol and Triglycerides found in rabbit's blood are the result of the protein, carbohydrate and fat metabolism in their body after the intake of cereal grains (Atchadé et al. 2019). These results provide a general overview of biochemical assimilation of usual West Africa cereal grains nutrients by rabbits. They are very useful for both researchers and other actors in efficient rabbits feeding.

Conclusion

At the end of this experiment, it is appeared that the dietary value of maize, sorghum and millet grains has been determined in rabbits for the first time in Benin. These cereal grains have a very similar nutritional statute and rabbits have an excellent digestible use of their nutrients. However, Millet appears to be the most digestible cereal compared to others. Despite of that, White maize EVDT-W may be preferred than other CG in feed production since it allows rabbits to synthesize more Total Proteins in the blood for a better animal productivity.

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