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Research Article

NUTRITIONAL VALUE OF CEREAL BRANS USED IN RABBIT FEEDING IN BENIN

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ABSTRACT

Cereal brans are by-products used in Benin for rabbit feeding. This study aimed to evaluate the nutritional value of industrial maize bran, rice bran and wheat bran. Twenty-four adult rabbits were divided into three groups of eight animals and fed exclusively one of the three types of bran studied. Chemical composition of the brans, feed intake, apparent coefficients of digestibility and digestible energy were determined. The results showed substantial variability in the chemical composition and digestive utilization of the brans. Dry matter intake was significantly similar for wheat bran (98.75 g) and maize bran (96.49 g), and was the highest. The highest apparent crude protein digestibility coefficients were recorded for wheat bran (72.02 %) and maize bran (63.58%). Ether extract digestibility of industrial maize bran was significantly the highest (90.39 %) in rabbits, compared with that of wheat bran (62.18 %). The apparent coefficient of digestibility of crude fiber among the three types of bran ranged from 33.14 to 44.30 % DM, with no significant difference. Digestible energy was higher for industrial maize bran (3,382 kcal/kg DM), followed by rice bran (2,395 kcal/kg DM) and wheat bran (2,195 kcal/kg DM). These results highlight the importance of characterizing the chemical profile of cereal brans for their efficient use in rabbit feeding.

Keywords: Cereal by-products, Chemical composition, Digestibility, Energy, *Oryctolagus cuniculus.*

INTRODUCTION

Rabbit farming is progressively developing in Benin, but its profitability remains constrained by the high cost of feed inputs and the lack of local technical and scientific data on the nutritive value of available resources. Feed formulation for livestock has traditionally relied largely on international standards (Sauvant *et al*., 2004; AFZ, 2017). However, these references do not fully reflect the agro-ecological specificities of Benin or the nutritional variability of local by-products, often resulting in a discrepancy between expected zootechnical performance and that observed under actual production conditions. Cereals play an important role in Benin's agricultural systems, and their processing generates various by-products, including rice, maize and wheat brans. However, these feedstuffs have variable chemical compositions depending on plant species, variety, growing conditions and, particularly, processing methods, and constitute abundant and economically accessible local feed resources. Their nutritional value therefore cannot be assessed solely from their chemical composition. The rational use of these by-products in rabbit diets requires accurate characterization of their chemical composition and digestive utilization in this animal species. Indeed, rabbits are non-ruminant herbivores whose caecal health is closely related to the nature of the dietary fiber they consume. According to Pinheiro and Gidenne (2024), the balance between digestible and poorly digestible fiber fractions is a major factor influencing dietary efficiency and digestive health in rabbits. Furthermore, Atchadé *et al*. (2019) highlighted the diversity of feed resources and their

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digestive utilization in rabbit feeding systems in Africa, emphasizing the importance of characterizing locally available feed resources.

Cereal brans contain proteins, lipids and carbohydrates, although their proportions vary among cereal types (Tufail *et al*., 2022). These nutrients are important components of rabbit diets and contribute to meeting the nutritional requirements of rabbits (Pinheiro and Gidenne, 2024). However, their nutritional value may be strongly affected by the presence of poorly digestible fractions. Rice bran, for example, may contain a high proportion of mineral matter and constituents originating from the grain hulls, whereas maize and wheat brans may exhibit different nutritional profiles depending on their origin and processing methods. Characterization of fiber fractions is therefore an important component in assessing their digestive utilization.

In this context, the present study aimed to determine the nutritional value of the main cereal brans used in the manufacture of complete diets for growing rabbits in Benin. It contributes to providing reference data for the development of chemical composition tables adapted to local feed resources, with the aim of optimizing diet formulation and strengthening the economic resilience of rabbit production systems in Benin.

MATERIALS AND METHODS

Study area

The feeding experiments were conducted at the research station, on the experimental and livestock farm of the Laboratory of Poultry Research and Zooeconomics (LaRAZE), located within the University of Abomey-Calavi, in the municipality of Abomey-Calavi, Atlantic Department, Benin. The Atlantic Department is characterized by a Sudanian-Guinean tropical climate, with annual rainfall ranging from 1,100 to 1,350 mm, an average temperature ranging from 26 to 28 °C, and four distinct seasons, including two rainy seasons and two dry seasons (Données Mondiales, 2024).

Feed resources studied

The feed resources used were cereal brans available in Benin for the manufacture of complete diets intended for livestock. The three (03) types of cereal brans tested were: rice bran (RB); industrial maize bran (MB); pelleted wheat bran (WB). Rice bran and industrial maize bran were obtained respectively from the Glazoué rice mill (in central Benin) and from maize-processing company SOCIA (Food Industries Company) in Bohicon, southern Benin. The pelleted wheat bran was purchased from a feed mill in southern Benin and came from Togo.

Animals and experimental design

The study involved twenty-four (24) adult male and female local-breed rabbits, aged Six (06) months, belonging to LaRAZE. At the beginning of the experiment, the animals had a mean live body weight of 2093.7 ± 42 g. Based on their live body weights, the rabbits were allocated to three (03) groups of eight (08) rabbits using a completely randomised block design, with each rabbit considered an experimental unit. Each group, representing a dietary treatment, corresponded to one of the three (03) types of cereal bran (RB, MB, and WB). Each rabbit was housed individually in a galvanized wire-mesh cage measuring 40 cm × 35 cm × 40 cm, equipped with a feeder, a drinker, and a device for collecting total droppings. Each group was fed exclusively one of the three types of cereal bran separately.

In vivo digestibility trial

The groups of rabbits were acclimated to the corresponding dietary treatments *ad libitum* for five (05) days and fasted for 12 hours. They were then fed individually 100 g FM daily for five (05) consecutive days and fasted again for 12 hours. During this period, each rabbit had free access to water. During the feeding phase, the amounts of feed offered and feed leftovers were weighed daily for each rabbit to determine feed intake (FI). Total droppings were collected daily at the same time in the morning from each rabbit, then pooled by dietary treatment and stored in airtight containers at +4 °C. At the end of the collection period, the droppings collected were weighed, thoroughly homogenized, and sampled by cereal bran type for laboratory analyses.

Chemical analyses and calculated parameters

Chemical analyses were performed according to the Association of Official Analytical Chemist (AOAC, 2000) methods on fecal samples to determine the Dry Matter (DM) content and, Crude Protein (CP), Ether Extract (EE), Crude Fiber (CF), Acid Detergent Fiber (ADF), Neutral Detergent Fiber (NDF), and Total Ash (TA) composition. The same analyses, including hemicellulose (HEM), were performed on the dietary treatments offered and feed leftovers. Gross Energy (GE) of the dietary treatment and total fecal samples collected was determined using a bomb calorimeter. Furthermore, digestible energy (DE) was calculated from the difference between gross energy intake and fecal energy excretion, according to the following formula:

$$\mathbf{DE\ (Kcal/kg\ DM)} = \frac{\mathbf{[(GEF \times QDMF) - (GED \times QDMD)]}}{\mathbf{QDMF}}$$

Where: GEF = Gross Energy of the Feed; QDMF = Quantity of Feed Dry Matter intake;

GED = Gross Energy of Droppings; QDMD = Quantity of Dry Matter excreted in Droppings.

The hemicellulose content of the different cereal brans was calculated according to the formula proposed by Maertens *et al*. (2002):

$$\mathbf{EM\ (\%) = \%\ NDF - \%\ ADF}$$

Where: NDF = neutral detergent fiber content; ADF = acid detergent fiber content.

The analytical results were used to calculate the apparent digestibility coefficient (ADC) for each nutrient, using the following formula:

$$\text{ADC of nutrient (\%)} = \frac{[(\text{NA x FI}) - (\text{NF x QC})]}{\text{NA x FI}} \times 100$$

Where: NA= nutrient content in the feed dry matter; FI = Quantity of feed dry matter intake; NF = nutrient content in fecal dry matter; QC = Quantity of fecal dry matter excreted

Statistical analysis

Statistical analysis of the data collected during the experiment was performed using R software version 3.6.1 (R Core Team, 2019). To determine the effect of cereal bran type on the apparent digestibility coefficients (ADC) of the different nutrients recorded in rabbits, a one-way analysis of variance (ANOVA) was performed, followed by the Student-Newman-Keuls (SNK) mean separation test at the 5 % significance level, using the agricolae package (Mendiburu, 2017). The values are presented in the tables as mean ± standard error.

RESULTS AND DISCUSSION

Table 1 presents the contents of the different nutrients and the energy value of the cereal brans used in this study. The three cereal brans showed markedly different chemical and energy profiles. Wheat bran was characterized by the highest crude protein content, whereas rice bran had the highest contents of total ash, crude fiber and ADF. Maize bran had the highest ether extract content and the highest gross and digestible energy values, while rice and wheat brans showed lower digestible energy values.

Table 1. Chemical and energy values of cereal brans.

Composition	MB	RB	WB
DM	95.24	96.21	96.07
OM (% DM)	96.88	80.15	94.93
CP (% DM)	14.7	7.42	22.26
EE (% DM)	6.84	3.96	3.11
CF (% DM)	5.85	38.95	11.11
ADF (% DM)	6.42	33.91	8.15
NDF (% DM)	38.52	39.41	33.99
HEM (% DM)	32.1	5.5	25.84
TA (% DM)	3.12	19.85	5.07
Gross Energy (Kcal/kg DM)	4696.34	3863.93	4200.82

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; MB = industrial maize bran; RB = rice bran; WB = wheat bran.

Table 2 presents feed intake and the apparent digestibility coefficients of the three types of cereal bran in rabbits. The type of cereal bran significantly affected dry matter intake as well as the ADC of most nutrients and energy ($P < 0.001$), except for crude fiber ($P = 0.1688$). Dry matter intake was similar and higher with wheat and maize brans than with rice bran. Maize bran showed the highest ADC values for dry matter, organic matter, NDF and ADF, as well as for energy. Wheat bran had the highest ADC of crude protein, whereas rice bran generally showed the lowest ADC values for dry matter, organic matter, crude protein, NDF, ADF and energy. However, the ADC of total ash was higher with rice bran. The ADC of ether extract, was the highest in maize bran compared to with the other types of bran.

Table 2. Feed intake, apparent digestibility coefficients and digestible energy of cereal brans in rabbits.

Parameters	Cereal brans (Means ± SE)			P
	MB	RB	WB	
Feed intake (g DM)	96.49±7.23 ^{a}	60.38±5.59 ^{b}	98.75±6.82 ^{a}	0.0000
Apparent digestibility coefficients (%)				
Dry matter	68.40±2.63 ^{a}	38.07±4.74 ^{c}	50.57±2.81 ^{b}	0.0000
Organic matter	70.33±2.47 ^{a}	49.29±3.56 ^{b}	52.83±2.68 ^{b}	0.0001
Crude protein	63.58±0.03 ^{b}	49.55±3.54 ^{c}	72.02±1.59 ^{a}	0.0001
Ether extract	90.39±0.80 ^{a}	80.59±2.49 ^{b}	62.18±2.15 ^{c}	0.0000
Crude fiber	38.96±5.08	44.30±3.91	33.14±1.73	0.1688
Neutral Detergent Fiber	72.01±2.33 ^{a}	40.10±6.88 ^{c}	56.36±2.48 ^{b}	0.0002
Acid Detergent Fiber	74.80±2.09 ^{a}	45.16±4.70 ^{c}	61.98±2.16 ^{b}	0.0000
Total ash	49.50±2.52 ^{b}	54.64±2.46 ^{a}	34.26±0.8 ^{c}	0.0000

Digestible energy (kcal/kg DM)	3381.50 [a]	2394.69 [b]	2195.38 [c]	0.0000

MB = industrial maize bran; RB = rice bran; WB = wheat bran; P = probability value; SE = standard error.

[a, b, c] Values followed by different superscript letters within the same row are significantly different among cereal brans ($p < 0.05$).

The average dry matter content of the cereal bran samples studied (96 %) is higher than that reported by Toléba *et al*. (2009), which was 87.4% for rice bran and 83.3 % for wheat bran. This difference may be related to the origin and storage conditions of the raw materials, as well as to the processing methods. Furthermore, the chemical compositions of the three types of cereal bran evaluated (MB, RB, and WB) reveal distinctly contrasting profiles, reflecting differences in grain structure and the effect of processing methods on the resulting fractions. The wheat bran evaluated in this study has a high crude protein content of 22.26 % DM, which is higher than the value of 17.10 % DM reported by Blas *et al*. (2000) and the reference value of 16.80 % DM reported in the INRA/AFZ tables (Sauvant *et al*., 2004). Its ADF content (8.15 % DM) was also lower than the commonly reported values of 12 to 13 % DM. This difference may be related to the origin of the by-product and the conditions of milling and separation of the grain fractions. Blas *et al*. (2000) also showed that the characteristics of wheat bran, particularly particle size and the degree of separation during milling, can affect its composition and nutritive value. Despite its high protein concentration, the wheat bran studied had a moderate digestible energy value (2195.38 kcal/kg DM), which may be related to its fiber profile, particularly the proportion and characteristics of insoluble fiber fractions (Farías-Kovac *et al*., 2020). The rice bran studied has a low crude protein content (7.42 % DM) and high fiber and total ash contents. This profile contrasts with the values reported by Montcho *et al*. (2016), who found 17.10 % DM crude protein, and by Zeid *et al*. (2025), who reported 13.40 % DM protein and 15.80 % DM ADF for de-oiled rice bran. These discrepancies highlight the high variability in rice bran composition, depending on its origin and processing methods.

The profile observed here may be linked, in particular, to local paddy processing conditions, as differences between parboiled and non-parboiled rice milling by-products have been reported (Anongo *et al*., 2023), and to the presence of husk fractions in the bran, which could contribute to the increased levels of fiber and mineral constituents. Indeed, rice husk differs from bran in its high content of structural fiber fractions and mineral constituents (Sapwarobol *et al*., 2021). However, this hypothesis will need to be confirmed by a specific characterization of any husk fraction potentially present in the rice bran studied and its silica content. These results are particularly important in the Beninese context, where the composition of rice byproducts can vary depending on processing methods. They show that the term “rice bran” alone is not sufficient to assess its nutritional value and that its chemical composition must be characterized before it is incorporated into balanced rabbit diets. Therefore, the rice bran studied should be used with caution, given its low protein content and high concentration of fiber and mineral fractions.

In contrast to rice bran, the industrial maize bran studied has a more favorable nutritional composition. Its crude protein content (14.70 % DM) is higher than the value of 10.80 % DM reported in the INRA/AFZ tables (Sauvant *et al*., 2004) and the values of 8.00 to 9.50 % DM reported in Benin by Montcho *et al*. (2016). Its low ADF content (6.42 % DM), combined with a high proportion of hemicellulose (32.10 % DM) and an ether extract content of 6.84 % DM, characterizes a byproduct whose composition is well-suited for energy recovery. This nutritional value may be related to the characteristics of the maize processing method and the proportion of the various grain fractions present in the byproduct. This hypothesis is consistent with its higher fat content (6.84 % DM). Consequently, under the conditions of this study, industrial maize bran exhibits the most favorable nutritional and energy profile of the three cereal byproducts studied, making it a particularly valuable feed resource for growing rabbits in Benin. The differences in chemical composition observed provide a better understanding of the variations in intake, digestibility, and energy value observed among the three types of cereal bran studied.

In this study, each type of cereal bran was fed as the sole experimental diet to evaluate its intrinsic intake and digestive use. The intake levels obtained differ from those reported by Laudadio *et al*. (2009), Carew *et al*. (2023), and Zeid *et al*. (2025), as these studies evaluated complete diets incorporating the by-products under investigation. Rice bran, whose intake is approximately 37 % lower than that of the other two bran types, thus exhibits lower consumption, which may be attributed to its high fiber and mineral content. Conversely, the intake levels close to 100 g DM observed for maize and wheat brans indicate good acceptability under exclusive feeding conditions. However, these results do not imply that these byproducts alone are capable of constituting a balanced diet. The ADC values for dry matter and organic matter are significantly higher for industrial maize bran than for wheat bran and, especially, rice bran, indicating better digestive use of these fractions. The ADC value for ether extract also follows a clear pattern, with the highest value observed for industrial maize bran. This difference may be related to the nature and availability of the lipids in the bran samples studied. Indeed, Casado *et al*. (2010) reported that the source of dietary fat can influence ether extract digestibility in growing rabbits. The ADC for total ash shows a different trend, with the highest value for rice bran (54.64 %). This value is close to those reported by Zeid *et al.* (2025),

namely 53.2 % for unfermented, de-oiled rice bran and 56.6 % for fermented rice bran. However, this comparison should be interpreted with caution, as the authors incorporated rice bran at 20 % into a complete diet, whereas it constituted the sole experimental feed in the present study.

The ADC of crude protein differed significantly among the three types of cereal bran, with a higher value for wheat bran (72.02 %) than for industrial maize bran (63.58 %) and particularly rice bran (49.55 %). This higher digestive utilization of wheat bran protein may be related to the specific characteristics of this by-product. Indeed, Blas *et al*. (2000) showed that protein digestibility varied among wheat bran samples according to their characteristics, whereas Li *et al*. (2023) showed that bran structure could influence the accessibility and in vitro digestibility of its proteins. The ADC of crude protein in wheat bran was also close to the value of 74 % reported in the EGRAN tables (Maertens *et al*., 2002). The ADC of crude protein in industrial maize bran (63.58 %) was lower than the values ranging from 93.34 to 97.14 % reported by Tchibozo *et al*. (2017) in diets containing 5.5, 11, and 16.5 % maize bran. Similarly, the value for rice bran (49.55 %) was lower than the values of 80.6 and 82.9 % reported by Zeid *et al*. (2025) for unfermented and fermented de-oiled rice bran, respectively. These differences may be partly explained by the feeding conditions, as the brans were incorporated into complete diets in these two studies, whereas each type of bran constituted the sole experimental feed in the present study.

The digestibility of the fibrous components of the three types of cereal bran studied varies depending on the fraction considered. The ADC of NDF and that of ADF are significantly higher in industrial maize bran, followed by wheat bran and rice bran. This improved digestibility of the parietal fractions of maize bran may be related to its low ADF content (6.42 % DM) and high hemicellulose content (32.10 % DM). This composition promoted better digestive utilization of the parietal fractions. Indeed, in rabbits, the structure and degree of lignification of fibers determine their accessibility to the cæcal microbiota and their digestive use (Gidenne, 2015). In contrast, crude fiber digestibility did not differ significantly among the three types of cereal bran, indicating relatively similar digestive utilization of this fiber fraction by rabbits. This relatively low digestibility (33.14 to 44.30%) may depend on the structure of cellulose and its association with other cell-wall constituents, which limit its accessibility to microbial fermentation. In this regard, Gidenne (2015) reported that, in rabbits, cellulose is less digestible than more fermentable fiber fractions. The ADC values for crude fiber obtained in the present study were nevertheless higher than those reported by Lakabi-Ioualitene *et al*. (2008) (21.9 to 32.2 %) in rabbits fed complete diets containing durum wheat bran at inclusion levels of 26, 50 and 57 %. The digestible energy differs significantly among the three types of bran studied, with the highest value for industrial maize bran, the lowest for rice bran, and an intermediate value for wheat bran. This hierarchy is closely linked to their chemical compositions and digestive use. The high energy value (3382 kcal/kg DM) of industrial maize bran can be attributed particularly, to its high fat content (6.84 % DM) and low ADF content (6.42 % DM), combined with the good digestibility of these components. Indeed, according to Fernández-Carmona *et al*. (1996), ether extract and ADF content contribute to variations in digestible energy in rabbits. Conversely, the low digestible energy of rice bran appears to be associated with its high total ash and parietal component content, as well as the low digestibility of its dry matter, organic matter, and fiber. The digestible energy value of rice bran obtained in the present study (2395 kcal/kg DM) was lower than the 2970 kcal/kg DM reported by Maertens *et al*. (2002). Similarly, the value of 2195.38 kcal/kg DM recorded for wheat bran in the present study was lower than the range of 2562 to 3284 kcal/kg DM reported by Blas *et al*. (2000) for eight wheat bran samples. These differences among studies may reflect the variability in the energy value of cereal by-products, which may be related to differences in the composition and characteristics of the products studied (Blas *et al*., 2000; Maertens *et al*., 2002).

CONCLUSION

An evaluation of the three types of cereal bran available and used in the diets of farmed rabbits in Benin revealed significant variability in their nutritional value. These differences in composition resulted in varying levels of intake, digestibility, and energy utilization depending on the byproduct. Industrial maize bran stood out for its superior digestive and energy utilization, wheat bran for its superior protein digestibility, while the rice bran studied was characterized by the lowest digestive and energy utilization. These results underscore the importance of characterizing local cereal byproducts in order to adapt their use to the nutritional needs of rabbits.

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CONFLICT OF INTERESTS

The authors declare no conflict of interest

ETHICS APPROVAL

Not applicable

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AI TOOL DECLARATION

The authors declare that no AI and related tools are used to write the scientific content of this manuscript.

DATA AVAILABILITY

Data will be available on request

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