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Impact of Four Fiber Sources and the Strategy of Feeding on the Nutritional Quality of Rabbit Meat (*Oryctogalagus cuniculis*)

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Abstract

This study was conducted to valorize four sources of fiber (*Gliricidia sepium*, *Leucaena leucocephala*, *Moringa oleifera* and palm nut fibers) in animal production. The experiments were carried out on 128 rabbits divided into 4 batches of 32 animals, reared for 8 weeks under the same conditions. Each batch was subdivided into two subgroups, one fed with a complete diet (a diet containing one of the fiber sources and served all day) and the other with the same diet separated from the fiber source (served at 9 a.m. and supplemented with the fiber source at 4 p.m.). Eight (8) experimental rations were, respectively, tested on the subgroups: complete feed *Gliricidia sepium* (CFG); supplemented feed *Gliricidia sepium* (SFG); complete feed *Leucaena leucocephala* (CFL); supplemented feed *Leucaena leucocephala* (SFL); complete feed *Moringa oleifera* (CFM); supplemented feed *Moringa oleifera* (SFM); complete feed palm nut fiber (CFF); supplemented feed palm nut fiber (SFF). In each subgroup, 4 rabbits were slaughtered at 15 weeks of age for a total of 32 rabbits. Physico-chemical parameters were evaluated on the feed and the meat. Data were analyzed using SAS 2013 software. Fiber content was similar ($p > 0.05$) for complete feeds. Fat content was high ($p < 0.001$) for the palm nuts fiber (27.34%) and the CFF feed (11.36%). Feeding rabbits with *G. sepium* leaves or palm nut fiber continuously increased the fat content of the meat in con-

trast to sequential feeding. Meat quality was also better when the fiber source was used in the feed of the rabbits in the evening.

Keywords

Strategy of Feeding Fiber, *L. leucocephala*, *M. oleifera*, *G. sepium*, Palm Nuts

1. Introduction

In Benin and in the West African sub-region, rabbit farming helps to strengthen food and nutritional security and contributes in part to the socio-economic development of the population [1]. The rabbit is a short-cycle species with a high prolificacy [2]. Its breeding is a source of employment and income for young and women [1]. Rabbit meat has a good profile in unsaturated fatty acids and proteins of high biological value, and has exceptional nutritional qualities. It is rich in minerals, trace elements (potassium, phosphorus, and selenium), and B vitamins [3].

Despite these advantages, rabbit production is not able to adequately satisfy the high demand for rabbit meat. It is still subject to several factors that hinder its development [4]. Among these, rabbit feed is one of the factors to be controlled to reduce the cost of production and to make the products more accessible to the population. Rabbits are herbivores and have the ability to convert fodder into meat [5]. Therefore, several local plants and by-products have been used as fodder resources to improve the zootechnical performance of rabbits and reduce the cost of production. These include the leaves of *Moringa oleifera*, *Cissus populnea*, *Synedrella nodiflora*, *Gliricidia sepium*, *Andropogon gayanus Aeschynomene histrix*, *Stylosanthès hamata* and *Arachis pintoïs* and maize bran which have been used in rabbit feeds due to their protein, fiber content and accessibility [6] [7] [8]. These forages are incorporated into or supplemented with conventional feed and provide fiber, vitamins, and minerals [5]. However, these studies have not highlighted the influence of forage and agricultural by-products on the nutritional quality of meat, even though the nutrition of an animal affects the quality of its meat [9]. It is, therefore, necessary to assess not only the effect of local forage and by-products, but also to determine the influence of their distribution strategy on the nutritional quality of rabbit meat. Hence, the present work whose general objective is to improve the nutritional quality of rabbit meat in Benin uses the leaves of *Gliricidia sepium*, *Leucaena leucocephala*, *Moringa oleifera* and palm nut fibers.

2. Materials and Methods

2.1. Study Framework

The experimental study on rabbits was carried out with the technical support of the Laboratory of Poultry Science and Zoo-Economy (LaRAZE) and occurred from August to November 2020 on the application form of the Faculty of Agronomic Sciences of the University of Abomey-Calavi (FSA) located in the Commune of Abomey-Calavi. The Commune of Abomey-Calavi is located in the Atlantic department in the south of Benin and lies between 6˚21 and 6˚42 North and 2˚13 and 2˚25 East. The climate is sub-equatorial with four seasons: a long dry season (early December to March), a long rainy season (March to July), a short dry season (August to mid-September) and a short rainy season (mid-September to early December). The average annual rainfall is around 1200 mm, of which 700 to 800 mm is for the long rainy season and 400 to 500 mm for the short rainy season. As for the temperature, the maximums vary between 28˚C and 32˚C while the minimums vary between 24˚C and 27˚C. As for humidity, the minima vary from 55% (January) to 77% (June) and the maxima from 88% (March) to 95% (June) [10].

2.2. Plant Material

Four sources of fiber, namely, *Moringa oleifera leaves*, *Gliricidia sepium*, *Leucaena leucocephala*, and palm nut fiber were used. **Table 1** showed depending on the fiber source, four complete rations were made up of concentrates of different compositions for each fiber source.

2.3. Animal Material

The experiment involved 128 local rabbits of masculine sex and aged seven (07) weeks. The young rabbits were subjected to different fattening regimes for eight weeks.

2.4. Methodology

In the first step, 128 local rabbits were fed with feed and fiber sources. The leaves have been dried to ambient temperature before use. At the end of the fattening period, the rabbits were slaughtered and the carcasses were used to determine the nutritional quality. At the same time, the physico-chemical characteristics of the feed used to feed the rabbits were determined.

2.4.1. Experimental Design

The young rabbits were housed in wire mesh cages equipped with a drinking trough and a feeder. They were divided into four (4) batches of 32 rabbits. Each batch was then subdivided into two subgroups of 16 rabbits. Two subgroups of the same batch were fed, one with a complete feed (feed with incorporated fiber source) served all the day (at 9:00 am and 4:00 pm); and the other, with the same feed without incorporated fiber source, served only in the morning (at 9:00 am) and supplemented with the fiber source (identical to the one used to prepare the complete feed) served only in the evening (at 16:00). This constitutes two feeding strategies for each fiber source; a continuous feed and sequential feed. A total of four complete feeds were then served for continuous feeding and four types of feeds (feeds supplemented with fiber sources) were served sequentially.

Table 1. Ingredients and nutritional composition of the four complete rations.

Ingredients	Rations			
	CFG	CFL	CFM	CFF
Maize	17	16.5	21	15
Wheat bran	18.89	20	13	22
Rice bran	8	8	7	5
Cotton cake	10	15	18	15
Palm kernel cake	21	20	22	15
Soybean seed	4	0	0	8
Red oil	2	2	1	2
Oysher shell	2	2	2	2
Lysine	0.31	0.4	0.1	0.19
Methionine	0.15	0.18	0.12	0.1
Dicalcium phosphate	1	0	0	0
NaCl	0.3	0.3	0.3	0.36
Iron sulfate	0.35	0.62	0.63	0.35
Dried leaves of *Gliricidia sepium*	15			
Dried leaves of *Leucaena leucocephala*		15		
Dried leaves of *Moringa oleifera*			15	
Palm nut Fibers				15
Nutritional composition				
Dry mater (%)	91.72	91.68	91.38	91.29
Fat content (%)	1.87	2.05	2.75	5.93
Ash (%)	3.33	3.41	4.50	2.23
Gross protein (%)	17.50	19.54	19.67	18.23
Metabolisable Energy (kcal/kg DM)	2632.81	2610.03	2610.52	2696.69
Gross cellulose (%)	16.02	15.89	16.26	17.52
Lysine (%)	0.82	0.88	0.85	0.86
Methionine (%)	0.38	0.41	0.43	0.35
Sulphur amino acids (%)	0.64	0.68	0.65	0.65
Ca (%)	1.07	0.89	1.20	0.94
P (%)	0.84	0.73	0.69	0.71
Na (%)	0.15	0.30	0.16	0.17

Complete feed *Gliricidia sepium*: CFG; Complete feed *Leucaena leucocephala*: CFL; Complete feed *Moringa oleifera*: CFM; Complete feed palm nut fiber: CFF.

The different rations served during the experiment for the eight (8) subgroups, were:

- complete feed *Gliricidia sepium* (CFG);

- supplemented feed *Gliricidia sepium* (SFG);
- complete feed *Leucaena leucocephala* (CFL);
- supplemented feed *Leucaena leucocephala* (SFL);
- complete feed *Moringa oleifera* (CFM);
- supplemented feed *Moringa oleifera* (SFM);
- complete feed palm nuts fiber (CFF);
- supplemented feed palm nut fiber (SFF).

2.4.2. Slaughter of Rabbits and Collection of Meat Samples

Four 15-week-old rabbits per feed treatment were selected according to the average weight of each batch for slaughter. The rabbits bled after being stunned by a sharp blow to the occipital region. The two-man dressing method described by [11] was used in this study.

2.4.3. Determination of the Physico-Chemical Composition of Feed and Meat

The physico-chemical composition of the rabbit feeds was determined through the levels of dry matter, ash, fat, and fiber. The Biceps femoris and Longissimus dorsi muscles from the different meat samples were dried at 65˚C for 72 hours. Subsequently, the contents of dry matter, ash, fat, and protein were determined according to standard procedures. The moisture content was determined in two replicates using the thermogravimetric method of the AOAC standard [12]. The determination of protein content was done according to the Kjeldhal method [13]. Lipids were determined by direct Soxhlet extraction and according to the AACC method [14]. The ash content was determined by the AACC method [14]. The crude fiber content of the feed was determined by the method of Weende [15].

2.5. Statistical Analysis

Data was encoded using Microsoft Excel 2013 spreadsheet software. Means and standard deviations were calculated using SAS (Statistical Analysis System) software [16]. The effect of the fiber source and the influence of the feeding strategy on the nutritional characteristics of the feed and meat were evaluated. The generalized linear model procedure [16] was used for the analysis of variance. Fisher test was used to determine the significance of each effect in the model and the least squares means were estimated and compared while doing an analysis of variance (ANOVA with two factors), and then the comparison of the averages using Tukey Post hoc test.

3. Results and Discussion

3.1. Physico-Chemical Composition of Feeds

Table 2 shows that the dry matter contents for the complete feeds of dried leaves of *Gliricidia sepium* (CFG), of *Leucaena leucocephala* (CFL), of *Moringa oleifera* (CFM) and palm nut fiber (CFF) were similar ($p > 0.05$). The dry matter contents

Table 2. Physico-chemical composition of rabbit feed.

Feed	Ration	DM (%)	Ash (%)	Fat (%)	Fibers (%)
Complete feed	CFG	89.42 ± 0.37ab	10.00 ± 0.21a	8.18 ± 0.45c	21.00 ± 0.21bc
	CFL	88.52 ± 1.51bc	8.56 ± 0.23a	7.95 ± 0.01c	19.76 ± 1.39c
	CFM	88.96 ± 0.92b	9.88 ± 0.30a	7.15 ± 0.50dc	20.80 ± 1.19bc
	CFF	88.48 ± 0.39bc	8.41 ± 0.42a	11.36 ± 0.13b	19.37 ± 0.87cd
Feed without fibers	SFG	91.07 ± 0.25a	10.25 ± 1.04a	7.08 ± 1.24dc	18.00 ± 0.57cd
	SFL	88.87 ± 0.04b	8.73 ± 0.04a	8.32 ± 0.04c	18.36 ± 0.85cd
	SFM	90.03 ± 0.70ab	9.44 ± 0.06a	8.08 ± 1.63c	20.50 ± 1.32bc
	SFF	90.08 ± 0.11ab	8.43 ± 0.12a	8.14 ± 0.73c	16.06 ± 0.54d
Sources of fiber	*G. sepium*	86.53 ± 0.17d	9.78 ± 0.10a	4.51 ± 0.44de	17.69 ± 0.54cd
	L. leucocephala	86.35 ± 0.74de	9.09 ± 0.58a	4.88 ± 0.21e	27.89 ± 3.01a
	M. oleifera	84.77 ± 0.08e	10.06 ± 0.62a	5.60 ± 0.11de	23.85 ± 2.62b
	Palm fiber	86.98 ± 1.63dc	10.30 ± 8.21a	27.34 ± 2.57a	29.64 ± 2.60a
Test		***	NS	***	***

CFG: Complete feed *Gliricidia sepium*; SFG: Supplemented feed *Gliricidia sepium*; CFL: Complete feed *Leucaena leucocephala*; SFL: Supplemented feed *Leucaena leucocephala*; CFM: Complete feed *Moringa oleifera*; SFM: Supplemented feed *Moringa oleifera*; CFF: Complete feed palm nut fiber; SFF: Supplemented feed palm nut fiber. NS: $p > 0.05$; *: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$; mean in the same column followed by different letters differ significantly at the 5% threshold.

were 88.42%, 88.52%, 88.96%, and 89.42% for the *Gliricidia sepium* complete feed (CFG), palm nut fiber complete feed (CFF), *Leucaena leucocephala* complete feed (CFL) and *Moringa oleifera* complete feed (CFM) respectively. These dry matter values are close to those found (90.5% - 91.4%) on feeds made with 10% of *M. oleifera* leaves in Benin [17]. These values are also close to those found (87.08%) by [7] who incorporated 16.5% maize bran in the rabbit feed. The dry matter for feed without fiber sources such as feed supplemented in the evening with dried *Gliricidia sepium* leaves (SFG), feed supplemented in the evening with dried Leucaena leucocephala leaves (SFL), feed supplemented in the evening with dried Moringa oleifera leaves (SFM) and feed supplemented in the evening with the palm nuts fibers (SFF) was significantly influenced by the fiber source. Indeed, the dry matter content was high ($p < 0.001$) for the feed supplemented in the evening with dried leaves of *Gliricidia sepium* (SFG) (91.07%) compared to the feed supplemented in the evening with dried leaves of *Leucaena leucocephala* (SFL) (88.87%). The feed supplemented in the evening with dried *Moringa oleifera* leaves (SFM) and feed supplemented in the evening with palm nut fiber (SFF) had similar dry matter contents ($p > 0.05$) (90.03% and 90.08% respectively). For the different fiber sources, dried *Leucaena leucocephala* leaves (84.77%) had recorded low dry matter content ($p < 0.001$) compared to dried *Gliricidia sepium* leaves (86.53%) which gave similar dry matter content ($p > 0.05$) to that obtained for dried *Moringa oleifera* leaves and palm nut fibers (86.35% and 86.98% respectively). Moreover, the dry matter was similar to the dried leaves of *Moringa oleifera* and *Leucaena leucocephala*.

The ash levels of the whole feed, feed without fiber sources, and the different fiber sources themselves were similar ($p > 0.05$). These ash levels ranged from 8.41% to 10.30% (obtained by whole feed with palm nut fiber and palm nut fiber respectively). The ash levels obtained in this study are lower than those found in rabbit feeds containing 50% of *Ipomoea batatas* (14.24%) and *Solanum melongena* (14.05%) leaves [5]. These levels are rather close to those found by the same authors on rabbit feed containing 50% of *Abelmoschus esculentus* leaves (10.69%). Moreover, similar values of mineral contents (7.4% - 9.5%) were found in feeds containing *Moringa oleifera* leaves [16].

Fat levels ranged from 7.15 (CFM) to 11.36% (CFF) for the complete feeds. The fat content recorded by the palm nut fiber-based complete feed (CFF) was higher ($p < 0.001$) than all other complete feeds. The fat levels were similar ($p > 0.05$) for whole feeds based on the dried leaves of *Gliricidia sepium*, *Leucaena leucocephala* (CFL) and *Moringa oleifera* (CFM). Feeds without fiber sources also had similar fat levels to whole foods made from the dried leaves of *Gliricidia sepium*, *Leucaena leucocephala* (CFL) and *Moringa oleifera* (CFM). These rates varied from 7.08 (SFM) to 8.32% (SFL). Regarding fiber sources, palm nut fiber obtained very high-fat contents (27.34%) ($p < 0.001$) compared to other fiber sources which gave similar fat contents ($p > 0.05$) (4.51%, 4.88% and 5.60% for dried leaves of *Gliricidia sepium*, *Moringa oleifera*, and *Leucaena leucocephala* respectively). This is due to the fact that palm nut fibers are residues from the oil extraction process. Therefore, the delipidation of palm nut fiber would be necessary for its efficient use in rabbit feed. In general, the fat percentages obtained for complete feed are high compared to the 3% to 5% margin recommended by Lebas [18] to cover the energy requirements of young rabbits.

The fiber contents were similar ($p > 0.05$) for all whole feeds. These fiber levels were 21.00%, 19.76%, 20.80%, and 19.37%, respectively, for the whole foods based on the dried leaves of *Gliricidia sepium* (CFG), *Leucaena leucocephala* (CFL), *Moringa oleifera* (CFM) and palm nut fiber (CFF). The fiber content of the feed without fiber sources ranged from 16.06% (SFF) to 20.50% (SFL). Feeds supplemented in the evening with the dried leaves of *Gliricidia sepium* (SFG), *Leucaena leucocephala* (SFL), and *Moringa oleifera* (SFM) also yielded similar fiber levels ($p > 0.05$). The fiber levels recorded by the feed supplemented in the evening with palm nut fiber (SFF) were also similar ($p > 0.05$) to those obtained by the feed supplemented in the evening with dried leaves of *Gliricidia sepium* (SFG) and the feed supplemented in the evening with dried leaves of *Leucaena leucocephala* (SFL). These fiber levels are close to those found in Nigeria (18.45% - 16.67%) on diets supplemented with some local plants (Bamboo, Senna, Gmelina) [19]. Palm nut fiber and dried *Leucaena leucocephala* leaves recorded high fiber levels (29.64% and 27.89% respectively) ($p < 0.001$) followed by dried *Moringa oleifera* leaves (23.85%) and dried *Gliricidia sepium* leaves (17.69%). These variations in the fiber composition of the various fiber sources are considered in the formulation of the different whole feeds such that their fiber compositions were the same.

3.2. Effect of Fiber Source and Distribution Method on the Nutritional Quality of Rabbit Meat

The nutritional parameters (dry matter, mineral content, fat, and protein) of the saddle and thigh of rabbits fed a continuous and sequential distribution of *Gliricidia sepium* (CFG), *Leucaena leucocephala* (CFL), *Moringa oleifera* (CFM) and palm nut fiber (CFF) sources are presented in Table 3.

3.2.1. Dry Matter Content

Across feeding strategies for the same fiber source, both in saddle and thigh muscle, no significant difference ($p > 0.05$) was found for the dry matter content of rabbits fed *Leucaena leucocephala* leaves or palm nut fibers. The dry matter content of the meat of rabbits fed the *Gliricidia sepium* complete feed was higher ($p < 0.05$) compared to that of rabbits fed the feed supplemented in the evening with *Gliricidia sepium* leaves. For the *Moringa oleifera* fiber source, the dry matter of the thigh was higher ($p < 0.05$) in favor of the rabbits fed the supplemented feed. However, the saddles of the same subjects had recorded similar dry

Table 3. Nutritional composition of rabbit meat according to fiber source and strategy of feeding.

Strategy of feeding / Parameters (%)		*Gliricidia sépium*		*Leucaena leucocephala*		*Moringa oleifera*		Palm nuts fiber		test
		Continue	Sequential	Continue	Sequential	Continue	Sequential	Continue	Sequential	
Saddle	Dry matter	28.65 ± 1.07a	24.71 ± 0.76b	26.37 ± 2.73ab	24.96 ± 0.60b	24.99 ± 1.03b	25.07 ± 1.91b	26.12 ± 2.31b	24.07 ± 1.39b	*
	Ash	3.49 ± 0.18a	1.09 ± 0.31c	2.23 ± 0.08b	2.32 ± 1.39b	0.99 ± 0.36c	2.16 ± 0.16b	0.91 ± 0.15c	1.05 ± 0.07c	***
	fat	3.78 ± 0.51a	2.29 ± 0.65b	3.04 ± 1.21ab	2.15 ± 1.39b	2.82 ± 0.42ab	2.75 ± 0.28ab	3.78 ± 0.08a	3.52 ± 0.44a	*
	Proteins	22.56 ± 1.55a	20.91 ± 0.63ab	20.11 ± 1.77abc	19.61 ± 2.24bc	18.09 ± 3.09c	20.42 ± 1.41abc	20.54 ± 1.09abc	20.55 ± 0.40abc	*
Thigh	Dry matter	27.27 ± 1.16a	23.43 ± 0.55bc	25.32 ± 1.05abc	23.61 ± 0.70bc	23.12 ± 0.73c	27.33 ± 2.32a	26.53 ± 5.08ab	26.03 ± 2.79abc	*
	Ash	3.56 ± 0.60a	1.10 ± 0.12c	2.21 ± 0.55abc	2.01 ± 1.81bc	1.21 ± 0.01bc	2.40 ± 0.15abc	2.63 ± 2.00ab	1.11 ± 0.21c	*
	Fat	3.34 ± 0.84c	1.83 ± 0.13e	2.75 ± 0.39dc	2.62 ± 0.07d	2.56 ± 0.53d	2.96 ± 0.17dc	5.12 ± 0.36a	4.18 ± 0.63b	***
	Proteins	22.98 ± 0.39ab	22.96 ± 0.57ab	22.01 ± 0.84b	22.10 ± 0.89b	22.18 ± 0.98b	22.51 ± 1.07b	23.05 ± 1.01ab	24.46 ± 2.75a	*

NS: $p > 0.05$; *: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$; mean in the same column followed by different letters differ significantly at the 5% threshold.

matter levels ($p > 0.05$). Therefore the supply of dried leaves of *Gliricidia sepium* or *Moringa oleifera* in the evening would have had an impact on the overall nutrient content of the rabbits' meat. This was not the case for fiber sources based on *Leucaena leucocephala* leaves or palm nut fibers, whose dry matter content remained unchanged regardless of the distribution method.

From one fiber source to another, at the saddle, the highest dry matter content ($p < 0.05$) was recorded by continuously distributed *Gliricidia sepium* (28.65%) compared to all other fiber sources which recorded similar content ($p > 0.05$). In the thigh, the lowest ($p < 0.05$) dry matter content (23.12%) was obtained by Moringa oleifera and the highest ($p < 0.05$) by the same fiber source distributed sequentially (27.33%). Thigh dry matter rates were equal ($p > 0.05$) for sequentially distributed *Moringa oleifera*, continuously distributed *Gliricidia sepium* and *Leucaena leucocephala* and for both sequentially and continuously distributed palm nut fibers. Similarly, the thigh dry matter rates recorded by the continuously distributed *Moringa oleifera* fiber sources were similar ($p > 0.05$) to those obtained by the sequentially distributed palm nuts and *Gliricidia sepium* fibers and continuously and sequentially distributed *Leucaena leucocephala*. These similarities observed between the dry matter contents of meat from different feed treatments show that the amount of nutrients in rabbit meat is not affected by the different fiber sources used. Thus, different fiber sources can be used as substitutes in rabbit feed without changing the overall nutrient content of the meat. The dry matter contents recorded in this study are close to those obtained by [20] (25% - 27.5%), and [21] (24.5% - 25.3%) on 15 - 18 weeks old rabbits fed commercial diets. These results are also similar to those of [8] (24.96% - 27.30%) on rabbits fed rations containing 30% of *C. populnea* or *S. nodiflora* leaves.

3.2.2. Ash Content

The mineral fraction of rabbit meat varied significantly ($p < 0.05$) at the saddle level for the *Gliricidia sepium* fiber source in favor of the continuous strategy and for *Moringa oleifera* in favor of the sequential strategy ($p < 0.001$). For *Leucaena* leucocephala and palm nut fiber sources, no significant difference ($p> 0.05$) in the ash content of the shavings was found between the distribution strategies. At the thigh level, there was no variation ($p > 0.05$) in ash levels between distribution strategies for Moringa oleifera and *Leucaena leucocephala* fiber sources. However, a significant difference ($p < 0.05$) was found for *Gliricidia sepium* and palm nut fiber sources in favor of continuous feeding. For rabbits fed *Leucaena leucocephala* leaves, ash levels were not affected by the mode of distribution regardless of muscle. Thus, the mineral fraction of the meat of the rabbits was not affected by the feeding method of *Leucaena leucocephala* leaves. Only the supply of dried leaves of *Gliricidia sepium* in the evening would have affected the mineral content of the rabbit meat. This is not clearly established for palm nut fibers and Moringa oleifera leaves.

Across fiber sources, ash levels were high ($p < 0.001$) in the saddles (3.49%)

and thighs (3.56%) of rabbits fed the *Gliricidia sepium* leaf-based complete feed. The saddles of the rabbits fed the continuous palm nut fiber had the lowest ($p < 0.001$) ash values (0.91%), which were equal to those of the continuously fed *Gliricidia sepium* and *Moringa oleifera* fiber sources. In the thigh, low levels ($p < 0.05$) of minerals were recorded in sequentially distributed *Gliricidia sepium* (1.10%), which were similar to sequentially distributed palm nut fibers and both continuously and sequentially distributed *Leucaena leucocephala* and *Moringa oleifera* fiber sources. This shows that the substitution of these different fiber sources in the rabbit diet will not have a margining effect on the mineral fraction of the meat. Thus, the different fiber sources can also be substituted for each other in the sequential feeding of rabbits without changing the mineral content of the meat. The mineral levels found in this study are high compared to those obtained (1.03% - 1.23%) in rabbits fed rations containing 30% of *C. populnea* or *S. nodiflora* leaves [8]. These differences could be explained by the diet, in this case, the presence of different kinds of forage. Indeed, Combes [22] mentioned that it is very likely that feeding through supplementation is the main factor of variation in the mineral fraction of meat.

3.2.3. Fat Content

Across feeding strategies and for the same fiber source, no significant difference ($p > 0.05$) was observed for the fat content of rabbits fed *Leucaena leucocephala* and *Moringa oleifera* leaves. However, in general, fat was low when the rabbits were fed the fiber source in the evening. This difference was highly significant for rabbits fed *G. sepium* leaves and palm nut fibers. Fat levels were indeed high in the saddles ($p < 0.05$) and thighs ($p < 0.001$) of the rabbits fed the *G. sepium* leaf-based complete feed. For rabbits fed palm nut fiber, it was in the thigh that the lipid content was high ($p < 0.001$) in favor of continuous distribution. Thus, the distribution mode of *Leucaena leucocephala* and *Moringa oleifera* leaves did not affect the quality of the rabbits' meat, in this case, its fat content. On the other hand, feeding rabbit with *G. sepium* leaves or with palm nut fibers on a continuous feeling basis increased the fat content of the meat. However, this effect on meat quality seems to be attenuated when the fiber is used in the evening.

Thigh meat from rabbits fed palm nut fiber had the highest fat levels ($p < 0.001$) in continuous and sequential distribution (5.12% and 4.18% respectively). At the saddle level, the fat levels of these same subjects were also high ($p < 0.05$) and similar ($p > 0.05$) to those recorded by *G. sepium* and *M. oleifera* in a continuous distribution, which is similar ($p > 0.05$) to all other fiber sources. The fat levels obtained in this study for thighs are high compared to the margin of 2.90% - 3.22%, obtained on labeled rabbits [23]. The high-fat content of meat from rabbits that were fed palm nut fiber as a source of fiber may be explained by the fat content of the palm nut fiber itself. Palm nut fibers, which are residues of palm oil extraction, give the feed a high-fat content, which relatively increases the fat content in the thigh meat. Therefore, the use of low-fat extraction residues will allow the production of rabbit meat with lower fat content. Indeed, Combes [22] mentioned that diet is one of the most important factors influencing the amount of lipid fraction in rabbit meat. Thus, to substitute palm nut fiber for other sources of fiber in rabbit diets, residues with low fat levels should be used.

3.2.4. Protein Content

The distribution strategy of the different fiber sources had no influence ($p > 0.05$) on the protein contents of the rabbits in both the thigh and the saddle. Therefore, these different fiber sources can be used continuously or sequentially without affecting the protein content of the rabbit meat.

From one fiber source to another, the highest protein contents in the saddle were obtained by the fiber source of *G. sepium* (22.56% and 20.91% in continuous and sequential distribution, respectively). For the other fiber sources, the protein contents were equal ($p > 0.05$). Protein contents were also similar ($p > 0.05$) for the shreds in sequential distribution. In the thigh, palm nut fiber gave the highest protein contents (24.46% and 23.05%) ($p < 0.05$) and similar ($p > 0.05$) to the *G. sepium* fiber sources which in turn were equal to all other fiber sources. The protein levels found were close to those obtained for rabbits at commercial slaughter ages and weight (19.5% - 22.5%) [22]. The similarities in protein content show that these different fiber sources can be substituted in the rabbit diet without changing the protein content of the meat. Moreover, the protein levels in the rabbits' thighs were higher than in the saddle. This is in line with Combes [22] who reported that among the cuts, the edible part of the leg is the richest in protein.

4. Conclusions

This study showed the influence of four sources of fibers and the strategy of feeding on the nutritional quality of rabbit meat. Complete feed of palm nut fibers, or of *Gliricidia sepium*, or of *Leucaena leucocephala* or of *Moringa oleifera* have been tested facing the supplemented feed of the same fiber sources. To ensure good nutritional quality of rabbit meat, *Leucaena leucocephala*, *Moringa oleifera*, *Gliricidia sepium* leaves, and palm nut fiber can be substituted as a source of fiber in rabbit feed. However, a delipidation of palm nut fibers is necessary for its use in rabbit feed. Regarding the mode of distribution, the sequential feeding method can be recommended in rabbit farming for the efficient use of palm nut fibers or *G. sepium* leaves.

It would be interesting to continue this work by determining the influence of the chemical composition of the leaves of *Leucaena leucocephala*, *Gliricidia sepium*, and *Moringa oleifera* on meat quality.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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