

Growth Performance and Carcass Characteristics of Rabbits Fed a Diet Based on Palm-Press Fibres in Benin

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Abstract

Palm-press fibres (PPF), a by-product available in Benin, represent a local source of fibre that could be valorized in rabbit feeding. This study aimed to evaluate, under real-world farming conditions, the effect of incorporating 15% PPF into a balanced diet on the growth performance and carcass characteristics of rabbits. A ten-week experiment was conducted on four rabbit farms in Dassa-Zoumé and Glazoué, using 96 crossbred rabbits aged 35 to 45 days, with an initial mean live body weight of 976.95 ± 40.88 g. The experiment was conducted using a randomized complete block design, with the four farms serving as blocks. Two dietary treatments, a control diet (AT) and an experimental palm-press fibre-based diet (AFNP), were compared, with three replicates of four rabbits per treatment in each block. Feed intake, live body weight, average daily gain, feed conversion ratio, and carcass characteristics were evaluated. The results showed that mean feed intake was 88.35 ± 1.52 and 92.01 ± 1.52 g DM/day for the AT and AFNP diets, respectively, with no significant difference ($P = 0.1061$). Average daily gain was also similar between the two dietary treatments, with values of 16.75 ± 0.94 g and 16.84 ± 0.94 g for AT and AFNP, respectively ($P = 0.9485$). Similarly, no significant difference ($P = 0.9286$) was observed between the feed conversion ratios recorded for the two tested diets (5.63 ± 0.38 vs 5.58 ± 0.38). Furthermore, carcass yield of rabbits fed the AT diet ($64.66\% \pm 0.68\%$) was comparable ($P = 0.0668$) to that obtained in rabbits fed the AFNP diet ($66.45\% \pm 0.64\%$). However, total carcass fat yield was significantly higher ($P = 0.0291$) with AFNP ($3.27\% \pm 0.57\%$) than with AT ($1.85\% \pm 0.21\%$). These results show that the incorporation of 15%

PPF into a balanced diet can maintain rabbit growth performance and carcass yields comparable to those obtained with the control diet under real-world farming conditions.

Keywords

Fibre, *Oryctolagus Cuniculus*, Pellets, Growth, Carcass, Benin

1. Introduction

Feed is a major determinant of production performance in rabbits. Dietary fibre plays an essential role in rabbit nutrition because of its role in regulating digestion and maintaining proper digestive function [1]. However, the availability of forages may be limited in some farming areas, particularly in urban and peri-urban areas; hence, the need to explore other locally available fibre resources that could serve as alternatives to forage. Palm-press fibres (PPF) are a by-product of oil palm fruit processing and are available in many palm oil processing units in Benin [2]. They have a nutritional value characterized by a high content of fibrous constituents, as indicated by their contents of 38% DM crude fiber, 26.5% DM ADF and 54.5% DM NDF [3]. In Benin, Houndonougbo *et al.* [2] showed, under experimental station conditions, that palm-press fibres could be included in diets for growing rabbits at up to 15% without significantly affecting growth performance and carcass yield. More recently, Gangbedji *et al.* [4] also reported satisfactory growth performance in growing rabbits fed a complete diet containing 15% PPF. However, these studies were conducted at research stations. The use of this feed technology under farmers' rearing conditions is therefore necessary to assess its outcomes, which remain poorly documented in this context.

The present study aimed to evaluate the growth performance and carcass characteristics of growing rabbits fed a complete diet based on PPF under on-farm conditions in Benin.

2. Materials and Methods

2.1. Study Area and Farm Selection

A study was conducted under on-farm conditions in four rabbit farms located in municipalities of Dassa-Zoumé and Glazoué, Department of Collines in Benin. These municipalities are characterized by a Sudanian-Guinean climate, with an average annual rainfall of approximately 1073 mm and temperatures between 25 and 34°C [5] [6]. The rabbit farms were selected randomly from the farms identified in the study area, with two farms selected in each municipality, based on pre-defined eligibility criteria. Each selected farm had at least 24 weaned rabbits aged 35 - 45 days, as well as suitable rabbit housing and adequate feeders and drinkers. The farmers agreed to participate in the experiment and to collaborate throughout the study.

2.2. Animals and Experimental Design

Ninety-six mixed-breed rabbits aged 35 - 45 days, including males and females, were used in the experiment and distributed among four rabbit farms, with 24 animals per farm. The initial mean live body weight of the rabbits was 976.95 ± 40.88 g. In each farm, the animals were assigned to two dietary treatments: a control diet (AT) and a palm-press fibre-based diet (AFNP). Rabbits were grouped according to their initial body weight and sex, with each replicate consisting of four rabbits (two males and two females). Each dietary treatment comprised three replicates of four rabbits. Each group of four rabbits constituted an experimental unit. The groups were then randomly assigned to the dietary treatments. Before the experiment, preventive treatment against intestinal worms and coccidiosis and vitamins were administered to the rabbits for four days.

2.3. Experimental Diets and Feeding Management

Two complete pelleted diets were used: a control diet (AT) and a palm-press fibres-based diet (AFNP). The dried palm-press fibres (FNP) were from a palm oil process unit. They were incorporated at 15% into the pellet feed. The ingredients and nutritional compositions of AFNP feed are in **Table 1**. The nutritional composition of the AFNP feed was determined by laboratory proximate analysis.

Table 1. Ingredients and nutritional composition of growing rabbits Palm-press fibre-based feeds (AFNP) as formulated and fed.

Feedstuffs	Proportion (kg)
Percentage Composition	
Maize	17
Wheat bran	21.5
Rice bran	5
Cottonseed cake	15
Palm kernel cake	15
Soybean grain	8
Oil shell	2
Lysine	0.19
Méthionine	0.1
Dicalcium phosphate	0.5
Nacl	0.36
Iron sulfate	0.35
Palm-press fibre	15
Nutritional composition	
Dry matter (%)	88.49
Organic matter (% DM)	93.05
Crude protein (% DM)	21.17

Continued

Ether extract (% DM)	10.68
Crude fibre (% DM)	12.27
Total ash (% DM)	6.95
Calcium (Ca) (%)	1.04
Phosphorus (P) (%)	0.80
Ca/P ratio	1.3
Gross energy (Cal/g)	4396
Metabolizable energy (Kcal/kg DM)*	3160

*Metabolizable Energy (ME) was calculated using following formula: $ME = 3951 + (54.4 \times \text{ether extracts}) - (40.8 \times \text{total ash}) - (88.7 \times \text{crude fiber})$ (Sibbald *et al.*, 1980).

The control diet (AT) was commercial complete pelleted feed used by rabbit farmers in the area. As a commercial feed, its centesimal ingredient composition was not available to the researchers. The nutritional composition declared on the feed bags is presented in **Table 2**. A three-day dietary transition was carried out before the beginning of the experiment, simultaneously with the health treatment. The rabbits received exclusively the respective corresponding diet without forage supplementation. Water was provided *ad libitum*. The following husbandry conditions were standardized across farms: feed was distributed once daily and weighed using a scale; no forage supplementation was provided; and the rabbit housing, feeders and drinkers were cleaned every morning. Each farm had two feeders and two drinkers. The cages used were those already available on each farm, and therefore their construction materials varied among farms, with either wooden or galvanized-wire cages. The experiment lasted ten weeks. During this period, the quantity of feed per rabbit per day was progressively increased from 60 g FM in the first week to 120 g FM in the tenth week. Served and leftovers feed (in g FM) were weighed and recorded weekly. Individual live weights of rabbits were collected at the beginning of the experiment and every fourteen (14) days. These data were used to determine feed intake (FI) (g DM), average daily weight gain (ADG) (g/day), and feed conversion ratio (FCR) (g feed/g live weight gain).

Table 2. Nutritional composition of the commercial control diet (AT).

Nutrient	AT
Metabolizable energy (kcal/kg MS)	2517
Crude protein (%)	17.95
Ether extract (%)	4.85
Crude fibre (%)	7.59
Calcium (%)	1.32
Non-phytate phosphorus (%)	0.93

Nutritional values declared on the label of the commercial feed; AT = control diet.

2.4. Evaluation of Carcass Characteristics

At the end of the experiment, at the sixteen weeks old, sixteen rabbits per dietary treatment (four rabbits per farm, including two males and two females) were selected for carcass characteristics evaluation. No mortality was recorded during the experimental period. Rabbits were subjected to a 24-hour feed withdrawal before slaughter, while water remained available *ad libitum*. Rabbits were slaughtered using the traditional method in accordance with ethical and experimental standards. Live weight, blood-drained weight, dressed weight, and hot carcass and the left thigh weight were recorded. All visible fat was removed from each carcass and weighed. Carcass, thigh and total fat yields were subsequently calculated as follows:

Carcass yield (%) = Hot carcass weight/Live weight before slaughter $\times$ 100;

Thigh yield (%) = Left thigh weight/Hot carcass weight $\times$ 100; and

Total fat yield (%) = Total fat weight/Hot carcass weight $\times$ 100.

2.5. Statistical Analysis

Data were recorded in Microsoft Excel, and variables were calculated. The experimental unit was the group of four rabbits within each farm, resulting in 12 experimental units per dietary treatment. Feed intake (FI), average daily gain (ADG), and feed conversion ratio (FCR) were calculated at the experimental-unit level, since feed offered and refusals were measured for each group of four rabbits. For FI, ADG and FCR, a linear model was fitted with dietary treatment as the main fixed effect and farm included as a blocking factor. For repeated live-body-weight measurements, a linear mixed-effects model was fitted with dietary treatment, measurement time, baseline body weight (P0), and the treatment $\times$ time interaction as fixed effects, with farm included as a blocking factor and the experimental unit (group of four rabbits) included as the repeated subject. Results are presented as means $\pm$ standard error of the mean (SEM), with $n = 12$ experimental units per dietary treatment. To assess the effects of dietary treatment and sex on carcass parameters, a fixed-effects linear model including dietary treatment and sex as fixed factors was used. All statistical analyses were performed using the R statistical computing environment [7].

3. Results

3.1. Feed Intake of Growing Rabbit

Table 3. Overall growth performance of rabbits.

Parameters	AT	AFNP	P value
Feed intake (g DM/day)	88.35 $\pm$ 1.52	92.01 $\pm$ 1.52	0.1061
Average daily gain (g)	16.75 $\pm$ 0.94	16.84 $\pm$ 0.94	0.9485
Feed conversion ratio	5.63 $\pm$ 0.3	5.58 $\pm$ 0.38	0.9286

Values are means $\pm$ SEM; $n = 12$ experimental units per dietary treatment. AT = control diet; AFNP = palm-press fibre-based diet; DM = dry matter; P = probability.

The daily feed intake of the rabbits increased progressively throughout the experimental period, regardless of dietary treatment. The average feed intake recorded for the rabbits was 88.35 ± 1.52 g DM/day for the AT diet and 92.01 ± 0.52 g DM/day for the AFNP diet, with no significant difference between the two treatments ($P = 0.1061$) (**Table 3**).

3.2. Growth Performance of Rabbits and Feed Efficiency

The growth of rabbits was regular throughout the experimental period under both dietary treatments (**Figure 1**). The rabbits body weight increased progressively from P0 to P70, with no significant difference between rabbits receiving the AT diet and those receiving the AFNP diet at any of the ages considered ($P > 0.05$). Overall, the average daily gain of rabbits was 16.75 ± 0.94 g for the AT diet and 16.84 ± 0.94 g for the AFNP diet, with no significant difference between treatments ($P = 0.9506$) (**Table 1**). Similarly, feed conversion ratio was comparable between the two dietary treatments, with respective values of 5.63 ± 0.38 and 5.58 ± 0.38 for AT and AFNP ($P = 0.9286$) (**Table 3**).

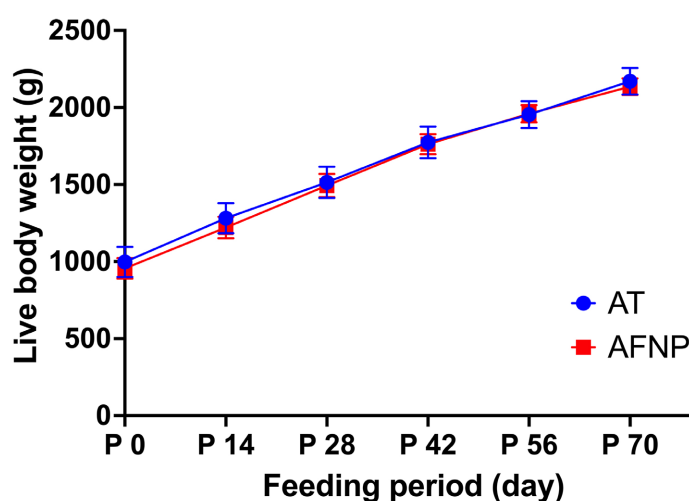


Figure 1. Growth curves of rabbits fed the experimental diets.

3.3. Rabbits Carcass Characteristics

Carcass yield, thigh yield, and total fat yield were not significantly affected by dietary treatment ($P > 0.05$) (**Table 4**), although a tendency towards a higher carcass yield was observed in rabbits receiving the AFNP diet ($66.45\% \pm 0.64\%$) compared with those receiving the AT diet ($64.66\% \pm 0.68\%$) ($P = 0.0668$). In contrast, total fat yield was significantly higher in rabbits receiving the AFNP diet ($3.27\% \pm 0.57\%$) than in those receiving the AT diet ($1.85\% \pm 0.21\%$) ($P = 0.0291$). Thigh yield was similar between the two treatments, with values of $12.48\% \pm 0.16\%$ and $12.77\% \pm 0.12\%$ for AFNP and AT, respectively ($P = 0.1733$) (**Table 4**). No significant effect of sex was observed on carcass yield, thigh yield, or total fat yield ($P > 0.05$) (**Table 5**).

Table 4. Carcass characteristics of experimental rabbits according to dietary treatment.

Parameters	AT	AFNP	P value
Carcass yield (%)	64.66 ± 0.68	66.45 ± 0.64	0.0668
Thigh yield (%)	12.77 ± 0.12	12.48 ± 0.16	0.1733
Total fat yield (%)	1.85 b ± 0.21	3.27 a ± 0.57	0.0291

Values are means ± SEM; n = 16 rabbits per dietary treatment. AT = control diet; AFNP = palm-press fibre-based diet; DM = dry matter; P = probability. (a,b) means of the same row followed by different letters are significantly different at the 5% level.

Table 5. Carcass characteristics according to sex of experimental rabbits.

Parameters	Male	Female	P value
Carcass yield (%)	66.30 ± 0.76	64.81 ± 0.58	0.1325
Thigh yield (%)	12.56 ± 0.14	12.70 ± 0.15	0.5148
Total fat yield (%)	2.60 ± 0.53	2.52 ± 0.40	0.8959

Values are means ± SEM; n = 16 males and 16 females. AT = control diet; AFNP = palm-press fibre-based diet; DM = dry matter; P = probability.

4. Discussion

Mean feed intake did not differ significantly between rabbits fed the control diet (AT) and those fed the palm-press fibre-based diet (AFNP), averaging 88.35 ± 1.52 g DM/day and 92.01 ± 1.52 g DM/day, respectively ($P = 0.1061$). Although feed intake was numerically higher with the AFNP diet, the difference was not statistically significant, indicating that the inclusion of 15% palm-press fibre did not adversely affect feed intake and that the diet was well accepted by the rabbits. Feed intake with the AFNP diet (92.01 g DM/day) was higher than the 79.94 g/day reported by Houndonougbo *et al.* (2012) for rabbits fed a diet containing 15% palm-press fibre. This difference may be partly related to the initial characteristics of the animals, as the rabbits used by Houndonougbo *et al.* [2] were younger (35 days) and had a lower initial body weight (854.4 g), which may have contributed to their lower feed intake. Indeed, Gidenne and Lebas [8] reported that feed intake increases markedly with age during growth. The value obtained in this study is nonetheless close to the value of 93.73 g/day reported by Gangbedji *et al.* [4] in rabbits fed a complete diet. In contrast, Adeyeye *et al.* [3] reported lower feed intake values, ranging from 52.75 to 64.00 g/day, when wheat bran was replaced with palm-press fibre at different inclusion levels. Differences in feed intake among studies may be related to differences in animal characteristics and in the physical and nutritional properties of the fibre sources used in the diets. Gidenne [9] emphasized that the response of rabbits to dietary fibre depends not only on the inclusion level but also on fibre quality and physical characteristics. The progressive increase in feed intake observed with both diets over the ten-week experimental period is consistent with the increase in feed intake associated with post-weaning growth in rabbits [8]. The satisfactory acceptance of the AFNP diet under on-farm

conditions is consistent with the findings of Houndonougbo *et al.* [2] and Gangbedji *et al.* [4] under experimental conditions, showing that palm-press fibre can be included in rabbit diets without adversely affecting feed intake and may reduce the need for forage.

The rabbits' weight gain was consistent throughout the 10-week experiment, with a gradual increase in live weight in both diet groups. The absence of significant differences in live body weight between rabbits fed the AT and AFNP diets at all ages indicates that, under on-farm conditions, inclusion of 15% palm-press fibre (PPF) in the complete diet can support growth comparable to that achieved with the control diet commonly used by rabbit farmers. The nutritional composition of the AFNP diet, which contained 21% Crude Protein (on a DM basis), 3160 kcal/kg metabolizable energy and 12.27% crude fibre (on a DM basis), may account for the similar growth performance observed between treatments. Indeed, Gidenne [9] emphasized that diets for growing rabbits should meet their energy and protein requirements while providing an adequate supply of dietary fibre. In the present study, the nutritional composition of the AFNP diet, together with the growth performance observed, indicates that inclusion of PPF at 15% did not compromise the nutritional supply required for rabbit growth. The similarity in live body weight development was also reflected in average daily gain (ADG), which averaged approximately 16.8 g in rabbits fed the AT and AFNP diets. The ADG recorded with the AFNP diet was nevertheless lower than the values reported by Houndonougbo *et al.* [2], ranging from 19.7 to 23.1 g with diets containing up to 15% PPF, and by Gangbedji *et al.* [4], who obtained 23.94 g with a complete diet containing 15% PPF. Conversely, it was higher than the values of 8.93 to 11.61 g reported by Adeyeye *et al.* [3] in growing rabbits fed diets in which PPF progressively replaced wheat bran; as well as the maximum ADG of 15.66 g reported by Agbomahena *et al.* [10] in growing Hyla hybrid rabbits fed complete diets containing different levels of PPF. Differences in ADG among studies may be partly related to differences in the characteristics of the PPF sources used. Indeed, the effects of a fibre source in rabbits depend not only on its inclusion level but also on its nature, composition and physical characteristics, which may influence digestion and caecal fermentation [11].

The ability of the PPF-based diet to support weight gain in rabbits comparable to that achieved with the control diet also prompts an examination of its efficiency in rabbits, as assessed by the feed conversion ratio (FCR). In this study, the AFNP diet resulted in an FCR of 5.58, which was very similar to the value of 5.63 recorded with the AT diet. This result indicates that inclusion of 15% PPF did not impair feed efficiency. The FCR obtained with the AFNP diet was, however, slightly higher than the range of 4.8 to 5.4 reported by Dahouda *et al.* [12] for fattening rabbits in Benin. This difference may be more closely related to differences in the overall composition of the diets among studies than to an intrinsic limitation in the digestive use of PPF. Indeed, Gangbedji *et al.* [4] reported apparent digestibility coefficients (ADCs) of 67.92% for Dry Matter, 69.04% for Organic

Matter and 91.56% for Crude Fiber in rabbits fed a complete diet containing 15% PPF, indicating good digestive use of this diet. The lower FCR values reported under research-station conditions with diets containing 15% PPF, namely 3.78 in Houndonougbo *et al.* (2012) and 4.01 in Gangbedji *et al.* [4], were lower than that obtained in this study (5.58), under on-farm conditions. This difference may be explained by the greater degree of control of experimental conditions at research stations, particularly with regard to the environment, feeding management and animal management, compared with conditions prevailing on farms. Nevertheless, the AFNP diet maintained feed efficiency comparable to that of the diet commonly used by farmers, supporting the practical relevance of this result.

The carcass yields recorded with the AFNP (66.45%) and AT (64.66%) diets were statistically similar. However, in absolute terms, carcass yield tended to be higher with the AFNP diet, with a difference of 1.79 percentage points. The carcass yields recorded in this study were higher than values ranging from 60.8 to 62.9% reported by Houndonougbo *et al.* [2] in rabbits fed diets containing different levels of PPF. Thus, inclusion of 15% PPF in the diet of growing rabbits can result in carcass yields comparable to those obtained with the control diet. In contrast, our results showed a significant increase of approximately 77% in total fat yield in rabbits fed the AFNP diet (3.27%) compared with those fed the control diet (1.85%). This may be related to the higher fat content of the AFNP diet (10.68% DM) compared with the AT diet (5.92% DM), with dried palm-press fibres themselves having a high fat content of 27.49% DM. Indeed, dietary lipid content can influence body composition and fat deposition in rabbits (Saiz del Barrio *et al.* [13]). However, this increase reflects a higher total visible carcass fat deposition in rabbits fed the AFNP diet, rather than an increase in meat ether extract content, which was not measured in the present study. In fact, Ouhayoun (1989) reports that most of the dissectable fat is located in specific adipose deposits, particularly the perirenal and interscapular regions, while the prime cuts of the carcass remain particularly lean. This value is close to the 3.58% reported by Gangbedji *et al.* [4].

Furthermore, the absence of a significant sex effect on the calculated yields indicates that carcass characteristics of the experimental rabbits were comparable between males and females. This finding suggests that, under the conditions of this study, sex was not a major source of variation in the carcass characteristics evaluated.

5. Conclusion

Under real-world rabbit farming conditions, the incorporation of 15% palm-press fibres into a balanced diet resulted in growth performance comparable to that obtained with the diet commonly used by rabbit farmers in the study area. The AFNP diet does not affect feed intake, average daily gain, or the feed conversion ratio, and also yields carcass and thigh yields similar to those of the control diet. However, its use led to an increase in total carcass fat yield. These results show that the technology using 15% palm-press fibres in balanced diet for growing rabbits can

be considered under real-world conditions to reduce the reliance on grass and forage in urban and peri-urban rabbit farms.

Author Contributions

The first author collected, processed and drafted this article. The other authors read and corrected the manuscript. All the authors read and approved the final manuscript.

Conflicts of Interest

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

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