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Research Article

Effect of In-Feed Coffee Pulp on the Zootechnical Performance and Production Cost of Rabbits (Oryctolagus Cuniculus)

Noumbissi Marie Noël Bertine[1,*], Miegoue Emile[1], Mweugang Ngouopo Nathalie[1], Nguema Nathanie Arnaud Jordy[1], Nounamo Langston Wilfried Edie[1], Tchouan Deffo Gilchrist[2], Tendonkeng Fernand[1]

[1]Faculty of Agronomy and Agricultural Sciences, University of Dschang, Dschang, Cameroon
[2]Faculty of Agronomy and Environmental Sciences, Evangelical University Institute, Bafoussam, Cameroon

Abstract

Rabbit is an animal with rapid growth and reproduction abilities that could make it an effective solution in the fight against protein deficiency in populations. Unfortunately, its diet often represents the main limiting factor in expressing its production potential in a tropical environment. This study was initiated with the aim of contributing to improving the productivity of rabbits through the incorporation of coffee pulp into their diet. A total of eighty (80) common rabbits (*Oryctolagus cuniculus*) were used in a completely randomized design, including 20 adults with an average weight of 2652 ±186 g for the digestibility trial and 60 rabbits aged 50 days with an average weight of 1183 ±134 g for the growth performance trial. A group of rabbits fed the control ration (R0) without coffee pulp was compared to three other groups fed rations containing 10% (R1), 20% (R2) and 30% (R3) of crushed dried coffee pulp. The ingestion of crude fiber significantly increased with the increasing level of coffee pulp in the ration. The highest value (13.89 ±0.25 g/d) was obtained with 30% coffee pulp, while the lowest (9.93 ±0.66 g/d) was with the control ration (0%). The crude fiber and protein digestibility significantly increased with increasing level of coffee pulp in the ration. The highest values (54.24 ±4.83 g/d; 58.36 ±2.13 g/d respectively for crude fiber and nitrogen) were obtained with 30% coffee pulp. Feed intake and feed conversion ratio were significantly influenced by the presence of coffee pulp in rabbits' ration. Coffee pulp inclusion in feed had no significant effect on the different carcass yields. The relative weights of the liver and kidney were significantly higher with increasing inclusion level of coffee pulp in the ration. The production cost per kilogram of live weight tends to decrease with the incorporation of coffee pulp in rabbit ration. Coffee pulp constitutes a by-product that can be recycled and their incorporation at 10% in rabbit ration can reduce production cost without negatively affecting their growth performance.

Keywords

Coffee Pulp, Growth Performance, In Vivo Digestibility, Production Cost, Rabbit

[*]Corresponding author: noumbissimarienoelbertinel@gmail.com (Noumbissi Marie Noël Bertine)

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1. Introduction

The rabbit is a monogastric herbivorous animal belonging to the Leporidae family. Its good prolificacy (40 - 45 rabbits/female/year), along with its growth and rapid reproduction abilities, could make it an effective solution against undernutrition and the lack of proteins of animal origin in the population [1]. However, the diet most often represents the main limiting factor in the expression of its production potential in a tropical environment [2, 3]. In Africa and particularly in Cameroon, there is a high competition between humans and animals for cereals, which limits productivity and increases feed costs, estimated to be 70% of the cost of production in intensive livestock farming [4]. To mitigate this problem, unexploited or poorly recovered agro-industrial wastes are being considered. According to [5], the agri-food sectors have generated significant by-products from first or second processing. Considered waste in the production process, 3/4 of these products, such as coffee pulp, are raw materials used in animal feed. Indeed, the coffee industry produces millions of tonnes of waste each year, notably grounds, pulp, and hulls; and it would be beneficial not to throw them but to integrate them into the value chain [6].

Coffee pulp is the fleshy outer layer of the coffee fruit that surrounds the coffee beans. According to figures revealed by [7], coffee production has experienced a considerable increase. However, the pulps are generally left in the fields or discarded after harvest. However, studies carried out by [8-11] indicate that it has significant nutritional values that can contribute to meeting the needs of animals in general and those of animals capable of valorizing cellulose in particular. Given the large quantities generated, their availability and low cost throughout the harvest and processing season, several studies have evaluated the use of coffee pulp as a dietary supplement for cattle, pigs, fish, sheep, chickens and horses [12, 13]. Thus, waste from the coffee industry, particularly coffee pulp, could contain significant and accessible quantities of nutrients that rabbits could use to improve their performance while lowering their production costs. The general objective of this work was to enhance knowledge on the valorization of local and available agro-food by-products in rabbit feed. More specifically, it aimed to evaluate the effect of incorporating coffee pulp into the diets of rabbits on digestibility, growth performance, carcass characteristics and production costs.

2. Materials and Methods

2.1. Study Area

The study was carried out at the Teaching and Research Farm of the University of Dschang (TRF-UDs) in West Cameroon, located at 05°26' North latitude and 10°26' East longitude, with an average altitude of 1,420 m. The climate of the Western Region is equatorial, modified by altitude. Temperatures range between 10℃ (July-August) and 25℃ (February). Precipitation varies between 1,500 and 2,000 mm per year. The dry season lasts from mid-November to mid-March, while the rainy season extends from mid-March to mid-November.

2.2. Animal and Housing

A total of 80 rabbits were used for this study. For the digestibility trial, 20 adult rabbits with an average weight of 2652 ± 186 g were housed individually in batteries of galvanized metal mesh cages measuring 97 cm x 46 cm x 26 cm, lined with mosquito net to collect faeces and topped with plastic to trap urine, which flowed directly into a bottle. The digestibility cages were also equipped with a feeder and a cylindrical drinker (800 ml capacity). Meanwhile, growth performance was evaluated using 60 rabbits with an average weight of 1183 ± 134 g aged 50 days. They were housed in hutches where each had three boxes or cages made of Chinese bamboo, each measuring 65 cm long, 65 cm wide, and 50 cm high. The cages were equipped with semi-automatic sheet metal feeders and pipettes connected to 30 L buckets for water supply.

2.3. Plant Material

Robusta variety coffee pulps collected from a coffee processing factory were sun-dried, ground, and preserved for incorporation in feed. In addition, a 100 g sample was taken and dried at 50℃ until a constant weight was reached in a Gallenkamp brand ventilated oven at the Animal Production and Nutrition Research Unit of the University of Dschang for chemical composition analysis. Thus, coffee pulp content in dry matter, organic matter, ash, crude protein, crude fiber, lipids, and metabolizable energy was determined according to the AOAC method [14] (Table 1).

Table 1. *Chemical composition of coffee pulp.*

Constituents	Chemical composition
Dry matter (DM)	89.05
Organic matter (%DM)	93.48
Ash (%DM)	0.75
Metabolizable energy (Kcal/kg DM)	2181
Crude protein (%DM)	12.10
Lipid (%DM)	0.35
Crude fiber (%DM)	17.36

DM = Dry matter

2.4. Ration Formulation

In addition to the coffee pulp powder, the other ingredients used in the ration formulation were sourced from resellers of industrial by-products in the study area. The basal ration or control ration (R0) had only industrial by-products. The other rations R1, R2, and R3 respectively, had 10%, 20%, and 30% of ground coffee pulp added to the basal ration. The formulated rations were served pelleted to the rabbits. The percentage and chemical composition of the rations are presented in Table 2.

Table 2. Centesimal and chemical composition of the rations used.

Ingredients	Rations			
	R0	R1	R2	R3
Centesimal composition (%)				
Yellow corn	42	34	25	25
Wheat bran	11	12	7	7
Cottonseed cake	0	0	7.5	7.5
Palm kernel cake	37.4	36.4	32.4	22.4
Coffee pulp	0	10	20	30
Fish meal	4	3	1.5	1.5
Shellfish	2	2	2	2
Lysine	0.4	0.4	0.4	0.4
Methionine	0.2	0.2	0.2	0.2
Premix 2%	2	2	2	2
Palm oil	0	1	1	1
Salt	1	1	1	1
Total	100	100	100	100
Bromatological characteristics of rations				
Crude Protein (%DM)	15.52	16.23	15.81	16.04
Metabolizable energy (kcal/kg DM)	2202	2307	2203	2430
Crude Cellulose (%DM)	9.78	9.34	11.32	11.35
Calcium (%DM)	1.19	1.28	0.99	1.10
Phosphorus (% DM)	0.61	1.03	0.99	1.92

R0 = control ration without coffee pulp; R1, R2, R3 = rations containing ground coffee pulp respectively at10%, 20% and 30%. DM = Dry matter.

2.5. Studied Parameters and Data Collected

2.5.1. Effect of Coffee Pulp on Feed Intake and Digestibility

Twenty (20) adult rabbits of comparable weight were distributed according to a factorial design (ration) into four groups, each containing five animals or repetitions / group, and the animals were placed randomly and individually in digestibility cages. After a 10-day adaptation phase for the animals to the digestibility cages, a 5-day post-adaptation phase for the animals to the experimental rations followed, along with a 5-day phase for data collection. Throughout the trial (20 days), the animals in the control group received the control ration (R0), while those in the other groups were fed with the rations R1, R2, and R3, respectively (Table 1). Feed and water were provided to the rabbits ad libitum. Feed was weighed and provided once a day (between 8 a.m. and 9 a.m.) to each animal and the refusals were collected the next day and weighed to determine feed intake FI) according to the formula below:

FI (Kg) = quantity of feed distributed - quantity of feed refused

The faeces of each animal were collected daily and weighed, and a sample of 100 g was taken, dried to constant weight in the same oven as above, and ground for the determination of dry matter (DM), ash (A), organic matter (OM), crude fiber (CF), and crude protein (CP). Likewise, the urine produced by each animal was collected after 24 hours using bottles connected to the digestibility device, inside which 10% concentrated sulfuric acid (H_2SO_4) had previously been introduced according to the average volume of urine produced by each animal during the adaptation period, in order to stabilize urinary nitrogen. Urine was measured in a graduated cylinder and 10 ml were taken using a syringe and transferred to test tubes for the determination of urinary nitrogen. The data collected allowed for the calculation of the apparent digestive utilization coefficients (aDUC) of DM, OM, CF and CP according to the following formula [15]:

$$aDUC\ (\%) = \frac{Feed\ component\ ingested - Feed\ component\ excreted}{Feed\ component\ ingested} \times 100$$

2.5.2. Effect of Coffee Pulp on Growth Performance of Rabbits

Sixty (60) rabbits of comparable body weight were randomly divided into four groups of 15 with 3 repetitions / group. From a control ration (R0) without coffee pulp, three other rations R1, R2 and R3 with respectively 10%, 20%, and 30% coffee pulp, were formulated. Feed was weighed every morning before being served to the animals, and the refusals were collected the next day, allowing for the calculation of feed intake. The rabbits were weighed at the start of the trial and at the end of every week until the end of the trial. This allowed for the evaluation of weekly weight change, total weight gain (TWG), average daily weight gain (ADWG), and feed conversion ratio (FCR) according to the formulas:

TWG (g) = final weight (g) - initial weight (g)

$$ADWG = \frac{weight\ obtained\ in\ one\ week\ (g)}{7}$$

$$FCR = \frac{amount\ of\ food\ consumed\ per\ week\ (g)}{weight\ gain\ per\ week\ (g)}$$

During the trial period (49 days), feed and drinking water were served ad libitum to each animal. At the end of this trial, three animals were randomly selected from each ration. They were fasted for 24 hours and then sacrificed to evaluate carcass yield (CY) and the relative weights of some organs (RWO) of the digestive system according to the formulas:

$$CY\ (\%) = \frac{carcass\ weight\ (g)}{fasting\ live\ weight\ of\ the\ animal\ (g)} \times 100$$

$$RWO\ (\%) = \frac{organ\ weight\ (g)}{live\ weight\ (g)} \times 100$$

2.5.3. Effect of Coffee Pulp on Production Costs

The production cost per kilogram of live weight of rabbit was calculated according to the formula below:

Production cost of Kg of rabbit (FCFA) = Price per kg of feed (FCFA) x FCR

2.6. Ethical Approval

The handling of rabbits was in accordance with the Cameroon National Ethical Committee (Reg. Num. FWAIRD 0001954) and in conformity with the international guidelines of the European Union on Animal Care (CEE council 86/609).

2.7. Statistical Analysis

Data collected were submitted to one-way (ration) analysis of variance (ANOVA) and the Duncan test was used to compare means when significant differences were found. Data were expressed as mean ± standard deviation. SPSS 23.0 software was used for the analysis at the 5% significance level.

3. Results

3.1. Ingestion and Digestibility of Feed Components in the Ration

From Table 3, the incorporation of coffee pulp did not significantly ($p>0.05$) affect the ingestion of dry matter, organic matter and crude protein, although the ration containing 30% coffee pulp showed the highest values for these parameters. On the other hand, the ingestion of crude fiber significantly ($p<0.05$) increased with the level of inclusion of coffee pulp in the ration. Indeed, the highest intake (13.89 ±0.25 g/day) was obtained with the R3 ration (containing 30% coffee pulp), while the lowest intake (9.93 ±0.66 g /day) was observed with the R0 ration (0% coffee pulp).

The incorporation of coffee pulp did not significantly affect ($p>0.05$) the digestibility of dry matter and organic matter whatever the ration (Table 3). Furthermore, significant differences were observed in the digestibility of crude fiber and protein. Indeed, the aDUC CF and aDUC CP of the ration containing 10% coffee pulp (R1) were significantly ($p<0.05$) higher than those of the R0, R2 and R3 rations which were otherwise comparable to each other ($p> 0.05$).

Table 3. *Ingestion and digestibility of food constituents depending on the level of coffee pulp in the rabbit ration.*

Feed constituents	Rations				p
	R0	R1	R2	R3	
Ingestion of feed components (g/day)					
DM	121 ±3.10	116	120 ±3.33	123 ±2.27	0.227
OM	130 ±3.34	127 ±3.79	128 ±4.72	130 ±2.41	0.692
CF	9.93 ±0.66[a]	10.84 ±1.05[a]	12.59 ±1.01[b]	13.89 ±0.25[b]	0.001
CP	16.28 ±1.41	15.49 ±1.09	15.94 ±1.81	17.56 ±1.73	0.063
Apparent digestible utilization coefficients (aDUC) (%)					
aDUC DM	67.31 ±2.26	65.83 ±3.14	69.06 ±3.08	67.77 ±2.20	0.563
aDUC OM	72.40 ±2.33	70.41 ±2.59	73.30 ±5.27	71.75 ±3.83	0.807
aDUC CF	49.12 ±3.22[b]	36.50 ±2.77[a]	52.31 ±3.24[b]	54.24 ±4.83[b]	0.001
aDUC CP	55.74 ±3.45[b]	50.70 ±2.06[a]	57.82 ±2.46[b]	58.36 ±2.13[b]	0.025

DM = Dry matter; OM = Organic matter; CF = Crude fiber; CP = Crude protein; a, b: means bearing the same letters on the same line are not significantly different at the 5% threshold; R0: control ration without coffee pulp; R1: ration containing 10% coffee pulp; R2: ration containing 20% coffee pulp; R3: ration containing 30% coffee pulp; p= probability.

3.2. Rabbit Growth Performance

Table 4 show that feed intake (FI) and feed conversion ratio (FCR) of rabbits were significantly ($p<0.05$) influenced by coffee pulp in the ration; the highest value of (FI) was obtained with animals fed the R3 ration (4997 ± 49.50 g), followed by those fed the R2 (4691 ± 36.12 g) and R0 (4593 ± 33.60 g) rations, respectively; the lowest value was obtained with the R1 ration (4357 ± 22.60 g). The lowest FCR was obtained with rabbits fed R1 ration (6.04 ± 0.03) and the highest with the R3 ration (6.92 ± 0.06). Furthermore, the inclusion of coffee pulp in rations had no significant effect ($p>0.05$) on live weights, total gains and average daily weight gains in rabbits.

Table 4. *Average growth parameters as a function of the level of incorporation of coffee pulp in rabbit ration.*

Growth parameters	Rations				p
	R0	R1	R2	R3	
Feed intake (g)	4593 ±33.60[b]	4357 ±22.60[a]	4691 ±36.12[c]	4997 ±49.50[d]	0.000
Live weight (g)	1948 ±151	1921 ±157	1916 ±147	1958 ±180	0.900
Total weight gain (g)	750 ±135	722 ±82.77	706 ±68.67	744 ±50.15	0.650
Average daily weight gain (g)	15.30 ±2.75	14.73 ±1.69	14.42 ±1.40	15.17 ±1.02	0.650
Feed conversion ratio	6.12 ±0.04[a]	6.04 ±0.03[a]	6.64 ±0.05[b]	6.92 ±0.06[c]	0.000

a, b, c: means bearing the same letters on the same line are not significantly different at the 5% threshold; R0 = control ration without coffee pulp; R1 = ration containing 10% coffee pulp; R2 = ration containing 20% coffee pulp; R3 = ration containing 30% coffee pulp; p = probability.

3.2.1. Weekly Evolution of Rabbit Feed Intake

Figure 1 illustrates that from the beginning to the end of the trial, feed intake of all animals increased regardless of the ration. However, from the 1st (S1) to the 3rd (S3) week of trial, the feed intake of the ration containing 30% coffee pulp (R3) was significantly higher than that of the other rations, but from the 3rd week until the end of the trial, the difference was no longer significant.

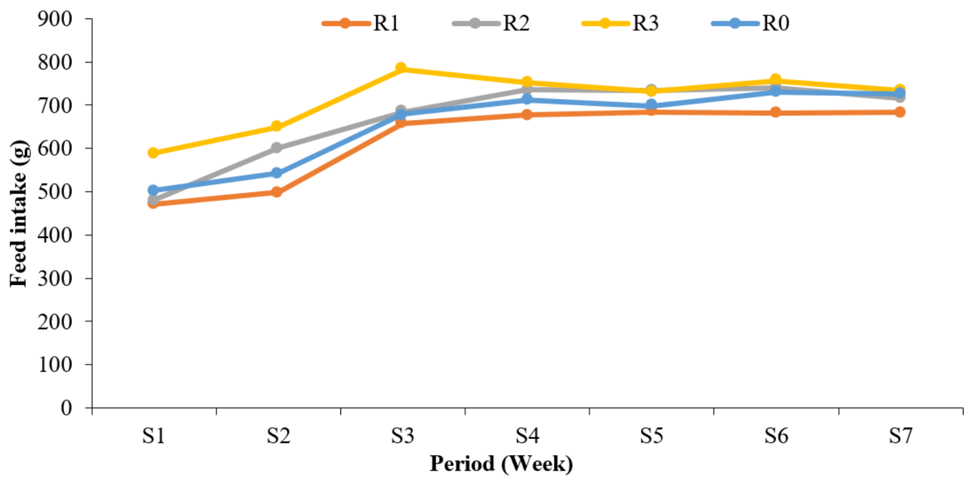

Figure 1. *Weekly evolution of feed intake of rabbits with respect to the level of incorporation of coffee pulp in the ration.*

R0: control ration without coffee pulp; R1: ration containing 10% coffee pulp; R2: ration containing 20% coffee pulp; R3: ration containing 30% coffee pulp; S: week

3.2.2. Weekly Evolution of Live Weight of Rabbits

From Figure 2 it appears that the evolution of the live weight of the rabbits was similar throughout the experiment although the average live weight of the animals fed with the ration containing 30% coffee pulp (R3) was regularly above others.

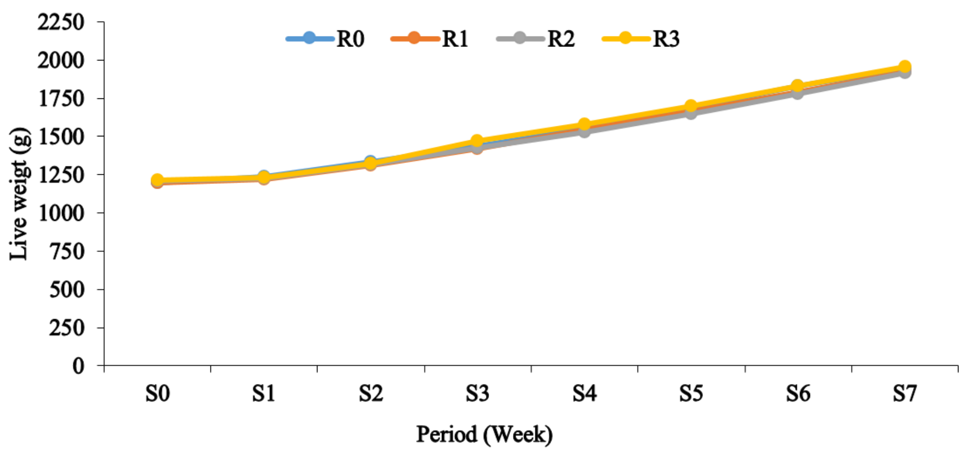

Figure 2. *Weekly evolution of the live weight of rabbits with respect to the level of incorporation of coffee pulp in the ration.*

R0: control ration without coffee pulp; R1: containing 10% coffee pulp; R2: containing 20% coffee pulp; R3: containing 30% coffee pulp; S: week

3.2.3. Rabbit Carcass Yield

Table 5 shows that the inclusion of coffee pulp in the ration did not significantly affect ($p>0.05$) the fasting live weights as well as the conventional and non-conventional carcass yields of rabbits. On the other hand, the relative weights of the liver and kidneys increased significantly ($p<0.05$) with the level of inclusion of the pulp in the ration. Thus, the highest weights (3.99 ±0.02% and 0.72 ±0.01% respectively for the liver and kidney) were observed in animals fed 30% coffee pulp in their ration (R3), and the lowest (2.01 ±0.01% and 0.52 ±0.01%

respectively for the liver and kidney) for those fed 0% (R0).

Table 5. Characteristics of carcasses and some organs of rabbits with respect to the level of incorporation of coffee pulp in the ration.

Carcass Characteristics	Rations				p
	R0	R1	R2	R3	
Live weight (g)	1960 ±47.15	1943 ±51.31	1984 ±58.82	194 ±043.19	0.701
Carcass yields (%LW)					
C CY	53.99 ±0.64	53.64 ±1.41	52.19 ±0.93	52.98 ±1.87	0.392
NC CY	63.94 ±1.13	64.23 ±1.80	65.19 ±1.10	66.32 ±2.54	0.403
Relative weight of organ (%LW)					
Liver	2.01 ±0.01^{a}	2.5 ±0.02^{b}	3.01 ±0.02^{c}	3.99 ±0.02^{d}	0.000
Kidney	0.52 ±0.01^{a}	0.55 ±0.00^{b}	0.60 ±0.01^{c}	0.72 ±0.01^{d}	0.000

a, b, c, and d: means bearing identical letters are not significantly different (p>0.05) for the same characteristics; R0: control ration without coffee pulp; R1: ration containing 10% coffee pulp; R2: ration containing 20% coffee pulp; R3: ration containing 30% coffee pulp; C CY: conventional carcass yield; NC CY: non-conventional carcass yield; LW: Live weight; p: probability.

3.3. Production Cost of Kg of Rabbit

It appears from Table 6 that the ration without coffee pulp (R0) presents the highest production cost per kg of rabbit (1775 FCFA), compared to those of the rations containing coffee pulp. Moreover, the ration containing 10% of coffee pulp coffee (R1) presents the lowest production price (1354 FCFA).

Table 6. Cost of production of rabbits with respect to the level of incorporation of coffee pulp in the ration.

Characteristics	Rations			
	R0	R1	R2	R3
Total weight gain (g)	750 ±135	722 ±82.77	706 ±68.67	744 ±50.15
Cost of Kg feed (FCFA)	290	224	229	221
Feed conversion ratio	6.12 ±0.04	6.04 ±0.03	6.64 ±0.05	6.92 ±0.06
Production cost per kilogram of rabbit (FCFA)	1775	1354	1519	1531

R0: control ration without coffee pulp; R1: ration containing 10% coffee pulp; R2: ration containing 20% coffee pulp; R3: ration containing 30% coffee pulp; FCFA: Franc for financial cooperation in Africa.

4. Discussion

The incorporation of coffee pulp in rabbit's ration at 20 and 30% induced a significant increase in feed intake. This could be explained by the fact that the increase in cellulose in the ration facilitated its digestibility and allowed the animal to consume more [3]. Furthermore, according to [16], coffee pulps have a strong potential in the production of aromatic compounds that can improve the palatability of the ration as its level increases, hence a higher ingestion observed in animals fed with the ration containing 30% coffee pulp. These results are similar to those of [17] obtained in hares fed with fermented coffee pulp, to those of [18] obtained in rabbits fed with cowpea tops, to those of [19], in their essay on the dietary supplementation of sheep with by-products from pineapple processing. However, the results obtained in this trial are in contradiction with those of [20] with the inclusion of bean tops in rabbit diets. This contradiction could be explained by the high level of anti-nutritional factors (tannins and lignin in particular) in bean tops, which surely reduced feed intake.

The incorporation of coffee pulp in the ration significantly affected the digestibility of crude fiber and that of crude protein in rabbits. These results are in agreement with those of [21], on the use of cocoa pods in rabbit feed. This could be due to the fact that rabbit has a digestive system adapted to the digestion of plant fibers and this adaptation would allow it to digest cellulose thanks to the presence of bacterial flora in their caecum [3].

The incorporation of coffee pulp in rations did not significantly affect weight gain and final weights of the animals. This could be attributed to the fact that the digestibility of crude protein and crude fiber was comparable after the incorporation of coffee pulp, therefore the weight gains were also comparable. These results are similar to those of [17] who did not obtain any improvement in weight gain after incorporating coffee pulp into hares. These weight performances are still less significant than those referenced by [22] at an average daily gain of around 35 g/d. This difference could be due to the quality of the animal strains but also of the ingredients used in his experiment.

The incorporation of 10% coffee pulp significantly reduces feed conversion ratio unlike other rations. This result could be explained by the existing positive correlation between feed intake and feed conversion ratio [23]. Indeed, weight gain of animals being comparable, the only variation factor of feed conversion ratio is feed intake which, according to Table 4, was precisely higher in rabbits fed rations containing 20 and 30% coffee pulp and lower with the ration containing 10% coffee pulp. Furthermore, [24] in her studies also found that the inclusion of 10% coffee pulp in feed reduced feed conversion ratio in pigs. However, feed conversion ratio obtained in this study are lower than those obtained by [20] after they incorporated bean tops in rabbit ration (10.45; 9.5; 10.81). This difference could be explained by the decrease in feed intake linked to the increase in bean tops in the ration.

Coffee pulp did not significantly affect conventional and non-conventional rabbit carcasses yields. This could be due to the fact that weight gains did not vary significantly following the inclusion level of coffee pulp, thus giving the same trend to carcass yields. These results are comparable to those of (18) who after incorporating cowpea and peanut tops in rabbit ration, obtained comparable conventional carcass yields.

The kidney and liver weights of rabbits significantly increased with the level of inclusion of coffee pulp in their ration. These results suggest hyperfunction of the kidneys and liver, organs involved in detoxification of the body. Indeed, [25] found that coffee pulps contained antinutritional factors. The gradual increase in the weight of these organs could therefore indicate their active involvement in the elimination of potential toxic substances in the diet since according to [26], the high weights of the kidneys and liver can be indicators of nephrotoxicity and hepato-toxicity respectively. The results of this study are different from those of [18] who noted no significant change in the size of these organs after incorporating cowpea and peanut tops in rabbit ration.

The production cost of a kilogram of rabbit in this study showed that the incorporation of coffee pulp in the ration strongly contributes in reducing production cost of rabbit. These results are in the same line as those of [27] who showed that the use of coffee pulp in livestock feed as a substitute for roughage would reduce the cost of feed by 33%. In addition, [13] reported that coffee pulp could replace up to 30% of chicken feed with a reduction of around 12% on production cost. Furthermore, the results of this study are more satisfactory than those of [20] who, after incorporating bean tops in rabbit ration, obtained a minimum feed production cost of 2289.19 FCFA compared to 1354 FCFA which was obtained in this study. This difference would be due to the availability and lower cost of coffee pulps which are currently considered waste and are almost not valued locally.

5. Conclusion

The results of the present study showed that the inclusion of coffee pulp in the ration of rabbits significantly affected feed intake but not the weight of the animals. The ingestion and digestibility of crude fiber as well as the relative weights of kidney and liver increased significantly. Production cost of a kilogram of rabbit decreased.

Coffee pulp, available and less expensive, can be incorporated at 10% in the ration of growing rabbits without adverse effects on their performance.

Abbreviations

TRF-Uds	Teaching and Research Farm of the University of Dschang
AOAC	Association of Official Analytical Chemists
DM	Dry Matter
aDUC	Apparent Digestive Utilization Coefficients
OM	Organic Matter
CF	Crude Fiber
TWG	Total Weight Gain
ADWG	Average Daily Weight Gain
FCR	Feed Conversion Ratio
CY	Carcass Yield
RWO	Relative Weight of the Organ
PC	Production Cost

Author Contributions

Noumbissi Marie Noël Bertine, Miegoue Emile, Mweugang Ngouopo Nathalie, conceived, designed the research, and reviewed the manuscript.

Nguema Nathaniel Arnaud Jordy, Edie Nounamo Langston Wilfried Edie, Tchouan Deffo Gilchrist, collected the data, carried out data analysis, and wrote the manuscript. All authors read and approved the final manuscript.

Tendonkeng Fernand, head supervisor.

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Conflicts of Interest

The authors declare no conflicts of interest.

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