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EFFECT OF SUPPLEMENTING PELLET-BASED DIETS ON GROWTH AND DENTAL WEAR IN FARM RABBITS (*Oryctolagus cuniculus*) IN CÔTE D'IVOIRE

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ABSTRACT

Feeding in rabbit farming is a very important factor because, in addition to providing the nutrients necessary for the rabbits' growth and health, it must also allow for dental wear. The main objective was to analyze the impact of four (4) diets on growth and dental structure in farmed rabbits. The study group consisted of 32 apparently healthy male rabbits aged 6–8 months, with weights ranging from 2.107 kg to 2.624 kg. Four (4) groups (pellets alone (CG), pellets + carrots (GC), pellets + hay (GFA), and pellets + carrots + hay (CO)) of 32 rabbits were formed. Each group received a specific type of diet. Analysis of variations in the animals' body weights according to the different types of diets showed a significant effect based on Tukey's test ($p = 0.02$, $p < 0.05$). It was noted that the GC group had the highest weight gain (0.42 ± 0.08 kg) compared to the other diets. Analysis of variance and post hoc tests identified major differences highlighting the influence of diet types on dental wear. Thus, the GFA group exhibited the most severe mandibular wear (4 ± 1.43) cm. This study demonstrated the impact of diet type on growth and dental wear in farmed rabbits, using four different diets. Hay emerged as the diet causing the greatest mechanical wear, whereas the maxilla showed a continuous tendency toward growth.

Keywords: Rabbit Rearing, Diet, Growth, Dental wear

1 INTRODUCTION

In sub-Saharan Africa, livestock production does not meet the population's total animal protein needs (1)(2). However, significant investments have been made since independence, with mixed results to date (3)(4). In fact, several problems have been identified in the rabbit farming sector in sub-Saharan Africa. These include training for farmers, the genetic potential of breeds, feeding issues, and diseases (5)(6).

An author (7) noted that livestock production accounted for approximately 30 percent of the agricultural gross domestic product in developing countries, and as much as 40 percent in developed countries. However, access to animal protein should not be limited to conventional livestock, namely, ruminants, which require ample space, as well as pigs and poultry.

Studies have shown that developing livestock farming is of particular interest in densely populated regions of Africa (8). In fact, new forms of livestock production have emerged from the domestication of wild animals. These include, among others, snail farming (9), aulacodiculture (10), beekeeping (11), white worm farming (12), and rabbit farming (13).

The rabbit "Oryctolagus cuniculus" is known for its high reproductive rate (14). Raising rabbits is beneficial for supplying households with animal protein (15). It requires prior knowledge of the animal's biology and physiology (2). Indeed, this species is particularly susceptible to dental diseases, mainly due to the continuous growth of their teeth (16). This characteristic is an evolutionary adaptation to their natural diet, rich in coarse fiber such as hay and various plants, which contributes to the regular and necessary wear of the teeth (17) . When this balance is disrupted, tooth growth can become excessive, leading to various complications such as dental lesions, oral abscesses, and, in some cases, serious systemic consequences (18).

Feeding in rabbit farming is a very important factor because, in addition to providing the nutrients necessary for the rabbits' growth and health, it must also allow for dental wear. However, reports on rabbit farming practices in sub-Saharan Africa point to difficulties in securing feed, high feed costs, and diseases, including viral hemorrhagic disease (VHD) that continue to decimate rabbit herds. Consequently, economic hardships are driving farmers to adopt inappropriate farming practices. An author (8) has found that in cities such as Butembo, Masereka, Luotu, and Nyabili in the Democratic Republic of the Congo (DRC), only 30% of farmers fed their animal's complete feed. The remaining 70% fed them forage and kitchen scraps. Such practices create difficulties for the sector and are likely to cause numerous diseases in the animals.

Given this situation, it was important to address the issue of selecting supplemental feeds that could ensure proper growth and dental health in animals in sub-Saharan Africa.

In fact, animals' nutritional needs are normally met by pelleted diets. According to an author (19), improper supplementation could lead to excess weight and should be avoided. Similarly, dental wear is a multifactorial condition characterized by irreversible loss of hard dental tissues, including enamel, dentin, and cementum. This deterioration can result from mechanical or chemical mechanisms, whether extrinsic or intrinsic (20). Thus, diet should contribute to the proper functioning of this mechanism.

The overall objective was to analyze the impact of four diets on growth and dental structure in farmed rabbits.

Specifically, the study aimed to:

- Determine the variations in body weight caused by the different diets
- Evaluate the changes in dental tissues (enamel, dentin) and periodontal tissues induced by the consumption of these diets.

2 MATERIAL AND METHODS

2.1 Study Design

This was a prospective, experimental study lasting five (5) weeks.

2.2 Study Setting

The study was conducted at a private animal facility located in Abidjan, where the animals were housed under controlled conditions in accordance with current ethical standards for animal experimentation (NIH Publication No. 85-23, revised 1985).

2.3 Materials

2.3.1 Animal Materials

The study group consisted of 32 apparently healthy male rabbits aged 6–8 months, with weights ranging from 2.107 kg to 2.624 kg.

2.3.2 Experimental Equipment in the Animal Facility

The equipment needed to conduct the experimental study in the animal facility consisted of several items, including 32 battery cages and 32 separate feeders and waterers for controlled feed distribution. In addition, a clinical examination table was used for handling and measurements. An automatic scale was used for precise monitoring of body weight. A vernier caliper was used to measure the depth of dental wear. A graduated periodontal probe was used to assess the depth of wear and the condition of the periodontal tissues. 70°C alcohol was used to disinfect instruments and any wounds, and a ketamine solution at 100 mg/kg body weight was used as an anesthetic at a dose of 1 ml/kg body weight.

2.4 Methods

2.4.1 Composition of Experimental Diets

Four (4) groups of 32 rabbits were formed. Each group received a specific type of diet (Figure 1). The control group (CG) was fed exclusively pellets at a rate of 120 g/day/animal and 100 ml of water/animal. The second group (GC) received the same ration supplemented with one whole medium-sized carrot (125 g/animal) and 100 ml of water/animal. The third group (GFA) received pellets supplemented with a bundle of hay harvested the previous day and dried, along with 100 ml of water/animal. Finally, the fourth group (CO) received a daily ration of pellets supplemented with hay and whole carrots in the same proportions as the previous groups, along with 100 ml of water. The rabbits had daily access to the various specific diets. Fresh water was provided daily, both in an open bowl and via a nipple drinker. A beverage containing an antibiotic, analgesic, and antiparasitic agent was administered regularly to maintain the animals' overall health.

2.4.2 Clinical Examination and Dental Measurements

After an assistant had restrained and secured the animal's head, the incisors and molars were examined to assess eruption, wear, and any risk of tooth loss, as well as the condition of the periodontal tissues (Figure 2). The observations were systematically recorded in an experimental database. The animals were weighed weekly. Weight gain was quantified at the end of the experiment using a precision scale. For the teeth, the height (clinical crown) was measured using a manual caliper. Reference points or milling marks were made on the teeth to quantify dental wear and growth (Figure 3). Changes relative to the tip of the tooth were used to assess wear, while the distance from the gingival line was used to assess dental growth.

2.4.3 Statistical Analysis

Microsoft Excel 2013 was used to enter the data, which was then exported to GraphPad 8 for statistical analysis. The results are presented as means (± standard deviation). The difference between the means was determined using one-way analysis of variance (ANOVA). Statistically significant differences between the means were determined at a significance level of $\alpha = 5\%$. Tukey's and Newman-Keuls' post-hoc tests were used for within-group comparisons of the parameters studied. The coefficient of variation for weight data was determined using the formula: standard deviation/mean, and the dental wear index was calculated by comparing the variations in final and initial heights of the mean measurements for the heights of the incisors and molars.

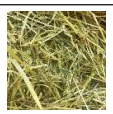
Experimental groups	Diets
Control group (CG) (n=8)	 Pellets
Group supplemented with carrots (GC) (n=8)	 Pellets  Carotts
Group supplemented with hay (GF) (n=8)	 Pellets  hay
Group supplemented with carrots and hay (CO) (n=8)	 Pellets  hay  Carotts

Figure 1: Summary of the diets used in the experiment

Figure 2*:* Lesions of the lower lip

Figure 31: Measurement marks (ink) on the teeth

3 RESULTS AND DISCUSSION

3.1 Morphometric Analysis of the Animals

3.1.1 Weight Analysis

Analysis of variations in the animals' body weights according to the different types of diets showed a significant effect based on Tukey's test ($p = 0.02$, $p < 0.05$). It was noted that the GC group had the highest weight gain (0.42 ± 0.08 kg) compared to the other diets: GT (0.31 ± 0.10), GFA (0.28 ± 0.04), and CO (0.24 ± 0.03), with $p < 0.05$. In terms of coefficients of variation, the CO group showed consistent growth with a CV of 2%, while the GC group exhibited the highest variation with a CV of 5.6% (Table 1).

In conclusion, the (GC) diet performed best in terms of average daily weight gain. The (GFA) and (CO) diets did not produce a significant synergistic effect. The weight changes recorded were lower than those of the control group (GT).

Table 1: Relationship Between Diet and Changes in Body Weight in Rabbits

Experimental groups	Average initial mass (kg)	Average Final Mass (kg)	Weight Gain (kg)	Coefficient of Variation (%)
GT (n=8)	2.29±0.07	2.60±0.17ab	0.31 ± 0.1b	4.8 %
GC (n=8)	2.33±0.12	2.75±0.20a	0.42 ± 0.08a	5.6 %
GFA (n=8)	2.26±0.10	2.54±0.06b	0.28 ± 0.04b	3.3 %
CO (n=8)	2.32±0.08	2.56±0.05b	0.24 ± 0.03b	2 %

Means followed by a different letter (in superscript) are significantly different at the 5% level. The "Pellet + Carrots" group (letter a) clearly outperforms the hay and mixed groups (letter b). The "Pellet" group alone shows a transition in final body weight (labeled ab).

3.1.2 Analysis of Dental Biometrics

Table 2: Determination of the Dental Wear Index

Experimental groups		Initial height (cm)	Final height (cm)	Dental Wear Index
GT (n=8)	Jaw	6.25 ± 0.25	7 ± 0a	1.25
	Lower jaw	6.5 ± 0.51	5.88 ± 0.22b	-0.62
GC (n=8)	Jaw	6.5 ± 0.51	7.03 ± 0.04a	0.53
	Lower jaw	6.3 ± 0.77	5.75 ± 0.85a	-0.55
GFA (n=8))	Jaw	6.5 ± 0.51	7.05 ± 0.08a	0.55
	Lower jaw	5.47 ± 0.49	4 ± 1.43c	-1.47
CO	Jaw	6.47 ± 0.49	6.97 ± 0.04a	0.5
	Lower jaw	5.85 ± 0.11	5.67 ± 0.11b	-0.18

Means followed by a different letter (in superscript) are significantly different at the 5% level.

Table 2 showed changes in the heights of the incisors and molars in the maxillae and mandibles between the So and S4 periods (first and fifth weeks) of the experiment. Overall growth was observed in the maxillae, with a highly significant increase ($p < 0.001$) in the GT group and a significant increase in the GC ($p = 0.02$; $p < 0.05$), GFA ($p = 0.015$; $p < 0.05$), and CO ($p = 0.023$; $p < 0.05$) groups. However, in the mandibles, overall wear was observed. No significant changes were observed for the GC group ($p = 0.19$; $p > 0.05$), but there was a significant decrease for the GT group ($p = 0.01$; $p < 0.05$), the CO group ($p = 0.006$; $p < 0.05$), and the GFA group ($p = 0.023$; $p < 0.05$). Analysis of variance and post hoc tests identified major differences highlighting the influence of diet types on dental wear. Thus, the GFA group exhibited the most severe mandibular wear (4 ± 1.43) cm. The final height of the incisors and molars in this group was lower than in all other diets ($p < 0.05$). In conclusion, dental wear was predominantly localized to the mandible. Hay emerged as the diet causing the greatest mechanical wear, whereas the maxilla showed a continuous tendency toward growth.

4 DISCUSSION

The results of this study showed that all of the diets tested led to an increase in body weight, although the extent of this increase varied depending on the composition of the diet. Thus, weight gain was highest with the pellet diet supplemented with carrots (CV = 5.6%), while the addition of hay significantly reduced the coefficient of variation in weight for GFA (CV = 0.28%) and CO (0.24%), respectively. These results highlight a dual effect of hay: on the one hand, energy dilution, and on the other hand, a regulatory effect on weight gain even in the presence of highly palatable foods rich in simple carbohydrates such as carrots. This observation is consistent with the available literature on rabbits (21). In fact, diets rich in concentrates (pellets, muesli) and simple carbohydrates promote rapid weight gain and, in some cases, obesity. 30 to 40% of domestic rabbits were found to be overweight upon examination (21). This imbalance is linked to a diet low in hay and high in pellets, combined with high-calorie, low-fiber treats.

Conversely, providing hay ad libitum dilutes the energy density of the ration and causes early satiety, even in the presence of palatable feed such as carrots. Hay thus limits weight gain, helping to maintain a body condition close to the norm. This trend corroborates recent data from rabbit farming reported (22), according to which rabbit growth can decrease by 10 to 20% when the diet becomes too fibrous or less energy-dense, affecting body weight. In a 9-month study of rabbits, animals fed a diet (muesli alone) without hay had a final weight 146% higher than that of the hay-only group (22).

Measurements of the dental wear index showed that the lower jaws were significantly affected by this phenomenon, while the upper jaws tended to compensate for wear through growth.

In fact, lateral movements during chewing promote healthy tooth wear, which is not the case when rabbits chew pelleted feed. They described vertical movements (23). This observation contrasts with that of an author (24) who support the hypothesis that pelleted feed reduces incisor wear compared to a natural diet, since the pellets are handled only briefly before they are first broken down.

The addition of carrots reduces maxillary overgrowth (25). However, it does not equalize the maxilla and mandible. The diet primarily influences the maxillary incisors, with almost no effect on those of the mandible. Thus, the interindividual variability in this group highlights the influence of anatomical, dietary, and metabolic factors (26). These results contrast with those obtained in the control group (GC), which received carrots in addition to pellets. Wear was observed only in the mandibles, regardless of the diet.

The significant wear observed in the GFA group that was fed hay corroborates the findings of an author (16), who demonstrated that hay is a feed containing naturally abrasive fibers that promote dental wear. Others authors (27) did not observe any wear in sheep after feeding them the same diets as those given to rabbits.

The CO group, which combined the three feed types—pellets, hay, and carrots—appeared to strike the best balance between growth and wear. This is consistent with the observations made by an author (16) in rabbits fed a varied natural diet. It has been demonstrated that a lack of roughage in the diet led to overgrown and misaligned teeth, whereas a diverse diet limited this risk (28). This dietary diversity is thought to promote prolonged chewing and lateral movements, which are essential for physiological tooth wear.

5 CONCLUSION

This study demonstrated the impact of diet type on growth and dental wear in farmed rabbits, using four different diets (pellets alone, pellets + carrots, pellets + hay, and pellets + carrots + hay). On the one hand, the diet containing carrots provided a considerable energy intake, disrupting the energy balance that the pellets are intended to provide. The diets enriched with hay were able to maintain this balance, promoting harmonious growth in the animals and proper tooth wear.

The pellet diet promotes active bone remodeling but also leads to maxillary overgrowth due to excessively vertical chewing motion. Carrots, which are low in calcium and not very abrasive, partially mitigate this overgrowth without correcting maxillomandibular asymmetry, whereas highly abrasive hay restores effective mandibular wear through its horizontal movement. However, the combined diet offers the best overall balance, both histologically (uniform bone architecture, active vascularized ligament) and morphometrically (the clearest dental symmetry).

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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Disclosure of conflict of interest

The authors declare that they have no conflict of interest regarding this article.

Statement of ethical approval

All authors hereby declare that "Principles of laboratory animal care" (NIH publication No. 85-23, revised 1985) were followed, as well as specific national laws where applicable. All experiments have been examined and approved by the appropriate ethics committee.

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