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Performance of growing New Zealand white rabbits fed fresh or ensiled ramie

Performance de coelhos Nova Zelândia branco em crescimento alimentados com rami fresco ou ensilado

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Highlights

Ramie silage was well accepted by growing rabbits.
Supplying ramie as silage did not affect apparent digestibility.
Ramie silage reduced the performance of growing rabbits.

Abstract

This study aimed to evaluate the performance of New Zealand White rabbits fed ramie-based diets in two different forms: fresh or ensiled. A total of 48 rabbits (24 males and 24 females), 35 days of age, were randomly assigned to two dietary treatments: Control (fresh ramie-based diet) or Silage (ramie silage-based diet). The Control diet consisted of fresh chopped whole ramie plants and a commercial pelleted rabbit feed. The silage diet consisted of a 1:1 ensiled mixture (wet basis) of fresh chopped whole ramie plants and the same commercial feed used in the Control diet, which served as a moisture-absorbing additive. Both diets were offered *ad libitum.* The animals were weighed weekly from 35 to 70 days of age. At 60 days of age, an apparent digestibility trial was conducted, with total fecal collection over four consecutive days. Feed and fecal samples were analyzed to determine the apparent digestibility coefficients. Daily weight gain during the first and last weeks of the experimental period and final body weight at 70 days of age were higher ($P < 0.05$) in the Control group. Dry matter intake differed between groups only during the second week of the experimental period. No significant differences ($P \geq 0.05$) were observed in the apparent digestibility coefficients of the nutrients. Feeding ramie silage reduced

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feed selectivity and, consequently, the performance of growing rabbits compared with offering fresh ramie separately from the pelleted feed provided *ad libitum.*
Key words: Animal nutrition. *Boehmeria nivea.* Conservation. *Oryctolagus cuniculus.* Silage.

Resumo

O objetivo deste estudo foi avaliar o desempenho de coelhos da raça Nova Zelândia Branco alimentados com dietas à base de rami em duas formas distintas: fresco ou silagem. Para isso, 48 coelhos (24 machos e 24 fêmeas), com 35 dias de idade, foram distribuídos aleatoriamente em dois grupos (dietas): Dieta Controle (dieta à base de rami fresco) e Dieta Silagem (dieta à base de silagem de rami). A Dieta Controle foi composta por planta de rami fresca, picada e integral, juntamente com ração comercial peletizada para coelhos. A Dieta Silagem foi composta pela silagem da mistura na proporção de 1:1 (base úmida) da planta de rami fresca, picada e integral, e a mesma ração comercial (usada como aditivo absorvente de umidade). Ambas as dietas foram fornecidas *ad libitum.* Os animais foram pesados semanalmente, dos 35 aos 70 dias de idade. Aos 60 dias de idade, realizou-se um ensaio de digestibilidade aparente, com quatro dias de coleta total de fezes. Amostras de fezes e de ração foram analisadas para estimar os coeficientes de digestibilidade aparente. O ganho de peso diário na primeira e última semana do período experimental e o peso corporal final aos 70 dias foram maiores ($P < 0,05$) no grupo Controle. O consumo de matéria seca diferiu ($P < 0.05$) somente na segunda semana do período experimental. Não foram observadas diferenças significativas ($P \geq 0,05$) quanto aos coeficientes de digestibilidade aparente dos nutrientes. A silagem de rami reduziu a seletividade alimentar e, consequentemente, o desempenho de coelhos em crescimento, quando comparada ao rami fresco oferecido separadamente da ração peletizada *ad libitum.*
Palavras-chave: Nutrição animal. *Boehmeria nivea.* Conservação. *Oryctolagus cuniculus.* Silagem.

Introduction

Ramie (*Boehmeria nivea*), a perennial forage crop of the family *Urticaceae*, has emerged as a promising alternative feed ingredient for herbivorous animals because of its high crude protein content, favorable amino acid profile, and abundance of digestible structural carbohydrates (Suryanah et al., 2017). It has long served as a low-cost, readily available forage in rabbit production systems, particularly in tropical regions such as Brazil and Southeast Asia, ramie has long been used as a low-cost, readily available forage where it is offered either fresh or sun-dried. Crude protein concentration of ramie leaves often exceeds 20%, whereas that of the whole plant typically ranges from 11% to 18%, making it comparable to other high-quality non-leguminous forages (Liu et al., 2022). Its nutritional value is further enhanced by a fiber fraction rich in neutral detergent fiber (NDF) but relatively low in lignin, characteristics that are well suited to the fiber requirements of growing rabbits.

The use of ramie in rabbit nutrition has been only marginally explored in the scientific literature. According to Jones and Jones (2026), the use of tropical fodder trees with high nutritive value may reduce feeding costs in rabbit fattening. Studies have evaluated ramie in ruminants and monogastric herbivores, highlighting its bioactive components such as flavonoids, phenolic compounds, and antioxidants, which may provide functional benefits beyond basic nutrition (Wang et al., 2022; Peng et al., 2025). However, the potential role of these functional components in rabbit physiology remains largely unknown.

A major constraint to the widespread adoption of ramie as rabbit feed is its marked seasonal production pattern. Biomass yields can decline sharply during winter or dry periods, limiting its continuous use. Ensiling, a technique widely used to preserve high-moisture forages, could overcome this limitation by stabilizing ramie's nutritional value and allowing year-round availability (Muck et al., 2018; Bueno et al., 2020). Ensiling ramie may also enhance nutrient availability through partial proteolysis, fiber solubilization, and the production of organic acids that favor hindgut fermentation, processes that have been documented in other non-leguminous silages such as mulberry, amaranth, and tropical grasses (Shah et al., 2018; Pahlow et al., 2003. Despite this potential, no published study has specifically evaluated ramie silage for rabbit feeding, representing a significant gap in the understanding of alternative forage resources for monogastric herbivores.

Evaluating ramie silage for rabbits is particularly relevant given the species' unique digestive physiology. Rabbits depend heavily on hindgut fermentation, and the cecum plays a crucial role in the breakdown of dietary fiber and the synthesis of microbial protein and vitamins. Effective fiber, particularly moderately fermentable fiber, is essential for maintaining cecal motility and preventing gastrointestinal disorders such as enterotoxemia, dysbiosis, and cecal stasis (De Blas & Wiseman, 2020; Van Der Sluis et al., 2024).

As a strategy to overcome the seasonality of forage production and enable the continuous use of this feed throughout the year, ensiling may be considered for forage-based rabbit production. However, the ensiling process modifies fiber characteristics by reducing NDF and hemicellulose while increasing soluble fractions (Van Soest, 1994), which may shift cecal fermentation patterns in ways that could influence both rabbit performance and health. Moreover, because of its low dry matter (DM) content, ensiling high-moisture forages such as ramie requires dry matter absorbent additives to prevent clostridial fermentation (McDonald et al., 1991). Thus, pelleted rabbit feed can fulfill this role while improving fermentation and providing additional nutrients for the animals.

Feeding behavior further complicates the use of silage in rabbit diets. Rabbits naturally exhibit selective feeding behavior, preferentially consuming concentrates over forages when both are offered separately. This behavior has been extensively documented under both laboratory and commercial conditions (Quaresma et al., 2023). By presenting a homogeneous mixture of ingredients, silage may reduce feed selectivity, an advantage in theory. However, it may also restrict the voluntary intake of concentrate compared with traditional *ad libitum* feeding systems in which pellets and forage are offered separately. Therefore, any silage-based diet should be evaluated not only for its chemical composition but also for its effects on feeding behavior, feed intake, fiber-to-starch balance, and overall energy intake.

Although research on silage for rabbits is scarce, existing studies underscore its potential while highlighting important complexities. Castro et al. (1995) reported that ryegrass silage can serve as a viable supplement for growing rabbits, although intake and performance depend on the feeding method. Shah et al. (2018) found that king grass silage inoculated with lactic acid bacteria enhanced antioxidant capacity, improved blood metabolite profiles, and supported satisfactory growth. Garcia et al. (2021a) showed that supplementation with corn, oat, or sorghum silages could reduce pellet intake but improve feed efficiency depending on forage type. Villa-Ramírez and Hurtado-Villegas (2016) observed improved growth performance in rabbits fed silages prepared from mixtures containing ramie, mulberry, or Mexican sunflower. These studies indicate that the nutritional and physiological effects of silage vary considerably depending on botanical composition, fermentation quality, inclusion level, and feeding strategy.

Given the growing emphasis on sustainable feeding systems, low-cost feed resources, and resilience to seasonal variability, evaluating ramie silage is both timely and relevant. Moreover, the potential functional properties of ramie, including antioxidant activity, polyphenolic compounds, and prebiotic fiber, may have additional implications for rabbit gut health, immune function, and meat quality, areas that remain unexplored. Understanding how ensiling affects these properties is essential for determining the true value of ramie as a conserved forage resource.

Given the above, this study aimed to compare growth performance, nutrient intake, and apparent digestibility of growing rabbits fed ramie offered either as fresh chopped forage alongside pelleted feed or as a 1:1 ramie–pelleted feed silage.

Material and Methods

Experimental site and design

This study was approved by the Ethics Committee on the Use of Animals (CEUA) of the Federal University of Paraná, Brazil (Protocol Nº 024/2023, approved on July 3, 2023).

The experimental work was conducted at the Rabbit Farming Teaching Laboratory, located at the Canguiri Experimental Farm of the Federal University of Paraná (UFPR), in Pinhais, PR, Brazil. The experiment followed a completely randomized design with two dietary treatments and 12 replicates per treatment, each replicate consisting of one male and one female rabbit, totaling 24 rabbits per treatment (12 males and 12 females). The study was carried out using 35-day-old New Zealand White rabbits, all offspring of the same sire, with an average initial body weight of 835 ± 67 g. Each pair of rabbits was housed in a wire-mesh cage (50 × 50 × 50 cm), arranged in a three-tier battery system with two cages per tier. The cages were located in a 6 × 10 m barn, where temperature and relative humidity were monitored using a thermo-hygrometer. The rabbits remained in this facility until the end of the growing period at 70 days of age.

Experimental treatments

The treatments consisted of two diets: Control, consisting of commercial pelleted rabbit feed and fresh chopped whole ramie plants offered separately, which represents the conventional method of supplying ramie in Brazil; and Silage, consisting of an ensiled 50:50 mixture (wet basis) of commercial pelleted rabbit feed and chopped whole ramie plants. The pelleted feed was added to increase the dry matter (DM) content and prevent effluent production during the ensiling of the high-moisture ramie forage.

Both diets included the same commercial pelleted rabbit feed (Table 1), composed of soybean hulls, ground whole corn, soybean meal, barley, wheat bran, malt rootlets, and oats. In the Control treatment, whole ramie plants were harvested close to the ground level when they reached approximately 1 m in height, chopped, and offered fresh in a feeder separate from the pelleted feed, with both feeds provided *ad libitum.*

Table 1
Chemical composition (g kg^{-1}) of the ingredients and experimental diets

	DM	MM	OM	CP	NDF	ADF	HEM	CEL	LIG
					Ingredients				
Ramie	166.9	161.8	838.2	138.6	477.4	379.5	97.9	332.6	46.8
Pelleted Feed*	889.2	79.4	920.6	148.9	349.8	187.9	161.9	161.6	26.3
					Diets				
Control	621.9	109.9	889.7	145.3	397.0	259.4	138.3	225.3	33.8
Silage	520.8	74.5	925.5	142.1	371.9	261.2	110.7	225.1	36.1

DM: Dry Matter; MM: Mineral Matter; OM: Organic Matter; CP: Crude Protein; NDF: Neutral Detergent Fiber; ADF: Acid Detergent Fiber; HEM: Hemicellulose; CEL: Cellulose; LIG: Lignin.
Chemical analyses were conducted at the Animal Nutrition Laboratory of the Federal University of Paraná.
*Supra® Coelho Agro commercial pelleted feed

The ramie silage was prepared from fresh whole ramie plants harvested under the same conditions as those used for the Control treatment. Plants were harvested when they reached approximately 1 m in height and chopped using a stationary forage chopper adjusted to a particle size of 10 mm. After chopping, 25 kg of ramie was mixed with 25 kg of pelleted feed. The mixture was compacted into 18-L plastic buckets lined with plastic bags using wooden pestles. The buckets were sealed with lids and adhesive tape and stored indoors for 70 days. At opening, the ramie silage had a pH of 4.35. This bucket-silage method was adopted because of the animals' relatively low feed intake, thereby preventing excessive losses caused by repeated opening of the silos (Magalhães et al., 2024).

During the experimental period, barn temperature ranged from 18 to 32 °C, whereas relative humidity varied from 21% to 74%. It is noteworthy that throughout the experimental period, all rabbits remained clinically healthy, showing no signs of anorexia, lethargy, abdominal distension, or diarrhea.

Housing, feeding, and performance parameters

The rabbits were housed in pairs per cage and fed *ad libitum* twice daily, at 08h00 and 15h00. During the first week, to facilitate adaptation to the experimental diets, the amount of dry matter (DM) offered daily was fixed at 70 g per animal. From the second week onward, the diets were offered *ad libitum,* with the amounts adjusted to maintain feed refusals at approximately 10% of the total feed offered (ramie, pelleted feed, or silage). Water was available throughout the experimental period.

Feed intake was recorded daily by calculating the difference between the amount of feed offered and the refusals from the previous day. Feed intake was expressed as dry matter intake (DMI) after adjustment for the dry matter (DM) content (Association of Official Analytical Chemists [AOAC], 2000). The rabbits were weighed weekly from 35 to 70 days of age. The performance parameters evaluated were daily weight gain (DWG) and feed conversion ratio (FCR). Daily weight gain was calculated as the difference between final and initial body weight divided by the number of days in the evaluation period (7 days), according to the following equation: DWG (g) = (final body weight, g − initial body weight, g)/days of evaluation. Feed conversion ratio was calculated as the ratio between DMI and DWG.

Apparent digestibility coefficients (ADC)

At 60 days of age, the rabbits underwent a digestibility trial following the procedures described by Perez et al. (1995). Total feces were collected for four consecutive days. Feces from each replicate were collected immediately after defecation from the feces collector located beneath each cage to avoid contamination with urine, separated from feed refusals, weighed daily, and stored in labeled plastic bags at −18 °C. At the end of the collection period, the feces were weighed, homogenized, and dried in a forced-air oven at 60 °C for 72 h. The dried samples were then ground and stored in labeled containers until dry matter (DM) analysis. Samples of the experimental diets and feed refusals were processed in the same manner to determine DM content.

The chemical composition of the diets and feces was determined according to the Official Methods of Analysis (AOAC, 2000). Gross energy was determined using an adiabatic bomb calorimeter. Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined sequentially using a fiber analyzer, as described by Van Soest et al. (1991). Hemicellulose (HEMI) content was calculated as the difference between NDF and ADF, whereas cellulose (CEL) content was calculated as the difference between ADF and acid detergent lignin (ADL).

The average nutrient intake of the Control and Silage treatments during the experimental period was calculated using the following equation: Nutrient intake (g) = [Average dry matter intake (g) × Nutrient concentration in the diet (%)]/100.

The apparent digestibility coefficients of dry matter (ADCDM), organic matter (ADCOM), mineral matter (ADCMM), crude protein (ADCCP), neutral detergent fiber (ADCNDF), acid detergent fiber (ADCADF), cellulose (ADCCEL), hemicellulose (ADCHEM), and gross energy (ADCGE) were calculated according to the following equation (Perez et al., 1995):

$$\mathbf{ADC}=\frac{\mathbf{(DM\ intake\ x\ \%nutrient\ in\ diet)\text{-}(DM\ in\ feces\ x\ \%nutrient\ in\ feces\ x\ 100)}}{\mathbf{(DM\ intake\ x\ \%nutrient\ in\ diet)}}$$

Statistical analysis

Data were tested for homogeneity of variances using Levene's test and for normality using the Shapiro–Wilk test, followed by analysis of variance (ANOVA). Means for dry matter intake (DMI), daily weight gain (DWG), feed conversion ratio (FCR), nutrient intake, and apparent digestibility coefficients were compared between treatments using Student's t-test ($P = 0.05$). When the assumptions of normality or homogeneity of variances were not met, the Wilcoxon rank-sum test was used ($P = 0.05$). All statistical analyses were performed using R software (R Core Team [R], 2024).

Results

From 42 days of age onward, rabbits in the Silage group exhibited lower body weight ($P < 0.05$) than those in the Control group (Table 2). This difference persisted until the end of the experimental period (70 days of age) and was accompanied by lower daily weight gain (DWG) between 35 and 42 days and between 64 and 70 days of age in the Silage group. In contrast, no differences ($P \geq 0.05$) were observed in feed conversion ratio (FCR). Dry matter intake (DMI) differed between groups ($P < 0.05$) only between 43 and 49 days of age, corresponding to the second week of the experimental period.

Table 2
Body weight (BW), dry matter intake (DMI), daily weight gain (DWG), and feed conversion ratio (FCR) of rabbits fed fresh ramie and pelleted feed (Control) or ramie silage mixed with pelleted feed (Silage)

Parameter	Control	Silage	P-value	SEM
BW_35d, g	844.58	824.61	0.30	13.45
***BW_42d, g**	1008.87	923.00	<0.001	15.58
BW_49d, g	1291.75	1194.00	<0.001	19.69
BW_56d, g	1562.09	1475.5	0.01	22.99
BW_63d, g	1787.5	1677.48	0.01	30.29
BW_70d, g	2089	1869	<0.001	33.35
DWG, 35 - 42d, g	22.25	17.02	0.004	1.18
DWG, 43 - 49d, g	40.78	37.92	0.22	1.12
DWG, 50 - 56d, g	38.15	41.01	0.12	1.27
DWG, 57 - 63d, g	33.93	30.79	0.18	1.62
DWG, 64 - 70d, g	42.24	36.03	0.02	1.74
DMI, 35 - 42d, g	63.45	63.0	0.47	1.33
DMI, 43 - 49d, g	146.36	119.67	<0.001	2.82
DMI, 50 - 56d, g	137.71	142.94	0.61	6.98
DMI, 57 - 63d, g	122.42	125.73	0.77	8.08
DMI, 64 - 70d, g	144.18	139.33	0.63	7.29
FCR, 35 - 42d	7.09	7.45	0.59	0.46
FCR, 43 - 49d	3.43	3.87	0.13	0.20
FCR, 50 - 56d	3.72	3.59	0.61	0.19
FCR, 57 - 63d,	3.85	4.28	0.20	0.23
FCR, 64 - 70d	3.51	3.92	0.20	0.22

Means with different letters differ between groups according to Student's t-test ($P < 0.05$).

The adjusted DM forage-to-concentrate intake ratio was 30:70 in the Control group, in which the rabbits were able to select between the two feeds offered *ad libitum,* and 37:63 in the Silage group, in which feed selection was not possible. Based on these proportions, mineral matter and hemicellulose intakes differed ($P < 0.05$) between treatments (Table 3).

Table 3
Daily intake of mineral matter (MM), organic matter (OM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), hemicellulose (HEMI), cellulose (CEL), and lignin (LIG) in rabbits fed the Control and Silage diets

Variable	Control	Silage	P value	SEM
*MM, g	12.3	8.3	<0.001	0.38
*OM, g	99.00	100.18	0.93	9.63
**CP, g	17.1	15.4	0.13	0.77
*NDF, g	46.3	43.8	0.28	1.57
*ADF, g	29.1	30.6	0.66	1.08
*HEMI, g	16.7	12.7	<0.0001	0.50
*CEL, g	25.2	26.2	0.55	2.70
*LIG, g	3.4	3.8	0.14	0.57

* Means were compared using Student's t-test ($P < 0.05$).
** Means were compared using Wilcoxon test ($P < 0.05$).

The apparent nutrient digestibility coefficients did not differ significantly between treatments ($P \geq 0.05$; Table 4).

Table 4
Apparent digestibility coefficients of dry matter (ADCDM), organic matter (ADCOM), crude protein (ADCCP), mineral matter (ADCMM), neutral detergent fiber (ADCNDF), acid detergent fiber (ADCADF), hemicellulose (ADCHEMI), cellulose (ADCCEL), and gross energy (ADCGE) in rabbits fed the Control and Silage diets

	Control	Silage	P-value	SEM
ADCDM, %	64.47	67.69	0.63	2.43
ADCOM, %	63.20	67.43	0.23	2.45
ADCCP, %	67.13	69.10	0.66	3.01
ADCMM, %	75.27	70.36	0.13	2.23
ADCNDF, %	42.53	44.02	0.67	3.57
ADCADF, %	38.97	43.95	0.62	3.85
ADCHEMI, %	46.24	44.13	0.68	3.49
ADCCEL, %	38.92	44.45	0.33	3.86
ADCGE, %	60.93	67.62	0.07	2.48

Means were compared using Student's t-test ($P < 0.05$).

Discussion

The ramie silage showed good fermentation quality, with a characteristic silage odor, no signs of heating, and no visible mold growth or effluent production. Losses during the ensiling process were minimal, with only the upper 5 cm of the bucket contents discarded, probably because of inadequate sealing. After opening, each bucket was consumed within a maximum of three days, with the quality of the silage checked daily. The ramie silage was readily accepted by the rabbits from the beginning of the experimental period, particularly after the fifth day onwards. Since ensiled forage is not a conventional feed for rabbits, the high acceptance observed in the present study should be further investigated with other conserved forages.

Dry matter intake (DMI) is a key variable for evaluating rabbit performance. In the present study, DMI in both groups was within the typical range reported for growing rabbits (65–80 g kg^{-1} body weight), as described by De Blas and Wiseman (2020). Moreover, the forage-to-concentrate intake ratio (30:70 in the Control group and 37:63 in the Silage group) indicates that rabbits in the Control group consumed more pelleted feed. This difference likely occurred because fresh ramie and pelleted feed were offered separately in the Control treatment, allowing the rabbits to selectively consume the pelleted feed. In contrast, rabbits in the Silage group received a homogeneous mixture, which prevented selective feeding. The greater intake of pelleted feed likely contributed to the higher body weight and, consequently, the greater DWG observed in the Control group. Importantly, our primary goals were to evaluate the use of pelleted rabbit feed as a dry matter absorbent additive to facilitate the ensiling of high-moisture ramie forage and prevent effluent production. Therefore, the forage-to-concentrate ratio adopted for the Control treatment was established based on our previous experience rather than being formulated to match the nutrient composition of the Silage treatment.

Regarding feed selectivity, Marín-García et al. (2021) evaluated the performance of growing rabbits fed diets with either low or high amino acid concentrations, as well as rabbits simultaneously offered both diets under a free-choice feeding system. Animals with free access to both diets exhibited performance similar to that of animals fed exclusively the diet with the higher amino acid concentration. These findings indicate that feed selectivity allows rabbits to adjust their nutrient intake according to their nutritional requirements, thereby directly influencing productive performance.

However, the lower DWG observed in the Silage group during the first and last weeks of the experimental period cannot be explained solely by the lower intake of pelleted feed. Another explanation involves the quality of the energy supplied by ramie silage. Although not evaluated in the present study, evidence from ruminants suggests that ramie silage can alter the profile of volatile fatty acids (VFAs), increase acetate production while reduce propionate production (Tian et al., 2022), with the latter being an important precursor for gluconeogenesis. In rabbits, a similar shift in cecal VFA proportions could reduce the availability of metabolizable energy for tissue deposition, partially explaining the lower DWG despite adequate

DMI. This hypothesis is further supported by the findings of Gabbi et al. (2004), who observed a linear decrease in DWG as the inclusion level of ramie hay increased (0–40%) in rabbit diets and attributed this response to the lower energy density of the fibrous fraction. Therefore, although feed selectivity likely explains the differences in concentrate intake, the intrinsic characteristics of ramie silage, particularly its fiber composition and fermentation profile, may also have contributed to the lower energetic efficiency observed in the Silage group.

The higher mineral matter and hemicellulose intakes observed in the Control group can be attributed to the greater consumption of pelleted feed, which contained higher concentrations of minerals and hemicellulose-rich ingredients, such as soybean hulls. It is important to note that no adjustments were made to equalize the energy or mineral contents of the ensiled diet. Despite these differences, the apparent nutrient digestibility coefficients did not differ between treatments.

This similarity in digestibility, however, does not necessarily imply equivalent nutritional value. The similar ADCDM and ADCNDF observed between treatments may mask differences in the digestibility of specific fiber fractions. Compared with pelleted feed, ramie silage contains a greater proportion of lignin and a lower hemicellulose content, which may result in slower and less extensive cecal fermentation (Tian et al., 2022). This interpretation is consistent with the findings of Arruda et al. (2005), who evaluated increasing inclusion levels (0, 10, 20, 30, 40, and 50%) of dehydrated ground ramie in rabbit diets and observed a linear decrease in the digestibility of dry matter, crude protein, ether extract, and gross energy as ramie inclusion increased. Interestingly, the authors also reported a quadratic response for ADCNDF and ADCADF, with the highest values (42.05% and 33.90%, respectively) observed at the 20% inclusion level, suggesting that the digestibility of the fibrous fraction may be optimized at an intermediate level of ramie inclusion.

This variation in digestibility and performance underscores the influence of forage type and processing on rabbit nutrition. A relevant comparison is provided by the study of Falcone et al. (2021), who evaluated the performance of growing rabbits supplemented with fresh ramie (*Boehmeria nivea*) offered *ad libitum* alongside commercial pelleted feed. In contrast to the results obtained with ramie silage in the present study, Falcone et al. (2021) reported that rabbits receiving fresh ramie, whether offered daily or three times per week, exhibited higher DWG and improved FCR than rabbits fed only commercial pelleted feed. This apparent discrepancy is likely related to the form in which the forage was offered. Fresh ramie, with its higher moisture content and preserved cellular structure, may have provided a more readily fermentable substrate for cecal microorganisms, thereby enhancing the overall digestibility of the diet. In contrast, although the ensiling process preserves the forage, it may also modify the fiber structure and reduce the bioavailability of certain nutrients. According to McDonald et al. (1991), soluble carbohydrates are converted into organic acids during the ensiling process. However, compared with ruminants, rabbits are less efficient at utilizing these organic acids.

Regarding the use of ensiled forage for growing rabbits, Castro et al. (1995) evaluated the supplementation of rabbit diets with ryegrass silage by comparing rabbits fed only pelleted feed with those receiving pelleted feed supplemented with ryegrass silage. Ryegrass silage, offered *ad libitum,* was readily accepted by the rabbits and, in contrast to the findings of the present study, improved DWG and FCR. However, the authors reported operational challenges associated with pile-silo production, which required specific machinery. In contrast, the ramie silage evaluated in the present study was produced in 18-L buckets, a system that simplifies both silage production and feeding management.

Garcia et al. (2021a) investigated the effects of supplementing the diets of growing New Zealand White rabbits with corn, sorghum, or oat silage on performance and nutrient digestibility from 58 to 100 days of age. Pelleted feed and the respective silages were offered *ad libitum.* The authors observed no differences ($P \geq 0.05$) in DWG, which averaged 31 g. However, the best FCR values were obtained in rabbits fed only pelleted feed or pelleted feed supplemented with oat silage. Nevertheless, pellet feed intake was lower in rabbits receiving oat or sorghum silage than in the control group fed only pelleted feed, suggesting a potential reduction in feeding costs with oat silage supplementation. Regarding apparent digestibility, no differences ($P \geq 0.05$) were observed in ADCCP, which averaged 75%. ADCDM was the highest in the control (60.1%) and sorghum silage (59.9%) groups. Conversely, ADCGE and ADCNDF were lowest in the oat silage group. Sorghum silage supplementation resulted in the highest ADCNDF (73.7%).

Villa-Ramírez and Hurtado-Villegas (2016) evaluated a silage composed of 68% garden grass (*Axonopus scoparius*), 2% molasses, and 30% ramie (*Boehmeria nivea*), comparing it with two alternative silages in which ramie was replaced by either Mexican sunflower (*Tithonia diversifolia*) or mulberry (*Morus alba*). The authors reported that rabbits consuming any of these silages exhibited higher DWG (20 g) than those fed a mixture of fresh forages (15 g).

Further studies are warranted to investigate additional effects of silage use, particularly its influence on the antioxidant status of rabbits. Garcia et al. (2021b) reported that supplementing rabbit diets with corn or sunflower silage from 31 to 100 days of age increased serum concentrations of vitamins C and E. Similarly, Pin et al. (2023) found that replacing ground alfalfa with 12% alfalfa silage in the diet not only improved DWG and FCR but also increased antioxidant enzyme activity in rabbits. Finally, Shah et al. (2018) evaluated the partial replacement (20%) of green alfalfa with elephant grass silage, with or without lactic acid bacteria inoculation, in diets for growing New Zealand White rabbits. They reported DWG values ranging from 24 to 28 g, which were lower than those observed in the present study, probably because their diets were based exclusively on forage. Inoculated elephant grass silage improved blood cholesterol profiles, antioxidant status, nutrient digestibility, and overall rabbit performance. In addition, the authors reported ADCDM and ADCNDF values ranging from 40% to 44% and from 50% to 52%, respectively, whereas the present study showed higher ADCDM but lower ADCNDF values.

Conclusions

Ensiling ramie represents a promising strategy for preserving forage for rabbit feeding throughout the year. However, the fixed 1:1 ramie-to-pelleted feed ratio adopted in this study likely limited the voluntary intake of pelleted feed by rabbits receiving the Silage diet, resulting in lower growth performance than that observed in rabbits offered fresh ramie and pelleted feed separately under *ad libitum* conditions. Further adjustments to the diet formulation, particularly to increase its energy, protein, and mineral density, are needed to better understand feed intake from the ensiled material and its effects on rabbit performance.

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