Colegio de Postgraduados

Inclusion of Hydroponic Green Forage in Rabbit Feeding

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ABSTRACT

Objective: The study aimed to evaluate the inclusion level of hydroponic corn green forage (HCGF) in rabbit diets and its effect on growth and carcass conformation characteristics.

Design/methodology/approach: Five inclusion treatments were established, in the daily diet of Tepexpan® brand commercial balanced feed (CBF) and hydroponic corn green forage (HCGF), in the following proportions (CBF:HGCF): T1:100:00, T2: 75:25, T3:50:50, T4: 25:75, and T5: 00:100. The HCGF was harvested and used 10 days after planting. The treatments were evaluated in 45 weaned rabbits, in a completely randomized design for 30 days. The productive performance variables were daily weight gain, live weight, carcass weight and carcass yield. Additionally, measurements of digestive tract organs were recorded.

Results: Higher productive performance and better carcass conformation were found in the rabbits from T1, fed with concentrate, followed by T2 and T3 in a 75:25 and 50:50 ratios, repectively. Rabbits in T3 exhibited lower productive performance during growth and carcass yield.

Limitations on study/implications: Further research is recommended on the the inclusion of HCGF at levels below 50% in rabbit diets.

Findings/conclusions: The inclusion of hydroponic corn green forage at levels of 25 to 50% maintains the productive performance of rabbits, while higher inclusion levels negatively impact feeding efficiency.

Keywords: feeding, rabbits, hydroponic corn green forage.

Citation: Sifuentes-Saucedo, D. M., Vargas-Monter J., Noguez-Estrada, J., Vargas-López, S., Rodríguez-Ortega L. T., &Nieto-Aquino, R. (2024). Inclusion of Hydroponic Green Forage in Rabbit Feeding. *Agro Productividad*. https://doi.org/10.32854/agrop.v17i12.2930

Academic Editor: Jorge Cadena Iñiguez
Associate Editor: Dra. Lucero del Mar Ruiz Posadas
Guest Editor: Daniel Alejandro Cadena Zamudio

Received: June 11, 2024.
Accepted: November 21, 2024.
Published on-line: December XX, 2024.

Agro Productividad, 17(12). December. 2024. pp: 189-195.

INTRODUCTION

Hydroponic green forage (HGF) is a type of forage obtained from the germination and early growth of grass seeds (Cisneros *et al.*, 2023). It represents an alternative in forage production for animal feeding due to its high digestibility and nutritional quality (Chavarria *et al.*, 2018; Bouadila *et al.*, 2022). The production of hydroponic green forage in short production cycles (6-10 days), with efficient use of land, water, and labor under

controlled conditions, offers an alternative for feeding poultry and rabbits in production units with limited land availability (Birgi *et al.*, 2018; Arif *et al.*, 2023). The use of HGF in rabbits proportionally replaces commercial balanced feed, aiming to reduce feeding costs during the growth and fattening phases without affecting productive performance (Miah *et al.*, 2020; Mohamed *et al.*, 2021).

Rabbit meat production is important globally due to its high protein content and low fat content. However, feeding costs account for 60-70% of total production costs. Therefore, alternative and cost-effective feed sources are being evaluated to meet nutritional needs for optimal production (Abdel *et al.*, 2023). However, the peculiarities of the digestive process in rabbits must be considered. Their voluntary intake is 5% of their body weight, and they require cellulose to regulate the movement of food during digestion. They also frequently need to eat and perform cecotrophy as a necessary physiological process (Gidenne *et al.*, 2004). Taking into account the digestive characteristics of rabbits, it is possible to partially replace the supply of balanced feed with hydroponic forages, thereby improving profitability. Reports on the use of sprouted grains in rabbit feeding are diverse and are influenced by the level of replacement in the diet, the type of sprout, and the duration of the evaluation periods (Fuentes *et al.*, 2011; Miah *et al.*, 2020; Mohamed *et al.*, 2021).

The use of hydroponic corn green forage during the fattening phase of rabbits affects productive performance. Therefore, this study aimed to evaluate the inclusion level of hydroponic corn green forage (HCGF) in rabbit diets and its effect on growth and the morphology of the digestive tract.

MATERIALS AND METHODS

Study Area Location

The study was conducted at the livestock unit of the Francisco I. Madero Polytechnic University in the state of Hidalgo. The location is situated at an altitude of 1,995 meters above sea level, with geographic coordinates of 20° 15’ 20” North latitude and 99° 00’ 10” West longitude. It has a temperate cold climate, with an average annual temperature of 17 °C and annual precipitation of 540 mm.

Production of Hydroponic Green Forage

It was carried out in an automated tray system, where disinfected and soaked seeds were germinated. Irrigation was applied until the fourth day, when the first uniform sprouts appeared, and the forage was harvested after 10 days for use in rabbit feeding.

Experimental Design for Rabbit Fattening

Forty-five F1 rabbits (New Zealand×California) at 30 days of age with an average weight of 948.3±92 grams were used. Five treatments were established based on inclusion levels: commercial balanced feed (CBF) Tepexpan® brand and hydroponic corn green forage (HCGF) in the following proportions: T1: 100:00, T2: 75:25, T3: 50:50, T4: 25:75, and T5: 00:100. The treatments were evaluated in three replications, each consisting of 3 rabbits, using a completely randomized design.

Study Variables

The difference between the offered amount and the leftover feed in the feeders determined daily consumption of hydroponic corn green forage and balanced feed. Initial live weight, final live weight, daily weight gain, feed conversion, and feed efficiency were determined. Rabbits were sacrificed 30 days after the experiment to determine carcass weight, carcass yield, and the weight of kidneys, stomach, intestines, cecum, as well as the length of the small and large intestines (Cantarero *et al.*, 2022).

Statistical Analysis

To determine the behavior of the evaluated productive parameters, a completely randomized design was used, as described below:

$$Y_{ij} = \mu + \alpha_i + \varepsilon_{ij}$$

Where: Y_{ij}=Observed Value of the Variable; μ=Population Mean; i=5 Experimental Treatments; j=3 Replicates; α_i=Effect of the i-th Treatment; ε_{ij}=Experimental Error.

The data were subjected to Shapiro-Wilk normality tests, followed by analysis of variance (ANOVA) using the GLM (General Linear Models) procedure. Mean comparisons between treatments were performed using Tukey's test with SAS version 9.4 (2015).

RESULTS AND DISCUSSION

The rabbits in the experimental groups were homogeneous (Table 1), so the initial weight did not show statistically significant differences ($P \geq 0.05$). The final live weight showed differences between treatments ($P \leq 0.05$), with the highest value observed in treatment T1, which consisted of 100% commercial balanced feed (2112.4 g), followed by the treatments with 25% (1861.40 g), 50% (1743.3 g), and 75% (1355.0 g) inclusion of hydroponic green forage.

The daily weight gain and carcass weight showed statistically significant differences between treatments ($P \leq 0.05$), with the highest values observed in treatment T1, which consisted of 100% commercial balanced feed, followed by the treatments with 25%, 50%, 75%, and 100% inclusion of hydroponic corn green forage, respectively. Higher carcass yield was found in the treatments with 25%, 50%, and 75% inclusion, followed by the commercial balanced feed treatment, and finally, the 100% hydroponic green forage inclusion treatment ($P \leq 0.05$).

Consumption decreased with the increase in the level of hydroponic green forage inclusion and the reduction of commercial balanced feed. The highest consumption was 129.53 g/rabbit/day for the 100% commercial balanced feed treatment, decreasing to 94.2 g/rabbit/day in the 25% HGCF treatment, then increasing to 115.6 g/rabbit/day at the 50% HGCF inclusion level, and showing declines at the 75% and 100% HGCF inclusion levels ($P \leq 0.05$). The results found in this study are similar to those reported in the literature. The inclusion of GCF at 50% has an effect on feed consumption, time to live weight at slaughter, final live weight, and carcass yield (Fuentes *et al.*, 2011). Cisneros *et al.* (2023)

Table 1. Effect of hydroponic corn green forage (HCGF) inclusion on the productive performance of F1 rabbits (New Zealand × California).

Variable	100:00 M±S.D.	75:25 M±S.D.	50:50 M±S.D.	25:75 M±S.D.	00:100 M±S.D.	Valor de F	N
Initial weight (g)	1020.01[a] ±322.5	1048.78[a] ±108.4	986.11[a] ±209.6	896.11[a] ±199.9	790.52[a] ±152.0	0.09	>0.1
Final weight (g)	2112.44[a] ±186.9	1861.40[ab] ±165.5	1743.33[b] ±254.9	1355.0[c] ±201.5	991.5[d] ±167.0	0.0001	>0.1
Daily weight gain (g)	39.03[a] ±10.3	27.10[b] ±2.3	27.04[b] ±11.6	16.38[c] ±3.8	6.81[c] ±3.0	0.0001	>0.1
Carcass weight (g)	1054.12[a] ±93.30	987.24[ab] ±152.0	913.85[b] ±133.6	711.37[c] ±105.81	419.33[d] ±88.33	0.0001	>0.1
Carcass yield (%)	50.32[a] ±3.53	53.01[a] ±0.01	52.42[a] ±0.09	53.0[a] ±1.3	42.2[b] ±3.6	0.0001	>0.1
Feed intake (g/day)	129.53[a] ±3.5	94.23[c] ±1.7	115.63[b] ±0.62	93.77[c] ±1.6	85.19[d] ±3.5	0.0001	>0.1
Feed conversion (kg/Kg)	3.5[b] ±0.8	3.50[b] ±0.2	5.25[b] ±3.0	6.11[b] ±1.9	14.5[a] ±5.8	0.0001	>0.1
Feed efficiency (g/g)	0.30[a] ±0.07	0.28[b] ±0.02	0.23[ab] ±0.1	0.17[b] ±0.04	0.08[c] ±0.03	0.0001	>0.1

Mean (M), Standard Deviation (S.D.), Normality (N). Means with different letters in the same row indicate significant differences according to Tukey (P≤0.05).

report that replacing concentrated feed with 30% barley CGF had a negative effect on feed consumption and growth, but no effect on feed conversion and carcass yield. The feed conversion ratio was 3.5, 3.5, 5.25, and 6.11 for the treatments with 100% commercial balanced feed, 25%, 50%, and 75% inclusion of hydroponic corn green forage (HCGF) (P≥0.05), while for the 100% HCGF treatment it was 14.50, which was statistically different (P≤0.05). Feed efficiency is significantly affected by the increase in the percentages of HGCF inclusion (P≤0.05). Monjica (2021) found that the inclusion of hydroponic corn green forage as a progressive substitute for commercial concentrate negatively affects weight gain, feed conversion, and feed efficiency, but does not affect carcass yield. In a diet based on hydroponic green oat forage, a daily weight gain of 35.09 g, a feed conversion ratio of 5.5, and an average market weight of 3136.6 g were obtained (Núñez *et al.*, 2017).

Figure 1 shows the effect of the treatments on the weight of the stomach, intestines, and cecum (P≤0.05). It was observed that as the proportional level of hydroponic corn green forage (HCGF) increased, the weight of the kidneys, stomach, and large intestine decreased.

The increase in the inclusion level of HCGF affects the morphometry of kidneys, stomach, cecum, and intestines (P≤0.05). The values found differ from those reported by Giusti *et al.* (2012), where the weight of viscera, intestines, head, skin, and legs showed no statistical differences in treatments with the supplementation of any alternative ingredient in the diet. They mention that replacing 30% and 50% of concentrated feed with hydroponic barley forage does not affect intestinal morphology. Dihigo *et al.* (2001) mentions that feeding rabbits 100% with hydroponic forage decreases the height and width of the intestinal villi, affecting digestion and the productive performance of the rabbits.

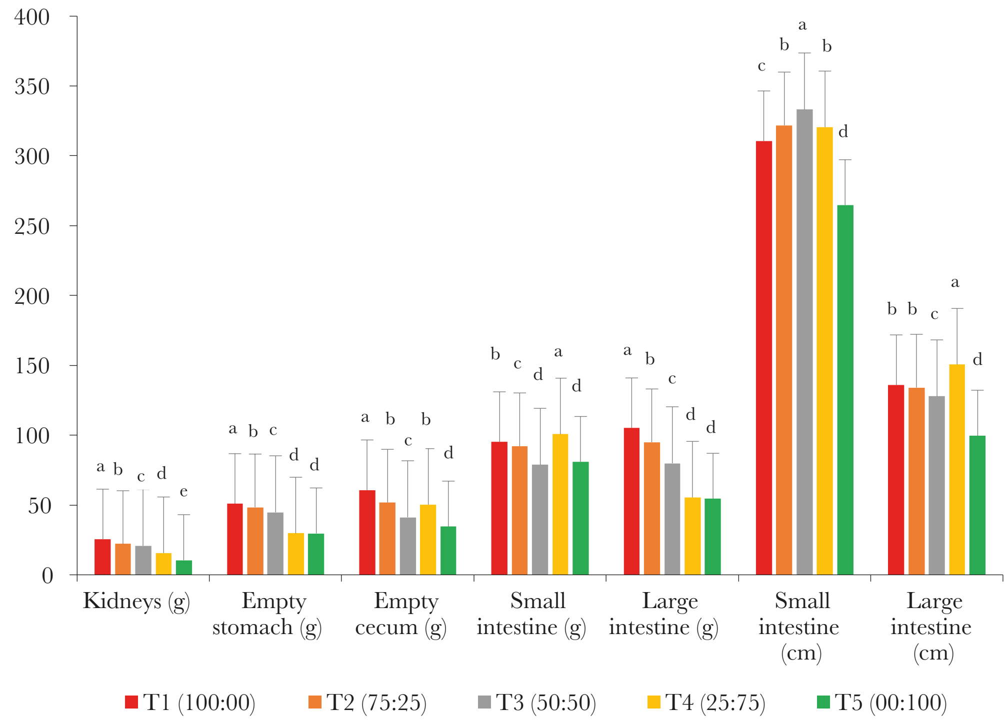

Figure 1. Effect of proportions (commercial balanced feed: hydroponic corn green forage) on the gastrointestinal tract morphometry and internal organs of F1 rabbits (New Zealand × California). Means with different letters in each structure indicate significant statistical differences (Tukey, P≤0.05).

They report changes in the length of the intestine, as fibers regulate the transit speed and the entry of chyme into the cecum.

This study found better productive performance in rabbits fed with commercial balanced feed (T1), followed by T2 and T3, with inclusion levels of 25% and 50%. Using HCGF at levels above 50% as a substitute for commercial feed implies negative effects on productive variables and digestive tract structures, likely due to the lack of digestive balance between fiber, starch, and protein. The inclusion levels of HCGF in the diet could be altering the fiber-starch ratio, affecting intestinal transit, fiber fermentation in the cecum, daily weight gain, and feed conversion (Zhu *et al.*, 2015 and Carabaño *et al.*, 2020). The increase in indigestible fiber contributes to lower nutrient digestibility and increased fecal excretion of endogenous protein (Cisneros *et al.*, 2023). Replacing the commercial diet with HCGF should take into account changes in digestion and nutrient utilization to optimize its use as an alternative forage in the feeding of rabbits during the fattening phase (Mohsen *et al.*, 2015).

CONCLUSIONS

Hydroponic corn forage has an effect on the productive variables of rabbits. The progressive substitution of commercial concentrate with hydroponic corn forage negatively affects weight gain, feed conversion, and feed efficiency. It is suggested to continue investigating the inclusion range of 25% to 50% and its effect on the productive performance of rabbits, considering factors that affect the nutritional quality of hydroponic forage, which may be associated with changes in the morphology of the digestive tract.

ACKNWLEDGMENTS

The authors would like to express their gratitude to the Francisco I. Madero Polytechnic University for providing the facilities to carry out this work.

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