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Productive performance of rabbits fed alfalfa (*Medicago sativa*)- or white clover (*Trifolium repens*)-based diets

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ABSTRACT

Objective: Evaluate the productive performance of rabbits fed alfalfa- and white clover-based diets.

Design/methodology/approach: Rabbits can consume high-fiber diets. Therefore, this study evaluated a white clover-based diet (Diet 1) and an alfalfa-based diet (Diet 2). The experiment was carried out during the Fall-Winter season of 2018. This study used 111 rabbits (males and females), weaned at 31 days of age. Diets were randomly assigned to 20 cages, four to six animals per cage. In total, 56 rabbits received Diet 1 and 55 Diet 2. All animals had free access to feed and water during the 35-day growth period. The weekly recorded response variables were live weight (LW), daily weight gain (DWG), and feed conversion (FC). At 67 days of age, hot carcass yield (HCY) and cold carcass yield (CCY) were determined.

Results: At the end of the fattening period (31 to 66 days of age), there were no significant differences between the two experimental groups. The results for Diet 1 and 2, respectively, were the following: LW=2012±36 and 1960±37 g, DWG=32.2±1.57 and 28.4±1.60 g/animal, FC=3.3±0.2 and 3.4±0.2 g/g, HCY=48.0±0.5 and 48.1±0.5%, and CCY=55.9±0.6 and 55.8±0.7%.

Limitations/implications: Due to the lack of significant differences (P≥0.05), further studies are required to better understand these legumes.

Findings/conclusions: White clover could completely replace alfalfa in rabbit diets.

Keywords: white clover, alfalfa, growing rabbits.

INTRODUCTION

Rabbit is a viable food alternative for humans. Its meat is rich in protein (Guevara-Hernández et al., 2014), with values ranging from 19 to 25%; protein content in chicken meat ranges from 12 to 18% (Gómez, 2017). However, in Mexico, concentrate-based feeding is expensive. In September 2019, the price per kilogram of balanced feed from the

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main brands fluctuated between 8.05 and 9.38 Mexican pesos. Therefore, it is necessary to evaluate alternative rabbit feeding ingredients that promote a more profitable production (Ogbuewu *et al*., 2017). Rabbits require fiber-rich diets (De Blas, 1989); thus, ingredients, such as alfalfa flour, are commonly used in their diets (Pond *et al*., 2012). These ingredients can constitute 100% of the ration when high weight gains are not intended (De Blas, 1989). Sánchez-Laiño *et al*. (2018) studied the use of *Morus alba*, *Erythrina poeppigiana*, and *Tithonia diversifolia* in rabbits. However, no information was found regarding the use of white clover instead of alfalfa. Therefore, this study aimed to evaluate the productive response of rabbits fed a white clover-based diet compared to an alfalfa-based diet.

MATERIALS AND METHODS

Localization

The experiment was carried out at the rabbitry unit, annex to the Experimental Poultry Farm of the Department of Zootechnics of the Universidad Autónoma Chapingo, located at 19° 29′ 13.7″ N and 98° 53′ 48.0″ W, at an altitude of 2278 m, in Chapingo, Texcoco, Mexico State. This location has a "Cb (w0) (w)" climate, the driest of the Cw type, which corresponds to a humid subtropical climate with fresh and rainy summers and an annual mean temperature of 12-18 °C (García, 2004).

Experimental development

The experimental phase comprised the Fall-Winter period of 2018. This study used 111 rabbits (males and females), weaned at 31 days of age. These rabbits resulted from crosses of the following breeds: New Zeland, California, Chinchilla, Mariposa, and Azteca Negro. Two rabbit groups were used; the first had an average initial weight of 725±21 g and the second of 793±21 g. Subjects in group 1 were fed with Diet 1 (white clover), those in group 2 with Diet 2 (alfalfa). Animals were housed in metallic commercial fattening cages (650 cm^2/animal) equipped with hopper feeders and water bottles.

Treatments

Two diets were evaluated, a white clover-based diet (Diet 1) and an alfalfa-based diet (Diet 2). The composition of diets 1 and 2, respectively, included: white clover flour (41.42 and 0.00%), alfalfa flour (0.00 and 66.82%), wheat bran (15.95 and 10.16%), ground corn (17.93 and 18.37%), sunflower shells (21.38 and 0.00%), vegetable oil (21.38 and 0.00%), molasses (0.00 and 1.21%), threonine (0.12 and 0.04%), L-lysine HCl (0.41 and 0.18%), DL-methionine (0.38 and 0.14%), dicalcium phosphate (1.53 and 0.00%), minerals and vitamins premix (0.28 and 0.27%). Both diets included 0.10% of robenidine and 0.50% of sodium chloride. Moreover, both diets were subjected to a proximate and Van Soest analysis according to the AOAC (1990) and Van Soest (1994). The chemical fractions determined as feed in diets 1 and 2, respectively, were: dry matter (88.8 and 88.5%), crude protein (17.5 and 16.0%), ether extract (2.6 and 2.6%), crude fiber (17.8 and 14.2%), ashes (9.9 and 9.7%), neutral detergent fiber (33.7 and 27.8%), cell content (66.3 and 72.2%), acid detergent fiber (25.3 and 18.8%), hemicellulose (8.4 and 9.0%), cellulose (19.1 and 14.9%), lignin (5.8 and 3.6%), calcium (1.1 and 1.7%), phosphorus (0.7 and 0.3%). The concentration of digestible energy in diets 1 and 2 was 2,224 and 2,228 kcal kg^{-1} of feed, respectively. Live weight (LW), feed intake, daily weight gain (DWG), and feed conversion (FC) were evaluated every seven days until reaching 35 days of fattening (66 days of age). Hot carcass yield (HCY) and cold carcass yield (CCY) were determined at 36 days of fattening (67 days of age). The clean, hot carcass, without its head, hind and forelegs, and viscera (except kidneys), was weighed at the end of the slaughter. The hot carcass was immediately placed in iced water (12 h at 2-8 °C), drained for 12 h, and weighed. HCY and CCY were expressed as a fraction of the LW.

Statistical analysis

This experiment followed a completely randomized design. For the LW and DWG variables, each rabbit was considered a replicate (55 and 56 replicates, respectively, for diets 1 and 2). For feed conversion (FC), each cage was considered a replicate (10 replicates per treatment, 4-6 rabbits per replicate). For HCY and CCY, each carcass was considered a replicate (41 and 36 replicates for diet 1 and 2, respectively). To compare the two diets, statistical models were run weekly for all the variables, except for HCY and CCY, for which the statistical models were only run once at slaughter. Means (of each diet) were compared using the F test ($P \leq 0.05$) of the analysis of variance (SPSS, 2011).

RESULTS AND DISCUSSION

Live weight was the same in both treatments ($P>0.05$), except at the beginning of the experiment (Table 1).

However, despite their lower initial live weight (68 g lower), rabbits fed a white clover-based diet reached the same final weight as those fed with alfalfa ($P>0.05$). They even showed higher final weights (52 g higher) than those fed with alfalfa. In a hypothetical example with 1000 rabbits, the 52 g difference would represent 52 kg of LW at slaughter.

There were no weekly differences between treatments (P>0.05) for DWG and FC (Table 2). Total weight gain (1-35 days) was not statistically different between treatments (P>0.05).

Table 1. Weekly mean live weight (g) of fattening rabbits.

Days on experiment	Diet 1 (White Clover)	Diet 2 (Alfalfa)
1	725±21[a]	793±21[b]
7	1118±29	1147±29
14	1295±31	1303±31
21	1509±37	1481±37
28	1814±42	1821±42
35	2012±36	1960±37

[a, b] Different letters in the same row indicate statistical differences (P≤0.05).

The HCY and CCY of rabbits fed with white clover (48.0±0.5 and 55.9±0.6%, respectively) were not statistically different (P>0.05) from the values observed in animals fed with alfalfa (48.1±0.5 and 55.8±0.7%, respectively).

Composition of the experimental diets

The white clover-based diet (41.4%) contained wheat bran (15.9%) and sunflower shells (21.4%) as fiber-rich ingredients (78.7% in total). The alfalfa-based diet (66.8%) also contained wheat bran (10.2%), 77% of fiber-rich ingredients. Thus, the white clover-based diet had a higher content of fiber-rich nutrients (1.7%). Moreover, its crude protein content was 1.5% higher than that of the alfalfa-based diet. High levels of fiber decrease feed intake and growth (Gidenne, 2015). Therefore, the similar productive response observed with both diets was probably due to the higher protein content of Diet 1 (white clover) compared to Diet 2 (alfalfa).

Chemical determinations

The CP content of the white clover-based diet (17.5%) was higher than that of the alfalfa-based diet (16.0%). Both diets met the nutrient requirements of fattening rabbits: 14% to 16% of CP (NRC, 1977; Cheeke, 1987; De Blas and Wiseman, 2010). Moreover, these diets had 17.8% and 14.2% of CF, respectively, which corresponds to the requirements reported by Clíment (1979), Cheeke (2002), Maertens (1998) and De Blas and Wiseman (2010). These authors indicate a minimum content of 14 to 15% of CF for fattening or more than 17% (Gidenne, 2000) for ADF.

Both diets met the FDA requirements, and only the white clover-based diet met the NDF requirements. According to De Blas and Wiseman (2010), ADF and NDF requirements are 18-20% and 33-35%, respectively.

Live weight

Jiménez (2005) reported LWs of 2053, 1969, and 1949 g after 35 days of fattening with different commercial feeds (Purina, Unión Ganadera Regional de Guanajuato, and Albapesa, respectively). These values are similar to those obtained in rabbits fed with white clover (2012±36 g) and alfalfa (1960±37 g). Additionally, Gómez (2017) observed that 50% supplementation with mata ratón legume (*Gliricidia sepium*) resulted in an average LW of 2771 g at 66 days. The lowest LW occurred with the control diet (concentrate). The 75% supplemented concentrate and the Mexican sunflower-based diet (*Tithonia diversifolia*) showed average values of 2184 g and 1979 g, respectively. Due to the high protein content of *T. diversifolia* (28.5%) and *G. sepium* (23%), these diets outperformed the experimental diets evaluated in this study.

Daily weight gain

In rabbit production, the DWG during fattening ranges from 30 to 40 g/day. The most frequent values are 35-38 g d^{-1}. These values depend on the breed and feeding conditions (Méndez, 2006). There were no significant differences in DWG (P>0.05) between treatments. Rabbits fed white clover-based diets showed DWG of 32.2 g; those fed with alfalfa had DWG of 28.4 g.

Table 2. Daily and total weight gain (g) and weekly and total feed conversion (g/g) of fattening rabbits.

Days on experiment	Daily weight gain		Feed conversion	
	Diet 1 (White Clover)	Diet 2 (Alfalfa)	Diet 1 (White Clover)	Diet 2 (Alfalfa)
1 - 7	56.1±2.1	50.6±2.1	1.89±0.11	2.18±0.11
8 - 14	31.9±2.0	35.3±2.1	3.68±0.39	3.68±0.39
15 - 21	38.9±1.6	36.3±1.6	3.56±0.44	3.10±0.45
22 - 28	37.9±3.1	46.3±3.3	3.46±0.34	3.15±0.39
29 - 35	33.1±3.0	37.6±3.7	5.61±0.82	5.61±0.87
1 - 35	32.2±1.6	28.4±1.6	3.33±0.15	3.41±0.15

[a, b] Different letters in the same row indicate statistical differences (P≤0.05).

Nieves *et al.* (2009) reported DWG of 29.5, 21.9, and 26.0 g with granulated *Leucaena leucocephala*, *Trichanchera gigantea*, and *Morus alba*, respectively. These values are lower than the ones obtained in this experiment with both experimental diets.

Gómez (2017) reported a DWG of 30.0 g when feeding diets supplemented with 50% *Gliricidia sepium*. The lowest DWG was observed when supplementing diets with 75% of *Trichantera gigantea* and 75% of *Tithonia diversifolia*, with average values of 22.8 g and 20.6 g, respectively. These values were lower than those obtained in this study with Diet 1 and 2.

Feed conversion

No significant differences (P>0.05) were observed between diets, weekly or from 0 to 35 days. Méndez (2006) suggests that FC significantly increases with age and weight.

The FC with Diet 1 was similar to Diet 2 because of its higher CP, CF, NDF, and ADF contents, which induced intestinal transit and feed intake (Gidenne, 2015).

Sánchez-Laiño *et al*. (2018) evaluated commercial feed, *M. alba*, *Erythrina poeppigiana*, and *T. diversifolia* and reported FC values of 2.93±0.27, 3.34±0.28, 3.23±0.19, and 4.08±0.45 g/g, respectively. According to Méndez (2006), FC values must range from 3.35 to 3.45 g/g, similar to the average values observed in this experiment (3.33±0.15 g/g for white clover-based diet and 3.41±0.15 g/g for the alfalfa-based diet).

Carcass yield

Roca (2009) defines HCY as the percentage relationship between the commercial carcass weight and the animal live weight. Oteku and Igene (2006) reported a HCY of 46.7±0.1% in 70-day-old rabbits fed a corn, soybean meal, and wheat bran diet. This result was lower than the one observed in this study: 48.0±0.5 and 48.1±0.5% for Diet 1 and 2, respectively. Sánchez-Laiño *et al*. (2018) reported a higher HCY in fattening rabbits fed a balanced feed and *Tithonia diversifolia* diet: 49.6±0.6%.

Furthermore, Hernández-Bautista *et al*. (2015) reported a HCY and CCY of 47.4 and 47.3%, respectively, in New Zeland × California rabbits fed with a commercial feed. These values are lower than those obtained with the white clover (HCY: 48.0±0.5% and CCY: 55.9±0.6%) and alfalfa diets (HCY: 48.1±0.5% and CCY: 55.8±0.7%).

CONCLUSION

White clover can completely replace alfalfa in diets for fattening rabbits.

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