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Meat production and quality of rabbits fed different diets and a biological activator

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ABSTRACT

Objective: To evaluate the effect of four diets on the productive performance of rabbits, carcass yields, meat color and pH.

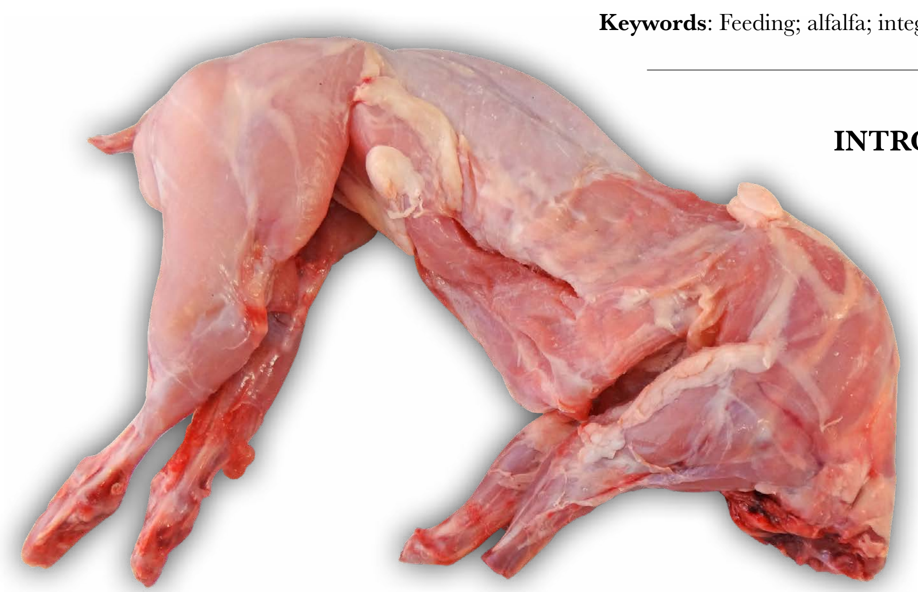
Design/Methodology/Approach: Thirty-two California breed rabbits were randomly assigned to each of the following diets: commercial feed alone (CF); commercial feed + biological-activator (CF + BA); alfalfa fodder + biological activator (AF + BA), and integral feed + biological-activator (IF + BA). The following were evaluated in the animals: daily weight gain (DWG), feed conversion (FC), daily feed intake (DFI), body weight (BW), empty body weight (EBW) and carcass yields (CY). The following were determined in the meat: pH, luminosity (L*), red color (a*) and yellow color (b*). Means were compared using Duncan's test ($\alpha = 0.05$).

Results: The commercial feed diets showed ($P<0.05$) higher values of DWG, DFI, BW and EBW than the other diets. The "commercial feed + biological-activator" diet produced ($P<0.05$) in general higher carcass weights and yields than the alfalfa-based diet, which produced ($P<0.05$) a higher pH and yellow color in the meat than the "commercial feed alone" diet.

Study Limitations/Implications: Feeding the rabbits by adding the biological-activator improves performance, meat color and pH.

Findings/Conclusions: Adding the biological-activator to the commercial feed improves the yield of empty body weight; adding it to the alfalfa fodder and comparing it with the commercial feed (alone or with activator) improves both the meat color (making it more yellow) and the pH (making it higher).

Keywords: Feeding; alfalfa; integral diet; weight gain; California breed.



INTRODUCTION

The livestock production sector in Mexico has been transformed at an unprecedented pace in recent decades, which is why the growing demand for foods of animal origin has been satisfied primarily by commercial livestock production and its associated chains. At the same time, millions of people in rural areas still breed livestock through traditional production systems, on which they base their means of subsistence and their family food security (García-Martínez, 2015). On the other hand, domestication of the rabbit has allowed its production in the livestock production sector and is considered, until today, a modest sector without growth at the national level (Del Toro *et al.*, 2016). However, rabbit production is characterized by the benefits that it represents, from which the following can be obtained: meat, skin, hair, urine, excrement and limbs. In addition, because of their short reproduction cycle, they require small spaces and have excellent productivity (Garcia 2012). These arguments are reinforced by Méndez-Zamora *et al.* (2016), who mention that rabbit meat is considered healthy because it has low cholesterol levels, similar to those of chicken and turkey meat. It also has high protein content, low content of sodium, fat and cholesterol, and characteristics that are apt for production at the small and medium scale (Selim *et al.*, 2021). Because of all these advantages, rabbit production is considered an alternative to satisfy the present and future dietary needs of sectors of the population that are economically disadvantaged, both in rural and urban areas (Nieves *et al.*, 2002). Therefore, the identification of adequate feeds is important, since it is not feasible to use similar ingredients in different geographical areas (Nieves *et al.*, 2009). Because of this, and with the purpose of reducing the indiscriminate use of antibiotics in animal production, studies have explored the use of various alternatives, including probiotics, which represent a potentially significant and safe therapeutic advance (Castro and Rodríguez, 2005). For example, vitafer is a biological product composed of bacteria, yeasts and their metabolites, which in addition contains vitamins and enzymes (Rodríguez *et al.*, 2013; Lazo-Pérez *et al.*, 2017). Therefore, the objective of this study was to determine the effects of four isoproteic diets on the productive behavior of rabbit, carcass yields, meat color and pH.

MATERIALS AND METHODS

The study was conducted in two phases: 1) Growth and fattening stage of the animals, which was carried out in the rabbit production unit of Instituto Tecnológico del Valle de Oaxaca, located in Ex-Hacienda de Nazareno, Xoxocotlán, Oaxaca. 2) Laboratory analysis of the products of animal origin in the FMVZ of Universidad Autónoma Benito Juárez de Oaxaca with address: Avenida Universidad S/N. Ex-Hacienda 5 Señores, Oaxaca, Mexico. This institute is located in the region Valles Centrales of the state of Oaxaca, at coordinates 17° 01' 16" latitude North and 96° 45' 51" longitude West, where Vertisol soils predominate (INEGI, 2010); with average temperature of 20.4 °C, maximum of 23.01 in the month of May, minimum of 17.51 °C in the months of December and January; with an average annual precipitation of 669.9 mm, the month of September is the one with most rainfall of 142.8 mm (CONAGUA, 2019). Thirty-two (32) rabbits of the California breed were used, of 35 d^{-1} of age, which were evaluated during 58 d^{-1} of fattening in the period of April to June 2016. The management of the animals was done intensively in wire cages (1.5×1.5 m), adapted with PVC troughs and water dispensers with plastic containers elaborated manually. Four diets were evaluated: commercial feed alone (CF); commercial feed + biological-activator (CF+BA); alfalfa fodder + biological-activator (AF+BA); and integral feed + biological-activator (IF+BA). The treatments were distributed in a completely randomized design, with 8 repetitions. The biological activator was elaborated previously based on: molasses at 10%, urea 0.5%, sulfates 0.3%, mineral salts 0.3%, soy paste 4%, corn 4%, lactobacillus 2%, and water 12%. The source of lactobacillus was Yakult (Ingredients: water, sugar, 3.6% powdered skim milk, glucose, artificial flavoring, *Lactobacillos casei* Shirota 108 Colony Forming Units (CFU/ml) (which means that the product contains 100 million bacteria) and two types of sweeteners: sugarcane and glucose. The activator was added directly to the feed at a rate of 15 ml per kg of LW. The concentrated meal in pellet form used was of commercial brand Malta Cleyton with 16% of protein. The alfalfa fodder was chopped into small particles of 2 to 3 cm and tedded; then, the activator was added and it was supplied directly in the feeding troughs. The treatment with integral diet was previously balanced at a level of protein inclusion of 16%, with the following ingredients: corn, soy paste, alfalfa, grass (Maralfalfa), mineral salts, and molasses.

The daily portion of feed that was supplied was 150 g of commercial feed or its equivalent of alfalfa fodder, and of the integral diet, at different hours of the day: 75 g in the morning and 75 g in the afternoon. The feed offered during the first week was 50% of the total portion, to later offer 100% of the total daily portion until the experiment ended.

The variables determined were: daily feed intake (DFI, obtained from the division of the total feed consumed by the live weight kilograms), daily weight gain (DWG, quantified weekly through the difference of final weight minus the initial weight by the number of days), and feed conversion (FC, obtained from daily feed intake over daily weight gain).

The sacrifice was done through the conventional methodology (NOM-033-ZOO-1995). The non-meat components (skin, legs, head, green and red entrails, gastrointestinal content) and the warm carcass were weighed after the sacrifice. The weighing of the cold carcass was done 24 h *post-mortem*. The variables quantified were: live weight, empty body weight and yield (EBWY, the empty body refers to the clean carcass without entrails and skin), warm (WCWY) and cold (CCWY) carcass weight and yield based on the weight of the empty body at 24 h *post-mortem* when the weighing of the cold carcass was done and the following variables were recorded on the *Longissimmus dorsi* muscle: intensity of luminosity (L*), of red color (a*) and of yellow color (b*), and the pH of the meat was also measured. A portable spectrophotometer brand Konica Minolta model CM-600D-Japan was used, which was previously calibrated to white. The measurement was performed three times per each meat sample in order to obtain an average and to have more accurate information. Likewise, the pH was measured three times with a general pH-501 potentiometer to obtain the average.

The data were subjected to an analysis of variance (ANOVA) and when statistical differences were found between treatments, Duncan's test was used for the multiple means comparison. All the statistical analyses were conducted with SAS (2016) using a significance level of 0.05.

RESULTS AND DISCUSSION

Productive behavior: The differences in daily weight gain (DWG) were highly significant ($p<0.01$) between treatments, as was the variable FC ($p<0.05$). Regarding the daily feed intake (DFI) there were also significant differences ($p<0.01$). The calculations of the coefficient of variation were found to be in a range of 2 to 15%, which indicates that the tests can be considered reliable (Coyac *et al.*, 2013).

The variables DWG, FC and DFI showed significant differences between treatments (Table 1) and it was documented that the best response for the variables DWG and FC (20.75 and 4.6 g/g) was presented by the rabbits fed with the treatment based on meal with the addition of the biological activator. The DWI was lower in the treatment that represented the integral diet with the activator (129 g/d).

The results were higher compared to those reported by Nieves *et al.* (2002) who found 19.11 g for the DWG variable in fattening rabbits with a dietary mixture in form of *Leucaena leucocephala* flour; the difference in the better response of this variable in this study can be attributed to the efficiency of the use of the biological activator in the rabbits' diet. For the DFI the same author reported 58.57 g, value that is below what was found in this study, results that can be attributed to the amount of fiber from Leucaena, which could indicate the immediate sensation of fullness, although not because of this reason did it contain the necessary nutrients for the productive parameters. On the other hand, Ponce de León *et al.* (2002) found values between 16 and 20 g of daily weight gain for the breeds Chinchilla, California and New Zealand. Regarding the FC, the results exceed numerically the 3.5 g/g reported by Peniche *et al.* (2010) using balanced meal and 3.4 g/g with tulip and breadnut fodder.

Diet evaluations in rabbits that have been conducted previously with the inclusion of hydroponic green oats fodder in different percentages have shown values of 29.10, 26.18, 24.40, 23.49 and 16.35 g of daily weight gain per animal (Fuentes-Carmona *et al.*, 2011). Other studies have found DWG of 26.69, 23.46, 22.00, 19.98 g with the inclusion of the Creole mango fruit in different percentages (Palma and Hurtado, 2010), as well as the daily weight gain of 29.49, 21.85 and 26.00 g with the inclusion of fodder shrub legumes of river tamarind (*Leucaena leucocephala*), naranjillo (*Trichanchera gigantea*) and mulberry (*Morus alba*) (Nieves *et al.*, 2009). Other studies have reported 20, 19 and 18 g of daily weight gain with the inclusion of flour from fruits and leaves of the breadfruit tree (*Artocarpus altilis*) (Leyva *et al.*, 2012). As can be observed there is great variation in the daily weight gain using fodder in rabbits' diet. The variations can be attributed to the different levels of protein used, among other experimental conditions.

Weight and yield in carcass: It was found that commercial feed alone, commercial feed + biological activator, presented higher averages ($p<0.05$) of live weight (LW), empty

Table 1. Averages of the variables of productive behavior of California breed rabbits with four types of diets.

Variable	Diets			
	CF	CF + BA	AF + BA	IF + BA
DWG, g	$19.6^{a} \pm 3.7$	$20.7^{a} \pm 1.94$	$11.1^{c} \pm 2.5$	$15.2^{b} \pm 2.5$
FC	$3.7^{b} \pm 48$	$4.6^{b} \pm 33$	$3.8^{a} \pm 29$	$4.0^{b} \pm 62$
DFI, g	$138^{a} \pm 2.5$	$136^{a} \pm 3.8$	$130^{b} \pm 1.6$	$129^{b} \pm 2.4$

CF: Commercial feed, BA: Biological activator, AF: Alfalfa fodder, IF: Integral feed, DWG: Daily weight gain; FC: Feed conversion, DFI: Daily feed intake. [abc] Different letters in rows indicate statistical difference (Duncan $p<0.05$).

body weight (EBW), warm carcass weight (WCW) and cold carcass weight (CCW); while alfalfa fodder + biological activator and integral feed + biological activator had the lowest averages of these variables (Table 2). These effects can be attributed to the last two diets having a higher proportion of fodder. In this regard, Fuentes-Carmona *et al.* (2011) indicated that the time of fattening with this type of diet was more prolonged. The averages of the empty body weight yield (EBWY) were affected ($p<0.05$) by the type of diet, since the animals that consumed commercial feed + biological activator presented the highest average, compared to the other three diets. This result can be attributed to the other three diets forming higher gastrointestinal content which caused a decrease in the yield. The warm carcass yield based on the empty body weight (WCYEBW) was lower ($p<0.05$) compared to the three remaining diets. The cold carcass yield based on the empty body weight (CCYEBW) was not affected by the type of diet, presenting a general average of 52.27%.

Regarding the values obtained in this study (WCYEBW, Table 2), the carcass yields obtained by Vásquez *et al.* (2007) in New Zealand and Chinchilla rabbits were slightly higher, 55.40%. On the other hand, for this variable, Pascual *et al.* (2005) found values of 54.31 and 54.14% in rabbits selected due to their growth speed, while Barrón *et al.* (2004) found higher values (56.7 and 55.6%) for the California breed.

Variables of pH and color: It can be seen (Table 3) that the variables pH and b* were significantly different ($p<0.05$) between diets, while the variables L* and a* were not different ($p>0.05$). Table 3 shows the pH and the intensities L*, a* and b* of the meat (*Longissimus dorsi* muscle) of the rabbits under study. The pH of the meat was higher ($p<0.05$) with the diet of alfalfa fodder + biological activator than with the diet of commercial feed alone. However, the four treatments were found within the normal range, considering an adequate pH for quality meat to be within a range of 5.6 to 5.9. The intensities L* and a* did not change ($p>0.05$) between diets. The intensity of yellow was higher ($p<0.05$) with the diet of alfalfa fodder + biological activator than with the diets based on commercial feed (Table 3).

Table 2. Averages of weight and yield of the California breed rabbit carcasses subjected to four types of diets.

Variables	Diets			
	CF	CF + BA	AF + BA	IF + BA
LW, g	$2097.4^{a} \pm 72.2$	$2106.4^{a} \pm 86.3$	$1630.0^{b} \pm 93.2$	$1773.0^{b} \pm 80.7$
EBW, g	$1873.2^{a} \pm 69.1$	$1903.1^{a} \pm 83.4$	$1393.3^{b} \pm 90.1$	$1525.5^{b} \pm 78.1$
EBWY, %	$89.3^{a} \pm 0.1$	$90.2^{b} \pm 0.9$	$85.2^{a} \pm 0.9$	$85.8^{a} \pm 0.8$
WCW, g	$911.2^{ab} \pm 14.9$	$947.5^{a} \pm 17.5$	$867.4^{b} \pm 20.5$	$884.6^{b} \pm 16.1$
WCYEBW, %	$52.8^{ab} \pm 0.7$	$53.8^{a} \pm 0.9$	$51.6^{b} \pm 0.9$	$52.8^{ab} \pm 0.8$
CCW, g	$906^{ab} \pm 17.6$	$941.32^{a} \pm 20.7$	$848.97^{b} \pm 24.2$	$877.76^{b} \pm 19.2$
CCYEBW, %	$52.6^{a} \pm 0.9$	$53.4^{a} \pm 1.1$	$50.3^{a} \pm 1.3$	$52.5^{a} \pm 1.0$

^{abc} Different letters in rows indicate statistical difference ($p<0,05$). CF: Commercial feed, BA: Biological activator, AF: Alfalfa fodder, IF: Integral feed, LW: Live weight, EBW: Empty body weight, EBWY: Empty body weight yield; WCW: Warm carcass weight, WCYEBW: Warm carcass yield based on the empty body weight, CCW: Cold carcass weight, CCYEBW: Cold carcass yield based on the empty body weight.

Table 3. Means of pH and color (L* a* b*) of the California breed rabbit carcass with four types of diets.

Variables	Diets			
	CF	CF + BA	AF + BA	IF + BA
pH	$5.8^{b} \pm 0.11$	$5.9^{ab} \pm 0.14$	$6.0^{a} \pm 0.06$	$5.8^{ab} \pm 0.19$
L*	$61.5^{a} \pm 2.8$	$61.4^{a} \pm 2.41$	$64.5^{a} \pm 3.41$	$64.4^{a} \pm 3.57$
a*	$-2.7^{a} \pm 0.37$	$-2.5^{a} \pm 0.96$	$-1.2^{a} \pm 2.02$	$-1.69^{a} \pm 2.05$
b*	$9.7^{b} \pm 1.19$	$9.6^{b} \pm 1.18$	$11.8^{a} \pm 2.09$	$10.8^{ab} \pm 1.52$

CF: Commercial feed, BA: Biological activator, AF: Alfalfa fodder, IF: Integral feed, L*: Luminosity, a*: green-red and b*: blue-yellow. abc Different letters in rows indicate statistical difference (Duncan $p<0.05$).

The results found in this experiment differ from what was found by Hernández *et al.* (2015), who reported a pH value of 6.27 for the California breed, in the *Longissimus lumborum* muscle, and a pH of 6.26 for the *Bíceps femoris* muscle. Another study carried out by Volek *et al.* (2014) found pH values of 5.61 and 5.58 in rabbit meat with two population densities. As for the results obtained in this study (Table 3), the pH values were approximate to those mentioned by García *et al.* (2012), with values of 5.66 and 5.64. On the other hand, Simonova *et al.* (2010) found values of 5.61-5.71, Bianospino *et al.* (2006) 5.57-5.61, Simitzis *et al.* (2014) 5.53, 5.52 and 5.53, with the addition of different percentages of herperisine in the rabbits' diet.

The intensities of color are similar to those found in a study carried out by Hernández *et al.* (2015) who measured these characteristics in different rabbit genotypes, finding values of L* (58.80, 63.21, 61.70); a* (0.11, 1.76, 1.29); b* (6.72, 12.61. 10.75). Simitzis *et al.* (2014) reported similar values to those of this study: L*52.3, 51.8, 52.1 and a* 3.55, 3.38, 3.41; and different in this variable: b* 9.44, 9.78, 9.56. On the other hand, Simonova *et al.* (2010) reported value ranges lower than those in this study, with values of L* 48.17-51.07; a* 1.49- 4.20; b* 8.45-9.07.

CONCLUSIONS

The treatment commercial feed + biological activator presented higher yield in the empty body weight. Therefore, the addition of the biological activator to the feed allowed a better use of the nutrients by the rabbits. Adding the biological activator to the commercial feed improves the empty body yield, adding it to the alfalfa fodder and comparing it with the commercial feed (alone or with activator), improves the color of the meat by making it more yellow, and improves the pH making it higher.

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