Journal MVZ Cordoba
2019; 24(3):7286-7290.
https://doi.org/10.21897/rmvz.1384

Research article

Growth of Guinea pigs (*Cavia porcellus*) with feed for rabbits and supplementation of vitamin C

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Received: September 2018; Accepted: April 2019; Published: August 2019.

ABSTRACT

Objetive. An experiment was conducted to evaluate the feed intake, digestibility and growth of pigs fed with two feeds (A and K) specially formulated for this species and a commercial feed for growing rabbits with supplementation of vitamin C (RF+VC). **Materials and methods.** Eighteen Guinea pigs of 248±38 g initial body weight were distributed in a completely randomized design with factorial arrangement 3×2 (dietary treatments and sex). Feed and neutral detergent fiber intake, weight gain, feed/gain, and morphometric variables were measured individually for 30 days. Dry matter and neutral detergent fiber digestibility were measured during the last seven days of the experiment. **Results.** There were no differences on feed intake ($p=0.88$); however, the dry matter digestibility was higher ($p<0.01$) in feeds formulated for Guinea pigs (A and K) and lower in the rabbit feed plus vitamin C. The intake and digestibility of NDF were higher in the RF+VC and lower in feeds for Guinea pigs ($p< 0.01$). The average daily gain was similar among the treatments ($p>0.05$). There were no differences ($p>0.01$) in the morphometric variables among dietary treatments, but there were sex differences as the males were bigger than the females ($p<0.01$). **Conclusions.** The results indicate that Guinea pigs can be fed with rabbit feed supplemented with vitamin C.

Keywords: Digestibility; feeding; feed intake; growth (*Source:CAB*).

RESUMEN

Objetivo. Evaluar el consumo, la digestibilidad y el crecimiento de cuyes alimentados con dos alimentos (A y K) formulados para esta especie y un alimento para conejos en crecimiento con suplementación de vitamina C (AC+VC). **Materiales y métodos.** Dieciocho cuyes (*Cavia porcellus*) de 248±38 g de peso vivo inicial se distribuyeron en un diseño completamente al azar con un arreglo factorial 3×2 (tipo de alimento y género). La ingesta de alimento, fibra detergente neutro, el aumento de peso, la conversión alimenticia, y los cambios en las variables morfométricas se midieron diariamente, mientras que la digestibilidad de la MS y FDN se determinaron al final del periodo. **Resultados.** No hubo diferencias en el consumo de MS ($p=0.88$); sin embargo, la digestibilidad de la MS fue mayor ($p<0.01$) en los alimentos para cuyes e inferior en AC+VC. El consumo y digestibilidad de FDN fueron mayores en AC+VC ($p<0.01$). La ganancia diaria fue similar entre los tratamientos ($p>0.05$). No hubo diferencias ($p>0.01$) en las variables morfométricas entre los alimentos, pero los machos fueron más grandes que las hembras ($p<0.01$). **Conclusiones.** Los cuyes pueden ser alimentados con alimento de conejo suplementado con vitamina C.

Palabras clave: Alimentación; crecimiento; digestibilidad; ingesta de alimento (*Fuente: CAB*).

How to cite (Vancouver)
Trejo-Sánchez F, Mendoza-Martínez G, Plata-Pérez F, Martínez-García J, Villarreal-Espino-Barros O. Growth of Guinea pigs (*Cavia porcellus*) with feed for rabbits and supplementation of vitamin C. Rev MVZ Cordoba. 2019; 24(3):7286-7290. DOI: https://doi.org/10.21897/rmvz.1384

ISSNe: 1909-0544

INTRODUCTION

The cuye (*Cavia porcellus*) is a rodent native to South America (1), which for centuries has been used for various purposes by the inhabitants of the mountainous region of the Andes. Currently, it is used as a laboratory animal because it is easy to use and occupies little space, which makes it ideal for medical research (2). It is also a popular pet all over the world (3), however, the price of food formulated for this species is expensive.

There are similarities in the nutritional requirements of rabbits and guinea pigs; however, it is not common to use commercial foods designed for rabbits to feed guinea pigs because rabbit feeds are not added with vitamin C, so they are considered a scurvy diet. Since guinea pigs lack L-gulonolactone oxidase, they can not synthesize ascorbic acid (4).

Considering that rabbits do not require large amounts of vitamin C, it is possible that commercial foods for these lagomorphs contain less than 200 mg/kg of vitamin C in the feed, which is the concentration required for guinea pig (5). Therefore, an experiment was carried out to evaluate the digestibility, growth and yield of guinea pigs fed two foods specially formulated for this species and a commercial food for growing rabbits with vitamin C supplementation.

MATERIAL AND METHODS

Animals and housing. Eighteen guinea pigs (*Cavia porcellus*) from a pet store, nine females and nine males, from 28 to 30 days of age, with an initial average body weight of 248 ± 38 g, were individually housed in spaces of 650 cm^2. and 18 cm high with 12 to 13 hours of artificial light. These shelters had ceramic floors covered with cardboard and individual feeders and drinkers. The ambient temperature was maintained between 20 and 24 ° C. At the beginning of the experiment and after seven days, the individuals were treated with 0.01 ml of injectable solution of ivermectin 1%. Water and food were provided ad libitum twice a day (04:00 and 16:00h). Its care and treatment were adjusted to the guidelines of the Autonomous Metropolitan University for the ethical treatment of laboratory animals.

Treatments. The dietary treatments were: guinea pig food (A); guinea pig food (K); Rabbit food supplemented with vitamin C (RF + VC) administered orally daily with a syringe equivalent to 200 mg / animal / day (Vitamin C® Daily Oxbow Animal Health).

Chemical composition, feed intake, feeding cost and digestibility. The content of dry matter (DM) and crude protein (CP) was determined in food and feces samples according to the AOAC procedures (6), while the fractions of neutral detergent fiber (ɑNDF) and acid (ɑADF) were determined with the technique of Van Soest et al (7) using ɑ-amylase and a fiber determinant TECNAL® TE-149 (Scientific equipment, Piracicaba, Brazil). The gross energy (GE) content in the feed was determined with a calorimeter (Parr instrument Company, Illinois, USA). The nutritional composition of the food samples and their price are shown in table 1. After an adaptation period of ten days, the food intake was estimated as the difference between the MS of the food offered and rejected daily. The coprophagy was not prevented or accounted for in this study. DM and NDF digestibility was determined using an internal marker, collecting samples of food and feces for seven consecutive days and measuring the concentration of insoluble ash in acid (8). The digestible energy content (DE) was estimated as the product of Gross Energy and DM digestibility of feed. The cost of feeding was estimated as the product of the value of each kg of feed by the feed intake per day.

Table 1. Chemical composition of two feeds specially formulated for Guinea pigs and a commercial feed for growing rabbits with supplementation of vitamin C.

Nutrient or fraction	Rabbit feed	Guinea pig feed	
	RF+VC[1]	A	K
Dry matter, % as fed	95.10	93.70	91.40
Crude Protein, (g/100g DM)	17.53	14.09	19.39
NDF, (g/100g DM)	53.32	40.79	36.00
ADF, (g/100g DM)	25.82	17.57	14.77
Hemicellulose, (g/100g DM)	27.5	23.22	21.23
Acid Insoluble Ash, (g/100g DM)	5.65	5.18	5.60
GE Mcal/kg	4.96	5.16	5.05
DE Mcal/kg	3.17	3.45	3.61
Price, Kg[2]	1.16[3]	5.50	5.83

RF: Rabbit Feed concentrate; A and K: Guinea pig concentrates.
[1]200 mg/animal/day (Vitamin C® Daily Oxbow Animal Health).
[2] US Dollar; [3]including Vitamin C

Daily body weight gain, feed conversion and morphometric variables. During a period of 30 days, the guinea pigs were weighed every seven days to determine the average daily gain. The feed conversion (A: G) was calculated for the total of the experiment. The morphometric measurements evaluated included: body length (nasal bone to the sixth coccygeal vertebra), the circumference of the thorax, cranial length, length of the femur and length of the radius. All morphometric variables were recorded at the beginning and end of the experiment.

Statistical analysis. The data were analyzed as a completely randomized design with a factorial arrangement of 3 × 2, where the factors and levels included the type of food and sex, with six repetitions per treatment. The initial weight was used as a covariate for food intake, feed cost, nutrient digestibility and feed conversion. The morphometric measurements were adjusted for their initial measurement as a covariate. The means were compared with the Scheffe test (9).

RESULTS

Feed intake, the cost of feeding, the increase in body weight and the feed conversion are presented in table 2; the main effects are presented because there was no interaction (type of feeding × sex). There were no differences (p> 0.05) in DM intake between treatments, but the intake of NDF was higher (p≤0.01) in animals that consumed food formulated for rabbits, because rabbit food contained higher amounts of NDF than food designed for guinea pigs (Table 1). As a result of a similar intake of dry matter and due to the lower price of RF+ VC, the animals fed with rabbit feed had a lower expense for feeding (Table 2).

The average daily gain (ADG) was similar between the treatments (p> 0.05, Table 2) and, consequently, no significant differences were detected in the feed conversion (p> 0.05). Regarding the digestibility, there were significant differences (p≤ 0.01) in all the fractions analyzed with higher values in DM and DE in food specially formulated for guinea pigs, while the NDF digestibility was higher (p≤0.01) in the food for rabbit (Table 3).

The morphometric measurements did not differ between treatments (p> 0.01), suggesting that the longitudinal growth was similar, but significant differences were found by sex (p≤0.001), with the males larger than the females (Table 4).

Table 2. Effects of feed type on intake, average daily gain and feed conversion of Guinea pigs fed with commercial feed for growing rabbits or Guinea pigs.

Item	Feed			Sex		Probability			
	RF+VC	**A**	**K**	**Male**	**Female**	SEM	Feed	Sex	**Sex× Feed**
Intake DM*	27.54^a	24.74^a	26.27^a	26.13^a	26.24^a	0.4	0.09	0.41	0.56
Feed Cost/day	0.040^b	0.23^a	0.25^a	0.25^a	0.26^a	0.09	0.001	0.21	0.25
NDF	15.06^a	10.51^b	9.46^b	12.44^a	12.21^a	0.51	0.001	0.87	0.7
ADG	3.74^a	3.30^a	3.54^a	3.47^a	3.24^a	0.73	0.196	0.59	0.11
FC, g/g	8.25^a	8.64^a	8.51^a	8.76^a	9.01^a	0.22	0.81	0.86	0.21

*g/day; RF+VC: Rabbit feed concentrate plus vitamin C; A and K: Guinea pig concentrates; SEM; Standard error of the mean; DM: Dry matter; NDF: Neutral detergent fiber; ADG; Average daily gain; FC: Feed Conversion.
^{a,b} Different superscripts within rows indicated statistical differences (p< 0.01).

Table 3. Effects of feed type on digestibility of Guinea pigs (*Cavia porcellus*) fed with commercial feeds for growing rabbits or Guinea pigs.

Item	Feed			Sex		Probability			
	RF + VC	**A**	**K**	**Male**	**Female**	**SEM**	**Feed**	**Sex**	**Sex× Feed**
				Digestibility					
DM, %	66.93^b	71.59^a	69.55^a	69.33^a	68.94^a	0.49	0.02	0.38	0.65
NDF, %	35.44^a	28.40^b	28.53^b	35.44^a	35.77^a	0.33	0.01	0.45	0.50
DE, Mcal/kg	3.32^b	3.69^a	3.17^c	3.39^a	3.44^a	0.04	0.01	0.26	0.62

RF+VC: Rabbit feed concentrate plus vitamin C; A and K: Guinea pig concentrates; SEM; Standard error of the mean; DMD: Dry matter digestibility; NDFD: Neutral detergent fiber digestibility; DE: Digestible energy.
^{ab} Different superscripts within rows indicated statistical differences (p< 0.01)

Table 4. Effects of sex and feed type on body measures of Guinea pigs (*Cavia porcellus*) fed with commercial feeds for growing rabbits or Guinea Pigs.

Item	Feed			Sex		Probability			
	RF+ VC	**A**	**K**	**Male**	**Female**	**SEM**	**Feed**	**Sex**	**Sex × Feed**
Length, mm/d	223^a	226^a	227^a	231^a	219^b	3.28	0.90	0.0001	0.04
TP mm/d	154^a	151^a	153^a	156^a	146^b	2.08	0.17	0.0001	0.09
CL mm/d	59^a	59^a	60^a	61^a	58^b	0.65	0.16	0.0001	0.75
RL mm/d	34^a	34^a	34^a	34^a	33^b	0.35	0.15	0.0001	0.08
FL mm/d	47^a	48^a	49^a	48^a	47^b	0.66	0.19	0.0001	0.98

RF+VC: Rabbit feed concentrate plus vitamin C; A and K: Guinea pig concentrates
Length: from the nasal bone to the sixth coccygeal vertebra; TP: Thoracic perimeter; CL: cranial length, From the nose to the occipital bone; RL: radius length; FL: femur length. A and K; Guinea pig concentrates
^{ab}Different superscripts within rows indicated statistical differences (p< 0.001).

DISCUSSION

The results of feed intake in this study are similar to those reported by Meyer et al (10), who demonstrated that the feed intake in guinea pigs is not affected by the inclusion of fiber. This lack of differences in DM consumption can be explained because guinea pigs are characterized by making a large number of small-volume meals throughout the day (5); this evades the satiety effect of the fiber, preventing the distention of the smooth muscle of the stomach, which is responsible for activating the receptors that induce the production of cholecystokinin in the small intestine and inhibit feed intake (11). The absence of differences in the ADG indicated that the diets were similar, and for that reason no significant differences were detected in the feed conversion. Other studies showed that, when there are small nutritional differences between the foods used to feed guinea pigs, the ADG and the feed conversion are similar (12).

In the production systems of guinea pigs in South America, 90% of the income comes from the sale of animals for fattening, while the cost of feeding represents 44% of the total costs (13). This same work shows that the inclusion of forage in the feeding system has a very reduced impact on costs. Under the conditions of this work, replacing rabbit feed with vitamin C can reduce the cost of feeding by almost 80% from 25 to 4 US cents, which can potentially improve system utilities.

The greater DM digestibility of foods for guinea pigs can be explained by the higher concentration of starch and cellular content in these concentrates, which were between 12.50 and 17.00% higher than in rabbit feed. The relationship between DM digestibility and starch level was previously described (14). These researchers found that as the cell content and starch increased, DM digestibility increased. Brownlee (11) has shown that increasing the dietary fiber in animals increases the viscosity of the chyme in the small intestine, resulting in a reduction in nutrient uptake and low DM digestibility, which reduces the ED.

The greater digestibility of the NDF in rabbit feed with vitamin C supplementation, indicated that the fibrolytic activity was stimulated by the higher fiber content in this food because it contains a greater amount of highly digestible hemicellulose. Guinea pigs have an important capacity for fermentation in the caecum and large intestine and is greater than that of rabbits, hamsters, and rats (15).

The absence of differences in morphometric measurements suggested that the longitudinal growth was similar. However, as previously mentioned, weight gain was greater in males; this ADG can be explained based on a higher mature weight, which is related to a slightly higher growth rate, which explains because males tend to be larger than females in this species (16).

In conclusion, the results of this experiment show that guinea pigs can be fed with concentrates formulated for rabbits, supplemented with vitamin C. Considering that the price of specialized foods for guinea pigs is very high, rabbit foods with adequate vitamin C are a good alternative to feed guinea pigs.

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