Feed restriction: productive performance, hematological parameters, gastrointestinal tract and carcass of rabbits

Restrição alimentar: desempenho produtivo, parâmetros hematológicos, trato gastrointestinal e carcaça de coelhos

Restricción alimentaria: rendimiento productivo, parámetros hematológicos, tracto gastrointestinal y canal en conejos

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ABSTRACT

Feed restriction is an strategy in animal production for cost reduction. The aim was to evaluate the effect of feed restriction on performance, hematological parameters, gastrointestinal tract and carcass of growing rabbits. The experimental period started at weaning (35 days) and finished at slaughter (84 days). A total of 24 New Zealand White rabbits were housing two per cage. A completely randomized design with two treatments and six replicates was used. The treatments were: Feed restriction (FR) and *ad libitum* (AL). In the FR each animal was feed about 45 g/day - 35 to 42 days of age - and 85 g/day - 56 to 63 days of age. Live weight was similar from both feeding treatment at 84 days, and higher body weight gain and better feed conversion was reported after first restriction period (42 to 56 days). These results could mean that rabbits were efficient to gain weight after restriction period, which may suggest the occurrence of compensatory gain. Lower number of red blood cell, hemoglobin and haematocrit has been observed in rabbits subjected to FR than AL, however, all the hematological parameters were in a physiological range. No differences were observed for carcass weight and carcass yield, which means that FR did not affect the crucial traits for rabbit meat market. No effects of FR were detected on either gastrointestinal, liver and kidneys yield. It seems that FR could be adopted in farms, however further studies should be carried out for substantiation.

Key words: *ad libitum*, blood profile, feed efficiency, health condition, rabbit breeding

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RESUMO

A restrição alimentar é uma estratégia de manejo da produção animal com o objetivo de reduzir custos. O objetivo deste estudo foi avaliar o efeito da restrição alimentar sobre o desempenho, parâmetros hematológicos, trato gastrointestinal e carcaça de coelhos em crescimento. O período experimental compreendeu o desmame (35 dias) até o abate (84 dias). Um total de 24 coelhos Nova Zelândia Branco foram alojados, dois por gaiola. O delineamento experimental foi inteiramente casualizado, com dois tratamentos com seis repetições cada: Restrição alimentar (RA) e *ad libitum* (AL). No tratamento RA cada animal foi alimentado com 45 g/dia – 35 a 42 dias – e 85 g/dia – dos aos 56 aos 63 dias. O peso vivo foi semelhante em ambos os tratamentos aos 84 dias, e houve maior ganho de peso corporal e melhor conversão alimentar após o primeiro período de restrição (42 a 56 dias). Estes resultados indicam maior eficiência para ganho de peso após o período de restrição, o que pode sugerir ocorrência de ganho compensatório. Menor número de glóbulos vermelhos, hemoglobina e hematócrito foram observados nos coelhos do grupo RA que no grupo AL, entretanto, todos os parâmetros hematológicos estavam na faixa fisiológica normal. Não foram observadas diferenças para peso e rendimento de carcaça, o que significa que a RA não afetou as características importantes para o mercado da carne de coelho. Além disto, não houve efeito de RA sobre rendimento do trato gastrointestinal, do fígado e dos rins. Sugere-se que a RA possa ser adotada nas granjas. No entanto, mais estudos devem ser realizados para comprovação.

Palavras-chave: alimentação à vontade, perfil sanguíneo, redução de custos, eficiência alimentar, estado de saúde, produção de coelhos

RESUMEN

La restricción alimentaria es una estrategia de manejo de la producción animal con el objetivo de reducir costos. Se objetivó evaluar el efecto de la restricción alimentaria sobre el rendimiento productivo, parámetros hematológicos, tracto gastrointestinal y canal en conejos de cebo. El período experimental comprendió desde el destete (35 días) hasta el sacrificio (84 días). Un total de 24 conejos de la raza Nueva Zelanda Blanca fueron alojados dos por jaula. El delineamiento experimental fue completamente casualizado, con dos tratamientos (restricción alimentaria - RA y ad libitum - AL) y seis repeticiones. Animales en restricción alimentaria recibieron 45 g/día – de los 35 a 42 días – y 85 g/día – de los 56 a 63 días. El peso vivo a los 84 días fue similar en ambos tratamientos, y hubo un mayor aumento de peso corporal y una mejor conversión alimenticia después del primer período de restricción (42 a 56 días). Estos resultados pueden significar eficiencia para el aumento de peso después del período de restricción, lo que sugiere ganancia compensatoria. Fueron encontrados menos glóbulos rojos, hemoglobina y hematocrito en conejos en el grupo RA que en el grupo AL, sin embargo, todos los parámetros hematológicos estaban en el rango fisiológico normal. No se observaron diferencias para el peso y el rendimiento de la canal, lo que significa que la RA no afectó las características importantes para el mercado de la carne de conejo. Además, no hubo ningún efecto de la RA en el rendimiento del tracto gastrointestinal, el hígado y los riñones. Se sugiere que se pueda adoptar RA en las granjas, sin embargo, se deben realizar más estudios para probarlo.

Palabras clave: *ad libitum*, perfil de sangre, eficiencia de alimentación, condición de salud, cría de conejos

Introduction

Rabbit production is a livestock activity that apply technical, practical and economic knowledge. In Brazil, the first challenge is to overcome cultural barriers to rabbit meat consumption and the second challenge is to reduce the rabbit production costs, especially the feed, which represents about 60 to 70% of the total cost. According to Machado and Ferreira (2014), alternatives to nutritional management are fundamental and need to be investigated.

Feed restriction (FR) is a strategy in animal production with the purpose of delimiting the amount of feed intake. In this way, there has been an increased interest in studying FR in growing rabbits in order to reduce the feeding costs and also be exploited in the feeding regimen, especially in periods of scarcity of commercial feed and forages. The FR can also reduce the incidence of gastrointestinal pathologies (ALABISO et al., 2016), especially after a stressful time, such as weaning (GALLOIS et al., 2008). Therefore, FR seems to be an important management tool for growing rabbits, capable of reducing the feeding expenses, improving the intestinal health and reducing the mortality rate after weaning (ROSELL, 2000; ALABISO et al., 2016).

Biologically, it is expected that FR would promote physiological and anatomical adaptation for an increased efficiency of nutrient absorption by the gastrointestinal tract after the restriction, as well as compensatory gain (GIDENNE et al., 2009). In this sence, feeding restriction could result in metabolic changes, immunosuppression and altered function of the digestive system, especially improved nutrient digestibility. Positive results were found by Di Meo et al. (2007), Oliveira et al. (2012), Ahmed et al. (2015) and Alabiso et al. (2016).

Blood profile provides valuable information about health condition of an organism and, thus, it is an indicator of internal changes, which can be caused by external conditions (TUMOVÁ et al., 2007). There is a little information available concerning the alternative feeding systems on the blood profile of rabbits.

The objective of the present study was to evaluate the effect of feed restriction in two periods on performance, hematological parameters, development of the gastrointestinal tract, organs and carcass yield of growing rabbits.

Material and Methods

The study was carried out at Minas Gerais Federal Institute, Bambuí Campus. The procedures involving animals were approved by the Institutional Animal Care and Use Committee, under protocol number

03/2017. The experimental period started at weaning (35 days) and finished at slaughter (84 days). A total of 24 New Zealand White rabbits were allocated in a completely randomized design with two treatments, feed restriction (FR) and *ad libitum* (AL) and six replicates with two animals each, a male and a female. Each animal in FR received 45 g/day – 56 to 63 days of age – and 85g/day - to 63 days of age. Average ambient temperature was 13.3ºC (minimum) and 31.4ºC (maximum) and average relative humidity was 61.5%. The lighting program consisted of natural photoperiod over the entire experimental period (from October to November, 2018).

The galvanized steel cages (0.6 x 0.6 x 0.4 m) were equipped with nipple water drinkers and semi-automatic feeders. The rabbits were allowed *ad libitum* access to water. A commercial pelleted diet for growing rabbits was provided (crude protein 17.7%, Acid detergent fiber 17.2%, and Digestible energy 2450 kcal kg^{-1}).

The evaluated parameters of productive performance were body weight at 35, 42, 56, 63 and 84 days, body weight gain, feed intake and feed conversion considering the period of 35 to 42, 42 to 56, 56 to 63 and 63 to 84 days of age. The carcasses (no blood and organs), and organs (full caecum, small intestine, liver and kidneys) were weighed and their yields (in percentage) were determined relative to slaughter weight (at 84 days). The length of the small intestine was also determined

At 84 days, 12 rabbits (six per treatment) were selected according to the body weight, and slaughtered by physical stunning and bleeding. Blood samples (3.0 ml) were collected via the jugular vein into blood collection tubes (Vacutube EDTA, Biocon Diagnósticos, Belo Horizonte, Minas Gerais, Brazil). Analyses were carried out at the laboratory (Agropec Centro de Saúde Animal, Bambuí, Minas Gerais, Brazil) within the next two hours using an ABX Micros 60 Hematology Analyzer (Horiba, Montpellier, France). Individual serum samples were analyzed for red blood cell, hemoglobin, haematocrit, leukocyte, band and segmented neutrophil, lymphocyte, monocyte, eosinophil, basophil, platelet, metamyelocyte, myelocyte, promyelocyte and blast.

For performance parameters, each cage with two rabbits constituted an experimental unit and for blood and carcass parameters, each rabbit constituted an experimental unit. For statistical analysis the programs Statistica 9.0 or Statgrafics were used and the averages data were compared using Kruskal-Wallis or SNK tests at the 5% probability level.

Results and Discussion

Performance.

Live weight was significantly higher in rabbits AL when than rabbits FR at the end of the two restriction periods (42 and 63 days), according to Table 1. However, live weight was similar (P>0.05) in both feeding treatment when the animals reached 84 days old. Ahmed et al. (2015) and Alabiso et al. (2016) submitted rabbits to severe restriction and reported decreased final body weight, which differed from our results. However, it is necessary to highlight that the low number of repetitions of the present experiment may have contributed to the statistical equality between so different values (2758.3g *vs.* 2601.2).

According to the expected, reduced body weight gain was observed in rabbits FR during the two periods (35 to 42 and 56 to 63 days). Therefore, body weight gain was significantly higher in FR rabbits after first restriction period (42 to 56 days), and also there was a tendency of higher weight after second restriction period (63-84 days). According to these results, it can be inferred that rabbits were extremely efficient to gain weight after restriction period, which may suggest the occurrence of compensatory gain. Our results are in agreement with those reported by Alabiso et al. (2016). The similar feed intake between FR and AL observed after restriction periods and also for the entire period (35-84 days) may reinforce the compensatory gain efficiency in restricted rabbits.

Better feed conversion was reported in rabbits after first restriction period. This result could suggest a physiological adaptation of these animals in relation to better feed efficiency. The improvement of feed conversion in restricted rabbits was also confirmed by Ahmed et al. (2015) and Alabiso et al. (2016). In the present study, feed conversion rate was similar for both feeding treatment when considered the entire period. These findings are very interesting from the practical point of view, which confirm the FR as strategy to be applied in rabbit breeding.

Table 1 – Performance of growing rabbits subjected to feed restriction *vs. ad libitum* feeding[1]

Trait	Feeding treatment		CV (%)	P value
	Ad libitum	Feed restriction		
Live weight (g)				
35 days	809.0	812.2	4.03	0.8701
42 days	1174.8[a]	946.2[b]	5.72	0.0001
56 days	1821.5	1698.7	5.52	0.0534
63 days	2103.7[a]	1839.2[b]	4.41	0.0004
84 days	2758.3	2601.2	6.24	0.1347
Body weight gain (g/day)				

35-42 days	52.26[a]	19.14[b]	14.26	0.0000
42-56 days	46.19[b]	53.75[a]	9.00	0.0155
56-63 days	40.31[a]	22.22[b]	18.93	0.0001
63-84 days	31.17	36.28	12.84	0.0682
35-84 days	39.78	36.51	8.05	0.0946
Feed intake (g/day)				
35-42 days	98.3[a]	45.0[b]	10.44	0.0000
42-56 days	126.0	123.5	14.22	0.8121
56-63 days	138.5[a]	85.0[b]	8.66	0.0000
63-84 days	140.6	153.8	13.32	0.1469
35-84 days	129.3	119.8	10.51	0.1968
Feed conversion				
35-42 days	1.89	2.49	21.87	0.0544
42-56 days	2.72[b]	2.29[a]	9.54	0.0104
56-63 days	3.44	4.07	39.36	0.2175
63-84 days	4.41	4.24	20.64	0.4307
35-84 days	3.21	3.28	9.79	0.3838

[1]Feed restriction from 35 to 42 days (45 g/day/rabbit) and 56 to 63 days (85 g/day/rabbit).
[a,b]Values followed by the same letter in a row are not significantly different (P>0.05) by SNK test.

Hematological parameters.

All measurements of blood profile in this study was within a in a physiological range. Significantly lower number of red blood cell, hemoglobin and haematocrit have been observed in rabbits FR (Table 2). For hemoglobin content, similar result was observed by Ebeid et al. (2012). According to those authors, this reduction could be due to the reduction in erythrocytes' counts. For haematocrit results, El-Moty and El-Moty (1991) also reported reduced content, however Ebeid et al. (2012) observed no significant alteration in rabbits restricted. Haematocrit is considered one of the most common haematological parameter which expresses a share of blood cells from total blood value (TUMOVÁ et al., 2007).

In our study most parameters of blood profile (leukocyte, band and segmented neutrophil, lymphocyte, monocyte, eosinophil, basophil and platelet) were not influenced by FR. Neutrophils act on the inflammatory response to inflamed tissue and the degradation of microorganisms and other materials and lymphocytes act on immunity. In the present study the tendency of increased lymphocyte under FR may represent a higher immunity response of the organism to combat the adverse effects of the restriction. The amount of basophil in the circulation is very small and are generally not found in the routine differential count, and the pathophysiological function in the circulation is practically unknown (THRALL, 2007).

In general, our results were similar to Tumová et al. (2007) except for the lower

number of neutrophiles and higher number of lymphocytes after nutrition deprivation. For leukocyte number, our result was similar to Ebeid et al. (2012). There was no result for metamyelocyte, myelocyte, promyelocyte and blast.

Table 2 – Means and standard deviations of the hematological parameters of rabbits subjected to feed restriction *vs*. *ad libitum* feeding[1]

Trait	Feeding treatment		CV (%)	P value
	Ad libitum	Feed restriction		
Red blood cell (mm^3)	6.15 ± 0.16[a]	5.74 ± 0.21[b]	14.12	0.0037[2]
Hemoglobin (g l^{-1})	12.08 ± 0.29[a]	11.60 ± 0.44[b]	5.05	0.0484[2]
Haematocrit (%)	39.03 ± 1.26[a]	37.12 ± 1.48[b]	5.86	0.0361[2]
Leukocyte (g l^{-1})	5.47 ± 2.62	5.72 ± 1.98	0.03	0.8559[2]
Band neutrophil (mm^3)	1.00 ± 0.89	0.33 ± 0.82	1.82	0.2073[2]
Segmented neutrophil (mm^3)	63.50 ± 8.55	52.00 ± 18.33	1.94	0.1939[2]
Lymphocyte (mm^3)	32.00 ± 8.94	43.50 ± 17.95	1.97	0.1905[2]
Monocyte (mm^3)	3.17 ± 1.47	2.83 ± 1.94	0.11	0.7444[2]
Eosinophil (mm^3)	0.33 ± 0.52	0.50 ± 0.55	0.29	0.5995[2]
Basophil (mm^3)	0.00 ± 0.00	0.33 ± 0.82	1.00	0.3173[3]
Platelet	153,500.00 ± 71,868.63	193,000.00 ± 86,190.49	0.74	0.4088[2]

[1]Feed restriction from 35 to 42 days (45 g/day/rabbit) and 56 to 63 days (85 g/day/rabbit).
[a,b]Values followed by the same letter in a row are not significantly different (P≥0.05) by F test(2) or Kruskal-Wallis test(3).

Gastrointestinal tract, organs and carcass.

No differences (P>0.05) were observed for carcass weight and carcass yield (Table 3) according to the feeding treatments. It means that FR did not affect the crucial traits for rabbit meat market. These findings corroborate the results reported by Oliveira et al. (2012), and also Alabiso et al. (2016), who reported similar carcass yield for rabbits subjected to FR.

No effects (P>0.05) of FR were detected on either gastrointestinal tract (caecum and small intestine yields, and small intestine length) or liver and kidneys yields (Table 3). Similar results were observed by Yakubu et al. (2007), Tumová et al. (2007) and Oliveira et al. (2012). Biologically, it is expected that FR would promote physiological and anatomical adaptation for an increased efficiency of nutrient absorption. Although our results have not reported differences, we speculate that the FR promoted some changes in the physiology and the metabolism of the rabbits if considered the performance results. However, further studies are necessary for substantiation, and also emphasis needs to continue to be placed on developing alternatives to, and

modifications of current FR programs in order to improve rabbit conditions.

Table 3 – Means of the gastrointestinal tract and carcass traits of rabbits subjected to feed restriction *vs*. *ad libitum* feeding[1]

Trait	Feeding treatment		CV (%)	P value
	Ad libitum	Feed restriction		
Slaughter weight (g)	2755.0	2630.0	8.60	0.2975
Carcass weight (g)	1450.0	1389.0	10.10	0.4090
Caecum weight (g)	157.80	158.60	17.95	0.9517
Small intestine weight (g)	76.75	76.00	9.62	0.8411
Small intestine lenght (cm)	308.10	306.80	9.09	0.9230
Liver weight (g)	83.38	83.50	18.51	0.9873
Kidneys weight (g)	15.63	16.38	10.53	0.3884
Body composition, % of slaughter weight				
Carcass	52.58	52.76	3.27	0.8208
Caecum	5.76	6.04	17.72	0.5973
Small intestine	2.78	2.89	8.67	0.3863
Liver	3.01	3.40	17.99	0.1932
Kidneys	0.57	0.61	10.97	0.2199

[1]Feed restriction from 35 to 42 days (45 g/day/rabbit) and 56 to 63 days (85 g/day/rabbit).
[a]Values followed by the same letter in a row are not significantly different (P>0.05) by SNK test.

Conclusion

Feed restriction does not affect the performance and also results in normal blood profile in growing rabbits. Besides that, feed restriction does not affect the crucial traits for rabbit meat market. However further studies with bigger number of animals should be carried out for substantiation.

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