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REGULAR ARTICLES

Performance, meat characteristics and economic viability of rabbits fed diets containing banana peel

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Abstract

In developing countries, agricultural areas are used to grow ingredients for rabbits' nutrition instead of food for the human population. In this context, in places where people starve, it is unreasonable to use ingredients, such as maize, in rabbits' diets. This research aimed to evaluate performance, meat composition and coloration, and economic viability in rabbits fed with diets containing banana peel (BP) in substitution to maize. Forty-five White New Zealand rabbits were used; they were weaned at 35 days old and divided into five treatments in a completely randomized design. The animals were fed with some of the following diets: control diet (0BP)—without banana peel; experimental diets: 25BP, 50BP, 75BP and 100BP—with 25%, 50%, 75% and 100% of banana peel in substitution to maize, respectively. Means were compared through analysis of variance, followed by Tukey test (0.05). Results indicate there were no differences in performance and meat parameters. Banana peel inclusion resulted in lower costs. Therefore, banana peel can replace maize up to 100% in diets for rabbits with no loss in performance and meat composition, representing a promising alternative in rabbits' nutrition.

Keywords Animal nutrition · By-products · Cuniculture · Sustainability

Introduction

Currently, in the agricultural context, productive emphasis relies on only one product, with little or no significance regarding residual biomass (FAO 2017a). In this sense, agro-industrial residues have been a constant subject in production and science contexts because those are environmental liabilities and cost reducers. Therefore, using these residues rationally, for rabbits' nutrition, for example, to reduce environmental burden and to improve economic profit is necessary (De Blas et al. 2018).

In developing countries, most of ingredients for rabbits' nutrition are grown in areas that could be used to grow food for the human population (Klinger et al. 2018). In this context, it is unreasonable that ingredients, such as maize, are used in diets for rabbits in places where people starve.

Rabbits are traditionally used for subsistence in farming communities, in systems with low feedstock usage (Oseni and Lukefahr 2014). In this system, animals are fed diets containing ingredients that would be considered waste, such as banana peel (BP). Banana is mainly produced in subtropical and tropical regions, predominant in developing countries such as India, China, the Philippines, Ecuador, and Brazil (FAOSTAT 2017b). As a consequence of the intense production—in 2017, 114 million tons were produced—there is a massive amount of discarded BP (from 30 to 40% of mass).

In this context, researches about the efficient utilization of residues—as BP—are relevant, especially in more deprived communities. Because of this, reducing costs, minimizing food insecurity and reaching environmental sustainability in productive systems is possible. Due to these information, this study aimed to evaluate performance, meat parameters and economic viability of rabbits fed diets containing different levels of BP in substitution to maize.

Materials and methods

This study was approved by the Biosecurity and Ethics Committee—project filled under number 098/2011. The bioassay was carried out in a rabbit breeding facility—

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Department of Animal Production, unit at the main campus of the Federal University of Santa Maria, Brazil (UFSM), located at 29° 41′ S latitude, 53° 48′ W longitude. Animals were kept in a closed room without control of temperature, humidity and light.

A total of 45 White New Zealand rabbits, males and females—weaned at 35 days old and weighing on average 660 g—were randomly assigned to one of the five experimental groups (nine rabbits/group) up at 84 days old. The rabbits were housed in individual cages measuring 50 × 50 cm and received one of the five experimental diets and fresh water *ad libitum* until the end of the bioassay. During the experimental period, body mass and feed consumption were registered weekly, in accordance with the guidelines for applied nutrition in rabbits (Fernández-Carmona et al. 2005).

Banana peel (BP) were obtained without cost at the University Restaurant (RU–UFSM), where 50 kg are produced weekly. The BP used in the diets were previously dried in a forced-air circulation at 55–60 °C for 72 h. Diets were formulated to contain a similar crude protein and fiber content (Table 1) and to comprise with growth requirements for growing rabbits (AEC 1987).

Table 1 Ingredients and chemical composition of ration with banana peels in replacement to maize for rabbits

	Experimental diets				
Ingredients (g/kg)	0BP	25BP	50BP	75BP	100BP
Maize	180	135	90	45	–
Banana peel*	–	45	90	135	180
Wheat meal	250	250	250	250	250
Soybean meal	167.5	167.5	167.5	167.5	167.5
Soybean oil	25	25	25	25	25
Rice hull	60	60	60	60	60
Alfalfa hay	300	300	300	300	300
Dicalcium phosphate	8	8	8	8	8
Calcitic limestone	2.5	2.5	2.5	2.5	2.5
Salt	5	5	5	5	5
Premix	2	2	2	2	2
Chemical composition of feed mixtures (%)					
Dry matter	85.92	86.43	86.85	87,04	87,12
Crude protein	18.54	18.47	18.40	18.33	18.27
Crude ash	7.72	8.60	8.95	9.45	9.96
Crude fiber	14.58	15.02	15.47	15.91	16.36
Crude fat	2.81	2.92	3.02	3.13	3.23

0BP: diet without banana peel; 25BP, 50BP, 75BP and 100BP: diets with 25%, 50%, 75%, and 100% of replacement of maize for banana peel, respectively. Premix composition (per diet kilogram): vitamin A 600,000 IU; vitamin D 100,000 IU; vitamin E 8000; vitamin K3 200 mg; vitamin B1 400 mg; vitamin B2 600 mg; vitamin B6 200,00 mg; vitamin B12 2000 mg; pantothenic acid 2000 mg; choline 70,000 mg; Fe 8000 mg; Cu 1200 mg; Co 200 mg; Mn 8600 mg; Zn 12,000 mg; I 65 mg; Se 16 mg. *Banana peel containing 6.7% crude protein, 6.44% crude fat and 12% crude fiber

Five mash diets were formulated. The control diet (0BP) without BP; 25BP, experimental diet with 25% BP as maize substitute; 50BP, experimental diet with 50% BP as maize substitute; 75BP, experimental diet with 75% BP as maize substitute; and 100BP experimental diet with 100% BP as maize substitute. After that, analyses were carried out at the Laboratory of Animal Nutrition of UFSM, following the methodology described by AOAC (2000). No antibiotics and no synthetic amino acids for supplementation were added to diets or water.

At the end of the bioassay, animals were stunned and slaughtered by jugular bleeding. The carcasses were submitted to chemical analysis to verify the contents of dry matter, crude protein and ashes at the Laboratory of Animal Nutrition of UFSM, Brazil. The carcass yield (CY) was calculated on the basis of carcass mass (CM) and animal body mass (BM) with 84 days old, in the following equation:

$$\mathrm{CY}(\%) = \frac{\mathrm{CM}}{\mathrm{BM}} \times 100$$

For color analysis in the meat, 6 measurements were taken at different points of the sample, in which the parameters of L^*, a^* and b^* were recorded. For this, the MINOLTA SpectraMagic™ NX, Color reader CM-S100w colorimeter was used. It was calibrated using the white standard. It was operated in the CIELAB system, which uses three coordinates: the space L^* indicates the luminosity, varying from white (+ L) to black (−L^*); chromatic coordinates a^* and b^*, in which a^* goes from green (− a^*) to red (+ a^*), and b^* varies from blue (−b^*) to yellow (+ b^*), according to CIE (1976). Color differences between samples (ΔE) were calculated in the following equation:

$$\Delta E_{1\text{–}2} = \sqrt{\left(a_1^* - a_2^*\right)^2 + \left(b_1^* - b_2^*\right)^2 + \left(L_1 - L_2\right)^2}$$

in which L_1, a_1^*, b_1^*, and L_2, a_2^*, b_2^* are the values of two different experimental groups. A variation in color (ΔE) of 2.3 units corresponds to a just noticeable difference (JND) for the human eye; higher variation is considered discernible (Mancini et al. 2019).

The economics index of the diets was evaluated according to the prices of ingredients of the year crop (IEA 2019). In this case, the cost per kilo of the diets and their respective economies were calculated in comparison to the control diet.

Data were analyzed in a completely randomized design, and each animal was considered an experimental unit. The means were compared through analysis of variance, followed

Table 2 Effects of replacing maize with banana peel on the performance of growing rabbits

Experimental diets							
	0BP	25BP	50BP	75BP	100BP	SDM	*P* value
Body weight at 35 days (g)	682	682	682	655	655	119	0.97
Body weight at 49 days (g)	1117	1082	1080	1132	1143	138	0.84
Body weight at 63 days (g)	1506	1526	1473	1521	1581	142	0.65
Body weight at 84 days (g)	2012	2025	1974	1970	2047	134	0.76
Post-weaning phase (35–49 days)							
Daily feed intake (g/day)	72.9	69.8	74.5	77.7	81.8	12.99	0.43
Daily weight gain (g/day)	31	28.5	28.3	34	34.8	5.4	0.06
Feed conversion ratio (g/g)	2.36	2.45	2.63	2.3	2.35	0.34	0.34
Intermediate phase (49–63 days)							
Daily feed intake (g/day)	96.5	100	103.4	94.2	103.7	12.65	0.56
Daily weight gain (g/day)	27.8	31.7	28	27.7	31.2	5.85	0.48
Feed conversion ratio (g/g)	3.48	3.15	3.7	3.4	3.34	0.5	0.41
Final phase (63–84 days)							
Daily feed intake (g/day)	112.5	111,2	112.3	113.4	115.4	8.64	0.90
Daily weight gain (g/day)	24	23.7	23.8	21.3	22.1	3.51	0.49
Feed conversion ratio (g/g)	4.7	4,7	4.71	5.33	5.23	0.66	0.13
Total trial period (35–84 days)							
Daily feed intake (g/day)	97.8	96.7	100.1	97.5	102.4	8.73	0.72
Daily weight gain (g/day)	27.14	27.4	26.36	26.82	28.4	2.51	0.57
Feed conversion ratio (g/g)	3.61	3.53	3.79	3.64	3.61	0.31	0.55

0BP: diet without banana peel; 25BP, 50BP, 75BP, and 100BP: diets with 25%, 50%, 75%, and 100% of replacement of maize for banana peel, respectively. *SDM*: standard deviation mean

by Tukey test ($P < 0.05$), with SAS statistical software (SAS 2009).

Results

The study shows that daily feed intake, mass gain, and feed conversion were similar in all five treatments (Table 2). However, there is a tendency of feed conversion reduction ($p = 0.13$) in final phases. No animals died during experimental period.

No differences were observed in carcass yield (CY) and centesimal compositions of meat in all five treatments (Table 3). Likewise, no differences were observed in L^*, a^* and b^* parameters. However, a small difference among colors (ΔE) was detected (Table 3). The ΔE was higher than 2.3 units—a JND for the human eye—in the $\Delta E_{0BP\text{-}25BP}$, $\Delta E_{0BP\text{-}50BP}$, $\Delta E_{0BP\text{-}100BP}$, $\Delta E_{25BP\text{-}75BP}$, $\Delta E_{25BP\text{-}100BP}$, $\Delta E_{50BP\text{-}100BP}$, and $\Delta E_{75BP\text{-}100BP}$.

Results for economic analysis indicate the inclusion of banana peel (BP) in diets for growing rabbits reduces cost (Table 4). BP inclusion resulted in saving 1.80%, 4.50%, 6.3% and 8.10% in diets containing 25%, 50%, 75% and 100% of BP in substitution to maize, respectively.

Discussion

The results are aligned with concerning data provided by FAO (2017), which indicate Earth is reaching stages of stagnation of agricultural areas. Furthermore, FAO (2017) reports that food demand in the world will have to be increased by 60% to assist the growing population demand until 2050. In this context, searching alternative ingredients is important because conventional ones, besides demanding big areas to be grown, cause negative changes in soil, water and local biodiversity.

Benefits and advantages of banana peel (BP) inclusion in animal feeding have been studied in several researches for the past years. However, similar studies to this one are scarce. In this context, it is important to compare data to similar studies, as Akinmutimi et al. (2006), in which five diets, with BP and different levels of energy, for growing rabbits were analyzed. Authors report that the use of this ingredient is advantageous due to performance data.

In this context, diets for rabbit fattening based on residues from vegetal cultures, such as BP, were established in developing countries, where these helped a lot of families to fight undernutrition (Khalil and Bolet 2010; Oseni and Lukefahr 2014). Still, Falcone et al. (2018) evaluated carcass of rabbits fed different levels of partial substitution of maize for BP

Table 3 Post-slaughter data of rabbits fed diets containing different levels of banana peel as a replacement for maize

Experimental diets						
	0BP	25BP	50BP	75BP	100BP	*P* value
Carcass						
Carcass mass (g)	1012	1074	1016	1088	1089	0.53
Carcass yield (%)	51	52	51	54	53	–
Meat composition (shoulder)						
Water (%)	77.11	76.37	76.20	75.02	76.77	–
Protein (%)	18.32	18.60	18.93	19.03	18.96	–
Ashes (%)	4.69	4.75	4.86	4.76	4.91	–
Color						
*L**	45.3	47.7	46.9	45.2	48.8	0.31
*a**	9.6	11.1	11.6	11.4	7.7	0.37
*b**	7.1	7.8	8.2	8	6.4	0.73
Differences between samples						
	x					
	0BP	25BP	50BP	75BP	100BP	
ΔE_{0BP-x}	–	2.91[a]	2.78 [a]	2.01	4.04 [a]	–
ΔE_{25BP-x}	–	–	1.02	2.52 [a]	3.83 [a]	–
ΔE_{50BP-x}	–	–	–	1.72	4.69 [a]	–
ΔE_{75BP-x}	–	–	–	–	5.40 [a]	–
$\Delta E_{100BP-x}$	–	–	–	–	–	

0BP, diet without banana peel; 25BP, 50BP, 75BP, 100BP, diets with 25%, 50%, 75%, and 100% of replacement of maize for banana peel, respectively. ΔE: difference between treatments. [a] Value over the threshold (2.3 points) with a noticeable difference in color between the samples

(from 25 to 50%). They checked similar nutritional quality which indicates that BP does not change carcass mass and yield nor percentage of meat protein.

Regarding meat coloration, there were no differences among *L**, *a** and *b** indexes, which shows that including BP does not interfere in coloration indexes. However, little differences in (ΔE) point out that some little variation happened among treatments. In this sense, meat color may be affected by a lot of variables (Wang et al. 2016). This variation, probably, is not related to BP because it did not happen in a homogeneous way and it was very subtle. Furthermore, only a very well-trained person would be able to notice these differences.

Regarding costs, Omole et al. (2008), in their research about including BP in diets for rabbits, report there was a decrease in food cost according to the level of banana. Still, the same authors emphasize that maize, an important energy source, is an expensive ingredient.

In cuniculture, food can represent 70% or more of total costs in production (Gidenne et al. 2017). In this context, using residues in diets for rabbits represents a viable strategy for production because of the possibility to reduce food costs and to benefit environment.

Another important issue, regarding costs, may be observed in other studies, in which researchers report that the high cost of ingredients has led to the search for non-conventional and more accessible ones (Akande 2015). In this way, human population would have access to a food with high biological/nutritional value—rabbit meat—in which the animals were fed agricultural residues. This initiative would reduce environmental liabilities and economic costs, besides helping people to reduce expenses with food.

After this research, the finding was that residues as banana peel, which generates environmental liabilities and takes massive density of nutrients, can be used in diets for rabbits. In this sense, the results enable diets to be less expensive and to

Table 4 Cost and economic viability of the experimental diets

Cost per ingredient needed to produce 1 kg of feed (R$)					
Ingredients	0BP	25BP	50BP	75BP	100BP
Maize	0.0954	0.0715	0.0477	0.0238	–
Banana peel	–	–	–	–	–
Wheat meal	0.1175	0.1175	0.1175	0.1175	0.1175
Soybean meal	0.1814	0.1814	0.1814	0.1814	0.1814
Soybean oil	0.07	0.07	0.07	0.07	0.07
Rice hull	–	–	–	–	–
Alfalfa hay	0.46	0.46	0.46	0.46	0.46
Dicalcium phosphate	0.0112	0.0112	0.0112	0.0112	0.0112
Calcitic limestone	0.00035	0.00035	0.00035	0.00035	0.00035
Salt	0.0015	0.0015	0.0015	0.0015	0.0015
Premix	0.18	0.18	0.18	0.18	0.18
Cost per kilogram of diet	1.11	1.09	1.06	1.04	1.02

0BP: diet without banana peel; 25BP, 50BP, 75BP, and 100BP: diets with 25%, 50%, 75%, and 100% of replacement of maize for banana peel, respectively. Amounts calculated based on price of 2019 crop in Brazil

contain a high-quality protein. Therefore, banana peel can replace maize up to 100% in diets for growing rabbits.

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Compliance with ethical standards

Statement of animal rights This study was approved by the Biosecurity and Ethics Committee—project filled under number 098/2011.

Conflict of interest The authors declare that they have no conflict of interest.

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