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DIGESTIBLE ENERGY OF UNPEELED CASSAVA ROOT MEAL AND ITS EFFECT ON GROWTH PERFORMANCE AND CARCASS TRAITS IN RABBITS

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Abstract: Two experiments were conducted to evaluate the use of cassava root meal (891 g dry matter [DM]/kg, 639 g starch/kg, 74.1 g neutral detergent fibre [NDF]/kg, and 26.6 g crude protein [CP]/kg) in diets for growing rabbits. In the first experiment, a basal diet (419 g NDF/kg and 181 g CP/kg) and a test diet, in which cassava replaced 25% of the DM of the reference diet, were used. Twenty 50-d-old New Zealand White rabbits weighing 1474±10 g were randomly assigned to the 2 treatments, and digestibility of DM and gross energy (GE) were determined. The inclusion of cassava root meal in the diet increased DM digestibility (67.0±0.80 *vs.* 58.0±1.12%, $P<0.01$) and digestible energy (DE) content (11.86±0.16 *vs.* 10.45±0.22 MJ/kg, $P<0.01$). Digestible DM and DE contents of the unpeeled cassava root meal, obtained by the substitution method, were 943.3±15.8 g/kg and 15.28±0.32 MJ/kg. In the second experiment, 5 experimental diets were formulated to contain 150 g CP/kg, 184 g acid detergent fibre/kg and 10.9 MJ DE/kg, and increasing levels (0, 7, 14, 21 and 28%) of unpeeled cassava root meal, mainly in substitution of corn. A growth trial was carried out using 90 rabbits from the Botucatu genetic group from weaning (35 d, weighing 951±13 g) up to 71 d of age. The rabbits were housed in pairs, and randomly assigned to the 5 treatments (9 replicates/treatment). No effect of the substitution of corn with cassava root meal was detected on growth performance (growth rate, feed intake and feed conversion ratio, on av. 44.6±0.50 g/d, 132±1.4 g/d and 2.97±0.028 g/g, respectively). The level of inclusion of cassava root meal had a quadratic effect ($P=0.005$) on the dressing out percentage, showing a minimal value (51.2%) for inclusion of 139 g/kg. No other effect was observed on slaughter and reference carcass weights (2383±19 and 1238±11 g, respectively). Unpeeled cassava root meal may be used to completely replace corn in the diet, supporting high performance in growing rabbits, but its effects on carcass traits should be investigated further.

Key Words: digestibility, growth performance, *Manihot esculenta*.

INTRODUCTION

Corn and wheat bran are the major energy sources in rabbit diets in Southeast Brazil. Availability and price of these ingredients vary considerably from year to year depending on the demand for human, poultry and swine diets and, more recently in the case of corn, for energy production in the US. These circumstances require that alternative feed sources for rabbit diets be secured.

The cassava plant (*Manihot esculenta* Crantz) is originally from South America and is regarded as a low input crop (Salla and Cabello, 2010). Its tuberous roots, rich in starch, are used in human and animal feeding. Several cassava by-products may be used in rabbit diets (Omole, 1990) including the cassava foliage hay (Scapinello *et al.*, 1999;

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Faria *et al.*, 2008), leaf meal (Machado *et al.*, 2012), root meal (Furlan *et al.*, 2005; Oso *et al.*, 2010) and root peel meal (Michelan *et al.*, 2006; Ekpo *et al.*, 2009).

The unpeeled cassava root is ground and oven or sun dried to obtain the unpeeled cassava root meal. These processing steps also help eliminate toxic compounds, especially cyanogenic glycosides (Cheeke, 1987). Rostagno *et al.* (2005) reported gross energy for unpeeled cassava root meal to be 15.46 MJ/kg, slightly less than for corn with 16.46 MJ/kg, but its starch content (71%) was found to be higher than that of corn (62.3%).

Although faecal digestibility of starch was found to be in general high (0.99) in growing rabbits, it may be modified by several factors, including rabbit age and the source of starch (Blas and Gidenne, 2010). In corn, the amylose-amylopectin ratio of a particular grain variety (Furlan *et al.*, 2003), in addition to the endosperm structure of seeds and their resistance to grinding (Rooney and Pflugfelder, 1986), may increase the faecal loss of starch in young rabbits. The activity of the caeco-colic microbiota can be potentially modified due to the presence of starch; therefore, before 6 wk of age, the role of starch in digestive troubles may not be ruled out (Blas and Gidenne, 2010).

The objectives of this study were to assess the digestible energy of unpeeled cassava root meal for growing rabbits and also to evaluate the effects of the increasing replacement of corn with unpeeled cassava root meal in the diet on growth performance and carcass traits.

MATERIALS AND METHODS

Experiment 1: digestibility trial

Twenty 50-d-old New Zealand White rabbits weighing 1474±10 g were used in a faecal digestibility trial carried out at the Rabbit Unit of the *Iguatemi Experimental Farm*, *Universidade Estadual de Maringá,* PR, Brazil. Rabbits were housed in metabolism cages, equipped with a nipple drinker, a metal feeder and an accessory for faeces collection. They were randomly assigned to the 2 following treatments. A basal diet (Table 1) was formulated to meet the requirements of growing rabbits (De Blas and Mateos, 1998). In the test diet, unpeeled cassava root meal was used to replace 25% of the basal diet (including minerals, premix, coccidiostat and synthetic amino acids). These diets were prepared and pelleted at the *Universidade Estadual de Maringá,* PR, Brazil.

A 14 d trial was conducted, in which the animals had free access to feed and water. A 10 d adaptation period was followed by continuous faeces collection for 4 d (Perez *et al.*, 1995). Total faeces excreted by each animal were collected daily and stored in plastic bags at –18°C for chemical analysis. At the end of the trial, all the faeces from

Table 1: Ingredients of the basal and test diets (Experiment 1), g/kg as fed.

Ingredients	Basal diet	Test diet
Cassava root meal	0	250
Corn	221	166
Wheat bran	235	176
Soybean meal	130	98
Alfalfa hay	200	150
Coast cross hay	190	143
Sodium chloride	4	3
Limestone	8	6
Dicalcium phosphate	4	3
Vitamin /mineral premix[1]	5	4
Coccidiostat (0.06% Robenidin)	0.6	0.5
DL- Methionine 99%	1.4	1.1
Threonine	1	0.8

[1]Provided by Nuvital, Brazil and included per kg of the basal diet: vitamin A, 3000 IU; vitamin D, 500 IU; vitamin E, 40 mg; vitamin K_3, 1 mg; vitamin B_1, 2 mg; vitamin B_2, 3 mg; vitamin B_6, 1 mg; vitamin B_{12}, 0.01 mg; pantothenic acid, 10 mg; choline chloride, 350 mg; Fe, 40 mg; Cu, 6 mg; Co, 1 mg; Mn, 43 mg; Zn, 60 mg; I, 0.32 mg; Se, 0.08 mg; Antioxidant, 100 mg.

each animal were pooled, weighed, pre-dried for 86 h at 55°C and ground. Chemical analyses for the digestibility trial (DM and GE of diets and faeces) were conducted at the Nutrition and Feeding Laboratory of the *Universidade Estadual de Maringá,* PR, Brazil. The procedure 930.15 (A.O.A.C., 1995) was used for DM and GE was determined by an adiabatic bomb calorimeter (Parr Instrument Co., Moline, IL, USA). Faecal digestibility of GE and DM were obtained by the substitution method using the calculation procedures proposed by Villamide *et al.* (2001). Therefore, estimations of digestible DM and DE contained in the unpeeled cassava root meal were performed based on the sum of the contributions of the basal diet and test ingredient in proportion to their relative inclusion rate in the test diet. Dry matter corrections were made.

Chemical analyses of unpeeled cassava root meal and of basal and test diets (Table 2) were carried out at the Bromatology Laboratory of the *Faculdade de Medicina Veterinária e Zootecnia,* UNESP, Botucatu, according to the recommendations from EGRAN (2001) and A.O.A.C. (1995) methods. The procedures 930.15 (dry matter, DM), 984.13 (crude protein, CP), 942.05 (crude ash), 920.39 (ether extract, EE) and 973.18 (acid detergent fibre, ADF) were employed. For neutral detergent fibre (NDF), the sequential method of Van Soest *et al.* (1991) was used with the notation indicated by Mertens (2002). The starch content of cassava root meal was determined at the CERAT (*Centro de Amidos e Raízes Tropicais*), UNESP, Botucatu, using the enzymatic hydrolysis method (ISO 6647, 1987).

Experiment 2: performance trial

Five experimental diets were formulated to contain 150 g/kg CP, 10.9 MJ DE/kg, 184 g/kg ADF (De Blas and Mateos, 1998) and increasing levels (0, 7, 14, 21 and 28%) of unpeeled cassava root meal (Table 3) gradually replacing corn from the control diet. Adjustments in wheat bran, soybean meal, alfalfa and coast cross hays and synthetic amino acid contents were necessary in order to maintain the appropriate balance of nutrients in all diets. These diets were also formulated and pelleted at the *Universidade Estadual de Maringá,* PR, Brazil, but the performance trial was conducted at the Rabbit Unit of the *Faculdade de Medicina Veterinária e Zootecnia, UNESP, Botucatu.*

Ninety rabbits from the Botucatu genetic group, 45 males and 45 females, weighing 951±13 g, were weaned at 35 d and housed in pairs (1 male and 1 female) in wired cages (33×60×45 cm). The building was open plan and equipped with plastic adjustable curtains. Animals were randomly assigned to the 5 treatments with 9 replicates of 2 rabbits (1 male and 1 female) each. Therefore, for performance traits the experimental unit was a cage containing 1 male and 1 female (n=9/treatment), but for carcass traits the experimental unit was the individual (n=90). Body weights were recorded at 35, 50 and 71 d of age, whereas average daily gain, feed intake and feed conversion were computed from 35 to 50 and from 35 to 71 d of age. Ambient temperature was on average 19.5°C, with average minimum and maximum temperatures of 14.8 and 24.8°C, respectively.

The animals were weighed and slaughtered at 72 d of age, after a 12 h fasting. Bleeding followed eletronarcosis and thoracic viscera (heart, lungs, trachea, oesophagus and thymus), liver, dissectible fat (scapular and perirenal deposits) and reference carcass (no head or viscera) were collected and weighed (Blasco and Ouhayoun, 1996). All measurements were made on hot carcasses. Percentages of thoracic viscera, liver, dissectible fat and reference

Table 2: Chemical composition of unpeeled cassava root meal and the basal and test diets (Experiment 1), g/kg dry matter (DM).

Ingredients	Cassava root meal	Basal diet	Test diet
Moisture	877	891	883
Ash	20	59	51
Starch	639	220[1]	325[1]
Crude protein	27	181	157
Neutral detergent fibre	74	419	352
Acid detergent fibre	45	238	214
Ether extract	3.2	17.7	9.6
Gross energy (MJ/kg DM)	16.69	18.22	18.02

[1]Calculated values.

Table 3: Ingredients and calculated composition of the experimental diets (Experiment 2).

	Level of cassava root meal in the diet (g/kg)				
Ingredient (g/kg, as fed)	0	70	140	210	280
Corn	262	197	131	65	0
Cassava root meal	0	70	140	210	280
Wheat bran	204	189	175	160	145
Soybean meal	132	142	151	160	170
Alfalfa hay	180	185	190	195	200
Coast cross hay	198	194	190	185	181
Sodium chloride	4	4	4	4	4
Limestone	8	7	6	5.1	4.1
Dicalcium phosphate	4	5	6	7	8
L- Lysine HCl (78.5%)	0.80	0.68	0.55	0.43	0.30
DL- Methionine 99%	1.6	1.7	1.8	1.9	2.0
Vitamin /mineral premix[1]	5	5	5	5	5
Coccidiostat (0.06% Robenidin)	0.6	0.6	0.6	0.6	0.6
Calculated composition					
Crude protein (g/kg)	150	150	150	150	150
Digestible energy (MJ/kg)	10.9	10.9	10.9	10.9	10.9
Starch (g/kg)	207	207	207	206	206
Neutral detergent fibre (g/kg)	308.4	303.8	299.2	294.6	290.0
Acid detergent fibre (g/kg)	183.3	183.5	183.7	183.8	184.0
Methionine+Cystine (g/kg)	6.0	6.0	6.0	6.0	6.0
Lysine (g/kg)	7.8	7.8	7.8	7.8	7.8
Calcium (g/kg)	8.0	8.0	8.0	8.0	8.0
Total phosphorus (g/kg)	5.0	5.0	5.0	5.0	5.0

[1]Provided by Nuvital; Brazil and included per kg of diet: vitamin A, 3000 IU; vitamin D, 500 IU; vitamin E, 40 mg; vitamin K_3, 1 mg; vitamin B_1, 2 mg; vitamin B_2, 3 mg; vitamin B_6, 1 mg; vitamin B_{12}, 0.01 mg; pantothenic acid, 10 mg; choline chloride, 350 mg; Fe, 40 mg; Cu, 6 mg; Co, 1 mg; Mn, 43 mg; Zn, 60 mg; I, 0.32 mg; Se, 0.08 mg; Antioxidant, 100 mg.

carcass were calculated relative to slaughter weight. Yields of retail cuts (fore legs plus thoracic cage, loin, and hind legs) were estimated relative to reference carcass weight.

Statistical analyses

The standard errors of the cassava root meal digestible DM and DE were estimated from the equation proposed by Villamide (1996), which takes into account the variance and number of replicates in both the basal and test diets used in the digestibility trial. To compare digestible DM and DE in basal and test diets, appropriate t tests were employed.

Polynomial regression analyses, including lack of fit tests of performance and carcass traits on the levels of cassava root meal in the diet, were conducted to define the best model for each trait (Kaps and Lamberson, 2004). Subsequently, analyses of covariance were implemented using SAS (2003) GLM procedure. Models included the linear and quadratic effects of treatment (level of cassava root meal in the diet) and the random error for performance traits and the fixed effects of sex, the level of cassava root meal in the diet, sex×linear and quadratic effects of treatment and the random error for slaughter weight and carcass traits. Found to be non-significant, the interactions were removed from the final models of analyses.

RESULTS AND DISCUSSION

The inclusion of cassava root meal in the (test) diet increased the digestibility of DM (67.0±0.80 *vs.* 58.0±1.12%, $P<0.01$) and digestible energy content (11.86±0.16 *vs.* 10.45±0.22 MJ/kg, $P<0.01$) relative to basal diet. The estimated digestibility coefficients for DM and GE contents of unpeeled cassava root meal were 94.3 and 91.5%,

Table 4: Effect of level of cassava root meal in the diet on performance traits.

	Levels of cassava root meal in the diet (g/kg)						*P*-value	
Trait	0	70	140	210	280	SEM[1]	L[2]	Q[3]
Body weight at 50 d (g)	1665	1657	1657	1643	1625	43	0.99	0.83
Body weight at 71 d (g)	2516	2507	2514	2524	2492	55	0.88	0.84
Weight gain 35 to 50 d (g/d)	47.4	46.9	46.8	46.6	45.1	1.5	0.96	0.71
Feed intake 35 to 50 d (g/d)	108	106	107	105	103	3.0	0.86	0.83
Feed conversion 35 to 50 d	2.29	2.27	2.29	2.25	2.31	0.049	0.68	0.64
Weight gain 35 to 71 d (g/d)	44.6	44.4	44.5	45.1	44.1	1.2	0.83	0.80
Feed intake 35 to 71 d (g/d)	134	133	132	133	128	3.3	0.77	0.52
Feed conversion 35 to 71 d	3.00	3.01	2.97	2.95	2.90	0.063	0.98	0.68

SEM: standard error of the means.
[1]n: 9 cages/treatment (a cage with 1 male and 1 female).
[2]L: linear effect of levels of unpeeled cassava root meal in the diet.
[3]Q: quadratic effect of levels of unpeeled cassava root meal in the diet.

therefore estimations of digestible DM and DE contents for this feed ingredient were 943.3±15.8 g/kg and 15.28±0.32 MJ/kg, respectively. A slightly higher value of DE (16.72 MJ/kg) was obtained by Furlan *et al.* (2003) for corn, although the estimated coefficients of digestibility of GE (90.2%) and DM (81.4%) were lower for that cereal grain. This difference in digestibility may be attributed to the endosperm structure of corn seeds, in which starch is involved with a protein matrix (Rooney and Pflugfelder, 1986) not present in cassava roots. Starch granules in cassava are more easily ground and therefore more easily exposed to digestive enzymes, increasing its digestibility when compared to corn (Otutumi *et al.*, 2005). Improved digestibility of nutrients as cassava replaced barley up to 335g/kg in diets for growing rabbits was reported by Radwan *et al.* (1989).

The level of cassava root meal in the diet did not affect growth performance of weaned rabbits either from 35 to 50 d of age, or from 35 up to 71 d of age (Table 4). High growth performance in terms of body weight, average daily gain, feed intake and feed conversion were supported by unpeeled cassava root meal replacing corn in rabbit diets. Similar results were reported by Radwan *et al.* (1989), who used cassava root meal to replace barley in diets for crossbred growing rabbits. Scapinello *et al.* (2006) used cassava root meal scrapings, a by-product from the cassava root meal processed for human consumption, whose composition is very similar to the unpeeled cassava root meal, in diets for growing New Zealand White rabbits. They found that body weights, feed intake and feed efficiency from 35 to 50 d of age decreased linearly when this by-product gradually replaced corn (from 53 to 264 g/kg) in the diets. But when the whole experimental period was considered (from 35 to 70 d of age), no effect of the substitution was observed on body weight and feed intake. Moreover, feed conversion was improved when at least 158 g/kg cassava root meal scrapings were included in the diets.

No sex×linear or quadratic interaction effects of level of cassava root meal in the diet on slaughter and reference carcass weights or carcass traits were found, so the main effects were considered separately. Males were heavier and yielded heavier reference carcasses than females, but no other differences were observed in carcass traits between males and females (Table 5).

No effect of cassava root meal level in the diet was detected on slaughter weight or carcass traits (Table 5), with the exception of linear and quadratic effects of the cassava root meal level in the diet on the percentage of reference carcass. Polynomial regression analysis (P=0.005) revealed that the minimum estimated reference carcass percentage (51.2%) occurred when cassava root meal was included at 139 g/kg in the diet. No explanation could be found for the fact that an intermediate level of replacement of corn with unpeeled cassava root meal would result in lower carcass yield than higher and lower replacement levels. It should be considered that wheat bran, soybean meal, alfalfa and coast cross hays, and synthetic amino acid levels were also changed in the diets to adjust nutrient levels, as cassava root meal replaced corn. Those changes could perhaps explain the variation in reference carcass percentage. Taking into account the recommendations made by Fernández-Carmona *et al.* (2005), sample size may have been a limiting factor in detecting effects of cassava root meal level in the diet on carcass traits.

Table 5: Effects of sex and level of cassava meal in the diet on carcass traits.

	Sex			Levels of cassava root meal in the diet (g/kg)						P-value		
Trait	Males	Females	SEM[1]	0	70	140	210	280	SEM[1]	Sex	L[2]	Q[3]
SW (g)	2424	2342	27	2400	2375	2399	2384	2355	42	0.030	0.90	0.75
RCW (g)	1262	1214	15	1258	1239	1228	1220	1245	24	0.030	0.25	0.31
Reference carcass (%SW[2])	52.0	51.9	0.30	52.4	52.2	51.1	51.2	52.9	0.47	0.79	0.007	0.005
Thoracic viscera (%SW)	1.15	1.12	0.031	1.12	1.12	1.17	1.17	1.086	0.048	0.56	0.23	0.20
Liver (%SW)	2.34	2.40	0.041	2.32	2.32	2.37	2.44	2.398	0.064	0.24	0.45	0.72
DsF (%SW)	1.29	1.38	0.058	1.45	1.25	1.29	1.34	1.36	0.092	0.30	0.19	0.20
Fore part (%RCW)	27.0	27.1	0.17	26.7	27.2	26.9	27.0	27.3	0.26	0.78	0.84	0.90
Loin (%RCW)	31.3	31.0	0.20	30.7	31.2	31.4	31.3	31.0	0.31	0.26	0.088	0.11
Hind part (%RCW)	39.1	39.2	0.18	39.5	39.2	39.0	39.0	39.0	0.28	0.65	0.29	0.48

SW: Slaughter weight; RCW: Reference carcass weight. DsF: Disectible fat. SEM: standard error of the means.
[1]n: 18 rabbits/treatment.
[2]L: linear effect of levels of unpeeled cassava root meal in the diet.
[3]Q: quadratic effect of levels of unpeeled cassava root meal in the diet.
Sex×L and Sex×Q interaction effects were non-significant (P>0.05).

Scapinello *et al.* (2006) reported that dressing out percentage increased linearly in New Zealand White rabbits when cassava root meal scrapings were included in the diets from 53 up to 264 g/kg, replacing corn, on a DE basis. Improved digestibility of diets containing cassava root meal in that study could, at least partially, explain the higher carcass yields. Ekpo *et al.* (2009), on the other hand, did not detect any effect of the diets, in which corn (370 g/kg) was replaced with unpeeled cassava root meal, peeled cassava root meal or cassava peel meal, on dressing percentage, organ weights or carcass cuts of crossbred rabbits in Nigeria. However, the cost/benefit analyses favoured the diets containing unpeeled cassava root meal and cassava peel meal relative to the corn based diet, due to the high cost of corn in that country at the time the study was conducted.

CONCLUSION

Unpeeled cassava root meal supports high performance in growing rabbits and may be used to completely replace corn in their diets. Its effects on carcass traits, however, should be further investigated.

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