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EFFECTS OF DIETS WITH *AMARANTHUS DUBIUS* MART. ex THELL. ON PERFORMANCE AND DIGESTIBILITY OF GROWING RABBITS

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Abstract: The effects on performance and digestibility in growing rabbits were studied by comparing 3 diets containing increasing inclusion rates of amaranth (*Amaranthus dubius* Mart. ex Thell.): 0 (A0), 160 (A16) and 320 g/kg (A32 diet). Diets were formulated isoproteic and isocaloric to meet the nutrient requirements of growing rabbits. One hundred and thirteen weaned New Zealand White rabbits (mean±standard deviation weight: 760±102 g), individually caged, were randomly assigned to one of the 3 experimental diets. Rabbits were fed *ad libitum* from 35 to 87 d of age, and health status and performance traits were monitored. The coefficients of total tract apparent digestibility of the diets were measured between 42 and 46 d of age in 12 rabbits per treatment. *Amaranthus dubius* contained 209 g/kg dry matter (DM) of crude protein and 398 g/kg DM of neutral detergent fibre. There were no significant differences between treatments in weight gain (mean 21.6 g/d) and live weight at the end of the fattening period (mean 1883 g). Daily feed intake was higher (P<0.05) in A0 than in A16 and A32 diets (85.4 *vs.* 73.7 and 69.9 g/d, respectively), and feed conversion rate improved with increased inclusion of *A. dubius* in the diet (from 3.84 to 3.28 for A0 and A32 diets, respectively; P<0.05). Health status was not affected by the amaranth inclusion rate. Total tract apparent digestibility showed high values, with no differences among diets except for ether extract. Thus, *A. dubius* could be considered as an alternative source of protein and fibre for rabbit feeding in tropical and subtropical regions.

Key Words: *Amaranthus dubius*, rabbit, diet, digestibility, growth performance.

INTRODUCTION

One of the main limiting factors that have been impairing rabbit production development in tropical and subtropical countries is the lack of balanced feeds at a competitive price. Therefore, alternatives are needed to formulate and produce balanced feeds by using local raw materials, mainly sources of fibre and protein (Cheeke, 1986; Oseni and Lukefahr, 2014). Particularly, one key factor is the need to replace alfalfa (*Medicago sativa*), soy (*Glycine max*), sunflower seed (*Helianthus annuus*), barley (*Hordeum vulgare*) and wheat bran (*Triticum* spp.), among others, which are raw materials prevalently used in diet formulation for rabbits in countries with a well-developed rabbit industry (Maertens *et al.*, 2002; De Blas and Mateos, 2010). These ingredients are scarce or expensive in developing countries, as they usually have to be imported. Therefore, in these regions it is of particular interest to use plants or raw materials of vegetable origin as alternative sources of fibre and protein meeting the nutritional requirements of rabbits, especially forage and other alternative ingredients (Volek *et al.*, 2013; Gerencsér *et al.,* 2014; Maertens *et al.*,

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2014; Alagon *et al*. 2014). These raw materials, potential candidates for feed formulation for rabbits, should be also available at competitive costs (Cheeke, 1986; Nieves *et al.,* 2001).

Amaranthus dubius Mart. ex Thell. is a plant belonging to the Amaranthaceae family, genus *Amaranthus,* distributed in tropical and subtropical regions. This species is highly productive and adapts itself to a wide range of edaphoclimatic conditions, especially dry soils and high temperatures (Repo-Carrasco-Valencia, 2009). *Amaranthus dubius* is native to Central and South America, being considered a weed species in subsistence crops, such as corn, sorghum and several legumes (Matteucci *et al*., 1999). The plant presents a high yield of green matter (4200 kg dry matter [DM]/ha; Arellano *et al*., 2004) and contains 263 and 205 g/kg DM of crude protein (CP) in leaves and panicles, respectively, and 333 and 230 g/kg DM of crude fibre (CF) in stems and panicles, respectively (Montero-Quintero *et al*., 2011). However, it is a species unexploited as a crop, although its seeds are eaten as a cereal and the leaves and stems as a vegetable (Matteucci *et al*., 1999). There are several reports of its use as a forage plant for feeding pigs, sheep, goats, cattle, among others (De Troiani and Ferramola, 2005; Barba de la Rosa *et al*., 2009), although it has received little attention for use in feeding rabbits.

So, the aim of this work was to determine the digestibility of balanced diets including *A. dubius* Mart. ex Thell. for growing rabbits and to assess the effects on their performance.

MATERIAL AND METHODS

Experimental diets

Mature *A. dubius* plants were collected manually during the rainy season in an experimental plantation located in Santa Rita, Zulia state, Venezuela. Samples, including leaves, stems and panicles, were harvested approximately 80 d after seeding and subjected to oven drying (between 50 and 60°C for 40 h), with constant rotation and aeration. They were subsequently ground and sieved at 0.5 mm (ReshMuhle Dietz, LB1–27) and meal was placed in hermetically-closed plastic containers, which were stored in a cool environment until analysis and utilisation as raw material in the manufacture of experimental diets. Three pelleted diets, whose ingredients and chemical composition are shown in Table 1, were formulated with increasing *A. dubius* levels of inclusion (0, 160 and 320 g/kg). A basal mixture (control diet; A0) which contained corn, soybean, wheat bran, Guinea grass (*Panicum maximum*), palm kernel, soybean oil and cane molasses as main ingredients was formulated to fit the nutritional requirements of growing rabbits (De Blas and Mateos, 2010). Two additional experimental diets containing increasing inclusion rates of *A. dubius* were prepared by partially substituting corn, wheat bran, Guinea grass and cane molasses in control diet with 160 and 320 g/kg of *A. dubius* (A16 and A32 diets, respectively), while soybean oil was increased. Salt, vitamin-mineral premix and binder (sepiolite) were added to all diets in constant proportions. Palm kernel and soybean contents were adjusted in A16 and A32 diets so that they were balanced. The diets were formulated to have similar levels of CP and digestible energy (DE). Diets were pelleted (3 mm diameter×5-10 mm length), using a meat mill adapted by means of a special disc, and subsequently baked (180°C for 30 min). During the milling and baking process, some soybean oil was lost from pellets, thus leading to a lower EE value than expected. No antibiotics, drugs or additives were added to feed and water, except robenidine hydrochloride included in the mineral and vitamins premix (13200 mg/kg of premix).

Experimental design, animals and housing conditions

A total of 113 New Zealand White rabbits of both sexes weaned at 35 d (mean±standard deviation weight: 760±102 g), were used to determine the effect of diets with *A. dubius* on growth performance during the fattening period. Once weaned, rabbits obtained from the farm of the National Institute of Hygiene "Rafael Rangel" (San Diego, Miranda state, Venezuela) were transported to the experimental farm in the town of Concepción, Jesús Enrique Lossada Municipality, Zulia state, Venezuela. Rabbits were individually housed in wire mesh cages measuring 50×25×40 cm (length, width and height), equipped with one nipple drinker and one hopper feeder. Water was filtered before storage in the farm water-tank. The farm was an open-air building equipped with a fan to circulate the air, with natural light during the day. Temperature and relative humidity during the experiment ranged from 23 to 32°C and from 50 to 80%, respectively.

Table 1: Ingredients and chemical composition of the experimental diets.

	Experimental diets		
	A0	A16	A32
Ingredient (g/kg, as fed)			
Amaranthus dubius	0	160.0	320.0
Corn	96.0	60.4	30.6
Soybean	110.6	95.0	107.0
Wheat bran	406.0	349.8	243.3
Guinea grass (*Panicum maximum*)	163.2	47.7	11.9
Palm kernel	119.0	154.0	110.6
Soybean oil	12.8	63.1	124.6
Cane molasses	57.4	35.0	17.0
Sodium chloride	10.0	10.0	10.0
Sepiolite[1]	15.0	15.0	15.0
Vitamin-mineral premix[2]	10.0	10.0	10.0
Chemical composition (g/kg dry matter)			
Dry matter (DM, g/kg)	909	893	917
Crude protein	159	154	151
Ether extract	2.0	3.6	4.6
Ash	70.6	71.2	72.7
Crude fibre	157	149	162
Neutral detergent fibre	347	337	307
Acid detergent fibre	204	203	234
Acid detergent lignin	101	121	90
Digestible energy[3] (DE, MJ/kg DM)	12.3	12.4	12.1

[1]Exal H®; provided by TOLSA Group (Madrid, Spain).

[2]Tecnovit Conejos Único®; provided by Tecnología & Vitaminas, S.L. (Tarragona, Spain). Mineral and vitamins composition (g/kg premix): Fe: 10; I: 0.2; Co: 0.02; Cu: 3; Mn: 10; Zn: 12; Se: 0.02; vitamin E: 3.2; vitamin B_1: 0.2; vitamin B_2: 0.6; vitamin B_6: 0.2; vitamin B_{12}: 0.002; calcium d-pantothenate: 2; Nicotinic acid: 4.4; choline chloride: 10; vitamin A: 1 800 000 IU; vitamin D_3: 300 000 IU.

[3]DE was calculated according to Fekete and Gippert (1986) as: DE (kcal/kg DM): 4253–32.6×Crude fibre (% DM)–144.4×Ash (% DM); it was subsequently converted to MJ/kg DM.

To determine the effect of diets on growth performance, rabbits were randomly assigned to one of the 3 experimental diets during the fattening period from 35 to 87 d of age (A0: n=37, A16: n=38, A32: n=38 rabbits). Rabbits were given *ad libitum* access to water and feed throughout the trial. Animals were weighed weekly from weaning to 87 d. Feed intake was measured on a daily basis. Daily feed intake, daily weight gain and feed conversion rate were subsequently calculated.

The individual health status of the animals was controlled daily through observation of clinical evidence of digestive troubles by using the methodology proposed by the European Group on Rabbit Nutrition (Fernández-Carmona *et al.*, 2005). For calculation of morbidity, rabbits were considered ill (only once throughout the trial) when showing signs of diarrhoea and significant reduction in feed intake (–30% approximately), while dead animals were only considered for mortality calculation. The sanitary risk index was calculated as the sum of morbidity and mortality (Bennegadi *et al.*, 2001).

Digestibility trial

A digestibility trial was performed according to Perez *et al.* (1995). After a 7-d adaptation period, faeces were collected during a 4-d period, from 42 to 46 d of age, on 36 rabbits (12 per treatment) randomly selected from the total of animals used in the fattening trial. The coefficients of total tract apparent digestibility (CTTAD) of DM, organic matter (OM) and CP were determined in individual samples, and CTTAD of CF, ether extract (EE), neutral detergent fibre (NDF) and acid detergent fibre (ADF) were determined in pools of samples (n=8 per treatment). Additionally, the digestible protein of diets (DPD) was calculated from the coefficients of digestibility, while DE was calculated according to the equation of Fekete and Gippert (1986).

Analytical methods

The chemical analyses were conducted at Laboratory of Animal Nutrition, Faculty of Agriculture, Universidad del Zulia, Maracaibo, Venezuela, on diets, faeces and on the *A. dubius* meal, according to the recommendations proposed by the European Group on Rabbit Nutrition (EGRAN, 2001). The AOAC International (2005) procedures were used to determine DM (method 934.01), CP (method 976.05, Kjeldahl: N×6.25) and EE (method 2003.05). Crude fibre, ash and ADF were determined according to AOAC International procedures (2000; methods 962.09, 942.05 and 973.187, respectively). The NDF was determined with a heat stable amylase and expressed exclusive of residual ash, without sodium sulphite (Mertens, 2002). Acid detergent lignin was determined according to Van Soest *et al.* (1991).

Statistical analyses

Data on growth performance and CTTAD of the diets were analysed as a completely randomised design with type of diet as the main source of variation, using the General Linear Model procedure of the SAS® statistical program (Statistical Analysis Systems package 9.3.1, SAS Institute Inc., Cary NC, USA). Tukey's test was used for a comparison of the means when appropriate. Morbidity and mortality were analysed using the chi-square test. As live weight was measured every week, it was analysed with the methodology of repeated measures over time through the MIXED procedure (SAS® statistical program), and second-degree polynomial models were subsequently selected that better explain the behaviour of said variable over time. Differences among treatment means with $P<0.05$ were accepted as representing statistically significant differences.

RESULTS AND DISCUSSION

Amaranthus dubius composition and experimental feeds

The chemical composition of *A. dubius* as raw material for animal feed is not available in the reference tables used for rabbit feeding (Maertens *et al.*, 2002; INRA, 2004; FEDNA, 2010) and has been reported in very few studies (Acevedo *et al.*, 2007; Odhav *et al.*, 2007; Montero-Quintero *et al.*, 2011).

Amaranthus dubius presented higher CP and ash contents (209.4 and 203.6 g/kg DM, respectively; Table 2) than most of the fibrous feedstuffs used in rabbit diets (Maertens *et al.*, 2002). Its CF, NDF and ADF contents (199.1, 398.0 and 288.0 g/kg DM, respectively; Table 2) were comparable to those of alfalfa meal (Maertens *et al.*, 2002). Furthermore, *A. dubius* showed a higher content in protein, fibre and ash than that reported in recent researches for unconventional vegetables used in rabbit feeding, such as plants of *Hedysarum flexuosum* (Kadi *et al.*, 2011), *Zea mays* (Martínez *et al.*, 2006) and *Tithonia diversifolia* (Nieves *et al.*, 2011), as well as hydroponic green barley forage (Morales *et al.*, 2009) and root of *Cichorium intybus* (Volek and Marounek, 2011). It should be noted that DE predicted for *A. dubius* meal by the Fekete and Gippert (1986) equation was underestimated in comparison with other prediction equations

Table 2: Chemical composition (g/kg dry matter) of *Amaranthus dubius* meal.

	Amaranthus dubius meal (whole plant)
Dry matter (DM, g/kg)	934
Crude protein	209
Ether extract	13.1
Ash	204
Crude fibre	199
Neutral detergent fibre	398
Acid detergent fibre	288
Acid detergent lignin	47.4
Digestible energy[1] (DE, MJ/kg DM)	5.3

[1]DE was calculated according to Fekete and Gippert (1986) as: DE (kcal/kg DM)=4253–32.6×Crude fibre (% DM)–144.4×Ash (% DM); it was subsequently converted to MJ/kg DM.

(Wiseman *et al.*, 1992; Fernández-Carmona *et al.*, 1996). Moreover, chemical composition of amaranth meal found in this research was similar that to reported by Montero-Quintero *et al.* (2011) for leaves, stems and panicles of *A. dubius* collected in Venezuela, for which low concentrations of toxic and anti-nutritional compounds such as nitrates, oxalates, phytates, totals phenols and condensed tannins were also observed.

Thus, *A. dubius* can be classified as a balanced fibre source for rabbit feeding (De Blas and Mateos, 2010), which is also rich in protein and minerals. In tropical countries it could become a substitute for raw materials currently used in balanced feed formulation (Molina *et al.*, 2011; Montero-Quintero *et al.*, 2011).

Amaranthus dubius was used in diets A16 and A32 to partially replace ingredients usually used in formulating rabbit pellets, particularly sources of protein and fibre (Table 1). Diets tested met nutritional requirements of the growing rabbit (De Blas and Mateos, 2010). However, ADL was about twice of the requirements in the 3 diets, while ADF was slightly higher in A32 diet and NDF was slightly lower in A0 diet (De Blas and Mateos, 2010; Table 1).

In the formulation of the diets (Table 1), in addition to using traditional ingredients for feed formulation (soybean, wheat bran, soybean oil and corn), it was necessary to include other unconventional raw materials available in the region, such as Guinea grass (*P. maximum*), palm kernel and cane molasses. This was because in Venezuela it is impossible to find other raw materials in the market that allow a more efficient and typical feed formulation suitable for rabbit requirements, a common situation in tropical and subtropical countries, which encourages research on alternative raw materials (Cheeke, 1986; Nieves *et al.*, 2008; Togun *et al.*, 2009). The inclusion of unconventional raw materials in this trial led to the formulation of isoproteic and isocaloric diets, which were adjusted to most of the requirements of fattening rabbits (De Blas and Mateos, 2010). However it was not possible to formulate isofibrous diets with the available raw materials.

Health status

There was no influence of experimental diets on mortality, morbidity and sanitary risk index (P>0.05; Table 3). Seventeen (15.0%) out of the total of 113 rabbits became ill during the 2nd and 3rd wk of the trial, showing decreased appetite and diarrhoea, of which 7 (6.2%) died and 10 (8.8%) were quickly recovered without medication. This agrees with the fact that the post-weaning period is a critical time because this stage is associated with a higher risk of digestive disorders in growing rabbits (Gidenne and Garcia, 2006; Carabaño *et al.*, 2010). However, given that the rabbits were not treated pharmacologically during the fattening period, it can be considered that mortality, morbidity and sanitary risk index remained at an acceptable level. This indicates, in general terms, a good health status that may be partly related to the strict hygienic-sanitary conditions in the experimental farm (Trocino *et al.*, 2010; Volek and Marounek, 2011).

Growth performance

No significant differences (P>0.05) among treatments were found in live weight at 87 d of age and growth rate (on av. 1883 g and 21.6 g/d, respectively; Table 4). Inclusion of *A. dubius* in A16 and A32 diets reduced daily feed

Table 3: Effect of *Amaranthus dubius* dietary inclusion level on mortality, morbidity and sanitary risk in growing rabbits from weaning (35 d) to slaughter (87 d)[1].

	Diets[3]			χ^2 values[4]		
	A0	A16	A32	χ^2 calculated	χ^2 tabulated	P-value
n[2]	37	38	38			
Mortality (%)	2.7 (1)	7.9 (3)	7.9 (3)	4.34	5.99	>0.05
Morbidity (%)	2.7 (1)	15.8 (6)	7.9 (3)	1.16	5.99	>0.05
Sanitary risk index[5] (%)	5.4	23.7	15.8	5.44	5.99	>0.05

[1]In parenthesis the number of dead or sick animals.

[2]n: Number of rabbits at the beginning of the experimental period.

[3]A0, A16 and A32 diets include 0, 160 and 320 g/kg (as feed) of *Amaranthus dubius*.

[4]In all cases χ^2 calculated< χ^2 tabulated, therefore there were independence between diets for mortality, morbidity and sanitary risk index.

[5]Sanitary risk index: mortality + morbidity.

Table 4: Growth performance of rabbits fed the experimental diets with *Amaranthus dubius*.

	Experimental diets[1]				
	A0	A16	A32	RMSE[2]	*P*-value
n[3]	36	35	35		
Live weight 35 d (g)	760	753	765	111	0.921
Live weight 87 d (g)	1923	1856	1871	199	0.418
Daily feed intake (g/d)	85.4 [a]	73.7 [b]	69.9 [b]	10.8	0.017
Daily weight gain (g/d)	22.4	21.2	21.3	2.1	0.136
Feed conversion rate	3.84 [a]	3.48 [ab]	3.28 [b]	0.44	0.029

[1]A0, A16 and A32 diets include 0, 160 and 320 g/kg (as feed) of *Amaranthus dubius*.

[2]RMSE: Root mean square error.

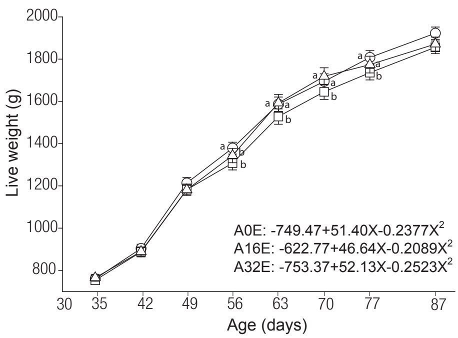
[3]n: Number of rabbits at the end of the experimental period.

[a,b] Mean values in the same row with a different superscript differ, $P<0.05$.

intake ($P<0.05$) compared with control diet (73.7 and 69.9 *vs.* 85.4 g/d, respectively), which could be due to lower palatability of *A. dubius,* as suggested for *Amaranthus* spp. by Bautista and Barrueta (2000), or other factors to be elucidated by further research. Consequently, feed conversion rate was better for A32 compared to A0 diet (3.28 *vs.* 3.84, respectively; $P<0.05$), whereas in A16 it was intermediate and similar to A0 and A32 diets ($P>0.05$).

There is little literature on the use of amaranth in rabbit feeding. As in our case, Bautista and Barrueta (2000) found a reduction in feed intake of pelleted diets formulated with increasing levels of leafs and seeds meal of amaranth (*Amaranthus* spp.; 20 to 30%) fed to New Zealand White rabbits. However, feed intake recorded in our trial was lower than recorded by these authors, which could be due to several factors, possibly because of reduced palatability, mainly due to the way in which the diets were manufactured, as the content of anti-nutritional factors in *A. dubius* is low (Montero-Quintero *et al.*, 2011). Moreover, daily weight gain and feed conversion rate were similar to those observed by Bautista and Barrueta (2000), while live weight at the end of the fattening period was higher in our case due to higher weaning weight. Also, Bamikole *et al.* (2000) reported an inverse relationship between feed intake and amaranth content when testing non-pelleted (meal) diets with increasing levels (up to 30%) of inflorescences and unthreshed grain amaranth seed head fed to mixed breed rabbits under similar environmental conditions to ours. The daily weight gain recorded by these authors was lower than in our study, partly because their rabbits were older (7-8 wk) but also due to the fact that presenting feed as meal drastically reduces intake and therefore weight gain (Gidenne *et al.*, 2010). In the same vein, Chhay *et al.* (2013) reported a decrease in growth rate and a worsening of feed conversion as amaranth (*Amaranthus* spp.) foliage replaced (at increasing levels up to 100%) water spinach (*Ipomoea aquatica*) as basal diet for growing rabbits, something that these authors attributed to quality of fibre or non-nutritional components of amaranth.

Figure 1: Live weight (g) of rabbits feed diets with *Amaranthus dubius* during the fattening period (35-87 d).



[a,b] Mean values at the same age with a different superscript differ, $P<0.05$.

A0E: A0 diet expected live weight; A16E: A16 diet expected live weight; A32E: A32 diet expected live weight.

–○– A0 measured weight; –□– A16 measured weight; –△– A32 measured weight

The evolution of live weight of rabbits throughout the fattening period is shown in Figure 1. No differences were observed among treatments at 35, 42, 49 and 87 d of age ($P>0.05$). At 56 d of age control rabbits weight was higher ($P<0.05$) than in A16 and A32 treatments, while at 63, 70 and 77 d of age rabbits weight of A0 and A32 diets were higher than in A16 diet ($P<0.05$). It was observed that at 87 d of age (end of trial; Figure 1) the rabbits continued to show steady growth, indicating that to achieve the recommended commercial weight (2000-2200 g in Venezuela; González *et al.*, 1990; Bautista and Barrueta, 2000) the slaughtering age should be delayed.

In general, rabbit performance may have been influenced by the imbalance in the fibre content of feeds, and high temperature and relative humidity under which the trial was conducted, which exceeded the critical values for this species (Ferré and Rosell, 2000). In fact, it has been reported that high fibre content in feeds (Gidenne *et al.*, 2010) and thermal stress conditions (Cheeke, 1986) reduce feed consumption, thereby lowering growth. Rabbit performance may have also been influenced by the genetic potential of the line used. In fact, maximum adult weight reached in the farm of the National Institute of Hygiene "Rafael Rangel" that supplied the rabbits used in this trial is 4.5 kg (Moya *et al.*, 2006), a weight that is lower than the typical average mature weight of the New Zealand White breed (British Rabbit Council, 2014). Genetic potential could also explain the fact that nutritional needs of the animals were satisfied despite the reduced feed intake. However, it may be considered that overall fattening performance observed in this research when using *A. dubius* is better than that reported in previous studies using amaranth.

Apparent digestibility and digestible protein of amaranth and diets

There were no significant differences (P>0.05) between treatments in the CTTAD of DM, OM, CP, CF, NDF or ADF (on av. 65.4, 67.2, 80.2, 31.9, 29.3 and 22.8%, respectively; Table 5). The CTTAD of EE was higher for A16 compared to control diet (P<0.05; 92.4 and 86.0%, respectively), although both were similar to A32 diet, which suggests that the differences observed were not related to the levels of amaranth included.

The CTTAD of DM, CP and CF found in the present study were higher than those reported by Bautista and Barrueta (2000) for pelleted diets including 20 to 30% of leaves and seeds of *Amaranthus* spp., although our diets were higher in CF and similar in CP to those of these authors. On the contrary, the CTTAD the of DM, OM, CP and CF were lower than that reported by Bamikole *et al.* (2000) in rabbits fed non-pelleted diets with increasing inclusion up to 30% of inflorescences and unthreshed grain amaranth seed head, which were lower in CF and higher in CP than diets in the present research. Moreover, our experimental diets showed DM, OM and CP digestibility higher than reported in diets including 30% of some tropical foliage types (Nieves *et al.*, 2008).

Digestible protein of experimental diets (DPD) decreased from A0 to A32 diets (from 132.1 to 121.5 g/kg DM, respectively; P<0.05; Table 5) with increasing level of inclusion of amaranth. Digestible protein of diets obtained in

Table 5: Effect of *Amaranthus dubius* dietary inclusion level on coefficients of total tract apparent digestibility (CTTAD) and digestible crude protein of experimental diets in growing rabbits between 42 and 46 d of age (12 rabbits/treatment).

	Experimental diets[1]				
	A0	A16	A32	RMSE[2]	*P*-value
Feed intake[3] (g/d)	76.7	73.8	71.4	11.6	0.510
CTTAD (%)					
Dry matter (DM)	65.6	65.6	64.9	8.0	0.910
Organic matter	67.0	67.7	67.0	7.6	0.930
Crude protein	81.3	80.6	78.6	4.0	0.230
Ether extract[4]	86.0[b]	92.4[a]	90.9[ab]	4.7	0.047
Crude fibre[4]	30.0	32.6	33.3	7.8	0.730
Neutral detergent fibre[4]	26.0	31.6	30.4	9.2	0.443
Acid detergent fibre[4]	19.7	21.7	27.2	7.1	0.110
Digestible crude protein (g/kg DM)	132.1[a]	127.3[ab]	121.5[b]	6.6	0.003

[a-c]Means in the same row with different letters differ significantly (P<0.05).

[1]A0, A16 and A32 diets include 0, 160 and 320 g/kg (as feed) of *Amaranthus dubius*.

[2]RMSE: Root mean square error.

[3]Feed intake during the digestibility trial (42 to 46 d of age).

[4]Digestibility determined from pooled faeces (n=8 per treatment).

our trial were higher than reported by Kadi *et al.* (2011) in diets with 15 and 30% of sun-dried sulla hay (*Hedysarum flexuosum*). In general, our DPD values were higher than those rated the minimum to be acceptable for mixed rabbit feeds (Lebas, 2004).

Thus, our results indicate that *A. dubius* presented a good nutrient content, and diets containing it showed acceptable values of CTTAD and DPD. Therefore, it can be considered an interesting raw material for rabbit feed manufacturing. However, further research is necessary to confirm the present results and to determine its optimal level of inclusion in balanced feeds without affecting performance and health status of rabbits.

CONCLUSION

Growth performance, digestibility and health status observed in rabbits fed diets including *A. dubius* suggest that this vegetal can be considered a good source of fibre and protein for the formulation of feeds for growing rabbits, thus becoming a potential substitute for conventional raw materials, especially in the tropical and subtropical regions.

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