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POTENTIAL USE OF *CERATITIS CAPITATA* EXHAUSTED DIETS IN GROWING RABBIT DIETS

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ABSTRACT: An *in vivo* digestibility trial and a fattening trial were carried out to evaluate the potential dietary use of a dehydrated *Ceratitis capitata* exhausted diet (CED) on growing rabbits. For the digestibility trial, 2 pelleted diets were manufactured including 0 and 50% of dry matter (DM), excluding the premix, from CED (CED0 and CED50 diets, respectively), using 10 three-way crossbred rabbits of 42 days of age per diet. For the fattening trial, 3 almost iso-energetic, iso-protein and iso-fibrous pelleted diets were manufactured including 0, 15 and 30% of DM from CED (CED0, CED15 and CED30 diets, respectively), and offered to 180 weaned rabbits (60 per experimental diet) randomly housed in collective cages (5 animals per cage). Health status and performance traits were monitored from 28 to 58 days of age. CED was characterised by high water content (51%), but its DM was rich in fibre (15% ADF), high-digestible carbohydrates (27% of soluble sugars) and protein (17% of CP). The lysine (0.94% DM) and methionine (0.93% DM) contents of CED were similar to those observed for some common vegetal protein concentrates, but cysteine content was low (0.26% DM). The dietary inclusion of CED at 50% increased DM, organic matter and gross energy apparent digestibility coefficients (approx. +8%; $P<0.001$), but decreased CP digestibility (-4%; $P<0.001$). CED can be considered as a high energy feedstuff (14.1 MJ DE/kg DM) with medium digestible protein (119 g/kg DM). The dietary inclusion of CED at 15% did not affect mortality rate of the animals, but its inclusion in 30% was related with higher mortality (+6.6%). Growing rabbits presented a similar DM intake with CED0 and CED15 diets throughout the fattening period (97 g/d), but rabbits given a higher dietary inclusion of CED (CED30) presented lower DM feed intake (-6 g/d; $P<0.05$), and daily gain (-4 g/d; $P<0.05$). Thus, CED have an adequate nutritive value to be used in the formulation of rabbit diets, showing similar final performance traits to a commercial diet when it was included at 15% DM, although a reduction in the health status of the animals under Epizootic Rabbit Enteropathy conditions was observed at greater inclusion levels.

Key words: Rabbit, *Ceratitis capitata*, growth, digestibility, health.

INTRODUCTION

An alternative to the use of conventional insecticides for agricultural pest control is the Sterile Insect Technique, which consists of the production and release of specific sterile males with the aim of minimising their offspring (Meats *et al.*, 2006). Currently, there are many bio-plants for the control of *Ceratitis capitata* (fruit fly) around the world, which produce large amounts of the exhausted nutritive medium (exhausted diets) after this process as residue, with the environmental problems entailed (Tragsa, 2006).

These residues could have a potential nutritive value for animal feeding, because the nutritive media for the larval development of the *Ceratitis capitata* mainly consist of a fibrous bulking compound (wheat bran, lucerne hay, beet pulp…) enriched with highly available sources of protein and energy (mainly brewer's yeast and granulated sugars), although contain around 60% of water (Fay and Wornoayporn, 2002). Moreover, these residues are not included in the list of raw materials forbidden

for animal feeding, and the amount of residual insects remaining in the exhausted diets is close to that recommend by the Codex Alimentarius (Codex Stan 153-1985; FAO/WHO Food Standards, 1995) for cereal grains (lower than 0.1% w/w), and clearly below the values sometimes observed in raw materials used in organic livestock production.

So, ruminants (fresh or ensilaged; Tragsa, 2006) and rabbits (dehydrated) could utilize this product, considering its high fibre content. This fibre could be useful also to prevent digestive disorders in rabbits (De Blas and Mateos, 1998), and the presence of live brewer's yeast could improve the performance of rabbit after weaning (Maertens and Ducatelle, 1996), supporting the possible interest of this product for rabbit feeds.

The aim of the present work was to determine the potential use of dehydrated CED for growing rabbits, determining its nutritive value throughout a digestibility trial and the effect of its dietary inclusion at 15 and 30% (on DM basis) on the performance and sanitary status.

MATERIAL AND METHODS

Ceratitis capitata exhausted diets (CED)
The product evaluated in the present work was provided by the *Ceratitis capitata* bio-plant belonging to the company Tragsa, S.A. (Valencia, Spain). The original diet (before larval development) consisted of water (61.2%), beet pulp (14%), white sugar (12.5%), dehydrated brewer's yeast (10%), cacao powder (1%), hydrochloric (1%) and benzoic acid (0.3%). After larval development and diet withdrawal (9-12 days after), the CED the target of this work was obtained.

On reception day, CED was oven dehydrated at 60ºC for 24 hours at the experimental feed factory of the Institute of Animal Science and Technology of the Polytechnic University of Valencia. After dehydration to 89% DM, CED were milled and stored until use.

Digestibility trial

Diets
For the digestibility trial, two pelleted diets were formulated and manufactured, including 0 and 50% of DM, excluding the premix, from CED (CED0 and CED50 diets, respectively). Table 1 shows the ingredients used in the preparation of the basal mix and the premix (mineral-vitamin-additive complex), and the chemical composition of the experimental diets. The substitution of the basal mix by CED until 50% DM maintained the chemical composition values of the CED50 diet within the values recommended by de Blas and Mateos (1998) for growing rabbits on crude protein (CP; 16-18% DM) and neutral detergent fibre (NDF; 35-39% DM). The main difference between both diets was their fibre content (ADF; ~8% DM for CED50), but both under the mentioned recommendations. In order to minimize the effects of Epizootic Rabbit Enteropathy (ERE) in the trial, feeds were medicated providing 308, 200 and 50.4 ppm of neomycin, oxytetracycline and tiamulin respectively.

Experimental procedure
Apparent digestibility coefficients of DM, organic matter (OM), CP, crude fibre (CF), NDF, ADF, ether extract (EE) and gross energy (GE) were determined for each diet using 10 three-way crossbred rabbits, aged 42 days with average live weight of 1.27 kg (S.E.: 0.023 kg). The rabbits were housed in metabolic cages and feed and water were offered *ad libitum* during the experimental period. Following an adaptation period of 7 days, the faeces collection lasted 4 days (Perez *et al.*, 1995). Faeces were individually analysed for DM, OM, CP and GE, while CF, NDF, ADF and EE of faeces was determined in a pool from the animals given the same diet.

Table 1: Digestibility trial. Ingredients and chemical composition of the experimental diets (g/kg DM).

	Diets	
	CED0	CED50
Ingredients		
Ceratitis capitata exhausted diet (CED)	-	*489.65*
Basal mix	*979.3*	*489.65*
Wheat grain	120	60
Beet pulp	180	90
Wheat bran	80	40
Sunflower meal (30%CP)	210	105
Lucerne hay	356	178
Pork lard	30	15
DL-Methionine	0.8	0.4
Lysine	1.3	0.65
Threonine	0.7	0.35
Arginine	0.5	0.25
Premix	*20.7*	*20.7*
Sodium chloride	4	4
Monosodium phosphate	5	5
Vitamin/mineral mixture[1]	5	5
Anticcoccidial[2]	1	1
Antibiotics[3]	5.7	5.7
Chemical composition		
Dry matter (DM; g/kg)	908	895
Ash	85	72
Crude Protein (CP)	162	170
Ether Extract (EE)	47	34
Crude Fibre (CF)	214	154
NDF	410	314
ADF	323	241
ADL	70	46
Soluble Sugars (SS)	79	187
Starch (ST)	127	70
Gross Energy (GE; MJ/kg DM)	19.08	18.77

[1]Contains (g/kg): thiamine, 0.25; riboflavin, 1.5; calcium pantothenate, 5; pyridoxine, 0.1; nicotinic acid, 12.5; retinol, 2; cholecalciferol, 0.1; α-tocopherol, 15; phytylmenaquinone, 0.5; cyanocobalamin 0.006; choline chloride, 100; $MgSO_4$ H_2O, 7.5; ZnO, 30; $FeSO_4$ $7H_2O$, 20; $CuSO_4$ $5H_2O$, 3; KI, 0.5; $CoCl_2$ $6H_2O$, 0.2; Na_2SeO_3, 0.03. [2]Robenidine (66 g/kg). [3]Provide 308, 200 and 50.4 mg/kg of neomycin, oxytetracycline and tiamulin respectively to the diet.

The digestible energy (DE) and digestible protein (DP) of CED were calculated by difference, assuming additivity and no contribution from the mineral-vitamin-additive complex (Villamide *et al.,* 2001), e.g. for the energy:

DE (MJ/kg DM) = [(DE$_{CED50}$) − (DE$_{CED0}$×P$_B$)] / [P$_{CED}$×(1 ~ P$_P$)]

where DE$_{CED50}$ is the DE of CED50 diet and DE$_{CED0}$ the DE of CED0 diet (both in MJ/kg DM), P$_P$ the proportion of the premix in the DM of both diets (0.0207), P$_B$ the proportion of the basal mix in the DM of CED50 diet excluding that from premix (0.50), and P$_{CED}$ the proportion of CED in the DM of CED50 diet excluding that from premix (0.50) (Table 4). Calculation of the standard errors of digestible nutrients contained in the tested ingredient was done following the recommendations of Villamide *et al.* (2001).

Fattening trial

Diets
For the fattening trial, three iso-energetic, iso-proteic and iso-fibrous pelleted diets were formulated and manufactured including 0, 15 and 30% of DM from CED (CED0, CED15 and CED30 diets, respectively), following the recommendations of de Blas and Mateos (1998) for growing rabbits. Table 2 shows the ingredients and chemical composition of the experimental diets, where the inclusion of CED was done as a partial substitution of wheat grain, beet pulp, wheat bran and sunflower meal. Feeds were medicated in the same way as in the digestibility trial.

Experimental procedure
A total of 180 weaned rabbits (60 per experimental diet), aged 28 days with average live weight of 0.58 kg (S.E.: 0.012 kg), were randomly housed in collective cages (5 animals per cage). All the rabbits were individually identified by tattoo and had free access to one of the experimental diets from 28 to 58 days of age. The experimental design was done following the recommendations for applied nutrition research in rabbits described by the European Group on Rabbit Nutrition (Fernández-Carmona *et al.*, 2005).

Mortality and morbidity of the animals was daily controlled following the recommendations of Bennegadi *et al.* (2000) for measuring morbidity in rabbits. Individual live weight and average feed intake of the cage were controlled at 28, 35, 42, 49, and 58 days. A correction of feed intake data was done when one or more animals died during the week, registering the dates of deaths in order to determine the number of rations offered. For death animals was considered that they did not eat during the day previous to death and the previous days of this week were considered as morbid days. In addition, feed intake and conversion rate values were also corrected considering the number of total morbid days in a cage by a weight procedure to give a proportional greater reliability to those data coming from cages without morbidity and proportionality lower to those with more incidences.

Analytical methods
Chemical analysis of CED, diets and faeces were performed following the methods of the Association of Official Analytical Chemists (AOAC, 1991) for DM, ash, EE, CP and CF, and of Van Soest *et al.* (1991) for fibre fractions, with a thermostable amylase pre-treatment. Gross energy was determined by adiabatic bomb calorimetry (European Group on Rabbit Nutrition, 2001). Total soluble sugars (SS) were analysed using the Fehling reagent according to the method described by Matissek *et al.* (1998). Galacturonic acid was extracted from the CED samples with ethanol (Yu *et al.*, 1996), their content in the extracts being determined by the hydroxydiphenyl method (Kintner and Van Buren, 1982). Dietary starch content was determined according to a two-step enzymatic procedure, using a thermostable amylase followed by amyloglucosidase (Tecator, application note 85/86), and the resulting glucose being measured by the hexokinase/glucose-6 phosphate dehydrogenase/NADP system (Boeringher).

Table 2: Fattening trial. Ingredients and chemical composition of the experimental diets (g/kg DM).

	Diets		
	CED0	CED15	CED30
Ingredients			
Ceratitis capitata exhausted diet (CED)	0	150	300
Wheat grain	120	70	20
Beet pulp	180	148	115
Wheat bran	80	40	0
Sunflower meal (30%CP)	210	180	150
Lucerne hay	356	356	356
Pork lard	30	30	30
DL-Methionine	0.8	0.8	0.8
Lysine	1.5	1.5	1.5
Threonine	0.7	0.7	0.7
Arginine	0.5	0.5	0.5
Sodium chloride	4	4	4
Monosodium phosphate	*5*	*5*	*5*
Vitamin/mineral mixture[1]	5	5	5
Anticcoccidial[2]	1	1	1
Antibiotics[3]	5.7	5.7	5.7
Chemical composition			
Dry matter (DM; g/kg)	886	889	892
Ash	85	85	86
Crude Protein (CP)	162	167	165
Ether Extract (EE)	47	46	48
Crude Fibre (CF)	214	216	210
NDF	410	388	369
ADF	323	313	303
ADL	70	69	65
Soluble Sugars (SS)	79	105	132
Starch (ST)	127	76	38
Digestible Energy (MJ DE/kg DM)[4]	11.59	11.91	12.23

[1]Contains (g/kg): thiamine, 0.25; riboflavin, 1.5; calcium pantothenate, 5; pyridoxine, 0.1; nicotinic acid, 12.5; retinol, 2; cholecalciferol, 0.1; -tocopherol, 15; phytylmenaquinone, 0.5; cyanocobalamin 0.006; choline chloride, 100; $MgSO_4$ H_2O, 7.5; ZnO, 30; $FeSO_4$ $7H_2O$, 20; $CuSO_4$ $5H_2O$, 3; KI, 0.5; $CoCl_2$ $6H_2O$, 0.2; Na_2SeO_3, 0.03. [2] Robenidine (66 g/kg). [3] Provide 308, 200 and 50.4 mg/kg of neomycin, oxytetracycline and tiamulin respectively to the diet. [4]Calculated from DE values obtained in the present work for CED0 and CED, and from FEDNA (2003) tables for the rest of ingredients substituted.

Amino acid determination was done following the method described by Liu *et al.* (1995). After hydrolysis with HCl 6N and derivatization with 6-aminoquinolil-N hydroxysuccinimidyl carbamate, the amino acid content was determined using a high pressure liquid chromatography equipment (HPLC) fitted with a fluorescent detector (mod. 474), an automatic injector (mod. 717), 2 pumps (mod. 515) and a column AccQ-Tag of 3.9×150 mm, all from Waters (Ma, USA). α-aminobutyric acid was included in all the samples as internal standard.

Statistical analyses

Statistical analyses of the data from digestibility trial (DM intake, average daily gain and digestibility coefficients of DM, OM, CP and GE) were carried out according to a general linear model (GLM) procedure by SAS (Statistical Analyse System, 1996). Data were analysed as a completely randomised design with a model accounting for the fixed effect of the experimental diet (CED0 and CED50).

Data concerning health status of the animals during the fattening period (mortality, morbidity and sanitary risk index (SRI), the last calculated as the sum of both), were analysed according to a non-parametric procedure (NPAR1WAY), using a chi-square test for mean separation. Data on feed intake, growth and conversion rate from fattening trial were analysed using the PROC MIXED procedure of SAS (Statistical Analyse System, 1996), including the live weight at 28 days of age as a covariate. Percentage of non-morbid days in a cage was included as weight variable for the feed intake and conversion rate data analysis.

RESULTS AND DISCUSSION

Chemical composition of CED

The chemical composition and the amino acid content of CED are presented in Table 3. CED was characterised by high water content (51%), but its DM was rich on fibre (ADF 15% DM), high soluble sugars (SS 28.5% DM) and protein (CP 17% DM). From a comparative point of view, dehydrated CED could be considered as a product having a chemical composition close to wheat bran (13, 24 and 17% DM of ADF, starch and CP, respectively; Blas *et al.*, 2000; FEDNA, 2003) frequently used it in rabbit feed manufacturing, but considering that the main sources of fibre (beet pulp), high digestible carbohydrates (white sugar) and protein (brewer's yeast) are completely different.

Table 3: Chemical composition and amino acid content (g/kg DM) of the Ceratitis capitata exhausted diet.

Chemical composition		Amino acid content	
Dry matter (DM, g/kg)	486	Aspartic Acid	15.48
Ash	39	Serine	8.14
Ether extract	39	Glutamic Acid	22.84
Crude Protein	170	Glycine	8.03
Crude Fibre	113	Histidine	4.91
NDF	315	Arginine	8.27
ADF	147	Threonine	7.92
ADL	26	Alanine	8.81
Soluble Sugars	285	Proline	8.79
Starch	16	Cysteine	2.58
Galacturonic Acid	52	Tyrosine	5.88
		Valine	9.92
		Methionine	9.30
		Lysine	9.41
		Isoleucine	7.43
		Leucine	10.99
		Phenylalanine	8.21
		NH_3 (N free and from Tryptophan)	13.85
		Total	170.7

Concerning the protein quality, in the original product (before larval development) protein mainly came from brewer's yeast, but also from beet pulp (approx. 75 and 25%, respectively). However, in the final product this proportion could have changed and a part of the detected N could also come from the chitin of the pupae residue from non-successfully migrated larvae. The lysine (0.94% DM) content of CED is similar to those observed for some common vegetal protein concentrates such as sunflower meal, corn gluten and cotton seed (1.1, 1.0 and 0.8% DM, respectively; FEDNA, 2003), as a consequence of the high lysine content of brewer's yeast (3.2% DM), and its methionine content (0.93% DM) is even higher than that reported for sunflower and soybean meal (0.70 and 0.66% DM, respectively). Finally, the very low cysteine content (0.26% DM) of CED, reducing the sulphur amino acid content to 1.2% DM, could be its only unfavourable characteristic, as the content of the other amino acids are all between 0.75 and 2.3% DM.

Digestibility trial

Main results obtained during the digestibility trial with CED are presented in Table 4. Rabbits receiving the CED50 diet showed a significantly lower DM intake (~25.7 g/d; $P<0.001$), which could be explained by its higher energy content compared with CED0 diet (+1.27 MJ DE/kg DM) and/or the higher fibre content of CED0 diet (+10 points of percentage for the NDF) also established in the fattening trial. This difference in fibre content between two diets was justified to maximise the inclusion level of the test feedstuff, as was recommended by Villamide *et al.* (2001) to increase precision in the evaluation of a feedstuff. However, the DM intake observed for the animals receiving the CED50 diet (around 97 g/d) is in the normal range for this age (49 to 53 days) and may be considered as valid to determine the nutritive value of the diet.

Table 4: Digestibility trial. Feed intake, average daily gain and apparent digestibility coefficients of the experimental diets (49 to 52 d of age).

	Diets[1]		SEM[2]	*P*-value
	CED0	CED50		
No. of animals	10	10		
Feed intake (g DM/d)	122	97	3	<0.001
Daily gain (g/d)	47.9	35.6	1.8	<0.001
Apparent digestibility coefficients (%)				
Dry matter	61.3	69.3	0.8	<0.001
Organic Matter	61.5	70.0	0.8	<0.001
Crude Protein	75.0	70.6	0.8	<0.01
Gross Energy	61.0	68.5	0.7	<0.001
Crude Fibre[3]	26.6	22.9		
NDF[3]	36.2	33.9		
ADF[3]	29.5	25.3		
Ether Extract[3]	82.7	73.3		
Nutritive value				
Digestible Energy (DE, MJ/kg DM)	11.59	12.86	0.13	<0.001
Digestible Protein (DP, g/kg DM)	12.14	12.01	0.12	

[1]CED0 and CED50 include 0 and 50% of Ceratitis capitata exhausted diet (CED). [2]SEM: Standard error of the mean. [3]Digestibility determined from pooled faeces, not statistically analysed.

The inclusion of CED at 50% increased DM, OM and GE apparent digestibility coefficients (approx. +8 points of percentage; $P<0.001$), but decreased the digestibility of CP ($P<0.001$), EE and fibrous fractions (~4,~9 and ~4 points of percentage, respectively). The increase on DM, OM and GE digestibility with CED50 diet could be related to its greater content on soluble sugars (+11 points of percentage). In fact, soluble carbohydrates are absorbed more easily even than cereal starch at intestinal level (Blas and Gidenne, 1998). The reduction of CP digestibility observed with CED inclusion means a lower CP digestibility for CED than for basal mix. Taking into account the high digestibility of brewer's yeast protein, this result could be related to a lower brewer's yeast/beet pulp protein ratio after larval growth, and/or the presence of N coming from the insect residues.

From the inclusion level of CED and the values of DE and DP of the experimental diets, the nutritive value of CED for growing rabbits was calculated. CED can be considered as a high energy feedstuff (14.1 ± 0.09 MJ DE/kg DM) close to cereal grain values (14.9, 14.7 and 14.9 MJ DE/kg DM for corn, barley and wheat, respectively), with a DP content (119 ± 0.09 g/kg DM; apparently digestibility for CP of 71%) higher than these same cereals (68, 82 and 96 g/kg DM, respectively) (Villamide *et al.*, 1998). So, this product could be interesting for rabbit feed manufacturing.

Fattening trial

Table 5 shows some health parameters controlled throughout the fattening period. During the last decade, the outbreak of ERE has led to an important decrease in production (15-30% of mortality in some periods) on commercial farms, and our experimental farm has also been affected in recent years. So, mortality values registered for the control diet (CED0: 17%) could be considered as expected under these circumstances, in spite of the use of antimicrobials. The dietary inclusion of CED at 15% did not affect mortality of the animals, but its inclusion at 30%, although no significant differences were obtained, seems to provoke a greater mortality rate (+6.6 points of percentage). However, linear increase of morbidity and sanitary risk index were observed with the inclusion level of CED on the diet (+1% of SRI per each +1% of dietary CED inclusion; $P=0.07$). This impairment in health status was more evident during the first 3 weeks after weaning, since it is well established that maximum morbidity and mortality in a ERE outbreak occur during this period. Usual sugar content of commercial diets is around 25 g/kg DM for adult animals (Gidenne and Ruckebush, 1989), the ileal flow of sugars being practically insignificant. A high inclusion of high soluble carbohidrates could increase this

Table 5: Fattening trial. Mortality, morbidity and sanitary risk index

		Diets[1]		
		CED0	CED15	CED30
Mortality (%)	28 to 49 days	8.3	10.0	16.7
	49 to 58 days	9.1	3.7	8.0
	Total[2]	*16.7*	*13.3*	*23.3*
Morbidity (%)	28 to 49 days	1.7	15.0	21.7
	49 to 58 days	0.0	3.7	8.0
	Total[2]	*1.7[a]*	*18.0[b]*	*28.3[b]*
Sanitary Risk Index (%)[3]	28 to 49 days	10.0	25.0	38.0
	49 to 58 days	9.1	7.4	12.0
	Total[2]	*18.3[a]*	*31.6[ab]*	*51.6[b]*

[1] CED0, CED15 and CED30 include 0, 15 and 30%DM of *Ceratitis capitata* exhausted diet. [2]Means with a row not sharing any superscript are significantly different at $P<0.05$ (χ^2 test). [3]Sanitary Risk Index calculated as mortality + morbidity.

flow, affecting both caecal flora and fermentation, but there is a lack of knowledge about the possible effects of dietary soluble sugars on growing rabbits to confirm this hypothesis.

As the growth parameters are concerned, Table 6 shows the average daily gain, feed intake and conversion rate of animals fed the three experimental diets. Growing rabbits presented a similar DM intake with CED0 and CED15 diets throughout the fattening period (a mean of 97 g/d), but rabbits given a higher dietary inclusion of CED (CED30) presented lower DM feed intake (-6 g/d; $P<0.05$), perhaps related to their worst sanitary status. As a consequence of this lower feed intake, CED30 rabbits showed a significantly lower daily gain (~4 g/d; $P<0.05$). So, CED0 and CED15 animals presented a greater and adequate live weight at the slaughter date of 58 days (1970 and 1951 g, respectively), while animals given CED30 diet showed a significantly lower live weight (1871 g; $P<0.05$). As the daily gain reflects the differences in feed intake, no significant differences in conversion rate were observed between diets (a mean of 2.4). The lower feed intake and daily gain with CED30 diet originated mainly during the first 3 weeks after weaning, when the impairment in health status in rabbits given this diet was also more evident (see Table 5).

From these results, it can be concluded that CED have an adequate nutritive value to be used in the formulation of rabbit diets, but its inclusion at 30% in the diets of growing rabbits could impair their health status and performance under ERE conditions, leading to a lower feed intake and growth of the animals during the fattening period. When CED is included at only 15%, health and final performance traits similar to the control diet have been observed, its use being possible at this level in growing rabbits.

Table 6: Average daily gain, feed intake and conversion rate of growing rabbits with the different experimental diets.

		Diets[1]		
		CED0	CED15	CED30
Live weight (g)	28 days	582±16	580±16	583±16
	49 days	1558±16[b]	1555±17[b]	1459±17[a]
	58 days	1972±17[b]	1950±17[b]	1872±18[a]
Average daily gain (g/day)[2]	28-35 days	43.84±1.05[b]	44.39±1.09[b]	40.61±1.07[a]
	35-42 days	48.70±1.07[b]	49.11±1.10[b]	42.92± 1.15[a]
	42-49 days	45.30±1.10[b]	44.83±1.15[b]	39.79±1.19[a]
	49-58 days	45.28±1.15	43.49±1.16	43.58±1.23
	Total	*45.78±0.66[b]*	*45.45±0.68[b]*	*41.73± 0.70[a]*
Feed intake (g DM/day)[2]	28-35 days	67.09±2.14	64.40±2.21	62.79± 2.21
	35-42 days	91.75±2.20[b]	91.05± 2.25[b]	84.29± 2.35[a]
	42-49 days	109.2± 2.2[b]	110.5±2.3[b]	101.7±2.2[a]
	49-58 days	123.8±2.3[b]	118.5± 2.2[ab]	116.6±2.3[a]
	Total	*97.95±1.49[b]*	*96.12±1.52[b]*	*91.35±1.52[a]*
Feed conversion rate[2]	28-35 days	1.85±0.09	1.82±0.09	1.97±0.09
	35-42 days	2.07±0.09	2.03±0.09	2.44±0.09
	42-49 days	2.99±0.09	2.82±0.09	2.90±0.09
	49-58 days	2.93±0.09	3.04±0.09	2.93±0.09
	Total	*2.46±0.06*	*2.43±0.06*	*2.56±0.06*

[1]CED0, CED15 and CED30 include 0, 15 and 30%DM of *Ceratitis capitata* exhausted diet. [2]The live weight at 28 days of age was included as a covariate ($P<0.05$).

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