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ASIAN JOURNAL OF ANIMAL AND VETERINARY ADVANCES, 7(6), 521-527

DOI: 10.3923/ajava.2012.521.527

Effects of diets with increasing levels of dried tomato pomace on the performances and apparent digestibility of growing rabbits

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Abstract: The aim of this study was to determine the effects of three levels (0, 3 and 6%) of tomato (*Lycopersicon esculentum* Mill.) pomace (TP), included in isonitrogenous and isocaloric diets, on the performances and *in vivo* apparent digestibility of growing rabbits. The growing trial, which lasted 50 days, was carried out on 144 crossbred (Hycole x Grimaud) rabbits randomly divided into three groups. Each rabbit was kept in an individual cage. The mean mortality was about 8%, and there was no difference between the groups during the trial. The weight gain, feed consumption and feed efficiency values did not differ significantly for the different dietary treatments, while the final weight was higher in the rabbits fed the diet with 3% TP than in the control group. Ten animal per groups (five males and five females) were also submitted to a digestibility trial. The faeces were collected at the beginning of the second week of the growing trial with the animal at 46 days of age. No obvious health problems were encountered during the digestibility experiment. The measured parameters were: digestibility of dry matter (DM), organic matter (OM), crude protein (CP), ether

extract (EE) and gross energy (GE). The rabbits fed diet with 0 and 3% TP showed higher apparent digestibility coefficients than the rabbits fed a diet with 6% TP, with the exception of EE digestibility, which resulted higher in the rabbits fed the 3% TP diet. Overall, dried tomato pomace may be used satisfactorily as a nutrient supplement for rabbits at levels of up to 6% in diets.

Key words: *Lycopersicon esculentum*, *In vivo* digestibility, Intake, Rabbit.

INTRODUCTION

The introduction of alternative feedstuffs is an interesting challenge for animal nutritionists, as it could overcome the problems of environmental and production costs. Studies have recently been carried out to determine the performances and nutritive value of various seeds (Meineri and Peiretti, 2007; Peiretti *et al*., 2007; Peiretti and Meineri, 2008a; Peiretti *et al*., 2010) and of by-products (Peiretti and Meineri, 2008b) in rabbit trials.

Among the various agricultural by-products, tomato pomace (TP) is usually considered just a waste product which is often underutilised and its potential value is therefore lost. From the zootechnical point of view, tomato processing by-products can instead be a valuable energy and nutrient source that is obtained more cheaply than alternative ingredients to feed broiler chicks (Al-Betawi, 2005) and rabbits (Ahmed *et al*., 1994; Alicata *et al*., 1986; El-Razik, 1996; Gippert *et al*., 1988; Sawal *et al*., 1996; Devasena et al., 2007), when it is appropriately preserved. Alicata *et al*. (1986) investigated the effect of tomato seeds and skins on microflora activity in the caecum and volatile fatty acid in the caecum contents. They indicated that this by-product could be used in rabbit diets. Up to 20% of dried TP can be introduced into the diet of growing rabbits without any problem (Gippert *et al*., 1988). Ahmed *et al*. (1994), using 0, 10, 20 and 30% of TP in experimental diets on growing rabbits, concluded that TP levels of 10 and 20% can successfully be used as suitable ingredients in pelleted complete feeds for growing rabbits and more economically than

alfalfa meal. El-Razik (1996) studied the effect of the substitution of corn with TP (0, 5 and 10%) in growing rabbit diets on growth performance and carcass traits and concluded that TP can satisfactorily substitute corn grains. Sawal *et al*. (1996) studied the incorporation of TP in the diet of rabbits and reported that the optimum level of TP for rabbit diets was about 13.2%. Devasena *et al*. (2007) found that dried TP is a valid feed ingredient due to its good protein and energy content, and can be included in rabbit diets in levels up to 15% to reduce the cost of production.

The aim of the present research was to evaluate the effects of TP based diets on the performances of rabbits, but also the effects of TP supplementation on apparent digestibility in growing rabbits.

MATERIAL AND METHODS

Animals and diets

The study was carried out in the experimental rabbitry at the Department of Animal Sciences, located in Carmagnola (Turin, NW Italy), during the spring of the 2011. 144 weaned 38 day old crossbred (Hycole x Grimaud) rabbits were randomly assigned to three groups of 48 (50% male and 50% female rabbits each) with equal initial weight variability (1166±13 g). The animals were housed individually, at a temperature of 22±2°C, in wire cages at a height of 90 cm from the concrete floor. These groups were fed an isocaloric and isonitrogenous diet *ad libitum*, enriched with different levels (0, 3 and 6%) of dried TP. This experiment was conducted using TP obtained from a private tomato processing company (Tomatofarm Srl, Pozzolo Formigaro, Italy) in July 2010. The TP was ensiled for 2 months without any additive in a trench silo on a concrete floor and then dried in an oven at 60°C until constant weight. All the diets were pelleted fresh and stored in darkness in a temperature controlled room to avoid auto-oxidation of the lipid sources.

Growth performance

The live weight and feed intake of the rabbits were recorded on a fortnightly basis during the experimental period, except for the last period, which lasted 8 days. The data on the average daily weight gain and feed conversion ratio were calculated. The trial lasted 50 days.

Digestibility trial and analytical methods

The apparent digestibility of the experimental diets was measured in a digestibility trial, carried out at the same time, on ten animals per group (five males and five females) according to the European standardized method (Perez *et al*., 1995). The apparent digestibility of the three diets was determined during the second week of the growing trial with the animals at 46 days of age. The measured parameters were: digestibility of dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE) and gross energy (GE). The total collection of feaces was carried out daily at 09:00. The feaces were collected using a nylon net placed under each cage floor, to avoid urine contamination. The total individual daily feaces were weighed and placed in a two-layer plastic bag, to prevent the loss of moisture, and immediately frozen at - 20°C. The 5-day cumulative samples of frozen feces of each rabbit were pooled, mixed thoroughly and ground in a homogenizer (Tecator, Herndon, VA, USA). The pooled samples were dried in a draft oven at 80°C to constant weight and stored for chemical analysis. In order to determine the DM content, feed samples were dried for 8 hours at 105°C. All the dried samples were ground in a 1 mm screen Cyclotec mill.

All the analyses were carried out on duplicate samples. The diets and faeces were analyzed to determine the total N content (AOAC 955.04, 1990), ash by ignition to 550°C, and EE using the Soxlet method (AOAC 963.15, 1990). The GE was determined using an adiabatic bomb calorimeter (IKA C7000, Staufen, Germany).

Determination of the digestibility coefficients and statistical analysis

The apparent digestibility of the rations was calculated using the total collection of feaces

for each rabbit and for each diet according to the following equation:

d(%) = (ingested amounts – excreted amounts) / ingested amounts

Statistical analyses were performed using the SPSS software package (version 11.5.1 for Windows, SPSS, 2002). The analysis of variance was used to evaluate the effects of the diet on the performances and *in vivo* digestibility coefficients. Significant differences among the treatments means were determined using Duncan's test.

RESULTS AND DISCUSSION

The data of the chemical composition of the TP and the experimental diets of the present study are reported in Table 1.

The TP had high concentrations of water, crude fibre, and nitrogen free extracts and a moderate content of CP and EE. The chemical analysis of this by-product showed that the TP contained 94.5% OM. Alicata *et al*. (1988) and Ahmed *et al*. (1994) reported that TP had 96.5% OM. This difference could mainly be due to the cultivar type, the environmental condition and the TP processing methods.

The present results showed that the TP had a 9.4% EE content and similar results were reported by Paryad and Rashidi (2009), who recorded a 10.0% of EE in dried TP. El-Razik (1996) and Boucque and Fiems (1988) found that TP had an EE content of 8.0 and 8.9%, respectively, while Sawal *et al*. (1996) reported an EE content of 5.6% in dried tomato pulp. The variation in the fat content observed by different workers may be due to the variation in the seed content of the TP.

In the present work, the crude fibre (CF) content of TP was 42.9% and resulted higher than the values reported by Devasena *et al*. (2007) and Teli *et al*. (1983). In general, the present data and the results of previous authors showed that TP contained from 24 to 43% CF.

The CP content of TP found in the present study was 18.7%, which is in agreement with other authors (Del Valle *et al*. 2006) and this value makes this by-product attractive as a supplement

or protein source for rabbit diets. Brodowski and Geisman (1980) reported a CP content of whole tomato seed meal ranging from 22.9 to 23.7%, which concurred with the findings of Teli *et al*. (1983) and of Devasena *et al*. (2007).

The productive performance data are given in Table 2. The mean mortality was about 8%, without any difference between the groups. The weight gain, feed consumption and feed efficiency values did not differ significantly for the different dietary treatments, while the final weight was higher in the rabbits fed a diet with 3% TP than the control group. The results obtained in the present study are in agreement with those of Caro *et al*. (1993), who showed that there was no significant differences in weight gain or feed conversion ratio in the experimental groups fed diets with 10, 20, 30 or 40 % TP. The same authors found that the average daily feed intake of rabbits fed diets containing 30% TP was lower than that of rabbits fed diets with 0, 10 or 20% TP, and they stated that the lower feed intake may be due to the effect of the fat content of the TP. Ahmed *et al*. (1994) showed no significant differences in live weight, total and daily weight gain for four experimental groups of rabbits that ingested four experimental rations containing levels of 0, 10, 20 and 30% TP as a substitute for alfalfa for 7 weeks. The rabbits fed the diet containing 30% TP consumed the lowest amount of feed, while the rabbits fed the control diet (0% TP) consumed the highest amount of feed and, also in this case, the authors stated that this was probably due to the effect of the high fat content of the TP.

Sawal *et al*. (1996) instead stated that the incorporation of TP at levels of 0, 10 and 20% in the diet of rabbits significantly increased feed intake, while feed conversion efficiency decreased with increasing dietary TP content, and they concluded, using regression analysis, that the optimum level of TP for rabbit diets was about 13.2%. El-Razik (1996) reported that there were no significant differences in live body weight, total or daily weight gain between experimental rabbit groups fed diets containing 0, 5 and 10% TP, for 8 weeks. However, the rabbits which were fed the 10% TP diet recorded the highest live body weight, and daily weight gain values, and this was followed by

those fed 0% TP, while the rabbits fed 5% TP recorded the lowest values at 14 weeks of age. The improvement in body weight and weight gain in rabbits fed 10% TP may be related to the high CP contents of TP (20-23% CP). The differences in productive performance between the present results and previous works may be due to the breed and age of the rabbits and to the type of TP and supplemented diets.

As far as the digestibility trial is concerned (Table 3), the rabbits fed diets with 0 and 3% TP showed higher apparent digestibility coefficients than the rabbit fed a diet with 6% TP, with the exception of EE digestibility, which was higher in the rabbits fed the diet 3% TP diet.

Devasena *et al*. (2007) found significant differences in the digestibility of EE, CF and cellulose. These authors found an increase in the digestibility of cellulose in 10 and 15% TP included diets, whereas they observed no significant differences in the digestibility coefficients of neutral detergent fibre (NDF), acid detergent fibre (ADF) and hemicellulose fractions, OM, DM, CP and nitrogen free extract (NFE). Improvements in digestibility of EE were reported by Sawal *et al*., (1996), who included TP at a 20% level in rabbit diets and suggested that the oil content was highly digestible. Gippert *et al*. (1988) reported that the substitution of 10 and 20% alfalfa meal with TP increased the utilization of nutrients in rabbits.

Alicata *et al*. (1988) and Sawal *et al*. (1996) showed that the inclusion of 20% TP in rabbit diets increased the digestibility coefficients of all the nutrients especially the CF and EE digestibilities. Sayed and Abdel-azeem (2009) found significant differences between different experimental groups of rabbits fed different levels of dried TP (10, 20 and 30%) in the EE and CF digestibilities and the diet containing 20% TP recorded higher values compared to the other treated groups, while they found no significant differences in the DM, CP and NFE digestibilities between groups.

Aghajanzadeh-Golshani *et al*. (2010) estimated the nutritive value of TP using an *in vitro* gas production technique and concluded that OMD was 62.4%. Mirzaei-Aghsaghali *et al*. (2011)

found a similar *in vitro* OMD value (62.0%), while Chumpawadee *et al*. (2007) found lower *in vitro* OMD values that ranged from 35.4 to 36.5%. Many factors, such as differences in the tomato cultivar, environment conditions, method type and animal species may partially explain the differences in the *in vitro* OMD in the different studies.

CONCLUSIONS

TP may be used satisfactorily as a nutrient supplement for rabbits at levels of up to 6% in the diet without any adverse effect on the performance or nutritive value, even though a better digestibility was found in rabbits fed diet with 3% TP.

ACKNOWLEDGEMENTS

Thanks are due to Dr. R. Bianchi and Dr. A. Micone (Tomatofarm s.r.l - Pozzolo Formigaro) for providing the tomato pomace silages, Mrs.V. Malfatto for the technical support and Mr. L. Sola and Mr. D. Sola for the care of the rabbits.

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Table 1: Ingredients of the experimental diets and chemical composition of the tomato pomace and diets

	Tomato pomace	Diets		
		0% tomato pomace	3% tomato pomace	6% tomato pomace
Ingredients (%)				
Alfalfa meal (17%CP)		29.0	27.0	25.0
Barley		19.0	19.0	19.0
Wheat bran		20.0	20.0	20.0
Dried beet pulp		14.0	14.0	13.0
Soybean meal (45%CP)		6.0	6.0	6.0
Sunflower meal (30%CP)		6.0	6.0	5.0
Tomato pomace		0.0	3.0	6.0
Molasse		1.5	1.5	1.5
Soybean oil		1.0	1.0	1.0
Corn gluten		1.0	1.0	1.0
Wheat straw		1.0	0.0	0.0
Corn meal		0.0	0.0	1.0
Vitamin-mineral premix[1]		1.0	1.0	1.0
Bicalcium phosphate		0.5	0.5	0.5
Chemical composition (% of DM)				
Dry matter	23.5	90.8	91.4	91.3
Organic matter	94.5	93.2	93.4	93.6
Crude ash	5.5	6.8	6.6	6.4
Crude fibre	42.9	18.9	18.8	19.2
Ether extract	9.4	2.9	3.5	3.5
Crude protein	18.7	18.2	18.1	18.2
Nitrogen free extract[2]	23.8	53.2	53.0	52.7
Gross energy (MJ kg^{-1} DM)	23.7	18.9	18.6	19.1

[1]per kg of diet: Vitamin A 200 U, α-tocopheryl acetate 16 mg, Niacine 72 mg, Vitamin B_6 16 mg, Choline 0.48 mg, DL-methionine 600 mg, Ca 500 mg, P 920 mg, K 500 mg, Na 1 g, Mg 60 mg, Mn 1.7 mg, Cu 0.6 mg.

[2] Calculated as: [100 – (%Crude protein +%Ether extract +%Ash +%Crude fiber)].

Table 2: Productive performance (mean ± s.e.) of the rabbits fed the experimental diets

	Tomato pomace (% of diet)		
	0	3	6
Number of animals	44	44	44
Initial weight (g)	1155±21	1188±25	1156±23
Final weight (g)	3101±39[a]	3268±48[b]	3196±41[ab]
Total feed consumption (g)	6866±131	7262±140	7071±118
Total weight gain (g)	1947±34	2081±46	2040±38
Daily feed (g)	143±3	151±3	147±2
Daily weight gain (g)	40.6±0.7	43.3±0.9	42.5±0.8
Feed/gain ratio	3.53±0.05	3.53±0.06	3.49±0.05

[a,b] The means in the same row with different superscripts differ (P<0.05).

Table 3: *in vivo* apparent digestibility coefficients obtained from the total collection of feaces (mean ± s.e.) of the experimental diets

	Tomato pomace (% of diet)		
	0	3	6
Number of animals	10	10	10
Dry matter	66.1±0.6[a]	66.3±1.6[a]	61.8±0.7[b]
Organic matter	66.5±0.6[a]	67.0±1.6[a]	62.7±0.7[b]
Crude protein	76.3±0.6[a]	76.6±1.3[a]	72.6±0.8[b]
Ether extract	76.3±0.6[a]	81.4±0.9[c]	78.5±0.6[b]
Gross energy	65.6±0.6[a]	66.6±1.8[a]	61.1±0.6[b]

[a,b,c] The means in the same row with different superscripts differ (P<0.01).