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Short communication

Influence of exogenous enzymes ensiled with orange pulp on digestion and growth performance in lambs

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ABSTRACT

Twenty-four Ossimi male lambs were used to evaluate effects of inclusion of ensiled orange pulp (EOP) in lamb diets either with or without addition of exogenous enzymes (ENZ) of ZADO® on digestion and growth performance. Lambs (21.1 ± 1.01 kg body weight (BW)) were assigned to one of three groups of 8 animals/group in a randomized complete block design being: Control (basal diet with 0 g/kg EOP), EOP (Control with 150 g/kg EOP) or EOP + ENZ (EOP with 5 g/kg of ZADO®) in a 90-day experiment. Ensiling the orange pulp increased the crude protein, ether extract and metabolizable energy of the silage by 29, 46 and 8%, respectively, and reduced the secondary metabolites, such as total phenolics, saponins and alkaloids. Silage lactic acid and ethanol were increased by 35% and 54%, respectively for EOP and EOP with ENZ, but all silage quality parameters were in the normal range. Concentration of NH_3–N before feeding was decreased ($P < 0.05$) by 11 and 13% in EOP and EOP + ENZ, respectively, whereas at 3 and 6 h after feeding ruminal VFA concentration was increased ($P < 0.05$) by 23 and 9% respectively, only in EOP + ENZ lambs. NDFom intake was increased ($P = 0.036$) by 52 and 59%, whereas the ADFom increased ($P = 0.032$) by 8 and 11% in EOP and EOP + ENZ lambs, respectively. Nutrients digestion were higher ($P < 0.05$) in EOP + ENZ than EOP lambs. Digestible DM was increased by 18%, whereas the fiber fractions (NDFom and ADFom) were increased by 93 and 47% with similar EOP + ENZ. DM intake among groups, whereas feed efficiency was higher ($P = 0.042$) by 19 and 31% in EOP and EOP + ENZ lambs compared to control diet. Live weight gain increased ($P = 0.038$) by 92% in EOP + ENZ lambs whereas it increased by 54% in EOP lambs. Addition of EOP to the diet improved feed efficiency and live weight gain suggesting a good quality feed, which could probably be used to replace a part of the concentrate in ruminant diets.

1. Introduction

Citrus pulp is an industrial by-product, used mainly in ruminant diets (Gohl, 1981), and could be fed fresh, ensiled or dried. Fresh citrus pulp, due to its high moisture content, cannot be stored for long and so ensiling is a practical option

Abbreviations: ADFom, acid detergent fiber; BW, body weight; CP, crude protein; DM, dry matter; ENZ, exogenous enzymes of ZADO®; EOP, ensiled orange pulp; NDFom, neutral detergent fiber; OM, organic matter.

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Table 1
Ingredient and chemical composition of the lamb diets.

	Diets[a]		
	Control	EOP	EOP + ENZ
Ingredients (g/kg)			
Yellow corn grain	300	230	230
Molasses, liquid	5.8	0	0
ZADO®	0	0	5
Cottonseed cake	165	90	90
Soybean meal	120	120	120
Berseem (*Trifolium alexandrinum*) hay	150	150	150
Ensiled orange pulp	0	150	150
Rice straw	231	231	230
Salt	6	6	5
Limestone	20.2	21	18
Mineral/vitamin premix[b]	2	2	2
Chemical composition (g/kg DM)			
Organic matter	914	918	919
Crude protein	125	127	126
Ether extract	26	36	35
Neutral detergent fiber (om)	296	310	307
Acid detergent fiber (om)	201	221	223
Lignin (sa)	101	116	112
Metabolizable energy[c]	2.49	2.49	2.64

[a] Containing/kg of diet: control (0 g/kg EOP); EOP (150 g/kg EOP); and EOP + ENZ (150 g/kg EOP with 5 g/kg ZADO®).
[b] Mineral/vitamin premix(per kg): Ca, 190 g; P, 115 g; Mg, 63 g; Cl, 167 g; K, 380 g; Na, 70 g; S, 53 g; Co, 3.3 mg; Cu, 197 mg; Fe, 360 mg; Mn, 900 mg; Se, 2 mg; Zn 810 mg; Vit. A 940 1000 IU; Vit. D 165 1000 IU; Vit. E 374 1000 IU.
[c] MJ/kg DM calculated according to Nsahlai et al. (2004).

to facilitate year-round feeding, particularly in the dry season when feeds are often scarce. These by-products (*i.e.*, citrus pulps) are widely available in Mediterranean countries, especially Egypt, and it is inexpensive relative to its nutritive value (Guessous et al., 1989; Gado et al., 2009). It contains a relatively high amount of pectin and soluble carbohydrates therefore dried citrus pulp has successfully been used to replace cereals in ruminant diets (Fegeros et al., 1995; Piquer et al., 2009). Use of citrus pulp has been associated with beneficial effects on ruminal fermentation, fiber digestion and microbial protein synthesis (Miron et al., 2001; Gado et al., 2009). Beneficial effects have also been reported in dairy cattle (Gado et al., 2009) and in small ruminants (Fegeros et al., 1995; Aregheore, 2000). Supplementation of low quality feeds with citrus pulps is therefore a strategy to improve voluntary feed intake and digestibility, that has been attributed to increased rate of forage digestion and passage (Scerra et al., 2001).

Research in the area of exogenous enzyme supplements for ruminants has focused on fibrolytic enzyme preparations and their effects on fiber digestion. In addition increased ruminal fiber digestion often explains improvements in ruminant productivity resulting from dietary supplementation with fiber degrading enzymes (Gado et al., 2009; Arriola et al., 2011; Holtshausen et al., 2011). Such enzymes have been shown to improve growth of steers fed some dry forages (Beauchemin et al., 1995), and milk production of dairy cows (Gado et al., 2009; Arriola et al., 2011; Holtshausen et al., 2011). However, information is scarce on effects of addition of exogenous enzymes during ensilage of citrus pulp on performance of ruminants. The objective of this experiment was to evaluate the effect of exogenous enzymes ensiled with orange pulp on digestion and growth performance in lambs.

2. Materials and methods

2.1. Animals, management and feeding

Twenty-four Ossimi male lambs of 20.9–21.4 kg body weight (BW) were used in a 90-day experiment and were randomly assigned to three treatment groups (8 animals of each) in a complete block design. Treatments (Table 1) were – Control group 0 g/kg EOP; EOP 150 g/kg EOP and EOP + ENZ was (150 g/kg EOP plus 5 g/kg ZADO®). For the EOP, it was ensiled fresh orange pulp with chopped 200 g/kg of chopped rice straw (*i.e.*, 3–5 cm) in a ratio 80:20 (DM) to limit ensiling losses due to the high moisture content of the orange pulp. After mixing, all the contents were transferred to a baling machine and pressed together into a plastic raving machine to remove air before ensiling for 30 days. The same process was used for the EOP + ENZ, except for the extraction of some EOP fluid to mix and dissolve the ZADO. ZADO® is a patented product manufactured by the Academy of Scientific Research and Technology, Egypt, and contains a mix of anaerobic bacteria and their enzymes of cellulases (7.1 unit/g), xylanases (2.3 unit/g), α-amylase (61.5 unit/g), protease (29.2 unit/g) in a powder form obtained through an anaerobic fermentation process. Ingredients and chemical composition of the diets are presented in Table 1. The concentrates were mixed and given separately from the silage to lambs. Lambs were fed the silage offered *ad libitum*. Rations were fed twice daily in equal portions at 8:00 and 16:00 h. Daily feed intake was calculated after weighing residues