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SUMMARY – The use of a by-product of the recently developed two-stage centrifugation process to extract olive oil, the *dry and extracted two-stage olive cake* (TSOC), in goats and sheep feeding is studied. Samples of TSOC were treated with PEG 4000 MW (0, 20, 60, 100 and 200 g/100 g by-product). The addition of PEG significantly modified the CP and the N-ADF contents ($P < 0.05$ and $P < 0.01$, respectively). The IVOMD, increased significantly ($P < 0.05$) when 100 g of PEG/100 g by-product was added. The extent and rate of rumen degradation of CP were determined using the *in sacco* procedure, in goats and wethers. The effective rumen degradability and the rate of degradation significantly ($P < 0.05$) increased with the addition of more than 20 g of PEG/100 g by-product either in goats and wethers.

Key words: Two-stage olive cake, by-products, PEG, tannins, goats, sheep.

RESUME – *"Effet de l'apport de PEG sur la disponibilité des nutriments chez la chèvre et le mouton avec le sous-produit issu des nouvelles technologies de l'extraction d'huile d'olive". L'utilisation dans l'alimentation des chèvres et des moutons du sous-produit issu d'un procédé récemment développé pour l'extraction de l'huile d'olive par centrifugation en deux phases,* "le grignon d'olive *sec* et épuisé en deux phases"*, a été étudié. Des échantillons du sous-produit ont été traités avec du PEG 4000 PM (0, 20, 60, 100 et 120 g/100 g sous-produit). Les contenus du sous-produit en matières azotées totales et celles rattachées aux parois cellulaires ont été modifiés significativement par l'addition du PEG ($P < 0,05$ et $P < 0,01$, respectivement). La digestibilité* in vitro *de la matière organique augmentait significativement ($P < 0,05$) avec l'addition de 100 g de PEG/100 g sous-produit. La quantité des MAT dégradées dans le rumen et la vitesse de la dégradation ont été déterminées en utilisant la méthode* in sacco*, aussi bien chez les chèvres que chez les moutons. La dégradabilité effective dans le rumen aussi bien que la vitesse de dégradation augmentait significativement ($P < 0,05$) avec l'addition de plus de 20 g de PEG/100 g de sous-produit chez les chèvres et chez les moutons.*

Mots-clés : *Grignon d'olive deux phases, sous-produit, PEG, tannin, chèvre, mouton.*

Introduction

A two-stage centrifugation process to obtain olive oil is being increasingly used in Spain. The initial residue from this new technology is subsequently dried and extracted giving a by-product, *dry and extracted two-stage olive cake* (TSOC). The phenolic compounds, especially those like tannins may have a deleterious effect on the nutrients utilisation (Reed, 1995; Ramirez and Ledezma-Torres, 1997) and, as a consequence, limit their use in animal feeding (Makkar *et al*., 1993). The addition of tannin complexing compounds like PEG could avoid the negative effects of the tannins. It is also generally accepted that there are animal species with different ability to adapt to feeds containing tannins (Nastis and Malecheck, 1981; Holechek *et al*., 1990).

The objective of the present work is to study the effect of the addition of PEG on the chemical composition of the TSOC and on both the *in vitro* digestibility and the rumen degradability of the TSOC's nutrients in goats and sheep.

Material and methods

Samples of TSOC (10.4 and 9.78 mg/g DM TSOC of total extractable polyphenols and tannins respectively), were treated with a water solution of PEG (4000 MW) to add 0, 20, 60, 100 or 200 g of

PEG/100 g TSOC. Treated samples were dried at 60°C for 72 hours. The content of dry matter (DM), organic matter (OM), crude protein (CP), crude fat (CF), gross energy (GE), neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent lignin (ADL) and N attached to the cell wall were analysed according to the methodology described in a previous work (García *et al*., 1995).

The *in vitro* organic matter digestibility (IVOMD) was determined according to the Daisy-Ankom technology. The rumen liquor was drawn from 3 dry non-pregnant Granadina goats or from 3 Segureña wethers fitted with permanent rumen cannulae. The animals were fed lucerne hay and a mineral-vitamin mixture at maintenance level and had free access to water.

The *in situ* rumen degradability of CP of samples was estimated using the nylon bag procedure (Madsen and Hvelplund, 1994). Three Granadina goats and three Segureña wethers were used for the incubation of samples for 0, 4, 8, 16, 24, 48 and 72 hrs in bags (7 x 12 cm; 36 µm of pore size). The degradation profiles were determined using the Ørskov and McDonald (1979) model. The effective degradability (ED) was calculated as *[ED = a + [bc/(c +k)]* using passage rate (k) values obtained in previous works (Isac *et al*., 1994; García *et al*., 1995), 0.032 and 0.025, respectively for goats and sheep.

Results and discussion

The effects of the addition of different amounts of PEG on the chemical composition, IVOMD and rumen CP degradability of the CP of TSOC are shown in Table 1. The addition of PEG significantly ($P < 0.05$) decreased the N-ADF content and did not significantly affect the cell wall components. The decreasing of the N-ADF could indicate that the PEG releases the complexes tannin-protein (Reed, 1995).

Table 1. Effect of the addition of polyethylene glycol on the chemical composition (g/100 g DM), on the *in vitro* organic matter digestibility (%) and on the crude protein ruminal degradation of the dry and extracted two stage olive cake

PEG g/100 g TSOC	0	20	60	100	200	LS
Dry matter (g/100 g fresh matter)	93.2^{e}	98.6^{a}	95.3^{b}	94.8^{c}	94.1^{d}	P < 0.001
Organic matter	84.7^{d}	85.5^{d}	90.4^{c}	92.2^{b}	94.9^{a}	P < 0.001
Crude protein	7.89^{a}	6.88^{b}	6.71^{b}	6.42^{b}	6.31^{b}	P < 0.05
N-ADF (g/100g TN)	71.0^{a}	64.7^{a}	63.7^{a}	52.7^{b}	50.9^{b}	P < 0.01
Crude fat	0.13	0.54	0.49	0.43	0.65	NS
Neutral detergent fibre	62.4	59.1	56.2	58.2	59.2	NS
Acid detergent fibre	54.0	47.0	45.3	52.7	53.7	NS
Acid detergent lignin	32.8	26.6	26.9	30.5	29.6	NS
Gross energy (cal/g DM)	4459	4347	4499	4550	4436	NS
In vitro organic matter digestibility (%)						
Goats	28.3^{c}	25.8^{c}	28.5^{c}	39.2^{b}	56.8^{a}	P < 0.001
Sheep	28.6^{b}	29.0^{b}	27.6^{b}	27.0^{b}	38.8^{a}	P < 0.01
Rate of CP ruminal degradation (/h)						
Goats	0.074^{b}	0.094^{b}	0.155^{a}	0.072^{b}	0.160^{a}	P < 0.01
Sheep	0.062^{b}	0.096^{a}	0.069^{b}	0.050^{b}	0.072^{ab}	P < 0.05
Effective degradability of CP (%)						
Goats	44.7^{c}	68.8^{b}	77.5^{a}	69.1^{ab}	76.3^{ab}	P < 0.01
Sheep	48.6^{d}	72.6^{ab}	68.9^{bc}	67.5^{c}	74.1^{a}	P < 0.05

^{a,b,c,d,e}For the same row values with the same letter do not differ significantly.

The IVOMD obtained by using either rumen liquor from goats or from sheep increased only by the addition of more than 100 g of PEG/100 g of the by-product but the effect was more important when

the inoculum was drawn from goats. The differences found between goats and sheep concerning the effect of PEG's addition could be explained by an especial ability of goats to adapt to the presence of tannins in the food (Nastis and Malecheck, 1981; Holechek *et al*., 1990). Our results are in agreement with those of Rittner and Reed (1992) and those of Makkar *et al*. (1987) who found a negative correlation of phenolics with the *in vitro* digestibility.

Both the rate of CP degradation and the effective degradability significantly ($P < 0.05$) increased by the addition of PEG. That observation may agree to Leinmüller *et al*. (1991) who considered that tannin containing feedingstuffs affect rumen metabolism mainly by inhibition of cellulose and protein degradation.

It is concluded that PEG addition improves the IVOMD and both the extent and the rate of protein degradation in the rumen of the TSOC. The effect is more important for goats than for sheep.

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