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Short communication

Effects of protein protection with orthophosphoric or malic acids and heat on fattening lamb diets

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ABSTRACT

The objective of this research was to examine the effects of treating sunflower and spring pea meals with orthophosphoric or malic acid solutions and heat on growth performance, concentrate intake, and carcass yield and fatness of growing-fattening lambs. Ninety "Entrefino" cross male lambs from three commercial farms (average initial body weights (BW) = 14.6, 15.3 and 13.3 kg) were randomly assigned to five diets with different acid treatment and protein levels, and fattened to an average slaughter weight of 25 kg. Protein sources in the control concentrate (C; crude protein (CP) = 18%) were soybean meal and untreated sunflower and spring pea meals. In three of the experimental concentrates, orthophosphoric acid-treated meals substituted untreated sunflower and spring pea meals (Orthophosphoric Control, PC; CP = 18% dry matter basis (DM)), and soybean meal was partially (Medium Substitution Orthophosphoric, MSP; CP = 16.7%) or totally removed (Total Substitution Orthophosphoric, TSP; CP = 15.6%). In addition, in one concentrate orthophosphoric acid was replaced by malic acid to protect these meals (Medium Substitution Malic, MSM; CP = 16.7%). Wheat straw (roughage source) and concentrate were offered *ad libitum*. No effect associated with the CP level was observed on any parameter. This suggests that with protected proteins it is possible to feed concentrates with 15.6% CP (on DM) reducing the need to include vegetable protein meals as well as the quality of the protein concentrates. Lambs fed MSM had higher average daily gains (15.2%; $P = 0.042$), and better hot carcass yields (1.3 percentage points; $P = 0.037$) than lambs fed MSP. This probably can be explained by ruminal malate actions and by greater protection effects obtained with malic acid.

1. Introduction

Sunflower meal is a co-product of sunflower oil extraction; with variable content of crude protein (CP) (31–37% as DM) depending upon the extent of de-hulling of the seed (Sauvant et al., 2004). Its protein is highly degradable in the rumen, normally above 80% (Arroyo et al., 2012; González et al., 1999; Woods et al., 2003). Since sunflower meal protein is characterized by a relative lysine deficiency and a high content in sulphur amino acids and tryptophan, it complements well the aminoacid profile of leguminous seeds (FEDNA, 2010). Due to their high protein content, the European Union has promoted the production of peas (*Pisum sativum*; Aufrere et al., 2001) although its proteins have the limitation to be also highly degradable in the rumen (Institut National de la Recherche Agronomique (INRA), 2007; Khorasani et al., 2001; Petit et al., 1997). Therefore, to reduce this degradability without reducing the intestinal digestibility of the by-pass protein is of interest to improve the use of these both meals. In this sense, Díaz-Royón et al. (2015) reduced CP effective degradability values (corrected by the ruminal microbial contamination) of sunflower meal from 80.1% to 69.1% and to 59.4% treating with orthophosphoric acid or malic acid plus heat, respectively. Similarly, the reductions for spring pea were from 88.1% to 75.3% and to 73.3%, respectively.

The objective of this research was to examine the effects of treating sunflower and spring pea meals with orthophosphoric or malic acid solutions and heat on growth performance, concentrate intake, and carcass yield and fatness of growing-fattening lambs.

2. Materials and methods

2.1. Animals, treatments, and experimental procedures

The experiment was carried out at "Los Campos de Prácticas of the E.T.S.I. Agrónomos". Animals' management was approved

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Table 1
Ingredient and chemical composition (% unless otherwise noted) of the experimental concentrates.

Item	C[a]	CP	MSP	TSP	MSM
Ingredient composition (%)					
Ground barley	53.2	53.2	55.9	58.5	55.2
Ground corn	13.1	13.1	13.8	14.6	13.7
Sunflower meal	10	0	0	0	0
Sunflower orthophosphoric meal	0	10	10	10	0
Sunflower malic meal	0	0	0	0	10.4
Spring pea	10	0	0	0	0
Spring pea orthophosphoric	0	10	10	10	0
Spring pea malic	0	0	0	0	10.4
Soybean meal	6.80	6.80	3.40	0.00	3.40
Lard	3.00	3.00	3.00	3.00	3.00
Calcium carbonate	2.50	2.50	2.50	2.50	2.50
Ammonium chloride	0.50	0.50	0.50	0.50	0.50
Salt	0.30	0.30	0.30	0.30	0.30
Sodium sulfate	0.35	0.35	0.35	0.35	0.35
Vitamin-Mineral Premix	0.30	0.30	0.30	0.30	0.30
Chemical composition (% of DM basis)					
Dry matter (% of fresh matter)	89.6	89.7	89.2	89.8	91
Organic matter	94.3	93.7	94.1	94.1	93.8
Crude protein	18.1	18.1	16.9	15.6	16.7
NDF	21.7	18.4	18.5	19.5	18.4
ADF	7.24	7.04	8.33	7.94	8.08
Lignin (sa)	1.35	1.47	1.95	2.06	1.82
Eter extract	5.51	5.5	5.52	5.54	5.53
UFV[b](/kg DM)	1.11	1.1	1.12	1.11	1.10

[a] C = control concentrate; CP = control orthophosphoric concentrate; MSP = medium substitution orthophosphoric; TSP = total substitution orthophosphoric; MSM = medium substitution malic concentrate.
[b] Unites Fourrageres Viande calculated according to values from tables Institut National de la Recherche Agronomique (INRA) (2007).

by the Animal Ethics Committee of Universidad Politécnica de Madrid and was carried out in accordance with the Spanish guidelines for experimental animal protection (Royal Decree 53/2013 of February 1st on the protection of animals used for experimentation or other scientific purposes). Ninety weaned "Entrefino" cross male lambs were used from three commercial farms (30 lambs each). Average initial body weight (BW) was 14.62 ± 3.21; 15.3 ± 2.31, and 13.3 ± 1.89 kg (mean ± standard deviation (SD)) for farm A, B and C, respectively. Lambs blocked by farm and initial BW were randomly distributed to pens of three lambs each in a factorial design of five dietary treatments with two replicates (pens) of each treatment per farm. The three lambs of each group were housed in slatted floor pens (1.5 m^2) equipped with two feeders (one for concentrate, another for straw), and an automatic drinker. Before weaning, lambs were vaccinated against enterotoxaemia and dewormed with Ivermectin. At the beginning of the experiment lambs were dewormed again with Closantel. Commercial spring pea and semi-decorticated sunflower meals were treated with solutions (200 ml/kg) of orthophosphoric acid (1.33 M; 130.6 g/l) or malic acid (2 M; 268.2 g/l) and heat (120 °C) following the procedure indicated in Díaz-Royón et al. (2015).

The five experimental diets consisted of wheat straw (roughage source) and one of five concentrate supplements. Concentrates were formulated to be isoenergetic and were designed to meet Institut National de la Recherche Agronomique (INRA) (2007) nutrient recommendation for male growing-fattening lambs with moderate growth potential. Concentrate ingredients and chemical composition are presented in Table 1. Contents (g/kg of dry matter (DM)) of CP, neutral detergent fibre (NDF) and acid detergent fibre (ADF) in wheat straw were 36.0, 791 and 508, respectively. Protein sources in the control concentrate (C; CP = 18%) were soybean meal, and untreated sunflower and spring pea meals. In three of the experimental concentrates, orthophosphoric acid-treated meals substituted untreated sunflower and spring pea meals (Orthophosphoric Control, PC; CP = 18%), and soybean meal was partially (Medium Substitution Orthophosphoric MSP; CP = 16.7%) or totally removed (Total Substitution Orthophosphoric, TSP; CP = 15.6%). In addition, in one concentrate orthophosphoric acid was replaced by malic acid to protect (Medium Substitution Malic, MSM; CP = 16.7%). The chemical composition and protein fractions of both untreated and treated sunflower and spring pea meals has been shown in Díaz-Royón et al. (2015). Both sunflower and pea meals supplied 31.1, 30.9, 33.0, 35.8 and 33.1% of the total CP in concentrates C, CP, MSP, TSP and MSM, respectively. All ingredients of the concentrates were ground through a 3-mm screen, mixed, and pelleted to 3-mm diameter. Wheat straw and concentrate were offered ad libitum, refilling the feeders daily and twice weekly, respectively. Lambs were individually weighed every two weeks throughout the experiment right before feed was offered. Concentrates orts by lamb pen were removed and weighed every two weeks. The average daily intake of concentrate by lamb pen was calculated as the difference between the total amounts of concentrate offered and refused. Individual average daily gain (ADG) was calculated using the initial and final measurements of BW, and average feed conversion ratio (FCR) was calculated as kg of concentrate intake (DM basis)/kg body gain.

The length of the experiment was variable depending on the lamb initial BW. Lambs with higher initial BW were slaughtered at a commercial plant at day 37, whereas lambs with lower initial BW were slaughtered at day 58. Animals fasted during 2 h, stunned with electricity, and then slaughtered. The commercial carcass, with kidneys and perirenal fat was weighed while still warm to register hot carcass weight, and then kept at 4 °C during 24 h. Carcass was then weighed again to record cold carcass weight. Dorsal-fat (DF; European Community, 1994) and kidney-pelvic-fat (KPF; Colomer-Rocher et al., 1988) were also evaluated. Finally, the hot (HCY) and cold carcass yield (CCY) was calculated as a percentage of the final BW.

2.2. Analytical methods

Feed samples were analyzed by triplicate according to the Association of Official Analytical Chemists (AOAC) (2000) as follows: DM (AOAC 934.01), ash (AOAC 967.05), and ether extract (AOAC 920.39). CP was analysed using a Leco FP-528 combustion analyzer (Leco Corp., St. Joseph, MI, USA) and estimated by 6.25 × Dumas N (Association of Official Analytical Chemists (AOAC), 2000, method 968.06). Fibre was analysed sequentially with the Ankom system (Model 220, Ankom Technology Corp., Macedon, NY, USA) as follows: NDF (Van Soest et al., 1991), ADF and acid detergent lignin (Robertson and Van Soest, 1981). NDF and ADF were expressed inclusive of residual ash and NDF analyses were performed with a heat stable alpha-amylase and without sodium sulphite.

2.3. Statistical analysis

Data were analyzed using a factorial design considering initial BW as covariate and farm of origin as block. Data on concentrate intake and FCR were analyzed using pen as experimental unit, while ADG, carcass yield, DF, and KPF data were analyzed with lamb as experimental unit. The model included initial BW, farm of origin, treatment, and interactions initial BW × farm of origin, initial BW × treatment, and farm of origin × treatment as fixed effects. For data estimated using individual measurement, the interaction initial BW × farm of origin × treatment was included on the models. Furthermore, treatments were compared through the following contrasts: C *vs.* PC, MSP and TSP; PC *vs.* MSP and TSP; MSP *vs.*TSP; C *vs.* MSM; MSP *vs.* MSM. All the statistical analyses were done using