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Digestibility and energy value of diets containing increasing proportions of olive soapstocks for Iberian crossbred pigs

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ABSTRACT

The effects of increasing proportions of olive oil soap stocks (OSS) in diets for crossbred Iberian barrows on productive parameters, nutrient digestibility and N balance were studied. Twenty four Iberian × Duroc 50:50 growing barrows of 46.7 ± 0.60 kg initial BW were placed in individual pens and allotted to 4 dietary treatments in which olive oil soap stocks replaced 0 (diet A), 25 (diet B), 50 (diet C) and 75 (diet D) g/kg of a basal diet based on barley, corn, soyabean meal and wheat middlings. Crude fat content of diets increased from 20.8 to 86.6 g/kg with OSS inclusion. At the finishing stage of growth, 16 pigs were randomly allotted to two homogeneous groups of eight pigs each. Two experimental diets were prepared by mixing at equal proportions diets A and B, and diets C and D. In both experiments, daily feed allowance was fixed at 0.90× *ad libitum* intake, which was given in two equal meals (0900 and 1500 h). The inclusion of OSS in the diet of the growing pigs did not affect the average daily gain and gain:feed, being 765 ± 18.6 g and 0.296 ± 0.007, respectively. However, the ratio gain:metabolizable energy (ME) intake (g/MJ) decreased linearly on increasing the level of OSS dietary inclusion ($P < 0.05$). At the finishing stage, all performance parameters measured, except the gain-to-ME ratio, were improved ($P < 0.05$ to $P < 0.001$) or showed a tendency to be improved in pigs fed a diet containing the 62.5 g dietary proportion of OSS ($P = 0.074$ to $P = 0.088$). The apparent digestibility of DM, OM, CP, EE and GE was not altered by the level of OSS inclusion in the diet, remaining at 0.793 ± 0.008, 0.825 ± 0.007, 0.767 ± 0.013, 0.857 ± 0.013 and 0.799 ± 0.008, respectively. The energy density of the diets increased linearly ($P < 0.001$) from 14.6 to 15.8 MJ of digestible energy (DE)/kg DM and from 14.0 to 15.4 MJ of ME/kg DM with the increase in the dietary proportion of OSS. Olive oil soapstocks contain 32.2 MJ DE/kg and 31.2 MJ ME/kg. No differences in N retention were found between the experimental diets. The average value of 23.2 ± 1.04 g N retained daily corresponds to average efficiencies of utilization of total N (retained N/N intake) and N apparently absorbed (retained N/apparent digestible N) of 0.405 ± 0.018 and 0.530 ± 0.024, respectively. It is concluded that the inclusion of olive soapstocks in the diet of growing crossbred Iberian pigs does not affect the apparent digestibility of nutrients or body protein accretion but increases the energy cost of gain. Also, OSS increases substantially the energy value of the diet. In finishing pigs, OSS tend to improve the gain-to-feed ratio.

Abbreviations: ADFI, average daily feed intake; ADG, average daily gain; BW, body weight; CP, crude protein; DE, digestible energy; DM, dry matter; DU, Duroc; EE, ether extract; FA, fatty acids; FFA, free fatty acids; GE, gross energy; IB, Iberian; ME, metabolizable energy; N, nitrogen; OM, organic matter; TTAD, total tract apparent digestibility.

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1. Introduction

Olive oil soap stocks (OSS), a by-product of the olive oil extraction industry, is a valuable source of oleic acid highly appreciated as supplement in diets for fattening Iberian (IB) pigs reared on intensive feeding systems (González and Tejeda, 2007; Serrano et al., 2009; González et al., 2012). This by-product is obtained by means of physical refinement processes which include pressing followed by distillation of the fatty acids (FA) present in the oil (Christakis et al., 1982). Its use is limited by the content in unsaturated fatty acids, due to the negative effect that these FA may have on meat quality [Fundación Española para el Desarrollo de la Nutrición Animal (FEDNA), 2010]. As other soapstocks derived from oil sources, OSS are a good source of energy, although their digestibility is lower than that of the oils they come from, due to its high proportion of free fatty acids (FFA), as found for other fat resources (Powles et al., 1993; Mateos et al., 1995; Jorgensen and Fernández, 2000). To the best of our knowledge, no specific work has been performed to determine the energy value of OSS when added to pig diets. Instead, estimations are currently made based on chemical parameters (FFA content, degree of unsaturation) by equations derived from studies carried out with other fat resources (Powles et al., 1995). Furthermore, in spite of their extensive use, no systematic evaluation has been carried out in IB pigs on the effects of the dietary inclusion of OSS on feed efficiency, digestibility of nutrients, energy value of the feed mixture and on protein accretion. It was hypothesized that the inclusion of OSS in the diet of growing crossbred Iberian pigs would not affect feed efficiency, the apparent digestibility of dietary nutrients or body protein accretion and that the energy value of OSS would be constant at all levels of inclusion. Bruce et al. (2006) observed in growing pigs a quadratic decrease in the apparent ileal digestibility of dry matter (DM), crude protein (CP) and some amino acids (AA) when increasing concentrations of soyabean soapstock were included in semipurified diets containing soyabean meal. With this background, the purpose of the present work was to determine the effects of OSS dietary content on growth performance, nutrient digestibility and N utilization in crossbred growing Iberian pigs.

2. Materials and methods

The experimental protocol was reviewed and approved by the Bioethical Committee of the Spanish National Research Council (CSIC), Spain, and pigs were cared for following the Spanish Ministry of Agriculture guidelines (Boletín Oficial del Estado (BOE), 2005, 2007).

2.1. Animals, experimental design and feeding

A feeding experiment followed by a digestibility and balance trial was performed in Iberian (IB) × Duroc (DU) 50:50 barrows of 46.7 ± 0.60 kg initial body weight (BW). The pigs (27.3 ± 0.32 kg BW), supplied by a commercial breeding company (Granja El Arenal, Almodóvar del Río, Córdoba, Spain), were individually housed in 2 m^2 pens located in an environmentally controlled room at 20 ± 2 °C, exposed daily to 12 h lighting, and given *ad libitum* a commercial pelleted feed (188 g CP, 9.7 g lysine (Lys)/kg DM) until they attained the target BW, when they were randomly assigned to four homogeneous groups of six or seven pigs each to carry out the feeding trial followed by the digestibility and nutrient balance experiment. Each group was offered restrictedly one experimental diet.

Four diets were prepared by replacing 0, 25, 50 and 75 g/kg of a basal diet (A) with OSS to provide four different dietary fat contents (A–D; Table 1). The AA pattern of the dietary protein followed the ideal protein concept [National Research Council (NRC), 1998; British Society of Animal Science (BSAS), 2003]. The nutrient composition of OSS appears in Table 2. The feed mixtures were prepared by NANTA S.A. (Tres Cantos, Madrid, Spain) and offered as pellets at a level of 0.90× *ad libitum* intake, in two daily equal meals (0900 and 1500 h). Water was freely available from nipples. Feed refusals were daily collected, dried and weighed to calculate actual feed intakes.

A second feeding experiment was also performed at the finishing stage of growth. Sixteen IB pigs of approx. 90 kg BW were randomly allotted to two homogeneous groups of eight pigs each. Two experimental diets were prepared by mixing at equal proportions diets A and B (diet AB) and diets C and D (diet CD). The daily feed allowance was fixed at 0.90× *ad libitum* intake, which was given in two equal meals (0900 and 1500 h).

An estimation of the *ad libitum* intake, defined as what the pig would consume when given sole access to its diet for two periods of 60 min/day, had been previously obtained with diets of the same nature offered to purebred IB barrows placed in pens with individual feeding spaces (Nieto et al., 2001). The daily feed allowance was calculated based on the pig's BW, measured once per week, according to the following regression equation derived for pigs of 50 to 85 kg BW:

$$\text{Voluntary intake (g/day as-fed basis)} = 1525 \pm 164 + 31.3 \pm 2.33 \times \text{BW, kg} \quad (P < 0.001;\ n = 20;\ \text{s.e.} = 230;\ r^2 = 55.2) \tag{1}$$

2.2. Measurements

After a period of 3 days on the restricted feed allowance at the pens, the feeding trial was initiated when the pigs attained 46.7 ± 0.60 kg BW, followed by the digestibility and balance trial, which was carried out with pigs of an average 57.2 ± 0.40 kg initial BW. Due to limited availability of metabolic cages, the digestibility measurements took place in two trial replicates with three or four pigs per dietary treatment. Average daily feed intake (ADFI), BW gain and feed efficiency (gain:feed)