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Digestibility coefficients of crude nutrients in raw hulled acorns (*Quercus pubescens* Willd.) fed to growing pigs

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ABSTRACT

Acorns (fruits of the *Genus Quercus*) are widely used in some Mediterranean countries as feed for pigs raised under extensive conditions. Despite the traditional use of acorns for fattening pigs, little is known about the digestibility coefficients of nutrients of this feed source. A feeding trial was carried out to determine the apparent total tract digestibility (ATTD) of crude nutrients in growing pigs fed with an acorn-based diet (70% raw hulled shredded acorns combined with a complete pelleted diet for pigs, as fed). The acorns were observed to contain about 510 g of digestible organic matter per 1 kg DM, a value lower than predicted from the fibre content (CFi) in raw acorns ($y = 92 - 1.68 \times$ CFi in DM). The digestible organic matter was found to be based on starch mainly, and to a lesser extent, on digestible fibre and digestible fat. On calculation, the metabolizable energy content (MJ ME/kg DM), based on the results of the digestibility of raw acorns, was observed to be 9.5 MJ ME/kg DM, making it comparable to sugar beet pulp or to about 70% of the energy density of cereals such as wheat, or to about 75% compared to barley. A negative value for crude protein ATTD (−30%) was highlighted: the high nitrogen faecal losses observed, perhaps due to the high tannin contents (51.2 g tannic acid equivalents/kg DM in raw acorns), can reasonably be considered to be due to the bacterial proteins synthesized during the increased microbial fermentation in the hindgut, then shed *via* faecal material. Due to the digestibility coefficients of nutrients, acorns may well be more suitable for use in combined diets for fattening pigs, rather than in diets for growers.

1. Introduction

Acorns are one-seeded and indehiscent fruits (*achaenium*) of oak trees, *Genus Quercus* (Holman and Robbins, 1944). In the Mediterranean basin, oaks cover vast areas and acorns represent an available feed source for wild and domestic animals, especially pigs, over the fall/winter season (Pinna et al., 2007). In some traditional production systems, free ranging pigs are

Abbreviations: AA, amino acids; ADF, acid detergent fibre; ADG, average daily gain; ADL, acid detergent lignin; ATTD, apparent total tract digestibility; BW, body weight; CFi, crude fibre; CP, crude protein; DE, digestible energy; DM, dry matter; EE, ether extracts; ESS, ethanol soluble sugars; EU, European Union; FAME, fatty acid methyl esters; ME, metabolizable energy; NDF, neutral detergent fibre; OM, organic matter; PPA, protein precipitating activity; Pro, proline; PRPs, proline rich proteins; PUFA, polyunsaturated fatty acids; TAE, tannic acid equivalent; Willd., Willdenow.

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fattened on acorn-based diets, mainly to produce dry cured ham (Nieto et al., 2002; Pinna et al., 2007; Cappai et al., 2010; Cappai et al., 2013a–c; Rodríguez-Estévez et al., 2009a,b, 2010; Tejerina et al., 2011). Both the fresh meat and the derived products appear to be highly preferred by consumers: such pork production represents a *niche* in the market and these products can be marketed at considerably higher prices than those for products derived from conventionally produced pork (Rodríguez-Estévez et al., 2010; Sogos, 2010). The large presence of oaks provides considerable amounts of acorns available in the forests every year. However, several species of oak trees show a pulsed-high production, every 1 to 2 years, depending on the botanical origin and the seasonal conditions (Cappai et al., 2013b). Therefore, the seasonal availability of acorns as a natural resource for animals, may vary from year to year on the basis of the composition of the oak species present. In some areas, the natural production of acorns can be considered as a valuable source of home-grown feedstuffs, for the sustainability of organic and extensive farming systems, while industrial use does not appear to be viable at present. The collection of fruits and further manufacturing may require large-scale investment, which is not justified by the benefits. Although the alternate production of acorns may be considerable, due to the high density of oak trees in some areas of the Mediterranean, the continuous availability of ripe acorns appears to be sustainable when directly grazed by free ranging animals. In such a feeding regime, the stocking rate appears to play a key role, as the acorn supply (energy source) is not continuously renewed in grazed areas, as in the case of grass (Rodríguez-Estévez, 2010). Moreover, a slower achievement of the pig's final body weight at slaughter can be observed in this extensive production system, if compared to the life span of pigs raised with an intensive regime: in fact, the average daily weight gain (ADG) is lower in grazing finishers fed with acorns (Rodríguez-Estévez et al., 2010; Sogos, 2010).

Commonly, ripe acorns can be either grazed by the free ranging pigs or offered to confined pigs as a part of conventional diets. These diets are composed of ground cereals, legume seeds, seed meal and acorns, and are often soaked before feeding (Cappai et al., 2013a). Differently from Iberian pigs (Aparicio Macarro, 1964), other Mediterranean autochthonous swine breeds do not display the capacity to shell acorns: therefore, in most cases, hulled acorns are consumed by the pig (Pinna et al., 2007; Cappai et al., 2010; Lanteri et al., 2009, 2011). Such feeding behaviour provides the pig with a high fibre intake, mostly lignin, represented by the lignified pericarp of the *achaenium* (Cappai et al., 2013b).

Pigs can cope with high amounts of acorns in their diet more successfully than other animal species which may be poisoned due to a high intake of tannins. Furthermore, the tannin binding protein activity has actually been seen to be efficiently counteracted by the increase of salivary binding proteins (likewise histatins or proline rich proteins, PRPs) in the pig (Cappai et al., 2010; Cappai et al., 2013a–c, 2014). This capability is also seen to correlate with the use by the pig of endogenous proline, to allow a buffering effect, granted by the high affinity of tannins to small size proteins with an open loose proline-rich structure. Despite proline being a non-essential amino acid, the effect on the utilization of proteins should be explored in detail. Despite the traditional widespread use of acorns for fattening pigs in extensive pork production throughout the Mediterranean, little is known about the digestibility coefficients of crude nutrients. The present investigation was undertaken with the purpose of determining the apparent total tract digestibility (ATTD) of crude nutrients and calculating the nutritive value of acorns offered to growing pigs fed with an acorn-combined diet.

2. Materials and methods

2.1. Animals and diets

Animal handling complied with the recommendations of European Union Directive 2010/63/EU and Italian law 116/92 concerning animal care.

A total of 8 cross-bred (Duroc sires on Large White X German Landrace) growing pigs were used in the experimental feeding trial. The inclusion criteria of growing pigs in this digestibility trial was based on the opportunity to have a larger number of individual data per experimental group, than would have been achievable with finishers. The eight pigs were individually housed and divided into two experimental groups, according to a matched pairs approach (based on the body weight of the pigs). An adaptation period of one week was included in the feeding plan (phase 1). During this phase, all animals were fed the same pelleted complete diet: on day 8, four pigs were switched to the experimental diet based on ripe hulled shredded acorns (phase 2). This experimental diet was formulated to test the effect of one single ingredient (acorn), according to the feeding method of the combined diet. In the experimental combined diet, the investigated ingredient was included in a diet with a reference complete feed. The pelleted diet administered during phase 1, based on cereals and soybean meal, was therefore combined with a proportion of 70% of raw hulled acorns, as fed, in the form of a mixed meal diet. Two nutritional hints were fulfilled with this proportion of acorn inclusion: (a) the achievement of comparable contents of starch and OM in the DM of the two diets; (b) acorns as the major source of those nutrients in the combined diet. Thus, this proportion (70%: 30% = raw acorns: dry pelleted complete feed, as fed) was calculated for experimental needs and not to meet productive yields.

The rest of the pigs continued to be fed with the pelleted complete diet and constituted the control group (phase 2).

The chemical composition of the two experimental diets is reported in Table 1.

Pigs of both groups (initial BW: 14.2 to 27.6 kg) were fed *ad libitum* and had free access to water. Daily feed consumption ($g\,d^{-1}$) was recorded individually in both experimental groups throughout the trial.