Animal Feed Science and Technology 207 (2015) 168–180

Contents lists available at ScienceDirect

Animal Feed Science and Technology

journal homepage: www.elsevier.com/locate/anifeedsci

Trade-offs among growth performance, nutrient digestion and carcass traits when feeding low protein and/or high neutral-detergent fiber diets to growing-finishing pigs

H. Morazán, J. Alvarez-Rodriguez*, A.R. Seradj, J. Balcells, D. Babot

Departament de Producció Animal, ETSEA, Universitat de Lleida-Agrotecnio Center, Av. Alcalde Rovira Roure 191, 25198 Lleida, Spain

ARTICLE INFO

Article history:
Received 3 February 2015
Received in revised form 2 June 2015
Accepted 3 June 2015

Keywords:
Dietary manipulation
Feed efficiency
Sugar-beet pulp
Total tract digestibility
Swine

ABSTRACT

This study evaluated the effects of reducing dietary crude protein (CP) and increasing neutral detergent fiber (aNDFom) on growth performance, nutrient digestibility, manure composition and carcass parameters of lean pigs as a means of reducing the environmental load of slurry. Sixty-four intact male Landrace × Large-White pigs (13.8, SD 2.3 kg of initial body weight (BW)) were assigned to one of two dietary CP levels (high, HP or low, LP) and one of two aNDFom levels (high, HF or normal, NF) in a 2 × 2 factorial design, and subjected to a three-phase feeding program from 6 to 21 weeks of age (15–110 kg of BW). The diets had similar metabolizable energy (ME), total lysine content and ideal amino acids (AA) ratio. Pigs fed HP diets had the highest average daily gain (ADG) and BW from 12 weeks of age ($P < 0.05$), which was associated with a gain:feed ratio that was higher than in the LP treatment ($P < 0.05$). Dietary aNDFom did not affect the ADG or gain:feed of pigs ($P > 0.05$). The coefficient of total tract apparent digestibility (CTTAD) of CP was higher in HP groups (0.765 ± 0.0075), than it was in the LP groups (0.732 ± 0.0075, respectively), independent of the dietary aNDFom level. Low dietary CP reduced aNDFom digestibility in pigs fed diets that had a normal aNDFom level (LP-NF: 0.45), but not in pigs that were fed a high aNDFom diet (LP-HF: 0.548), compared to pigs fed HP diets (HP-NF: 0.546, and HP-HF: 0.583 ± 0.011). Low dietary CP increased the manure output at 21 week of age ($P < 0.001$) and high dietary aNDFom increased manure output from 16 weeks of age ($P < 0.001$). The slurry pH was higher in the HP groups than it was in the LP groups (7.42 vs. 7.18 ± 0.085, $P = 0.05$), but the level of dietary aNDFom did not alter the pH of slurry ($P = 0.66$). Back-fat thickness at slaughter was highest in pigs fed low CP ($P < 0.001$) or high aNDFom diets ($P = 0.03$). In summary, the effects of dietary CP and aNDFom on growth performance were largely independent of each other. From 12 to 21 weeks of age, lowering dietary CP up to 50 g/kg reduced growth performance and increased back-fat at slaughter. High aNDFom diets did not reduce growth performance, but hampered lean tissue gain. An increase in dietary aNDFom in low CP feed did not reduce the CTTAD of aNDFom in growing-finishing pigs. However, this dietary manipulation had the lowest economic return.

Abbreviations: AA, amino acids; ADFI, average dairy feed intake; ADFom, acid detergent fiber expressed exclusive of residual ash; ADG, average dairy gain; AEE, acid hydrolysed ether extract; aNDFom, neutral detergent fiber expressed exclusive of residual ash; BFT, back-fat thickness; BW, body weight; CF, crude fiber; CF, crude fiber; CHO, carbohydrates; CP, crude protein; CP, crude protein; CTTAD, coefficient of total tract apparent digestibility; DM, dry matter; EC, electrical conductivity; HF, high fiber; HP, high protein; LP, low protein; ME, metabolizable energy; NF, normal fiber; SID, standardized ileal digestible; TDF, total dietary fiber.

* Corresponding author. Tel.: +34 973706458; +34 973702874.
E-mail address: jalvarez@prodan.udl.cat (J. Alvarez-Rodriguez).

http://dx.doi.org/10.1016/j.anifeedsci.2015.06.003
0377-8401/

1. Introduction

To increase lean growth rate and gain:feed, intensively managed growing-finishing pigs are fed diets that are rich in essential amino acids (AA). Thereby, fiber-rich ingredients are rarely used in feed formulation because they may reduce the energy density of diets and decrease average daily feed intake (ADFI) and carcass yield. However, a minimum amount of fiber might be necessary to maintain intestinal peristalsis and to avoid gut ailments (e.g. stomach ulcer and rectum prolapse; FEDNA, 2006).

Phase feeding programs are commonly used in rearing growing-finishing pigs as a means of meeting the animals' nutrient requirements accurately and preventing nutrient waste (Alvarez-Rodriguez et al., 2013). In Spain, the most common feeding protocol for growing-finishing pigs is a three-phase program that reduces dietary crude protein (CP) from 17.1% at 19 kg of body weight (BW) to 15.6% at 108 kg of BW (Agostini et al., 2014). In dose-response trials that used Large White × Landrace crosses from 45 to 95 kg of BW, reductions in dietary CP to 122.5 g/kg (Carpenter et al., 2004) or 140 g/kg (Madrid et al., 2013) did not reduce significantly the ADFI, average daily gain (ADG) and gain:feed. However, some studies have shown that growth performance was reduced when pigs were fed diets that contained <120 g/kg CP, which led to one or more AA becoming limited in the diet (Figueroa et al., 2002).

Furthermore, feedstuffs that contain fermentable fiber (e.g. sugar-beet pulp) can shift the balance of nitrogen excretion from urine to feces (Zervas and Zijlstra, 2002) by binding nitrogen into microbial protein (Bindelle et al., 2009). Most of those studies, however, were performed over short periods (e.g. 25–40 kg of BW, or 50–70 kg of BW).

Although there is a general agreement in the scientific board that low CP diets, with adequate amount of lysine, and balanced in AA with the use of free AA, do not impair growth performance, there are few studies covering the evaluation of low CP diets with different neutral detergent fiber (aNDFom) levels during the whole growing-finishing period. We hypothesized that increasing dietary aNDFom in low CP diets may reduce steadily the CTTAD of CP throughout the growing-finishing period, without detrimental effects on productive performance. The objective of this study was to evaluate the effects of reducing dietary CP and increasing aNDFom on growth and carcass performance, fecal nutrient digestibility, manure output and economic evaluation of lean pigs from 6 to 21 weeks of age (15 to 110 kg of BW).

2. Material and methods

All procedures were carried out under Project Licence CEEA 03/01-10 and approved by the in-house Ethics Committee for Animal Experiments at the University of Lleida. The care and use of animals were in accordance with the Spanish Policy for Animal Protection RD53/2013, which meets the European Union Directive 2010/63 on the protection of animals used for experimental and other scientific purposes.

2.1. Animals, diets and experimental design

Sixty-four crossbred 6-week-old intact male pigs (mean initial BW = 13.8 kg, SD = 2.3 kg) were used in the experiment, which was carried out in the cool-warm season (March–June 2012) and lasted 105 d. All the pigs were the progeny of Large-White sires and Landrace dams (Nucleus S.A.S., Le Rheu, France). Pigs were housed in 55% concrete slatted-floor pens (2.1 m × 2 m) in a controlled-environment barn (from 6 to 11 weeks of age: 23.9 (SD 2.4) °C and 52.3 (SD 13.9) % relative humidity (RH), from 12 to 16 weeks of age: 21.7 (SD 2.5) °C and 67.5 (SD 10.3) % RH, and from 17 to 21 weeks of age: 25.9 (SD 3.4) °C and 60.5 (SD 11.1) % RH) and were randomly assigned, within treatment, to one of four pens (four pigs/pen, with a space allowance of approximately 1 m^2/pig), based on minimum BW variation within pens.

The effects of two dietary CP concentrations (High, HP or Low, LP) and two aNDFom concentrations (Normal, NF or High, HF) were assessed in a 2 × 2 factorial design throughout a three-phase feeding program: phase I (from 6 to 11 weeks of age), phase II (from 12 to 16 weeks of age), and phase III (from 17 to 21 weeks of age), with four replicates per treatment. The diets (Table 1 and Table 2) were formulated to be iso-energetic and to meet or exceed the CP and aNDFom levels recommended by the Fundación Española para el Desarrollo de la Nutrición Animal (FEDNA, 2006). The diets (milled-ground through a 6 mm screen, which yielded 1–2 mm-sized feed meal) mainly comprised cereals, with soybean meal and/or rapeseed meal as a source of CP, and/or sugar-beet pulp as a source of aNDFom. To achieve an ideal AA ratio (NRC, 1998), the diets were supplemented with synthetic AA, which ensured that lysine was the first-limiting AA. In addition, diets were fortified to meet vitamin and mineral requirements (FEDNA, 2006) and enzymes (phytases and carbohydrases) were added to improve the digestibility of phosphorus and non-starch polysaccharides (Table 1).

Each pen had a dry single-space self-feeder in the concrete floor area and a square nipple drinker in the slatted floor area. Throughout the growing-finishing period, pigs had ad libitum access to feed and drinking water (pH = 8.0, electrical conductivity (EC) = 485 μS/cm, sodium concentration = 22.2 mg/L; chloride concentration = 33.7 mg/L). To prevent feed wastage or shortages, the amount of feed dropped was adjusted weekly.

2.2. Measurements and calculations

Individual BW and feed consumption per pen were recorded weekly, which were used to calculate the ADG and ADFI of each replicate. The amount of feed wasted remaining inside the feeder cup was recorded for each replicate weekly. Feed