Universitat de Lleida

Emisión de amoníaco (NH3) y gases con efecto invernadero (CH4 y N2O) en cerdos en crecimiento: efecto del nivel de proteína y fibra de la ración

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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

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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[1]

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ABSTRACT

This study evaluated the effects of reducing dietary CP and increasing NDF on growth performance, nutrient digestibility and carcass parameters of lean pigs as a means of reducing the environmental load of slurry. Sixty-four intact male Landrace x Large-White pigs (13.8 ± 2.3 kg of initial BW) were assigned to one of two dietary CP levels (high, **HP** or low, **LP**) and one of two NDF levels (high, **HF** or normal, **NF**) in a 2 x 2 factorial design, and subjected to a three-phase feeding program from 6 to 21 wk of age (15 to 110 kg of BW). The diets had similar ME, total lysine content and ideal AA ratio. Pigs fed HP diets had the highest ADG and BW from 12 wk of age ($P < 0.05$), which was associated with a G:F ratio that was significantly higher than in the LP treatment ($P < 0.05$). Dietary NDF did not affect significantly the ADG or G:F of pigs ($P > 0.05$). The overall fecal CP digestibility coefficient was higher in HP groups (76.5 ± 0.75%), than it was in the LP groups (73.2 ± 0.75%, respectively), independent of the dietary NDF level. Fecal CP digestibility coefficient did not vary significantly between 11 and 16 wk of age (73.8 vs. 73.6 ± 0.72%, $P < 0.01$) but it was significantly higher at 21 wk of age (77.3 ± 0.72%, $P < 0.001$). Low dietary CP reduced NDF digestibility in pigs fed diets that had a normal NDF level (LP-NF: 45.0%), but not in pigs that were fed a high NDF diet (LP-HF: 54.8%), compared to pigs fed HP diets (HP-NF: 54.6%, and HP-HF: 58.3 ± 1.09%). Low dietary CP increased the fecal output at 21 wk of age ($P < 0.001$) and high dietary NDF increased fecal output from 16 wk 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 NDF did not alter the pH of slurry ($P = 0.66$). The economic margin (diet cost minus carcass income) was lower in the LP group than it was in the HP group (reference = 100%; 105.9 vs. 129.6 ± 5.5%; $P = 0.004$), but dietary NDF and economic outcome were not correlated (111.5 vs. 123.9 ± 5.5%, $P = 0.12$). In conclusion, adding free AA to reduce dietary CP is unlikely to have a significant effect on growth performance up to 11 wk of age; thereafter, however, it would be appropriate to increase dietary NDF at a constant energy density to avoid impaired growth performance, excess carcass fatness, and decreased economic margin.

Key words: dietary manipulation, feed efficiency, economic performance, swine

INTRODUCTION

To increase lean growth rate and G:F, intensively managed growing-finishing pigs are fed diets that are rich in essential AA. Thereby, dietary fiber is reduced to improve energy density and avoid decreased ADFI and carcass yield, although 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 animal 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 CP from 17.1% (19 kg of BW) to 15.6% (108 kg of BW) (Agostini et al., 2013). However, feeding programs that minimize nutrient excretion without causing detrimental effects on growth performance and carcass traits have yet to be developed.

Dietary CP restriction reduced heat production, which in turn increased the efficiency of metabolic utilization of energy (Le Bellego et al., 2001), but moderate increases in dietary fiber did not influence that these traits (Le Goff 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 to 40 kg of BW, or 50 to 70 kg of BW). To test the hypothesis that the observed response does not vary significantly during the fattening period, an integrated assessment is needed. The objective of this study was to evaluate the effects of reducing dietary CP and increasing NDF by adding sugar-beet pulp on growth and carcass performance, and nutrient digestibility of lean pigs from 6 to 21 wk of age (15 to 110 kg of BW).

MATERIALS 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.

Animals, diets and experimental design

Sixty-four crossbred 6-wk-old intact male pigs (mean initial BW= 13.8 kg, SD = 2.29 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 × 2 m) in a controlled-environmental barn [from 6 wk to 11 wk of age: 23.9 ± 2.4ºC and 52.3 ± 13.9% relative humidity (**RH**), from 12 wk to 16 wk of age: 21.7 ± 2.5ºC and 67.5 ± 10.3% RH, and from 17 wk to 21 wk of age: 25.9 ± 3.4ºC and 60.5 ± 11.1% RH] and were randomly assigned to one of 16 pens (4 pigs/pen, with a space allowance of approximately 1 m^2/pig), based on their initial BW.

The effects of two dietary CP concentrations (High or Low) and two NDF concentrations (Normal or High) were assessed in a 2 x 2 factorial design throughout a three-phase feeding program: phase I (from 6 to 11 wk of age), phase II (from 12 to 16 wk of age), and phase III (from 17 to 21 wk 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 NDF levels recommended by the NRC (NRC, 1998) and 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 NDF. To achieve an ideal AA ratio (NRC, 1998), the diets were supplemented with synthetic AA, which ensured that Lys 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.

Each pen had an automatic single-space dry feeder in the concrete floor area and a nipple square 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 feed drop was adjusted weekly.

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. Feed wastage was recorded for each replicate weekly. Feed samples were collected at each feeding phase shift for chemical analysis. At the end of each feeding phase, back-fat thickness (**BFT**) was measured at the P2 position (above the last rib at 6.0 to 6.5 cm from midline), using an A-mode ultrasound device (Renco sonograder 4.2, Renco Corporation, Minneapolis, USA). Energy efficiency was calculated as the ratio between ME intake and the sum of maintenance ME and growth ME based on FEDNA (2013).

Thirty-two pigs [8 (two pens) per treatment] were used to assess apparent whole-tract digestibility. In the last week of each feeding phase (11, 16 and 21 wk of age), chromic oxide (Cr_2O_3), an indigestible marker, was homogeneously mixed (2 g/kg DM) with ground feed. After a 5-d adaptation period, fecal samples (approx. 50 g) were collected using rectal stimulation at 8 h intervals for 2 d. Fecal samples were stored at -20ºC until chromium and proximate chemical analysis (DM, Ash, CP, aNDFom and EE). After thawing, fecal samples from each pig were pooled to produce one grab sample per collection period (11, 16 or 21 wk of age).

The apparent whole-tract digestibility of nutrients was calculated using the nutrient-to-marker ratio in the diet and feces, as follows (Equation [1]):

$$\text{Apparent digestibility (\%)} = 100\ [100\ (Cr_2O_{3,diet} / Cr_2O_{3,digesta})\ (Z_{feces}/Z_{diet})], \qquad [1]$$

where Z_{feces} and Z_{diet} are the nutrient concentrations (%) in the feces and in the diet, respectively; and $Cr_2O_{3,feces}$ and $Cr_2O_{3,diet}$ are the concentrations (%) of chromium oxide in the feces and in the diet, respectively.

To compare different diets under *ad libitum* feeding conditions, the amount of nutrients digested were estimated from whole-tract digestibility coefficients and ADFI.

The slurry collection system was a shallow pit (maximum depth = 0.5 m) that was drained into a lagoon at two-week intervals. Each shallow pit collected the slurry from four treatment pens. Before draining the pit, excreta production was estimated by using a meter rule to measure the slurry depth, and 1-kg homogeneous samples were collected for analysis of physical and chemical composition.

At the end of the experiment, 48 pigs were slaughtered at a commercial abattoir following standard procedures. Feed was withdrawn 18 h before the animals were slaughtered. After the pigs were placed in the slaughterhouse holding pens, they were allowed to rest for 2 h and had *ad libitum* access to water but did not have access to feed. The pigs were stunned by CO_2 (Butina ApS, Holbaek, Denmark) using a dip lift system, exsanguinated, scalded, skinned, eviscerated and split down the midline. Hot carcass weight was recorded before the carcass sides were refrigerated in line processing at 2ºC. Back-fat thickness was measured 6 cm off the midline between the third and fourth last ribs using the Autofom automatic carcass grading (SFK-Technology, Herlev, Denmark).

Laboratory analysis

Feed and fecal samples were analyzed following recommendations of the AOAC (2000) whereas the slurry samples were analyzed based on the Standard Methods for the Examination of Water and Wastewater (APHA, 1995). All of the samples were analyzed in duplicate for DM (gravimetry at 105ºC), Ash (Incineration at 550ºC) and N content (Kjeldahl method). Feed samples were analyzed for total lysine (HPLC-Fluorescence), crude fiber (Weende method), starch (polarimetry), acid hydrolized ether extract (**AEE**) (Soxhlet method), NDF and ADF contents (sequential procedure, following Van Soest et al. (1991)). Neutral-detergent fiber was assayed with a heat-stable amylase and expressed exclusive of residual ash (aNDFom). The concentration of carbohydrates (**CHO**) in diets and feces was calculated as follows (Urriola and Stein, 2012, Equation [2]):

$$\text{CHO} = \text{DM} - (\text{CP} + \text{AEE} + \text{Ash}) \qquad [2]$$

The slurry was analyzed for bulk density (densimeter), electrical conductivity (EC) (conductometry), pH (electrometry), ammonium-N (volumetric titration), phosphorus (ultraviolet-visible spectroscopy) and potassium (atomic absorption spectrometry).

Feed and fecal samples were analyzed for Cr concentration after nitro-perchloric acid (ration 5:1) digestion (de Vega and Poppi, 1997) using inductively coupled plasma optical emission spectroscopy (HORIBA Jobin Yvon, Activa family, with AS-500 Autosampler, HORIBA Scientific, Madrid, Spain).

Economic analysis

The economic analysis was based on partial budgeting principles, which only includes the financial components that change in response to a particular decision (e.g. nutritional strategy), only (Warren, 1998). Estimates of the costs and incomes associated with each diet were used to compare the diets in economic terms. The economic evaluation accounted for a reduction in dietary CP and an increase in dietary NDF; therefore, four diets were assessed (HP-HF, HP-NF, LP-NF and LP-HF).

Diet cost included feed price (all raw ingredients excluding manufacturing, delivery, financial and overhead costs) and overall pen ADFI in each growing-finishing phase. Carcass price was based on individual carcass weight and the standardized EU classification, which uses lean content (BOE, 2011). The economic gross margin was carcass income minus diet costs. To account for changes in market price over time, diet cost (as-fed basis), carcass income, and economic gross margin were assessed as a proportion of the lowest outcome (shown as 100%). Labor and facility requirements were assumed to be the same for all treatment groups and therefore not considered.

Statistical analysis

The data were analyzed using the SAS statistical software (SAS Institute Inc., Cary, NC, USA). Production indicators (ADFI, BW, ADG, FCR, energy efficiency index and BFT), apparent fecal digestibility coefficients and the amounts of nutrients digested (DM, OM, CHO, CP, NDF and EE) were tested using repeated measures ANOVA (PROC MIXED), based on the following mixed model (Equation [3]):

$$Y_{ijklm} = \mu + AGE_i + A_j + CP_k + NDF_l + (AGE_i \text{ x } CP_j) + (AGE_i \text{ x } NDF_l) + (CP_k \text{ x } NDF_l) + E_{ijklm} \quad [3]$$

where Y_{ijklm} = dependent variable, μ = overall mean, AGE_i = age effect (i = 6 to 11 wk, 12 to 16 wk, 17 to 21 wk of age), A_j = animal/pen random effect j, CP_k = dietary CP level effect (k = HP, LP), NDF_l = dietary NDF level effect (l = HF, NF), and E_{ijklm} = residual error.

Factors that influenced excreta composition and yield were evaluated using a linear model (proc GLM) that considered the same fixed effects (age, dietary CP level, dietary NDF level) and their second-degree interactions. Factors that influenced carcass traits were evaluated using a linear model (proc GLM) that considered the fixed effects of dietary CP level, dietary NDF level, and their interaction effect, and slaughter BW was included as a covariate. Significant differences between carcass classification groups were assessed using the Chi-square test (FREQ procedure in SAS). The economic analysis was evaluated using a linear model (proc GLM) that included the fixed effects of dietary CP level, dietary NDF level and their interaction effect. The experimental unit for the parameters included in the study was the individual animal, with the exception of ADFI and G:F, which used the pen, and the slurry parameters, which used the pit. Variances were unequal; therefore, calculations of the SE and degrees of freedom were based on the Kenward-Roger Method. Differences between least square means were assessed using the Tukey test. Values are presented as least square means±SE. The level of significance was set at 0.05. Second degree interaction effects were retained in the models and they are specifically commented in the text if they reached statistical significance.

RESULTS

Growth performance

There interaction between dietary CP and NDF effects on production parameters was not significant (P > 0.05); thus, both factors influenced the ADFI, BW and growth efficiency of

Landrace x Large-White pigs independently. Dietary CP did not have a significant effect on ADFI ($P > 0.05$; Table 3); however, from 17 to 21 wk of age, elevated dietary NDF reduced ADFI ($P < 0.05$). Dietary CP had a significant effect on the development of pig BW throughout the growing-finishing period ($P < 0.001$). Pigs fed HP diets grew faster from 12 to 21 wk of age ($P < 0.05$), which was associated with higher G:F and energy use efficiency than did pigs fed the LP diet ($P < 0.05$); however, dietary NDF level did not have a significant effect on pig growth, G:F, or energy use efficiency ($P > 0.05$).

In vivo BFT was not affected by dietary CP ($P = 0.77$) or NDF ($P = 0.79$) throughout the growing-finishing period (data not shown); however, from 12 to 21 wk of age, mean BFT increased steadily from 4.6 to 11.1 ± 0.19 mm ($P < 0.001$).

Whole-tract digestibility coefficients of nutrients

The interaction between dietary CP and NDF effects did not have a significant on the apparent fecal DM, OM, AEE and CHO digestibility throughout the growing-finishing period (all with $P > 0.07$); therefore the effects of dietary CP and NDF acted independently (Table 4).

Low dietary CP decreased the fecal digestibility of DM and CHO at wk 11 of age ($P < 0.05$), but not thereafter ($P > 0.10$). Dietary CP reduction decreased the fecal AEE digestibility coefficients at 11 wk and 21 wk of age ($P < 0.05$).

Pigs fed the high fiber (HF) diets had higher whole-tract DM digestibility coefficients at 11 wk and 16 wk of age ($P < 0.05$) and had higher AEE digestibility than did pigs fed the normal fiber (NF) diets ($P < 0.05$). In contrast, elevated dietary NDF reduced CHO digestibility at 21 wk of age ($P < 0.05$).

The combination of dietary CP and NDF level influenced the apparent NDF digestibility coefficient ($P = 0.007$; Figure 1). In pigs fed diets that had normal NDF levels, dietary CP reduction reduced NDF digestibility (LP-NF: 44.99%) compared to pigs fed a HP diet (HP-NF: 54.56%, and HP-HF: 58.34 ± 1.09%); however, a reduction in NDF digestibility did not occur in animals fed a high-NDF diet (LP-HF: 54.80%).

The whole-tract CP digestibility coefficient did not differ between 11 wk and 16 wk of age (73.8 vs. 73.6 ± 0.72%) but it was significantly higher at 21 wk of age (77.3 ± 0.72%, $P < 0.001$). Conversely, the apparent NDF digestibility coefficient was higher at 11 wk and 16 wk of age than it was at the end of the finishing period (53.6 and 54.6 vs. 51.2 ± 0.94%, respectively; $P < 0.05$).

Amount of nutrients digested through the digestive tract

At wk 11 of age, the amount of DM and OM digested did not differ significantly between the two dietary CP levels ($P > 0.10$), but the amount of CHO digested was higher in the LP groups than it was in the HP treatments ($P = 0.04$). At 21 wk of age, the amounts of DM, OM, and CHO digested were higher in pigs fed the LP diets than it was in those fed the HP diets ($P < 0.05$). Throughout the growing-finishing period, dietary CP restriction did not have a significant effect on the amount of AEE digested ($P > 0.10$).

High NDF diets reduced the amount of DM, OM and CHO digested at 21 wk of age ($P < 0.05$), but they increased the digestion of dietary AEE at 16 and 21 wk of age ($P < 0.05$). The interaction between dietary CP and NDF affected the amount of CP digested (g/d) ($P = 0.02$; Fig. 1). Pigs fed HP diets digested more CP when dietary NDF was at a normal level (HP-NF: 327.2 g CP/d) than when they were fed a diet high in dietary fiber (HP-HF: 311.1 ± 5.37 g CP/d, $P < 0.05$). Pigs fed LP diets digested the least amount of CP (LP-NF 252.6 g CP/d and LP-HF 260.6 ± 5.37 g CP/d). The average amount of CP digested increased linearly from 11 wk to 21 wk of age (242.3, 331.8 and 348.7 ± 4.58 g/d, $P < 0.001$).

There interaction between dietary CP and NDF on the amount of NDF digested (in g/d) was not significant ($P = 0.24$); thus, pigs fed diets that had normal NDF content had the lowest amount of NDF digested ($P < 0.05$), independent of dietary CP level. The average amount of NDF digested was lower at 11 wk of age than it was at 16 and 21 wk of age (128.3 vs. 226.0 and 230.0 ± 3.83 g/d, respectively; $P < 0.05$).

Slurry composition and yield

At 11 wk of age, neither dietary CP nor NDF levels had a significant effect on fecal output (based on DM) (Fig. 2; $P > 0.10$); however, low dietary CP produced higher fecal output at 21 wk of age ($P < 0.001$). High dietary NDF induced elevated fecal output at 16 wk and 21 wk of age ($P < 0.001$). Slurry density and EC did not differ before 16 wk of age (1,015 ± 5 kg/m^3 and 14.72 ± 1.42 dS/m) but they were significantly higher at 21 wk of age (1,029 ± 4 kg/m^3 and 18.37 ± 1.15 dS/m). In addition, density and EC were highest in the slurry from pigs fed a high CP and high NDF diet ($P = 0.003$ and $P = 0.002$, respectively; Fig. 3). The slurry from pigs fed HP diets had higher pH than did the slurry from pigs fed LP diets (7.42 vs. 7.18 ± 0.08, $P = 0.05$), but the slurry pH did not vary significantly with the level of dietary NDF or growth period ($P = 0.07$ y $P = 0.66$, respectively). Neither the levels of dietary CP and NDF, nor the growth period were correlated with the concentrations of the main macronutrients (N, P and K) in the slurry (average organic N = 37.5 ± 10.1 g/kg DM, NH_4-N = 52.6 ± 13.6 g/kg DM, P = 42.6 ± 2.1 g/kg DM and K = 62.5 ± 12.3 g/kg DM; all with $P > 0.08$).

Carcass traits

The interaction effect of CP and NDF on carcass traits was not significant ($P > 0.25$); thus, the two factors influenced these traits independently. Neither dietary CP nor NDF had a significant effect on carcass yield or carcass classification based on the Spanish National

Standard (Table 5); however, BFT (measured between 3rd to 4rd last ribs) was highest in pigs fed low CP diets ($P < 0.001$) or high NDF diets ($P = 0.03$).

Economic evaluation

The interaction between dietary CP and NDF level had a significant effect on diet cost ($P = 0.04$; Fig. 4). The diet that had low CP and high NDF had a significantly lower cost than did the diet that had high CP and high NDF ($P = 0.02$), however, the other two diets (LP-NF and HP-NF) did not have a significant effect on diet cost ($P > 0.10$).

There interaction between dietary CP and NDF did not have a significant effect on carcass income and economic gross margin ($P > 0.60$). Pigs fed LP diets had reduced carcass income (118.9 vs. 104.6 ± 3.4%; $P = 0.004$) and economic margin (129.6 vs. 105.9 ± 5.5%; $P = 0.004$) compared to pigs fed HP diets; however, the level of dietary NDF did not have a significant effect on carcass income (115.2 vs. 108.3 ± 3.4%, $P = 0.15$) or economic margin (123.9 vs. 111.5 ± 5.5%, $P = 0.12$).

DISCUSSION

Effect of lowering dietary CP by incorporating AA in feed

Although the ADFI of intact male Landrace x Large-White pigs did not differ significantly between the two levels of dietary CP, from 12 wk to 21 wk of age the growth performance of pigs fed low CP diets was lower than that of the pigs fed HP diets, which led to a 17.8% (12 to 16 wk of age) and 14% (17 to 21 wk of age) difference in G:F. Thus, the efficiency of energy use for maintenance and gain was reduced, concomitantly. 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, ADG and G:F. 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). Recently, Gloaguen et al. (2014) suggested that dietary N requirements should be expressed as the minimum amount of dietary N:Lys that is required to maintain growth in pigs so that non-protein N, dispensable AA and indispensable AA requirements would be accounted for. Their study showed that the optimal digestible N relative to SID Lys was between 19.1 g/kg and 20.4 g/kg. In the present study, low CP diets led to digestible N:SID Lys ratio of 23.0 to 30.5 g/kg. Yet, growth performance was impaired, which suggests that, although the low CP diets in our study were formulated to have the ideal protein balance, some AA can limit protein deposition. Indeed, the recent Spanish guidelines for swine feed formulation have been modified to include recommendations for lean well-conformed genotypes (FEDNA, 2013), which might respond positively to an increase in nutrient supplies. Assuming that lysine is the first limiting AA and ideal protein balance may be maintained, the level of dietary Lys should be >9.1 g/kg from 12 wk to 16 wk of age, and >6.7 g/kg from 17 wk to 21 wk of age so that optimum growth performance can be allowed.

In our study, lowering dietary CP reduced fecal **AEE** digestibility at some points in the growth process (11 wk and 21 wk of age), but the amount of **AEE** digested did not differ significantly between treatments because the pigs fed low CP diets had slightly numerically higher ADFI than did the pigs fed HP diets, which led them to digest more DM at 21 wk of age compared to their counterparts fed high CP diets. This may be explained by an improvement of the non-structural carbohydrate fraction (e.g. starch) digestion, given that the amount of AEE digested did not differ between treatments and the amounts of CP and NDF digested were lower in pigs fed low CP diets. The pH of slurry from pigs fed low CP diets was lower that that of the slurry from pigs fed high CP diets, and low pH mitigates the release of ammonia (Morazán et al., 2014).

In our experiment, dietary CP manipulation did not have a significant effect on carcass yield, but it did increase BFT and therefore, carcass value (which is primarily based on its lean content) decreased slightly. Other studies have reported similar results (e.g. Kerr et al., 1995, 2003; Madrid et al., 2013; Wood et al., 2013), but they did not explanations for the results. Assuming that pig's lean growth potential and dietary protein:energy ratio are the primary factors that influence the rates of protein and lipid deposition, the increase in BFT might be a result of more efficient utilization of energy because of a reduction in heat loss through catabolism and urinary excretion of excess dietary N (Kerr et al., 2003; Madrid et al., 2013). Alternatively, reduced productive performance might have been because the reduction in dietary CP did not allow the required dietary ratios of sulfur AA and threonine relative to lysine , which increase with pig's age (Tuitoek et al., 1997). Although low CP diets can reduce nitrogen emissions and improve eating quality simultaneously (Wood et al., 2013), the economic margins that result under current market conditions make this dietary manipulation an infeasible nutritional strategy.

Effect of increasing dietary NDF by adding sugar-beet pulp

In the present study, high dietary NDF reduced ADFI at the end of the finishing period, but it did not reduce the G:F ratio or energy efficiency, although carcass yield tended to be reduced and BFT increased. It has been hypothesized that dietary fiber does not have a significant effect on growth performance, which implies that pigs can tolerate a wide range of dietary fiber levels, if dietary energy density is adequate (Baird et al., 1975; Beaulieu et al., 2009; Gutiérrez et al., 2013). In our study, the slight decrease in carcass yield might have occurred because of an increase in intestinal content and/or increased organ development, although the effect was negigible after the usual pre-slaughter fasting periods (12 to 24 h) used (Santomá, 1997).

The effect of dietary NDF on growth performance and carcass traits might be conditioned by the diet CP level, because adding extra dietary AA above requirements to pigs fed low CP and high NDF (from ethanol co-products sources) diets increased carcass leanness, but reduced growth performance (ADFI and ADG) (Jha et al., 2013). In fact, high fiber intake increases threonine requirements because this AA is a main constituent of mucin protein, which can be secreted into the intestinal lumen as a function of fermentable fiber flow (Zhu et al., 2005).

Increasing dietary NDF did not lower slurry pH (see also Shriver et al., 2003); however, some studies have shown that high fiber diets can reduce excreta pH (Lynch et al., 2008). In our study, fecal output was highest in pigs that were fed a high soluble fiber diet. Inevitably, increased intake of dietary fiber influences bowel habits because of the mechanical action and water-holding properties of fiber, which increases the bulk of the colon and feces (Bach Knudsen and Hansen, 1991).

Although an increase in dietary NDF led to a higher DM digestibility coefficient at 11 wk and 16 wk of age, the amount of DM, OM and CHO digested at the end of the finishing period was lowest in high NDF diets. In addition, an increase in dietary NDF led to concomitant increase in apparent fecal AEE digestibility. Noblet and Shi (1993) reported a curvilinear relationship between dietary AEE and apparent fecal AEE digestibility, which is reduced when the fiber content of the diet is >200 g NDF/kg. In our study, the fiber content of HF diets was below that threshold. Furthermore, the use of a basal diet composed of natural ingredients that contained dietary fiber (barley, wheat and soybean meal) and dietary lipids might have diminished the potential negative impact of dietary fiber from sugar-beet pulp on nutrient digestibility.

An increase in dietary NDF did not trigger remarkable differences in the carcass classification based on lean content; therefore, this dietary manipulation did not have detrimental effects on carcass income or economic margin, at least when the CP level in the diet was kept high.

Interaction effects of lowering dietary CP and increasing dietary NDF

In our study, the interaction effect of dietary CP and NDF did not have a significant effect on growth performance and carcass parameters; thus, reducing dietary CP has similar effects on most of the studied traits, independent of the level of dietary NDF. In addition, the effects of dietary NDF on productive parameters were also independent of the level of dietary CP. In weaned piglets (9-18 kg BW) (Hermes et al., 2009) fed wheat bran and sugar-beet pulp, and in growing-finishing pigs (30-115 kg BW) fed ethanol byproducts as fiber sources (Jha et al., 2013), dietary CP and NDF affected ADFI and growth performance, independently.

Nevertheless, an increase in dietary NDF without a reduction in dietary CP led to a decrease in whole-tract apparent CP digestion and an increase in the amount of DM excreted, which was reflected by the physic-chemical characteristics of slurry (EC and density). Adding fiber to the diet increases N retention in the large intestine, which increased microorganism growth, but leads to an increase in fecal N output (Malmlöf and Hakansson, 1984). The influence of dietary fiber on CP digestibility might be mediated by the flow of fermentable carbohydrates into the large intestine, which in turn increases microbial growth and might induce the secretion of blood urea into the large intestine for microbial protein synthesis (Shriver et al., 2003).

In our study, an increase in dietary NDF (170 g NDF/kg in HF diets by including 50 g/kg of sugar-beet pulp and the cell wall contribution of the cereals used) had a negative effect on apparent fecal CP digestibility when the feed had high CP (175 g CP/kg), but not when the feed had low CP (125.5 g CP/kg). Some studies found that the negative correlation between whole-tract CP digestibility and dietary fiber content (200 g/kg of sugar-beet pulp, which resulted in 185 g NDF/kg) was independent of dietary CP level (200 vs. 150 g CP/kg) (Lynch et al., 2008; in pigs from 75 to 95 kg of BW), while others found a smaller but yet significant reduction in whole-tract CP digestibility because of a high fiber content (177 g NDF/kg) in low CP diets (157 g CP/kg) (Zervas and Zijlstra, 2002; in pigs from 25 to 40 kg of BW).

Elevated dietary NDF can reduce apparent CP digestibility because of increases in endogenous losses of AA (Schulze et al., 1994). In turn, dietary fat can increase apparent CP digestibility (Imbeah and Sauer, 1991) because it reduces digesta passage rate and, thereby, allows more time for proteolytic enzymes to hydrolyze dietary proteins (Kil et al., 2013), without affecting endogenous losses of AA (de Lange et al., 1989). Therefore, in our study, the high AEE content of the HF diets in phase II (12 to 16 wk of age) and III (17 to 21 wk of age), which was necessary to allow an iso-energetic formulation, might have compensated for any negative effects of dietary NDF on CP digestion.

Diet cost, carcass income and economic margin were lowest when the diet combined low CP and high NDF levels. A reduction from 190 g/kg down to 123 g/kg in feed CP might be achieved by substituting soybean meal and extruded soybean (from 197 kg/t down to 70 kg/t) by cereals and synthetic AA (lysine, threonine, methionine, tryptophan and valine), which reduces feed costs concomitantly (García-Launay et al., 2014). In our study, a reduction in dietary CP did not reduce the feed cost when the NDF level was at normal range; however, formulating low CP feed without an increase in the NDF level was a useful means of counterbalancing the deleterious effects of low CP on economic margin.

In conclusion, reducing dietary CP and adding synthetic AA to the feed did not affect the growth performance of pigs from 6 wk to 11 wk of age; thereafter, however, to avoid impairing production parameters and excess carcass fatness in pigs from 12 wk to 21 wk of age it was more feasible to increase dietary NDF and maintain a constant energy density. An increase in dietary NDF in low CP feed did not reduce whole-tract CP digestibility, which suggests that this dietary manipulation would only be useful for shifting the balance of nitrogen excretion from urine to feces at the high dietary CP levels. Although the low CP and high NDF diet was least expensive, to avoid detrimental effects on the economic margin of growing-finishing pigs, a reduction in dietary CP should not be coupled with an increase in dietary NDF.

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Table 1. Ingredients and additives (g/kg) of the three-phase experimental diets, differing in CP content (high, HP vs. low, LP) and/or NDF content (normal, NF vs. high, HF) from 6 to 21 wk of age.

	Feeding phase											
	I (6 to 11 wk of age)				II (12 to 16 wk of age)				III (17 to 21 wk of age)			
	HP		LP		HP		LP		HP		LP	
Item	NF	HF	NF	HF	NF	HF	NF	HF	NF	HF	NF	HF
Barley	267	193	203	253	276	297	268	301	274	217	253	398
Soybean meal, 47% CP	265	266	217	199	246	186	156	102	226	114	90	16
Sorghum	260	52	151	59	205		227	-	200	-	101	-
Wheat	152	379	375	382	205	296	288	298	199	201	396	201
Rapeseed meal 00	-	-	-	-	-	70	-	78	-	100	-	81
Maize	-	-	-	-	-	16	-	95	60	173	101	152
Sunflower meal	-	-	-	-	-	-	-	-	-	80	-	36
Sugar beet pulp	-	53	-	50	-	53	-	50	-	50	-	50
Soybean oil	-	3.1	-	3.2	-	8.6	-	6.9	-	9.9	-	8.7
Blended animal-vegetable fat 3/5	31	30	31	31	31	40	30	40	23	40	31	40
Calcium carbonate	8.9	2.8	-	2.0	5.9	2.5	0.8	0.8	7.0	4.3	13.5	4.2
Monocalcium phosphate	5.5	9.0	9.1	8.1	6.3	6.1	7.5	7.1	4.2	3.4	6.3	5.5
Sepiolite	-	-	-	-	8.4	4.1	4.2	3.3	-	-	-	-
Vitamin-mineral premix[1]	4.1	4.1	4.1	4.1	4.4	4.4	4.4	4.4	4.5	4.5	4.5	4.5
Rehydra Pro® (organic acids and surfactant)	-	-	-	-	10.0	10.0	10.0	10.0	-	-	-	-
Sodium chloride	2.1	1.8	2.1	2.1	1.9	2.0	2.1	1.9	2.2	1.9	2.2	1.9
L-Lys, (CP 50%)	3.57	2.51	3.66	1.63	-	-	1.40	0.90	-	-	1.53	1.40
DL-Met, 88%	0.50	1.60	-	1.73	-	-	-	-	-	-	-	-
L-Thr	0.30	1.10	3.96	1.22	-	5.29	-	-	-	-	-	-
L-Trp	-	1.08	-	1.21	-	-	-	0.82	-	0.50	-	-

[1] The vitamin and mineral premix for pigs between 6 and 11 wk of age (CN-A. Piglets Enz + Phy 0.5%) contained (per kg of complete diet): 8,000 IU of vitamin A; 800 IU of vitamin D_3; 40 mg of α-tocopherol; 2.4 x 10^{-2} mg of vitamin B_{12}; 0.8 mg of vitamin B_1; 1.6 mg

of vitamin B_6; 4 mg of vitamin B_2; 1.2 mg of vitamin K_3; 16 mg of nicotinic acid; 8 mg of pantothenic acid; 280 mg of choline; 0.08 mg of biotin; 0.4 mg of folic acid; 72 mg of Fe ($FeCO_3$); 0.32 mg of I (KI); 0.16 mg of Co ($CoSO_4.7H_2O$); 128 mg of Cu ($CuSO_4.5H_2O$); 23.8 mg of Mn (MnO); 80 mg of Zn (ZnO); 0.24 mg of Se (Na_2O_3Se); 0.264 mg of citric acid; 600 FYT 6-phytase; 2,000 BGU of endo-(1,4)- β-glucanase; 4,800 FXU of endo-(1,4)- β-xylanase; 0.264 mg of ethoxyquin.

The vitamin and mineral premix for pigs between 12 and 16 wk of age (SETNAMIX TM fattening C/C 0.2% FIT-500 VIT E15) contained (per kg of complete diet): 6,250 IU of vitamin A; 1,920 IU of vitamin D_3; 14.4 mg of α-tocopherol; 1.7 x 10^{-2} mg of vitamin B_{12}; 1.44 mg of vitamin B_6; 3.84 mg of vitamin B_2; 17.28 mg of nicotinic acid; 8.64 mg of calcium pantothenate; 36 mg of choline chloride; 16.6 mg of betaine anhydrous; 96 mg of Fe ($FeCO_3$); 0.96 mg of I (KI); 0.19 mg of Co ($2CoCO_33Co(OH)_2.H_2O$); 14.4 mg of Cu ($CuSO_4.5H_2O$); 48 mg of Mn (MnO); 105.6 mg of Zn (ZnO); 0.97% $CaCO_3$; 0.21 mg of Se (Na_2O_3Se); 1.92 mg of butyl-hydroxytoluene; 6.62 mg of citric acid; 0.19 mg of sodium citrate; 192 mg of sepiolite; 480 FTU of 6-phytase; 1.9 g of vitamin mineral premix; 0.5 g of Belfeed B 220 ® (xylanase) and 2 g of Toxidex ® (mycotoxin inhibitor).

The vitamin and mineral premix for pigs between 17 and 21 wk of age (NE-Fattening 0.2%) contained (per kg of complete diet): 6,500 IU of vitamin A; 2,000 IU of vitamin D_3; 15 mg of α-tocopherol; 1.8 x 10^{-2} mg of vitamin B_{12}; 1.5 mg of vitamin B_6; 4 mg of vitamin B_2; 18 mg of nicotinic acid; 9 mg of calcium pantothenate; 37.5 mg of choline chloride; 17.28 mg of betaine anhydrous; 100 mg of Fe ($FeCO_3$); 1 mg of I (KI); 0.198 mg of Co ($2CoCO_33Co(OH)_2.H_2O$); 15 mg of Cu ($CuSO_4.5H_2O$); 50 mg of Mn (MnO); 110 mg of Zn (ZnO); 0.97% $CaCO_3$; 0.22 mg of Se (Na_2O_3Se); 2 mg of butyl-hydroxytoluene; 6.9 mg of citric acid; 0.2 mg of sodium citrate; 200 mg of sepiolite; 500 FTU of 6-phytase; 2 g of vitamin mineral premix; 0.5 g of Belfeed B 220 ® (xylanase) and 2 g of Toxidex ® (mycotoxin inhibitor).

Table 2. Energy and nutrient composition of the experimental diets, differing in CP content (high, HP vs. low, LP) and/or NDF content (normal, NF vs. high, HF) from 6 to 21 wk of age (three-phase feeding program) (g/kg as-fed basis).

	I (6 to 11 wk of age)				II (12 to 16 wk of age)				III (17 to 21 wk of age)			
	HP		LP		HP		LP		HP		LP	
Item	NF	HF	NF	HF	NF	HF	NF	HF	NF	HF	NF	HF
Calculated values												
ME,[1] kcal/kg	3,300				3,300				3,300			
NE,[1] kcal/kg	2,425				2,425				2,425			
SID Lys[1]	10.1		8.6		7.9		6.5		7.3		5.0	
Dig N:SID Lys[1]	23.6		23.0		26.1		27.1		30.5		30.2	
SID Met[1]	3.6		3.1		2.5		2.2		2.6		1.9	
SID Met + Cys[1]	5.5		5.0		5.3		4.6		5.4		4.1	
SID Thr[1]	6.8		7.8		8.3		4.5		5.5		3.6	
SID Trp[1]	2.7		2.5		2.0		2.0		2.2		1.3	
Analyzed values												
DM	891.0		887.0		883.0		883.0		890.0		887.0	
CP	197.5		172.0		173.0		151.5		175		125.5	
Total Lys	13.8		11.6		10.3		9.1		10.0		6.7	
NDF	120.0	140.6	123.2	153.7	130.0	173.5	125.7	162.3	122.6	174.7	134.6	166.5
ADF	36.2	40.6	35.4	43.1	44.3	50.7	32.0	51.5	35.0	66.4	30.6	56.3
CF	27.1	25.6	20.7	29.3	27.0	38.6	23.3	38.8	28.3	55.2	25.9	47.1
Starch	380.1	382.9	379.6	398.8	384.0	374.0	444.3	380.2	416.8	360.9	471.9	425.8
AEE[2]	49.0	49.7	47.8	47.8	49.2	60.4	44.8	64.2	41.9	66.8	46.1	60.0
Ash	66.1	55.5	48.1	50.7	66.9	44.2	46.0	47.7	46.5	48.2	62.6	46.3
P	6.4	6.6	5.8	6.4	6.1	6.0	5.7	6.1	5.2	5.5	4.8	5.5
K	7.1	7.4	5.5	6.6	6.2	6.0	5.3	5.3	6.0	5.9	4.3	4.5

[1] ME, NE and Standardized ileal digestible (**SID**) AA content calculated according to FEDNA (2010); Dig N = fecal digestible N, calculated from the analyzed N content, the fecal N digestibility and ileal Lys digestibility of the feed ingredients (FEDNA, 2010).

[2] AEE = acid hydrolized ether extract

Table 3. Growth performance [BW, ADG, ADFI, G:F and calculated energy efficiency] in growing-finishing pigs as affected by dietary CP (high, HP vs. low, LP) and/or NDF content (normal, NF vs. high, HF) from 6 to 21 wk of age.

	CP		NDF		SEM	*P*-value	
Item	HP	LP	NF	HF		CP*Phase	NDF*Phase
ADFI (6 to 11 wk of age), kg/d	1.21	1.26	1.25	1.22	0.036	0.3724	0.0426
ADFI (12 to 16 wk of age), kg/d	2.27	2.29	2.33	2.23			
ADFI (17 to 21 wk of age), kg/d	2.87	2.85	2.94^{x}	2.78^{y}			
Overall ADFI, kg/d	2.12	2.13	2.17^{x}	2.07^{y}	0.029	0.7304	0.0186
Initial BW (at 6 wk of age), kg	13.7	13.9	13.9	13.7	1.38	<.0001	0.1055
BW (at 12 wk of age), kg	39.1	38.2	39.2	38.0			
BW (at 17 wk of age), kg	75.1^{a}	70.5^{b}	74.3	71.4			
Final BW, kg	114.6^{a}	102.8^{b}	110.9	106.5			
ADG (6 to 11 wk of age), g/d	756	718	750	725	28.0	0.0012	0.7226
ADG (12 to 16 wk of age), g/d	1,007^{a}	889^{b}	982	915			
ADG (17 to 21 wk of age), g/d	1,125^{a}	892^{b}	1,030	988			
Overall ADG, g/d	963^{a}	833^{b}	920	876	17.8	<.0001	0.0757
G:F (6 to 11 wk of age), g/g	0.53	0.48	0.52	0.49	0.076	0.0131	0.8865
G:F (12 to 16 wk of age), g/g	0.44^{a}	0.38^{b}	0.41	0.40			
G:F (17 to 21 wk of age), g/g	0.36^{a}	0.30^{b}	0.33	0.32			
Overall G:F, g/g	0.43^{a}	0.37^{b}	0.40	0.39	0.055	<.0001	0.3707
ME intake / ME requirements[1] (6 to 11 wk of age)	1.02	1.01	0.99	1.05	0.025	<.0001	0.5293
ME intake / ME requirements (12 to 16 wk of age)	1.16^{b}	1.27^{a}	1.21	1.23			
ME intake / ME requirements (17 to 21 wk of age)	1.26^{b}	1.42^{a}	1.32	1.36			
Overall ME intake / ME requirements	1.15^{b}	1.23^{a}	1.17	1.21	0.019	0.0036	0.1442

Within each row, means without a common superscript letters (CP: $^{a, b}$ and NDF level: $^{x, y}$) differ ($P < 0.05$).

[1] ME requirements = ME need for maintenance + ME need for growth (FEDNA, 2013).

Table 4. Apparent whole-tract digestibility coefficients (%) and amount of nutrients digested (kg or g/d) in growing-finishing pigs as affected by CP (high, HP vs. low, LP) and/or NDF content (normal, NF vs. high, HF) from 6 to 21 wk of age.

Item	Age (wk)	CP		NDF		SEM	*P*-value	
		HP	LP	NF	HF		CP*Phase	NDF*Phase
DM digestibility coefficient, %	11	95.33^{a}	94.23^{b}	94.34^{y}	95.22^{x}			
	16	94.39	94.61	94.10^{y}	94.91^{x}	0.189	0.0014	0.0063
	21	94.40	94.00	94.27	94.12			
Digested DM, kg/d	11	1.46	1.52	1.47	1.52			
	16	2.28	2.35	2.37^{x}	2.27^{y}	0.031	0.0102	<.0001
	21	2.43^{b}	2.62^{a}	2.62^{x}	2.43^{y}			
OM digestibility coefficient, %	11	82.75	80.14	80.73	82.16			
	16	83.34	83.05	82.64	83.75	0.544	0.0744	0.3147
	21	84.74	83.71	84.25	84.20			
Digested OM, kg/d	11	1.03	1.11	1.05	1.09			
	16	1.73	1.74	1.74	1.73	0.028	0.4991	0.0005
	21	2.13	2.18	2.25^{x}	2.06^{y}			
Ether extract (EE) digestibility coefficient, %	11	63.34^{a}	54.55^{b}	55.19^{y}	62.70^{x}			
	16	68.88	68.66	63.69^{y}	73.85^{x}	1.374	0.011	0.0035
	21	67.92^{a}	63.80^{b}	57.39^{y}	74.33^{x}			
Digested EE, g/d	11	46.40	43.02	41.57	47.84			
	16	93.85	94.77	75.87^{y}	112.75^{x}	2.432	0.4649	<.0001
	21	110.87	105.94	80.79^{y}	136.02^{x}			
Carbohydrates (CHO) digestibility coefficient, %	11	86.82^{a}	84.37^{b}	85.06	86.14			
	16	87.15	86.67	86.95	86.87	0.417	0.0319	0.0006
	21	87.54	86.80	88.23^{x}	86.13^{y}			
Digested CHO, kg/d	11	0.76^{b}	0.86^{a}	0.78	0.82			
	16	1.31	1.37	1.36	1.33	0.022	0.0428	<.0001
	21	1.61^{b}	1.78^{a}	1.82^{x}	1.58^{y}			

Within each row, means without a common superscript letters (CP: $^{a,\ b}$ and NDF level: $^{x,\ y}$) differ ($P < 0.05$).

Table 5. Carcass parameters in growing-finishing pigs as affected by dietary CP (high, HP vs. low, LP) and/or NDF content (normal, NF vs. high, HF).

	CP		NDF		*P*-value[1]	
Item	HP	LP	NF	HF	CP	NDF
Carcass wt, kg	75.42	73.61	75.89	75.13	0.71	0.12
Carcass yield, %	71.79	71.02	71.30	70.49	0.66	0.09
BFT (3rd-4rd last ribs), mm	13.51^{b}	16.06^{a}	14.09^{y}	15.47^{x}	<0.001	0.03
Carcass classification[2]	95.7% R, 4.3% O	79.2% R, 20.8% O	87.5% R, 12.5% O	87.0% R, 13.0% O	0.09	0.95

Within each row and effect (CP or NDF), means without a common superscript letters ($^{a, b}$) differ ($P < 0.05$).

[1] Interaction CP x NDF = all the parameters with $P > 0.25$.

[2] According to SEUROP (BOE, 2011): R = 45.1 to 50% lean meat; O = 40 to 45% lean meat.

BFT: Backfat thickness

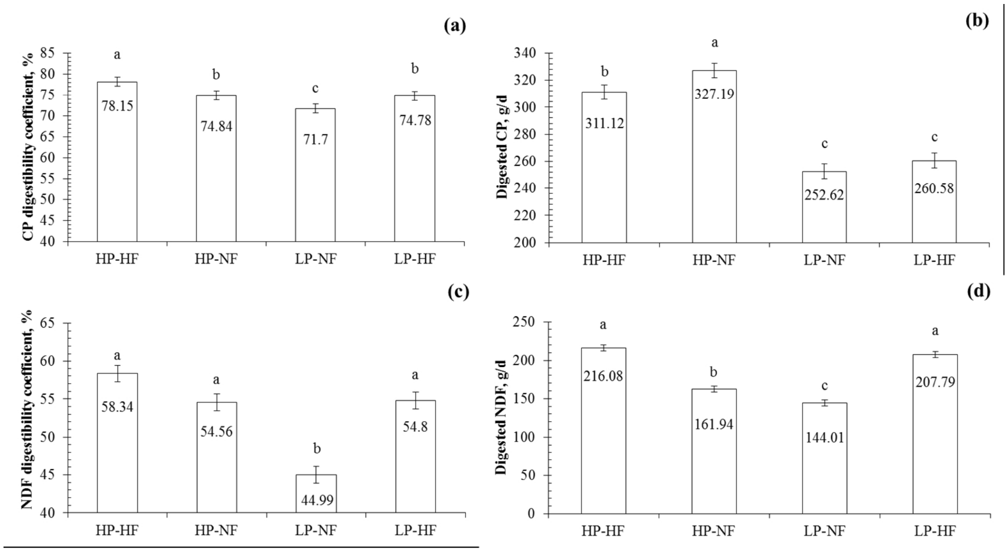
Figure Legends

Figure 1. Average whole-tract CP digestibility (%) (Fig. 1a), amount of CP digested (g/d) (Fig. 1b), NDF digestibility (%) (Fig. 1c), and amount of NDF digested (g/d) (Fig. 1d), as affected by the interaction between dietary CP (high, HP vs. low, LP) and NDF content (normal, NF vs. high, HF) ($P < 0.01$) in growing-finishing pigs from 6 to 21 wk of age. Above each bar, different letters ($^{a, b}$) indicate significant differences among diets ($P < 0.05$). Error bars = SEM.

Figure 2. Fecal output on a DM basis in growing-finishing pigs as affected by dietary CP (high, HP vs. low, LP) (Fig. 2a) and/or NDF content (normal, NF vs. high, HF) (Fig. 2b). Above each bar, different letters indicate significant differences ($P < 0.05$) between dietary CP level ($^{a, b}$) or NDF level ($^{x, y}$). Error bars = SEM.

Figure 3. Density (kg/m^3) (Fig. 3a) and electrical conductivity (EC) (dS/m) (Fig. 3b) of slurry from growing-finishing pigs (6 to 21 wk of age) as affected by the interaction between dietary CP (high, HP vs. low, LP) and NDF content (normal, NF vs. high, HF) ($P < 0.01$). Above each bar, different letters ($^{a, b}$) indicate significant differences among diets ($P < 0.05$). Error bars = SEM.

Figure 4. Diet cost, carcass income and economic gross margin of different nutritional strategies for growing-finishing pigs differing in dietary CP (high, HP vs. low, LP) and NDF content (normal, NF vs. high, HF). To account for changes in market price over time, the results were assessed as a proportion of the lowest outcome (shown as 100%). $^{a\text{-}c}$ Means without a common litters differ ($P < 0.05$). Error bars = SEM.



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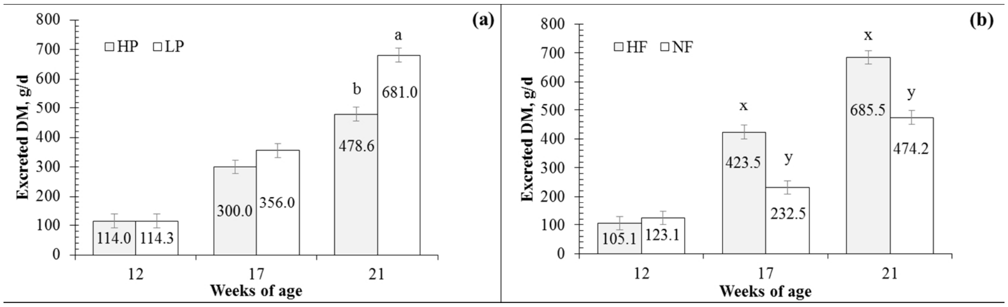

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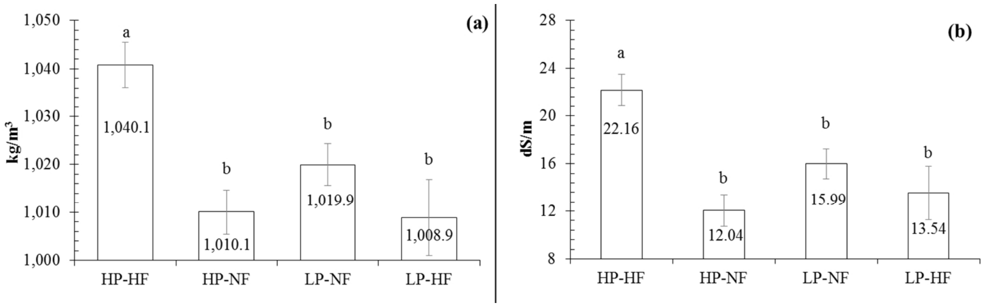

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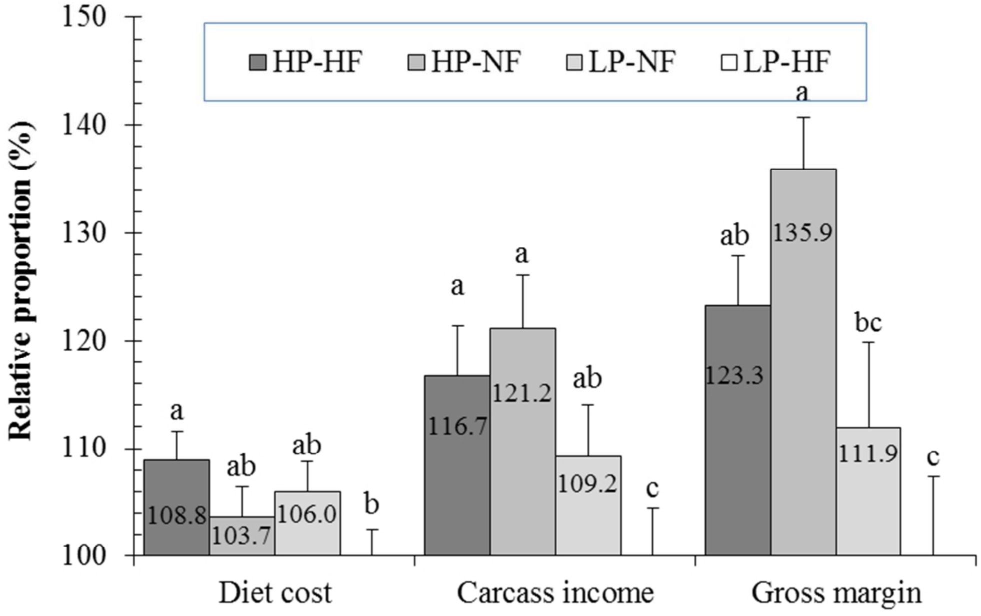

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