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The impact of feeding growing-finishing pigs with reduced dietary protein levels on performance, carcass traits, meat quality and environmental impacts

A.N.T.R. Monteiro[a,1], T.M. Bertol[b], P.A.V. de Oliveira[b], J.-Y. Dourmad[c], A. Coldebella[b], A.M. Kessler[a,*]

[a] Animal Science Department, Universidade Federal do Rio Grande do Sul, 91540-000 Porto Alegre, RS, Brazil
[b] Embrapa Suínos e Aves, 89700-000 Concórdia, SC, Brazil
[c] INRA Agrocampus Ouest, UMR 1348 Pegase, 35590 Saint-Gilles, France

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ABSTRACT

The objective of this study was to evaluate the effect of reducing dietary nutrient content for pigs from 25 to 130 kg live weight, on performance, carcass traits, meat quality and environmental impact. Forty gilts and 40 barrows were distributed in a randomized block design with two treatments and 10 replications per treatment, with four animals per experimental unit. The feeding program was in four phases. Two diets were formulated for each feeding phase. One was adjusted using the InraPorc® model to minimize crude protein, amino acid and phosphorus excess (LN), and the other (ST) was formulated with standard Brazilian recommendations. No differences were found on performance. The mean ADG and ADFI were 0.919 and 2.46 kg/day, respectively. Carcass characteristics and meat quality were also not affected by the experimental diets. The average total feed cost was 6.8% lower ($P < 0.05$) for animals fed the LN diets. For nitrogen and phosphorus balance, there was no statistical difference in retention, but the nitrogen and phosphorus intake were 15.8% and 9.42% lower for pigs fed LN diets, respectively, and the excretion levels were 24.1% and 14.6% lower for pigs fed LN diets, respectively. Life cycle assessment showed that LN strategy can reduce the environmental impacts of climate change and terrestrial ecotoxicity by about 4%, acidification and eutrophication by 8% and 10%, respectively, and land occupation by 9%. Data suggest that nutritional adjustment is a valuable alternative to standard formulations, without affecting performance, but lowering costs and reducing environmental burdens.

1. Introduction

Optimizing nutrient efficiency is essential to increase pig chain sustainability, since it may reduce nutrient excretion and production costs, at the same time meeting government environmental policies (Jean dit Bailleul et al., 2000; Hauschild et al., 2010). Several studies have indicated that nutrient efficiency could be improved by better adjusting the nutrient supply to pig requirements (Hauschild et al., 2012; Pomar et al., 2014; Andretta et al., 2014), via more precise knowledge of the metabolic availability of dietary nutrients and a proper definition of requirements, as well as by the use of highly digestible ingredients and phytase (Miller et al., 2016).

In practice, the approach used to estimate the nutrient requirements of pigs is often based on empirical methods and average recommendations. It is the case in Brazil where nutritional recommendations are derived from the response of animals, in growth performance studies, to increasing levels of the studied nutrient (Sakomura and Rostagno, 2016). However, in practical situations feed intake and daily weight gain may evolve differently due to differences in climatic conditions, animal health status or genetic potential. Moreover, Hauschild et al. (2010) indicated that the amount of digestible lysine required for the optimal feed conversion ratio of a given population can be lower than the amount required for maximal average daily weight gain.

In this context, modelling appears an interesting approach to enable a more dynamic and adaptive determination of nutrient requirements (van Milgen et al., 2008), compared to standard tabulated recommendations. The determination of nutritional requirements for a given herd and a given genotype can be better adjusted by using decision-support tools based on these models, such as InraPorc®

* Corresponding author.
E-mail address: akessler@ufrgs.br (A.M. Kessler).
[1] Present address: Animal Science Department, Universidade Estadual de Maringá, 87020-900 Maringá, PR, Brazil.

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software. This makes it more efficient than empirical models for nutrient requirement estimation. Besides, use of phytase has been consolidated as an efficient tool to improve phosphorus utilization, while reducing phosphorus excretion (Lei et al., 2013). Moreover, environmental restrictions are now being imposed on new pig farms in many countries, compelling the pig industry to balance the amount of nutrients applied to soil as manure against the amount extracted by crops. For instance, in Brazil, through the Ministry of Agriculture, Livestock and Supply, the Brazilian government proposed the ABC Plan (Agriculture Low Carbon) in 2010, in order to plan actions for the adoption of sustainable production technologies, focusing on pig production with low carbon emission (Brasil, 2012).

Reducing the excretion of excess nutrients and restricting the use of non-renewable resource could be essential components in the development of sustainable pig production (Dourmad and Jondreville, 2007). However, nutritional requirements are still not estimated using mathematical models in the Brazilian industry, because nutrient excess ensures that there are no underfed pigs. Indeed, empirical guidelines express nutrient recommendations with safety margins instead of nutrient requirements, resulting often in a surplus of nutrient supply. In addition to performance, carcass and meat quality are also key factors of concern in the pig industry, since the reduction of some nutrients, such as protein (CP), could increase fat deposition (Pomar et al., 2014; Andretta et al., 2014), due to the fact that low CP diets provide more net energy because of reduced amino acids deamination, reduced urea excretion and lower heat production (Noblet et al., 2001).

This study was thus undertaken to evaluate if a feeding strategy of growing-finishing pigs based on the modelling of nutrient requirements according to a target of performance could achieve at least similar growth performance, carcass traits and meat quality as a strategy based on standard recommendations with rather large safety margins, whilst reducing the environmental impacts evaluated by life cycle assessment.

2. Materials and methods

2.1. Animals, housing and management

Eighty 68-day-old crossbred pigs (MS-115×(LW×LD)), 40 barrows and 40 gilts, with an average initial weight of 24.5 ± 1.79 kg were used. The terminal sire line Embrapa MS-115 is the synthetic line of Pietrain (62.5%), Large White (18.8%) and Duroc (18.8%) breeds, developed at Embrapa Swine and Poultry. The pigs had free access to feed and water throughout the experiment and were cared for in accordance with Brazilian guidelines reviewed and approved by the Ethics Committee of the Embrapa Swine and Poultry (protocol No. 002/2013). The Brazilian guidelines are based on Federal Law No. 11794 of October 8, 2008.

Pigs were weighed and allotted in a randomized complete block design, blocked by initial body weight within sex. Animals were assigned to one of 20 pens, each one housing four animals (housed separately according to gender), totaling 10 replications per treatment. The pen (2.80 m×2.40 m) designed with partially slatted floor in a naturally ventilated room, i.e. with large windows controlled by curtains, was considered the experimental unit. Four datalogers (Model Testo® 135H; Testo Inc.), two indoors and two outdoors, were used to record the temperature and relative humidity of the environment. Feed was provided with one semi-automatic feeders (Model CAP 1BT, Suin®) per pen and water with one low-pressure nipple drinker (Model eco cup, Suin®).

The experiment was divided into four phases over the growing-finishing period, with a specific diet for each phase: phase 1 (from 25 to 50 kg BW), phase 2 (from 50 to 80 kg BW), phase 3 (from 80 to 105 kg BW) and phase 4 (from 105 to 130 kg BW). The growing period was considered from 25 to 80 kg BW (from 0 to 63 d) and the finishing period was from 80 to 130 kg BW (from 64 to 112 d).

Table 1
Ingredient composition and nutrient content of the experimental diets (as fed basis).

	Growing				Finishing			
	Phase 1		Phase 2		Phase 3		Phase 4	
	ST	LN	ST	LN	ST	LN	ST	LN
Ingredients, g/kg								
Maize	647.1	764.1	703.0	777.3	751.0	811.0	797.3	834.3
Soybean meal	304.5	200.0	268.1	199.0	223.9	165.8	179.6	145.8
Soybean oil	21.3	6.30	4.90	2.62	1.94	1.88		
Dicalcium phosphate	11.7	12.0	9.23	9.40	8.29	5.95	7.59	5.39
Limestone	8.13	6.70	7.42	5.75	6.64	7.51	6.06	6.88
Mineral mix[a]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Vitamin mix[b]	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Salt	3.52	3.54	3.30	2.04	3.09	3.09	4.04	4.04
L-Lysine HCl	0.93	3.10	1.31	1.36	1.83	1.58	2.11	1.03
DL-Methionine	0.35	0.43	0.31		0.40	0.24	0.30	
L-Threonine		0.90	0.08		0.44	0.30	0.47	
L-Tryptophan		0.27		0.01		0.05	0.03	
Phytase[c]						0.10		0.10
Composition, g/kg								
ME (MJ/kg)	13.8	13.8	13.8	13.8	13.6	13.6	13.6	13.6
Crude protein[d]	182	148	171	146	161	144	135	125
SID[e] lysine	9.43	8.67	8.91	7.34	8.29	6.73	7.48	5.85
SID methionine	2.86	2.52	2.70	2.11	2.60	2.20	2.32	1.89
SID met+cys	5.56	4.77	5.26	4.37	4.97	4.32	4.50	3.91
SID threonine	6.15	5.68	5.79	4.83	5.57	4.69	5.03	4.15
SID tryptophan	1.96	1.69	1.78	1.44	1.55	1.30	1.35	1.15
SID valine	7.82	6.15	7.28	6.17	6.57	5.63	5.86	5.32
Calcium[d]	7.55	6.94	6.41	6.51	7.20	8.00	4.21	4.61
Total P[d]	5.78	5.46	4.87	4.90	4.82	4.39	4.56	3.86
Digestible P[f]	3.04	3.47	2.68	3.02	2.48	2.70	2.30	2.57

[a] Content/kg of feed: Zn, 0.1 g; Cu, 0.01 g; Fe, 0.1 g; Mn, 0.04 g; I, 1.5 mg; Co, 1 mg.
[b] Content/kg of feed: Vit. D3, 225 IU, Vit. E, 22.5 IU, Vit. K3, 2.25 mg, Vit. B1, 2.03 mg, Vit B2, 6 mg, Vit B6, 3 mg, Vit. B12, 30 mcg, Pantothenic Ac., 14 mg, Niacin, 0.03 g, Folic Ac., 0.9 mg, Se, 0.45 mg, Biotin, 0.12 mg, Vit. A, 9000 IU.
[c] Content/kg of feed: 0.5 FTU (Natuphos® – BASF Chemical Company).
[d] Analyzed composition.
[e] SID=standardized ileal digestible. Calculated from Rostagno et al. (2011).
[f] Digestible P. Calculated from Rostagno et al. (2011).

2.2. Nutritional requirements and diets

Two dietary treatments were evaluated (Table 1): a standard (**ST**) strategy with diets formulated with the nutritional recommendations for barrows with superior performance, as published in Rostagno et al. (2011); and a low nutrient (**LN**) strategy with diets formulated with the nutritional requirements estimated using the InraPorc® model (version 1.6.5.3; Institut National de la Recherche Agronomique, Saint-Gilles, France). Crude protein (nitrogen×6.25), standardized ileal digestible amino acids (**SID AA**) and digestible phosphorus requirements were used for the feed formulation, with the same metabolizable energy (**ME**) content between treatments, within each phase. Phytase enzyme was added to LN diets at finisher phases, to keep the line of nutrient reduction. Ingredients were analyzed and their composition was added to the InraPorc® feed database, as well as into the linear least-cost diet formulation software. For maize and soybean meal, standardized digestibility of AA was calculated from total content as in Rostagno et al. (2011).

Diets were mixed twice for each phase, totaling eight batches per diet over the trial. When fed, diets were sampled and one sample was analyzed for each batch of feed.

To determine the nutritional requirements by InraPorc® software, an animal profile was created based on characteristics such as age, feed intake and weight gain (Table 2), following the performance data proposed by Rostagno et al. (2011). Ad libitum feed intake was modeled as a linear function of BW (a+b*BW), being ‘a’ (dimensionless) equal to 0.832 and ‘b’ (per kg BW) equal to 0.021. Protein