Effect of genetic type and low protein diets on the environmental footprint of intensive medium-heavy pig production system

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Abstract

This study aims to evaluate the effect of two different genetic groups and of the dietary protein content (16.1 vs 14%, conventional - CONV vs low crude protein - LCP) on the environmental footprint of the intensive medium-heavy pigs (final BW of 145 kg) system in northern Italy through Life Cycle Assessment (LCA). The experiment involved 92 barrows with the same age, originated by the same maternal line and by two different commercial paternal lines intended for medium-heavy pig production. Pigs were allotted 12 individuals per pen and fed according to the same feeding curve, based on a moderate restricted feed allowance increased on a week-by-week basis. The LCA model included emissions related to animal handling, manure storage and feedstuffs production. The functional unit was 1 kg of body weight gained (BWG). Impact categories assessed were (mean values into brackets): global warming (GWP, 2.3 kg CO_2-eq), acidification (AP, 48 g SO_2-eq) and eutrophication (EP, 24 g PO_4-eq). Impact values were analyzed with a mixed model testing the effect of diet and genetic group. All the impact categories were affected by diet ($P<0.001$) and genetic group ($P<0.05$). The LCP diet showed lower values of GWP, AP and EP than CONV diet (-18, -12 and -3%, respectively). Low protein diets can effectively reduce the environmental footprint of intensive pig production, with no effects on productive performances. However, feedstuffs type and origin should be considered to not nullify the emissions savings.

Keywords: feed efficiency, life cycle assessment, low protein diet, pig fattening

Introduction

Intensive pig systems contribute to human-induced release of reactive nitrogen (Nr) through feeding animals diets characterized by high levels of crude protein (CP), since they are often formulated in order to avoid amino acid (AA) deficiencies that may lower the growth performance (Pomar, 2017). Various studies have explored the possibility to use low-crude protein diets (LCP) compared to conventional ones (CONV) to reduce Nr (Gallo et al., 2014). However, an integrated analysis of the environmental footprint of LCP versus CONV diets through Life Cycle Assessment method (ISO, 2006) has been less studied, especially in emerging production chains such as the medium-heavy pig (final body weight – BW – of 145 kg) systems. This study aimed to evaluate the effect of the protein content of diets (CONV vs LCP) and 2 specialized genetic groups on the environmental footprint of the intensive farming system delivering medium-heavy pigs through Life Cycle Assessment (LCA) method.

Materials and methods

All the experimental procedures were reviewed and approved by the Ethical Committee for the Care and Use of Experimental Animals of the University of Padua. The experiment involved 96 barrows with the same age, originated by the same maternal line and by two different commercial paternal lines intended for medium-heavy pig production. At the start of the trial, pigs were allotted in 8 pens (12 pigs/pens). All pigs were fed according to the same feeding curve, based on a moderate restricted feed allowance increased on a week-by-week basis (Schiavon et al., 2018). After 28 days of acclimation (A), the pigs of 4 pens received CONV diets, with conventional CP and standardized ileal digestible (SID) lysine content (CCP), in slight excess than those recommended by NRC (2012). The pigs in the remaining 4 pens received LCP diets, with CP and SID lysine lowered by nearly 10% and nearly 20% respect to CCP in growing (B1, 29 to 70 days in feed, 60 to 104 kg of BW) and finishing (B2, 71 to 118 days, 104 to 145 kg of BW) (Table 1). During the experimental period 4 animals presented were removed from the trial; as a consequence, the results are referred to 92 barrows.

About LCA model, animal handling, manure storage (slurry-based) and the production of the purchased feedstuffs were included into the system boundaries. The functional unit (FU) was 1 kg of BW gained (BWG). Impact categories assessed were global warming (GWP), acidification (AP) and eutrophication (EP) potentials. Methane and nitrous oxide emissions were based on the Intergovernmental Panel on Climate Change, IPCC (2006), as well as for ammonia and nitrogen oxides emissions due to manure storage. Emission due to land use change (LUC) was included. The eutrophying effect of ammonia deposition was considered. The impact factors for the purchased feedstuffs were derived from Ecoinvent database (Ecoinvent Centre, 2015). The conversion of single compounds in the common unit of the impact category which they contribute was equal to that used in Berton et al. (2018). The impact due the breeding period was derived from Pirlo et al. (2016). Impact categories were analyzed with a mixed model (PROC MIXED, SAS, 2012) testing the random effect of the pen and the fixed effects of the diet (2 levels: CONV and LCP) and genetic group (2 levels, A and B). Differences between LS means were adjusted for Bonferroni.

Table 1. Ingredients (%) and chemical composition of diets (n = 92)

	Phase[a]				
	A	B1		B2	
		CONV[b]	LCP[c]	CONV	LCP
Cereals	79.7	80	84	82.4	90
Protein by-products	13.5	14.5	10.5	13	5.5
Amino acids (synthesis)	1.1	0.7	0.8	0.5	0.5
Fat, minerals, additives	5.7	4.8	4.7	4.1	4
Gross energy (MJ/kg DM)	16.4	16.6	16.6	16.6	16.5
Crude protein (g/kg DM)	164	163	146	158	126

[a] Phase: A - acclimation phase; B1- growing phase; B2 - finishing phase; [b] CONV - conventional diet (n = 47); [c] LCP - low-crude protein diet (n = 45).

Results

Table 2 shows the descriptive statistics of animal performance. The mean initial BW was nearly 30 kg and final BW 145 kg, with a daily BWG of nearly 1 kg and a daily dry matter (DM) intake nearly to 2.5 kg DM per head on average. The variability was low for all the variables (from 3 to 7%). Productive performances were not affected by different diets, and pigs fed LCP had growth rate and feed efficiency comparable to those provided by pigs fed CONV. On average, GWP was 2.3 kg CO_2-eq. Besides, the production of 1 kg BWG during the experimental period caused the emission of nearly 48 g SO_2-eq and 24 g PO_4-eq on average (data not shown). Figure 1 shows LS means of each impact category for the diet effect and the contribution of each production stage to each impact category, per 1 FU. For all the impact categories, feed production was the first contributor to the total emission (from 51 to 90%). All the impact categories were affected by diet (P<0.001) and by genetic group (P<0.05). For diet effect, the LCP diet showed lower values of GWP, AP and EP than CONV diet (-18, -12 and -3%, respectively), whereas for genetic type, group A showed lower values of GWP, AP and EP with respect with group B (+2% for all impact categories).

Table 2. Descriptive statistics of animal performance (mean ± SD; n = 92)

Variable	General	Phase [a]		
		A	B1	B2
Initial BW (kg)	30.4 ±2	30.4 ±2	58.9 ±3.2	103.8 ±4.4
Final BW (kg)	145.1 ±6.1	58.9 ±3.2	103.8 ±4.4	145.1 ±6.2
Average daily gain (kg/d)	0.97 ±0.05	1.02 ±0.09	1.07 ±0.06	0.86 ±0.07
Dry matter intake (kg/d)	2.49 ±0.07	1.85 ±0.13	2.60 ±0.07	2.76 ±0.09

[a] Phase: A - acclimation phase; B1 - growing phase; B2 - finishing phase.

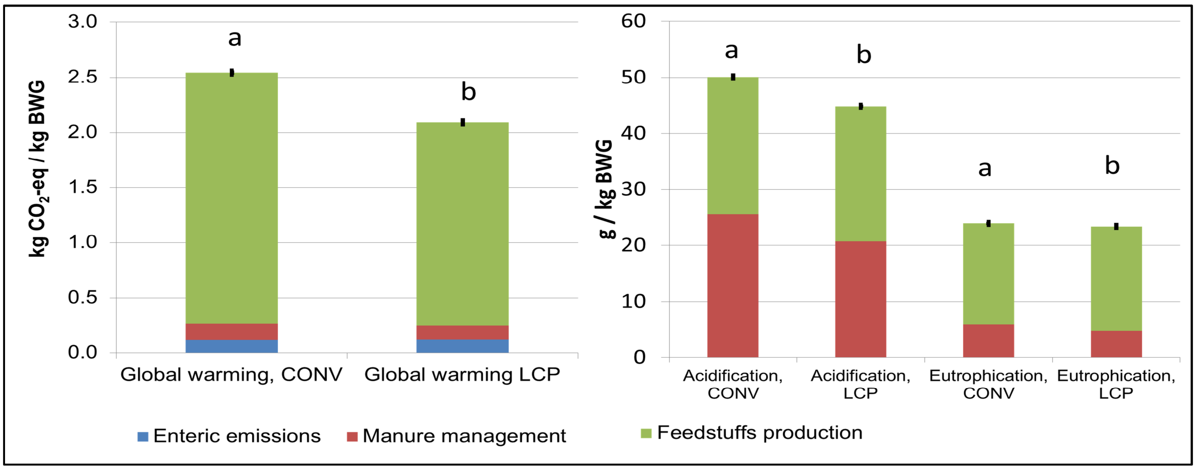

Figure 1. LSmeans and production stages' contribution per impact category (acidification: SO_2-eq, eutrophication: PO_4-eq) and per diet (CONV: conventional, LCP: low crude protein) (n = 92)

When the impact due to the breeding period (delivering of piglet of BW equal to initial BW) was added, the whole life cycle (breeding plus fattening periods) resulted in an average GWP per kg BWG of 2.6±0.2 kg CO_2-eq, whereas mean AP and EP resulted 49.3 g SO_2-eq and 25.5 g PO_4-eq.

Discussion

In general, GWP and EP values were in the range of, and AP were greater than, values found in literature (McAuliffe et al., 2016), with differences in AP values probably due to different emission factors. An actual comparison is difficult because of methodological differences. As found in literature, feed production was the first contributor and the share related to fattening phase outweighed that of breeding one (McAuliffe et al., 2016; Pirlo et al., 2016). The results of statistical analysis evidenced that LCP diet was effective in reducing impact categories values; the effect on GWP is firstly due to LUC, related to a greater use of soybean meal in CONV diet, but a significant difference was observed also about the on-farm emission ($P<0.05$) due to lower N excretion for LCP diet (data not shown). For AP and EP, the significant effect of diet was related to on-farm emissions, whereas no differences were found for feed production stage. As a consequence, mitigation strategies based on diet formulation should consider not only CP level but also the origin and production of the feedstuffs included. On the other hand, the significant difference in impact categories values due to genetic group was probably due to the differences in the feed efficiency (computed as feed: BWG): group A showed significant lower feed:BWG during the growing (B1) and finishing (B2) phases (-3% in both phases).

Conclusions

The use of LCP diet against CONV can effectively reduce the environmental footprint of intensive pig production system, through lower N releasing in the environment However, the type and the origin of each feed ingredients used in these diets should be considered for a global evaluation of the emissions.

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