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# Environmental impact of the typical heavy pig production in Italy

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ABSTRACT

The Italian pig sector is mainly focused on the production of heavy pigs used for the traditional dry-cured hams. At slaughter a minimum of 160 kg and 9 months age are required to comply with the production specifications of the ham consortia. Advancing livestock age and increasing fat deposition negatively affect feed conversion ratio, which is one of the main determinants of meat production environmental impact. The aim of the study was to provide a first evaluation of the environmental impact potentials of heavy pig production in Italy through a Life Cycle Assessment approach. Additional objectives were to identify the main hot spots and the most important data gaps in the analysis. A cradle to farm gate Life Cycle Assessment was performed in 6 intensive pig farms located in Northern Italy. Key parameters concerning on-farm activities, inputs and outputs were collected through personal interviews with farmers. The functional unit was 1 kg live weight. Direct land use change was considered in the emissions of imported soybean. The average pig slaughter live weight was 168.7 ± 33.3 kg. Environmental impacts per kg live weight were generally higher than those generated in the production of pigs slaughtered at lower weight. The global warming potential was on average 4.25 ± 1.03 kg $CO_2$ eq/kg live weight. Feed chain (crop production at farm and purchased feed) was the major source of impact for all the categories and the most important hotspot of heavy pig production. Farm size and reproductive efficiency appeared important factors in the environmental burden of heavy pig production: the largest and most efficient farm (as live weight produced per sow) had impact potentials per kg live weight much lower than those generated in the less efficient farm and similar to the ones reported on pigs slaughtered at a lower weight. The wide range of impact values within farms reveals opportunities for environmental improvements in the production of the traditional heavy pig. There is a need for further data and models on methane enteric emissions and nitrogen excretions above 100 kg of live weight.



## 1. Introduction

The Italian pig sector is primarily focused on the production of heavy pigs, used to provide thighs for dry-cured ham, a traditional processed meat product. Dry-cured ham is a typical food product of many countries worldwide: Spain, Italy, France, Germany, Poland and Greece are the major producers and consumers in Europe (Resano et al., 2011). Currently in Italy there are eight labels of dry-cured ham registered by the European Union as Protected Designations of Origin (PDO) products; Parma and S. Daniele are the most important labels with a total production of about 11.4 million hams (Consorzio Prosciutto di Parma, 2015; Consorzio Prosciutto di S. Daniele, 2015). Overall, approximately 24% of the production of the two labels is exported, mainly in Europe. For Parma ham the most important European markets are Germany, France and UK while US is the first overseas export market.

According to ERSAF (2014), out of the total 13,100,000 pigs slaughtered in Italy in 2013, 91.2% had a slaughter live weight (LW) higher than 160 kg and 67.6% of these heavy pigs were used for the production of PDO dry-cured hams.

For this high quality production, meat with an excellent suitability for salting and seasoning is required (Bosi and Russo, 2004). In particular, based on PDO specifications, fresh thighs must have a minimum weight of 10 kg (11 kg for the S. Daniele label). This implies a very high slaughter LW (>160 kg) and a suitable thickness of subcutaneous adipose tissue, at least 15 mm (Lo Fiego et al., 2005). Moreover, to obtain optimal meat characteristics, heavy pigs have to be slaughtered not before 9 months of age; this condition implies restricted feeding and longer finishing phases in comparison with production systems adopted in other European countries. Advancing age and increasing final LW and fat deposition negatively affect feed conversion ratio (Latorre et al., 2003;

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Malagutti et al., 2012), which is one of the main determinants of meat production environmental impact.

A number of papers analyzed through a LCA approach the environmental impact of the production of pigs slaughtered at a standard LW of 90–120 kg (Basset-Mens and van der Werf, 2005; Dalgaard, 2007; Vergé et al., 2009; Pelletier et al., 2010; Wiedemann et al., 2010; Aramyan et al., 2011; Dourmad et al., 2014; Mackenzie et al., 2015) but studies focusing on the impact evaluation of heavy pig production are presently lacking.

The aim of the study was to provide a first evaluation, through a Life Cycle Assessment approach, of the environmental impact potentials of heavy pig production in Italy. Other purposes were to identify hot spots and margins for improvement and to outline the major data gaps in the analysis.

## 2. Materials and methods

### 2.1. System description and data collection

A total of 6 pig farms located in the Po valley (Northern Italy) were involved in the study. The farms had different production systems: five of them were farrow-to-finish operations while one of them was a grow-to-finish farm. Pigs were crossbred animals reared in compliance with PDO ham consortia requirements, in intensive indoor system on slatted-floor or straw litter.

Data collection was performed through personal interviews with farmers. Gathered information concerned: herd composition and management, housing system, slurry management, crop production for feed, diets, fuel and electricity consumption, external inputs (purchased feed, fertilizers, pesticides, animals), outputs (sold animals).

### 2.2. Emission and excretion estimation

Methane ($CH_4$) emissions from enteric fermentations and slurry management were estimated using the equations suggested by IPCC (2006a; Tier 1 and Tier 2, respectively) in accordance with the recommendation of LEAP (2015).

Volatile solid excretion was estimated considering the gross energy of the diets (kJ/kg DM) evaluated using Ewan equation (1989). For the digestibility of the diets the values suggested by IPCC (2006a) for mature (80%) and growing swine (85%) were used.

From information on ration composition, chemical analysis of the diets and N and P excretions were estimated through the model developed by the National Research Council (2012) which considers the LW/physiological phase of the animals and the feed characteristics. The model does not cover the finishing phase above 140 kg LW; according to Galassi et al. (2005), from 140 to 170 kg LW a 4% reduction in N utilization efficiency, compared to the previous phase, was assumed and the N excretions were corrected accordingly.

Nitrous oxide ($N_2O$) emissions from slurry storages as well as $N_2O$ losses from fertilizers and slurry application in direct and indirect forms were both estimated using the Tier 2 method from IPCC (2006a, 2006b). N applied to the soils from synthetic fertilizers and slurry plus N from crop residues were accounted in the estimation. Emissions of $CO_2$ from fuel combustion on farm were estimated according to the Agri-footprint v1.0 database (Blonk Consultants, 2014). Emission factors and equations adopted are detailed in Bava et al. (2014).

Ammonia ($NH_3$) and nitrogen oxide (NOx) emissions that occur during animal housing and slurry storages were estimated following the method proposed by EEA (2009a) on the basis of the total N excreted by the animals, considering the slurry management systems and the manure type (liquid slurry or solid). $NH_3$ and NOx emitted during slurry and synthetic fertilizers application to the soils were estimated following EEA guidelines (2009b). For the evaluation of N leached, the IPCC (2006b) model was adopted, while the P, lost in dissolved form to surface water (run-off) and leached, was calculated according to Nemecek and Kägi (2007).

The emissions related to off-farm activities were calculated using LCA software, Simapro 8.0.3 (PRé Consultants, 2014). The following processes were considered: production of commercial feed (from crop growing to feed factory), production of bedding material, rearing of purchased animals, production of chemical fertilizers, pesticides, diesel and electricity used at the farms. Transportation was considered only for feed, bedding materials and purchased animals. Mineral feed, vitamins and other feed ingredients used in negligible amounts were not included in the assessment.

A simplified LCA was performed to assess the impacts associated to purchased piglets of 30 kg LW in the grow-to-finish farm: for gestating and lactating sows and for piglets, standard rearing and feeding conditions were assumed.

### 2.3. Impact assessment

The environmental impact of pig production in each farm was evaluated through a detailed “cradle-to-farm-gate” attributional LCA. The system boundaries included both on-farm processes and off-farm activities linked to the production of external inputs without considering slaughtering (Fig. 1). System boundaries included also pig slurry that was used as fertilizer to increase feed crop productivity and to maintain soil organic matter content; it represents a direct input for feed production. According to LEAP (2015) the pig farms studied can be defined as mixed crop-livestock systems.

The selected environmental impact categories were: global warming, eutrophication, acidification, non-renewable energy use, land occupation, abiotic resource depletion, terrestrial ecotoxicity and ozone layer depletion. These evaluations were performed using CML-IA baseline 3.01, but for non-renewable energy use and for land occupation, the Cumulative Energy Demand 1.08 method and the Ecological Footprint 1.01 method were used, respectively.

The functional unit (FU) was established as 1 kg LW at the farm gate. No allocation procedure was applied because farms sold only finished heavy pigs and culled sows but the weight of sows yearly culled represented a negligible percentage of total LW sold (0.5–1.3%).

Direct land use change (LUC) for soybean production in Brazil was considered using the value reported by the Agri-footprint database (Soybean, at farm/BR Economic; Blonk Consultants, 2014). According to Assalzoo (2015), soybean used for pig feeding was assumed as coming from Brazil (80%) and Italy (20%).

## 3. Results and discussion

Table 1 reports the main farm characteristics and herd performances of the 6 pig farms. As mentioned above, 5 farms were farrow-to-finish operations while one of them was a grow-to-finish farm. Moreover, 2 of them were large farms (more than 15,000 heavy pigs sold per year) while 4 of them were medium-sized farms (less than 5000 heavy pigs). Average slaughter LW was 168.7 ± 3.33 kg, with an average dressing percentage of 79.2 ± 0.8%. Technical herd traits show variability among farms, but on average they are consistent with those reported by BPEX (2014) for Italian swine herds; according to BPEX report, reproductive traits of Italian herds are worse than average performances of EU countries.

The average agricultural area of the farms was 198.3 ± 132 ha. Most of the farm land was used for cereal production (corn,