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ORAL COMMUNICATION

Life Cycle Assessment of pig production systems of the Noir de Bigorre chain

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ADDITIONAL KEYWORDS

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SUMMARY

Outdoor pig production systems relying on local pig breeds may cope with environmental and socio-economic challenges. They produce high quality products with added economic value and rely mainly on local feed resources. Within the European TREASURE project, we conducted the Life Cycle Assessment (LCA) of the Noir de Bigorre (NDB) pig production systems located in South West of France. The environmental impacts were calculated at farm gate and expressed per kg live pig and per ha land use. From surveys on 25 farms of the NDB chain and data collected by the chain, we estimated the flows and average live weights of animals produced as well as the average quantities of feeds distributed to the animals. Formulas of the complete feeds were collected from manufacturers. Climate Change (CC), Acidification (AC), Eutrophication (EU), Cumulative Energy Demand and Land Occupation impacts per kg of pig were in the range of the impacts of traditional systems previously studied. CC impact per kg pig was higher than in intensive systems due to the higher amount of feed needed to reach slaughter weight. AC and EU impacts per ha of land were relatively low. NDB pig farming systems exhibit LCA impacts typical of extensive and outdoor systems. Further studies within the European project TREASURE will also give insights on the economic and societal dimensions of sustainability of these systems.

Analyse de Cycle de Vie des systèmes de production de la filière Noir de Bigorre

RÉSUMÉ

Les systèmes de production porc plein air reposant sur des races autochtones doivent répondre à des enjeux environnementaux et socio-économiques. Ils fournissent des produits à haute valeur ajoutée et reposent principalement sur des ressources alimentaires locales. Dans le projet européen TREASURE, nous avons mis en œuvre une Analyse de Cycle de Vie (ACV) des élevages appartenant à la filière Noir de Bigorre (NDB) localisée dans le Sud-Ouest de la France. Les impacts environnementaux ont été calculés en sortie de ferme et exprimés par kg de porc vif et par ha de terres occupé. A partir d'enquêtes dans 25 élevages et des données collectées pas la filière, nous avons estimé les flux et poids vifs moyens des animaux produits ainsi que les quantités moyennes d'aliments distribuées. Les formules des aliments achetés ont été collectées auprès des fabricants d'aliments. Les impacts potentiels sur le Changement Climatique (CC), l'Acidification (AC), l'Eutrophisation (EU), la Demande Cumulée en Energie (CED) et l'Occupation des Terres (LO) par kg de porc étaient dans la gamme des systèmes traditionnels précédemment étudiés. L'impact CC par kg était élevé en raison d'une quantité supérieure d'aliment nécessaire pour atteindre le poids d'abattage. Les impacts AC et EU par ha étaient relativement faibles. Les systèmes NDB ont des impacts typiques des systèmes extensifs et plein air porcins. Des études complémentaires dans le projet européen TREASURE permettront d'éclairer les dimensions économique et sociale de la durabilité de ces systèmes.

MOTS-CLÉS SUPPLÉMENTAIRES

Race Gascon.
Impacts environnementaux.
Durabilité.

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INTRODUCTION

Pig production is facing environmental challenges all around the world. Indeed, pig production systems (PPS) are associated to various environmental impacts like climate change, land use, eutrophication and acidification. In intensive pig production, environmental impacts have been extensively assessed (de Vries and de Boer 2010) and are related to i) utilization of feed ingients of high impacts, ii) transportation of feed ingredients over long distances, iii) excretion of nutrients that results in various emissions (ammonia, nitrous oxide, nitrates, phosphates,…), iii) methane production (both from enteric origin and from manure). Regarding traditional pig production systems, relying partly on outdoor grazing and consumption of acorns and/or chestnuts, there is less information available in the literature and whether the environmental impacts of these systems are higher or lower than those of conventional systems is still controversial (Basset-Mens and van der Werf 2005; MacLeod et al. 2013; Dourmad et al. 2014). However, these systems are considered environmentally friendly by citizens (Degre et al. 2007). Recent studies have evaluated the environmental impacts of traditional and organic pig production systems (Dourmad et al. 2014; Espagnol and Demartini 2014).

They highlighted that traditional pig production has rather high global impacts expressed per kg of pig at farm gate due to the low feed efficiency of traditional breeds. They underlined that local impacts expressed per ha of land occupied of these systems are lower than in conventional systems, in relation with utilisation of land for grazing and low stocking densities applied. Espagnol and Demartini (2014) also mentioned that in the systems heavily relying on natural resources, impacts can be even lower. Therefore, there is an interest in a better characterization of the environmental impacts of pig production systems relying on autochthonous pig breeds in Europe, which are usually held in various production systems. This characterization is being performed in the frame of the Horizon 2020 project Treasure. This paper presents preliminary results of the first case study on the Noir de Bigorre (NDB) chain raising Gascon pigs in South West of France.

MATERIAL AND METHODS

System description and data collection

The NDB system is characterized by breeding of purebred Gascon pigs as well as outdoor rearing of the gestating sows and the fattening pigs. The pigs are slaughtered at minimum of 12 months of age with a minimum cold carcass weight of 100 kg. Pigs are fattened outdoor from at least 6 months of age on grasslands with or without an additional woodland area, at a maximum stocking rate of 20 pigs/ha. Gestating sows are reared on grasslands with a maximum stocking rate of 12 sows/ha. For the farrowing and lactating periods, sows and piglets can be kept indoor on straw or outdoor with an outdoor shed. Piglets are not weaned before 33 days of age and are reared indoor on straw with or without outdoor access prior to fattening. Pigs are fed with cereals that are locally grown except in immediate post-weaning stage when they are given adapted starter feed mixture. Among the farms of the NDB chain, 48% are fattening-only farms, 44% are farrow-to-finish farms and 7% are farrowing-only farms. Data were collected from 25 farms (there are 50 farms belonging to the chain) during on-farm surveys and from information gathered regularly by the chain (litter sheets including number of alive born piglets and mortality rates, slaughter data including cold carcass weight of each slaughtered pig). Data included animal performance like sow productivity and mortality rates, initial and final weights for each period of growth (before weaning, post-weaning, growing indoor, fattening outdoor), feed formulas (or at least global amount of each feed ingredient for each type of animal) and feed composition including metabolisable energy, crude protein and phosphorus contents (for bought feeds) as well as amounts distributed when available, animal housing with both type of housing and type of floor, and manure handling. Average amounts of feeds distributed per period of life were collected from the chain, i.e. 5 kg of 1st post-weaning feed, 50 kg of 2nd post-weaning feed, 900 kg of feed per fattened pig (from the beginning of the growing period to slaughter) and 1200 kg of feed / sow / year.

System boundaries and functional units

A cradle-to-farm gate life cycle analysis (LCA) was conducted for each of the farm surveyed. The system boundaries were derived from Wilfart et al. (2016) and Espagnol and Demartini (2014) and included the production of piglets (farrowing unit) as well as post-weaning and growing-finishing periods. Land used for either the production of feed ingredients or the outdoor raising of pigs was included within the LCA perimeter. In the LCA perimeter were included the production and transport of the feed ingredients up to the feed factory, the production of feeds on the farm and at the feed factory, the emissions from the animals and from manure storage. The environmental consequences of manure use were estimated using system expansion as suggested by Dourmad et al. (2014). Performance, nutrient flows and emissions were calculated for each production stage (sows and piglets, post-weaning piglets and pigs) and averaged for farrowing farms and fattening farms. These average values were used to build entire production systems considering sows prolificacy and mortality rates in each production stage, as performed by Dourmad et al. (2014). To consider the two main functions of traditional pig production systems, i.e. producing food and keep up landscape, we calculated environmental impacts according to two functional units suggested by Dourmad et al. (2014): 1 kg of live weight (LW) of pigs leaving the pig unit, including culled sows and slaughter pigs, and 1 ha of land used to produce feed and raise animals.

Life cycle inventory analysis

Production of feeds and feed ingredients

Most of the complete feed mixtures (both list and incorporation rates of ingredients) were obtained from feed manufacturers and feeds composition were collected from labels on bags on farm. Compositions of feed mixtures produced on-farm were obtained from the farmers. To further calculate nutrient contents of on-farm produced feeds, we used the feeds' formulas and the nutrient contents of feeds' ingredients provided in the INRA-AFZ feed tables (Sauvant et al. 2004). Impacts of feed ingredients were found in the EcoAlim dataset (Wilfart et al. 2016) and consequently the EcoAlim dataset covered the production of feed ingredients. Few feed ingredients were lacking in the EcoAlim dataset and were consequently discarded from the analysis because of very low incorporation rates into feeds (e.g. puffed rice in used in the starter feed or potatoe proteins).

Production of pigs

Emissions to air were estimated for NH_3, N_2O, NO_x and CH_4, separately for sows, weaned piglets and fattening pigs. N and P retentions in live weight were calculated for each physiological stage and excretion of nutrients resulted from the difference between intake and retention. N retention was calculated according to the equation proposed by Rigolot et al. (2010a) with a body lean tissue percentage of 35% for finished pigs according to Sans et al. (1996). Retention of each element was calculated by difference between its initial and final contents for each physiological stage. For the periods during which the animals are kept outdoors, the emissions of N-NH_3, N-N_2O, and N-NO_3 were calculated according to the emission factors provided by Basset-Mens et al. (2007). For the periods during which the animals are kept indoors, gaseous N emissions were calculated step-by-step with an emission factors for housing, storage, and field application of solid manure. Emission factors for housing and storage of solid manure came from Rigolot et al. (2010b) for $N-NH_3$ and $N-N_2O$ and from Dämmgen and Hutchings (2008) for $N-NO_x$. We also considered solid manure composting in the farms applying this treatment, according to the emission factors provided by Paillat et al. (2005). Emissions following field application of solid manure were calculated according to EMEP/EEA (1996) for $N-NH_3$, IPCC (2006) for $N-N_2O$ and Nemecek and Kägi (2007) for $N-NO_x$. Energy use for light and for heating lamps in farrowing units was calculated, but not the emissions and resources used for the construction of buildings and of outdoor sheds. Veterinary and cleaning products were not included.

Life Cycle Impact Assessment

We calculated the impacts of pig production, using the CML-IA method, on climate change (CC) including the effect of land use change (corresponding to greenhouse gas emissions, kg CO2-eq.), eutrophication (EU, kg PO4-eq.), acidification (AC, kg SO2-eq.) and land occupation (m^2.year). Non-renewable energy demand (NRE, MJ) according to CED v1.8 method was also calculated. The indicator result for each impact category was determined by multiplying the aggregated resources used and the aggregated emissions of each individual substance with a characterisation factor for each impact category to which it may potentially contribute.

RESULTS AND DISCUSSION

The farms of the NDB chain have in average 32 sows and produce 280 pigs per year. The sample highlights a relatively important variability around this mean value because there are farms raising only 132 pigs per year and farms raising 450 pigs per year (which is the maximum authorised in the PDO specifications). The productivity of the sows is of 11.6 weaned piglets per year. Piglets are weaned at an average of 9.3 kg and the pigs have a mean weight of 39.9 kg at the entrance in the fattening period. Slaughter weight is in average 173.7 kg at 424 days of age. Mortality rates are 10.5%, 4.7% and 1.1% in lactation, post-weaning and fattening phase, respectively. Crude protein (CP) contents of pig feed mixtures are in accordance with the low potential of protein deposition for the Gascon breed: 122.4 g CP / kg of feed for sows, 127.1 g/kg for post-weaning, 126.7 for growing-finishing period. **Table I** shows the average environmental impacts for the pig production in the NDB chain. Environmental impacts expressed per kg of pig live weight at farm gate are in the upper range of the values available in the literature (Halberg et al. 2010; Dourmad et al. 2014; Espagnol and Demartini, 2014) for traditional and/or organic pig farming systems. In particular climate change impact per kg of pig is higher than previous results obtained in traditional (Dourmad et al. 2014) and Corsican systems (Espagnol and Demartini 2014). Indeed, fattening pigs in the NDB chain are slaughtered at an average weight of 173.7 kg whereas in previous studies slaughter weights ranged in average between 120 and 140 kg. The longer the fattening period, the lower is the N body retention at the end of fattening and the higher is the N excretion per slaughtered pig. As a consequence, feed conversion ratio also explains high environmental impacts in NDB chain and can be roughly estimated at an average of 6.7 kg feed / kg gain (an average of 900 kg of feed for the fattening period from 40 kg of body weight to 174 kg of slaughter weight).

Figure 1 also provides the proportion of climate change impact which is related to feed production,

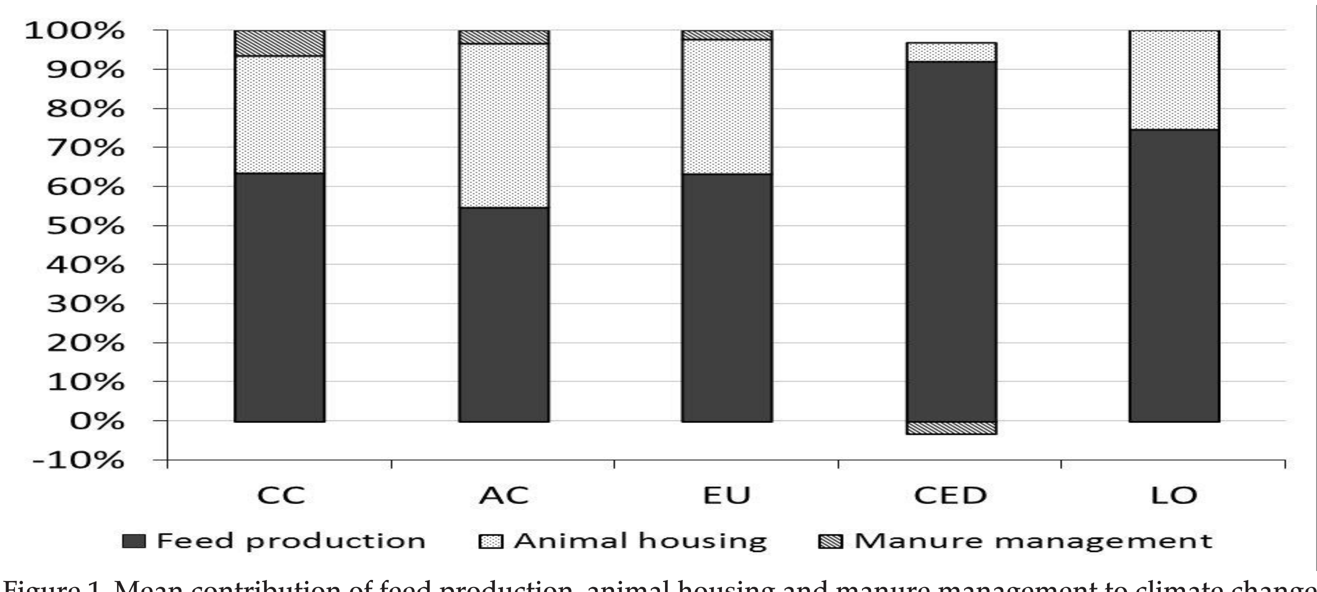

Figure 1. Mean contribution of feed production, animal housing and manure management to climate change (CC), energy demand (CED), acidification (AC), eutrophication (EU) and land occupation (LO) impacts expressed per kg of pig live weight (Contribution moyenne de la production d'aliments, du logement des animaux et de la gestion du fumier aux impacts du changement climatique (CC), de la demande d'énergie (CED), de l'acidification (CA), de l'eutrophisation (UE) et de l'occupation du sol (LO) exprimée par kg de poids vif de porc)

Table I. Potential environmental impacts of pig production systems raising Gascon pigs in the Noir de Bigorre chain, either expressed per kg of pig live weight at farm gate, or per ha of land used during one year. (Effets potentiels sur l'environnement des systèmes de production de porcs Gascon dans la filière Noir de Bigorre, exprimés par kg de poids vif en porc à la ferme ou par hectare de terres utilisées pendant un an).

Environmental impacts	mean± standard deviation	Minimum value	Maximum value
Global impacts expressed per kg of live pig at farm gate			
Climate Change (kg CO_2-eq)	4.54 ± 0.508	3.85	5.76
Non-renewable Energy (MJ)	19.9 ±2.45	15.9	26.4
Land Occupation (m².year)	22.7 ± 4.83	18.0	36.4
Acidification (g SO_2-eq)	65.6 ± 9.93	51.5	89.1
Eutrophication (g PO_4-eq)	46.8 ± 5.61	38.7	62.6
Local impacts expressed per ha of land occupied			
Climate Change (kg CO_2-eq)	2044 ± 286.0	1357	2764
Non-renewable Energy (GJ)	9.0 ± 1.65	6.1	14.3
Acidification (kg SO_2-eq)	29.4 ± 4.06	21.1	36.8
Eutrophication (kg PO_4-eq)	21.0 ± 2.43	14.3	25.2
Pig produced (kg live weight)	455 ± 75.4	274.5	555.7

and this proportion is quite consistent with previous studies. Regarding eutrophication and acidification, values obtained in our study are also in the upper range of the literature data and in the range of the values obtained by Espagnol and Demartini (2014) for the Corsican farms where the pigs fed available natural resources are supplemented with complete feed mixtures. Land occupation per kg of pig's LW is much higher in the NDB chain than in the previous studies reported. This is related to both the low technical efficiency of these systems (more land needed to provide the high amounts of feed needed) and to the use of land for grazing at a low stocking density. Indeed, Figure 1 shows that about 25% of land occupation is related to pig housing, i.e. to the land used for grazing.

Environmental impacts were expressed with two functional units (kg of LW at farm gate and ha of land occupied). The kg of pig unit represents the function of production of market goods and ha of land used reflects the function of non-market goods production (e.g. environmental services) (Basset-Mens and van der Werf 2005). Regarding the environmental impacts expressed per ha of land occupied, it is noteworthy that all of them are lower than those calculated in previous studies (Basset-Mens and van der Werf, 2005; Dourmad et al., 2014). This result is primarily related to a low production of kg of pigs per ha occupied. In the present study, this production is in average 455 kg per ha whereas it was 1013 kg and 1592 kg in the organic and "label rouge"[1] production systems in Basset-Mens and van der Werf (2005), and 1229 kg for traditional systems in Dourmad et al. (2014). Due to very low stocking densities applied in the NDB chain, the local impacts of the production per ha are very low. These are indeed lower than in the other traditional systems previously studied and are in line with those of organic systems that have low EU impact due to low impact of feed ingredients (Dourmad et al. 2014). NDB systems appear more sustainable for local impacts than for global impacts; similar as other traditional systems as already stated by Casabianca (2013). Moreover, NDB systems based on grazing of permanent and semi-permanent grasslands, as well as on woodland areas for acorns, may contribute to the carbon sequestration like other alternative systems (Halberg et al. 2010).

[1]The "label rouge" is a quality label in which pigs are born and raised outdoors until weaning, and in an open-front straw-litter building at low animal density after weaning.

Therefore, even if the evaluation of carbon sequestration is still under debate, it would be valuable to include this phenomenon into the evaluation of CC impact of traditional pig production systems. The NDB chain would also benefit from a multicriteria analysis of its sustainability, including economic and social dimensions as well as an identification of public goods provided by this production chain. These different studies will be conducted in the frame of the Treasure project.

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