Assessing the environmental impact of meat production

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According to data from the United Nation's Food and Agriculture Organisation (FAO), in 2009 global meat production was about 280 Mt.

Europeans eat an average of 80kg of meat per person per year, while for North Americans consumption is 120kg per year.

Globally, pork accounts for 37.7% of all meat consumption, followed by poultry (28.3%), and beef (22%). Other types of meat that are consumed less include sheep (2.9%), goat meat (1.8%), turkey (1.9%), duck (1.4%) and buffalo (1.2%).

Most meat is produced by slaughtering livestock and processing pork cuts after the animal has been raised by farming and husbandry activities. These activities account for most of the environmental impact of meat production, such as greenhouse gas emissions (carbon footprint) and resource usage (field, water, etc).

Animal foods are associated with considerably more greenhouse gases than plant foods.

The tables introduce some reference figures for animal and plant foods according to a selected list of internationally recognised sources for the carbon footprint indicator; the variability may depend on the definition system boundaries, system management and efficiency of local practices.

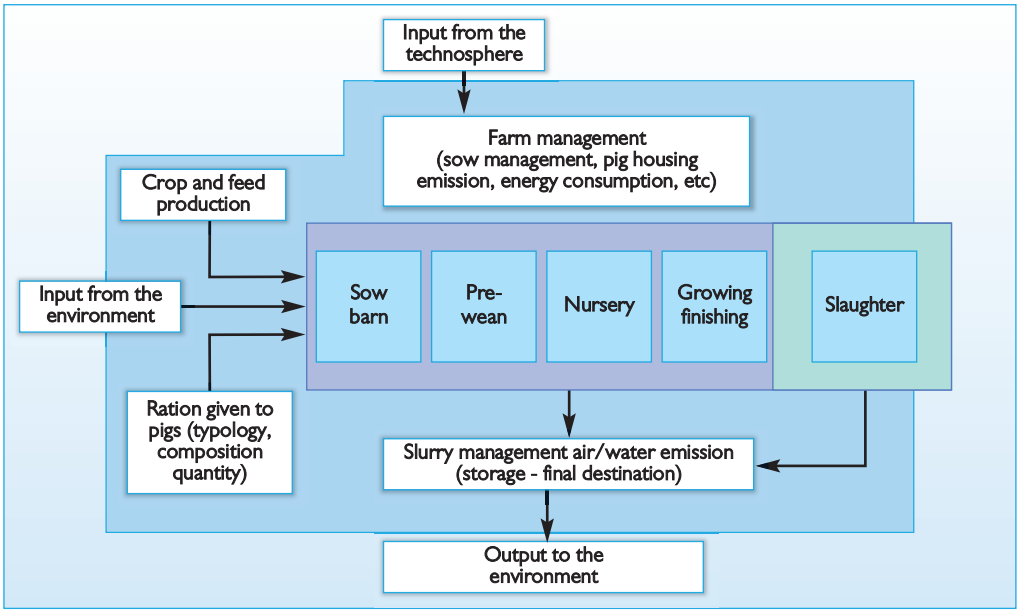

Fig. 1. System boundaries related to intensive swine farming.

Growing consumer concern over environmental issues, and in particular the green credentials of specific industries and products, has prompted studies to analyse the environmental impact of food production. Recent decades have seen the development of standardised life cycle assessment (LCA) methodologies which have been used to quantify the environmental burden of livestock farming.

The LCA approach has been used to quantify the entire environmental burden of a product or activity; in the case of meat production, this means evaluating the production of animal feed, the management of their manure, as well as resource consumption and waste production associated with animal rearing, slaughtering and meat processing.

The application of LCA methodology has allowed us to identify the most relevant phases in the product life cycle and to find suitable ways of reducing the impact, i.e. in terms of carbon footprint and resource consumption. Such life cycle assessments are internationally regulated and covered by the ISO standards.

This article introduces some of the LCA elements that are used to calculate the overall environmental burden of raising animals for meat production in order to show how data and results can be used to understand and mitigate that impact.

Previous LCAs have demonstrated that raising cattle has the greatest environmental impact, followed by pork and then poultry. This article

Continued on page 25

Table 1. Reference figures for carbon footprint of animal foods.

Animal foods	CO_2 equivalent (g/kg foods)	Source
Cheese	8784	Berlin (2002)
Beef	6000-44800	Ogino et al. (2007), Japan (SIK report); Casey & Holden (2006a, b), Suckler, Ireland (SIK report); Williams et al. (2006), Average UK beef (SIK report); Verge, et al. (2008), Average Canadian beef (SIK report); Cederberg et al. (2009a), Average Brazilian beef (SIK report); Cederberg et al. (2009b), Average Swedish beef 2005 (SIK report); Cederberg & Darelius (2000), Swedish beef from combined systems dairy-beef (SIK report); Cederberg & Stadig (2003)
Eggs	4600-5800	Williams et al.
Pork	2300-8000	Williams et al., 2006; Basset Mens & van der Werf (2003); Cederberg & Flysjö (2004); Strid Eriksson et al. (2005); Cederberg m.fl. (2009)
Poultry	1500-7300	Thynelius (2008); Pelletier (2008); Cederberg et al. (2009b); Williams et al. (2006), conventional
Milk	1050-1500	EPD for high-quality Granarolo milk; Cederberg & Stadig (2003); William et al. (2006)

Continued from page 23
uses the pork meat system as an example to illustrate how the LCA methodology works.

Environmental impact

The LCA calculates the potential environmental impact of producing a piece of pork by quantifying and evaluating the resources consumed (water, electricity, etc) and the emissions to the environment (polluted water, CO_2 emission, ammonium, etc) along the pork production chain.

The added value of an LCA study lies in the availability of an operative model which represents the entire production system and thus provides a scientific way of evaluating the contribution of any given phase to the gross environmental burden; it also facilitates a simulation of the effect of any potential change, such as the introduction of a new technology in the farming activities.

Focusing the attention on the boundaries of the system analysed, the key aspects of intensive swine farming are represented by: pig ration (from nursery to fattening), sow breeding, farm and slurry management (Fig. 1).

The ration given to pigs is important in evaluating the impact of the crop production necessary to feed the animal for its entire life cycle; this is linked to agricultural practices, including direct energy use of machinery for soil cultivation, fertilisers and transportation.

The phase related to farm management also takes into account:

- Energy consumption (in particular, electricity and fuel used).
- Slurry/manure production and management.
- Generation of wastes and their final destination.
- Consumption of raw materials (detergent and any other auxiliary materials used).
- Emissions during housing (most of all methane and ammonia).
- The sow breeding phase for piglet production.

Among those, management of slurry generates the biggest quantity of greenhouse gas emissions into the environment, usually associated with methane, nitrous oxides and ammonia emission into the air; it is also important to highlight that this stage is characterised by emission into water and soil of nitrate, phosphate and potassium which contribute to eutrophication.

The LCA also considers transportation of pigs from the farm to the slaughterhouse as well as slaughter activities and carcase processing for meat production.

The main factors analysed for meat processing are: energy, raw materials and water consumption, air and water emissions and management of all waste produced; with regard to the last element, a relevant factor is the incineration of animal wastes or their destination to the pet food industry.

All the assessments are based on a single pig from birth to slaughter as the functional unit; the results have been put into the context of the final product through conversion factors based on the average pig carcase yields and the lean meat percentage.

Study results

Based on a selection of the available LCA literature on pork meat production and from the Reference Document on Best Available Techniques for Intensive Rearing of Poultry and Pigs – Integrated Pollution Prevention and Control (IPPC), it is possible to produce an average model showing the environmental burden of each pork meat production phase.

The indicator used here to report the environmental impact is the carbon footprint, which represents a measure of the total greenhouse gas emissions and is usually expressed in units of carbon dioxide equivalent (CO_2e) – for example as kg or tonnes; this makes comparison between different products or activities much simpler.

Fig. 2 shows the range of results from a sample of LCA models in terms of carbon footprint (kg CO_2-equivalent) related to the pork production chain. The elements that contribute most are slurry management (about 44-66% according to the existing management practice) and feed production (pig ration ranging from 15-33% according to the specific composition and agricultural practices).

Plant foods	CO_2 equivalent (g/kg foods)	Source
Pasta	1500	EPD pasta, Barilla, www.environdec.com
Bread	630-1000	LCA Food dk
Fruits	40-100	Milà i Canals et al. (2006)
Potatoes	98-200	LCA Food dk Ecoinvent 2004
Vegetables (seasonal)	100-500	Hospido et al. (2009) Andersson (2000)
Oil	2500-3900	Avraamides, Fatta (2008) Yusoff, Hansen (2007) LCA Food dk

Table 2. References figures for carbon footprint of plant foods.

Solutions for mitigation

Possible solutions for mitigating life-cycle environmental impact should be directed primarily at the phases with the highest contributions: feed production/consumption and slurry management.

Agricultural practice, such as fertiliser and pesticide use, water consumption and crop yield, affects the environmental impact of feed production. Different manure management systems result in different quantities of greenhouse gases emitted to the atmosphere: for example anaerobic lagoons generate higher emissions of methane than pit storage. Focusing on slurry production, it is also important to consider that this element is directly related to the quantity of feed given to the pig during fattening, and depends on the feed conversion efficiency.

Specifically, entire pigs show a higher feed conversion ratio (less feed needed to get the same weight) and a major percentage of lean meat compared to physically castrated animals; also an aggressive behaviour towards each other. In addition, meat from non-castrated male pigs can have an offensive odour or taste that is evident during the cooking or eating, the so called 'boar taint'.

Feed manufacturers in the EU recognise their contribution to the environmental impact and sustainability of livestock production, and have commenced a number of initiatives aimed at improving the environmental performance of their feeds. Governments are also aware of the environmental issues surrounding farm animals. For example, in 2009, the Scottish government funded a five-point plan called Farming for a Better Climate (FBC) to help local farmers increase productivity and tackle climate change.

Life cycle assessment (Fig. 3) is a valuable tool which can help to identify the parts of the meat production chain which contribute most to its environmental burden, and thus provide a means to improve its future performance. ■

Fig. 2. Contribution to the carbon footprint of different phases of pork production chain (average and range on LCA models).

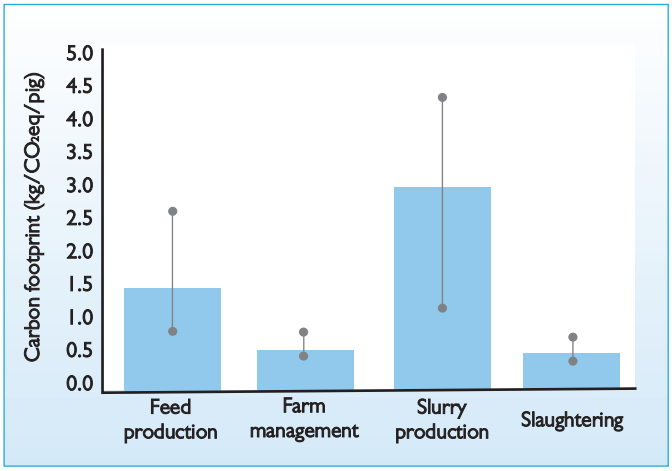

Fig. 3. Life cycle assessment.