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Evaluation of the sustainability of contrasted pig farming systems: the procedure, the evaluated systems and the evaluation tools

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Although a few studies consider the sustainability of animal farming systems along the three classical main pillars (economy, environment and society), most studies on pig farming systems address only one of these pillars. The present paper is the introduction to a series of companion papers presenting the results of a study undertaken within the EU-supported project Q-PorkChains, aiming at building a comprehensive tool for the evaluation of pig farming systems, which is robust to accommodate the large variability of systems existing in Europe. The tool is mostly based on questions to farmers and comprises a total of 37 dimensions distributed along eight themes: Animal Welfare, Animal Health, Breeding Programmes, Environmental Sustainability, Meat Safety, Market Conformity, Economy and Working Conditions. The paper describes the procedure that was used for building the tool, using it on 15 contrasted pig farming systems and analysing the results. The evaluated systems are briefly described and a short overview of the dimensions is provided. Detailed descriptions of the theme-wise tools and results, as well as the results of an integrated evaluation, are available in the companion papers.

Keywords: pig, farming system, sustainable, assessment

Introduction

There is to our knowledge no evaluation of the sustainability of pig farming systems considering the three classical pillars of sustainability (economy, environment and society) in an integrated way, although such studies are available in other species (dairy: Van Calker *et al.*, 2005; egg: Mollenhorst *et al.*, 2006; conceptual: Van Cauwenbergh *et al.*, 2007; sheep: Ripoll-Bosch *et al.*, 2012). Previous studies on pig farming have mostly focused on environmental impact (e.g. Basset-Mens *et al.*, 2005), economy or social acceptance (e.g. Boogaard *et al.*, 2011).

A collaborative work has been conducted within the EU-funded research project Quality PorkChains (Q-PorkChains (www.q-porkchains.org)) to build a tool for the multidimensional evaluation of the sustainability of pig farming systems. Within the same framework, the tool was then used to assess the sustainability of 15 contrasted pig farming systems. The systems were selected on the basis of an inventory of farming systems that was conducted within the same project (Bonneau *et al.*, 2011) and documented the variety of existing farming systems in European countries. The tools for the evaluation of sustainability were elaborated from literature and from the expertise of the participants to the research project (Edwards *et al.*, 2008). Sustainability was evaluated along eight themes: Animal Welfare, Animal Health, Breeding Programmes, Environmental Sustainability, Meat Safety, Market Conformity, Economy and Working Conditions. An overall evaluation was also performed.

This paper is an introduction to a series of companion papers providing the results of the evaluation of the systems regarding Breeding Programmes (Rydhmer *et al.*, 2014), Environmental Sustainability (Dourmad *et al.*, 2014), Market Conformity (Gonzàlez *et al.*, 2014), Economy (Ilari-Antoine

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et al., 2014) and the Integrated Evaluation (Bonneau *et al.*, 2014). The integrated evaluation was conducted with inputs from the eight theme evaluations. The aim of this paper is to present the procedure that was used for the evaluation, the farming systems that were evaluated and a brief overview of the tools that were used to evaluate sustainability.

Procedure used for the evaluation

The evaluation was carried out as a collaborative work between the people and organisations presented in the list of authors and affiliations. The first step was the elaboration of the tools for the evaluation of sustainability of pig farming systems. This work was carried out in 2007 and 2008 under the responsibility of S.A. Edwards. Eight themes were defined and each of them was placed under the responsibility of a theme leader (Animal Welfare and Working Conditions: H.L. Edge; Animal Health: C. Phatsara; Breeding Programmes: L. Rydhmer; Environment: J.Y. Dourmad; Meat Safety: D. Brinkman; Market Conformity: J. Gonzàlez; Economy: E. Ilari-Antoine).

A survey of the literature was performed and resulted in the elaboration of an internal document that served as a basis for the elaboration of the eight tools, described in the relevant companion papers, and summarised in the section 'The tools used for sustainability evaluation' below.

In a second step, the tools were used for the evaluation of 15 farming systems. This work was carried out in 2009 to 2010 under the overall responsibility of M. Bonneau. The data for the eight themes were collected, using a form under Microsoft Excel that was specially designed for this study, under the responsibility of five country leaders (Denmark: M. Hviid; France: J.Y. Dourmad; Germany: C. Zimmer; Spain: J. Gonzàlez; The Netherlands: K. de Greef). The third step was the analysis of the results. Theme-wise analyses were first performed, under the responsibility of S.A. Edwards (Animal Welfare and Working Conditions), L. Rydhmer (Breeding Programmes), J.Y. Dourmad (Environment), M.U. Cinar and T.N. Klauke (Animal Health), T.N. Klauke (Meat Safety), J. Gonzàlez (Market Conformity) and E. Ilari-Antoine (Economy). Each theme then contributed with a restricted number of the most representative variables (primary indicators) to an integrated evaluation that was carried out under the responsibility of M. Bonneau.

Evaluated systems

In this paper as well as in all companion papers, the studied 'pig farming systems' were defined nationally from the expertise of national scientists working in the Q-porkChains team and having a good knowledge of pig production in their country. The wording 'pig farming systems' stands for a group of farms within a country that are similar in terms of objectives, production methods and market orientation. The previously performed inventory (see 'Introduction' section) resulted in the identification of 84 production systems of which 40 were considered as 'conventional' whereas 44 were identified as 'differentiated' on the basis of claims for better achievements regarding Animal Welfare, Eating Quality, Nutritional Quality or Environment or of claims to be local or organic. The 15 systems assessed in the present study were selected on the basis of:

- Availability of a national team to perform the studies.
- Presence of a conventional system and two differentiated systems in each of the five countries.
- Representation of all claims in the differentiated systems.
- Achieve a high diversity of systems.

Our hypothesis was that putting the tools to the test of very diverse systems would enable us to develop a final tool that is robust to accommodate the very diverse situations that can be found in Europe and worldwide, from intensive, indoor, conventional systems using highly performing breeds for standard meat to extensive, outdoor systems using local breeds for very high quality target markets.

Our aim was to evaluate 10 farms/system, mostly through interviews of farmers (see 'The tools used for sustainability evaluation' section). Farms were selected on the basis of representativeness of the system, availability at the time of the study and willingness of the farmer to participate. The achieved number of farms per system was somewhat lower (average: 8.7; range 3 to 13). In all, 11 systems were represented by 9 to 13 farms. Four systems were represented by three to five farms, the reasons for such low numbers being either availability of farms (one system was real tiny) or lack of willingness of farmers to participate. Overall, even for the best represented systems, the farm numbers are too low to enable a statistically satisfactory representation of the systems. Therefore, in this series of papers, the emphasis will be put on exploring the capacity of the tools to exemplify differences between farms and systems rather than on comparing systems and the systems will be kept anonymous.

The selected systems were evaluated in five countries (Denmark, France, Germany, The Netherlands and Spain) with three systems per country ranging in size from 2500 to 32 million slaughter pigs produced per year. Farms were predominantly family owned except in two systems (one was mostly on the integration model; one was partly family owned, partly integrated). They were classified in four categories: Conventional ($n = 5$, one per country), Adapted Conventional ($n = 5$), Organic ($n = 2$) and Traditional ($n = 3$), on the basis of three parameters: breeding line, targeted market segment and extent of outdoor housing, as described in Table 1. These parameters were considered as good markers of conventionality (conventional breed, standard meat as targeted market, no outdoor rearing) or distanciation from conventionality (local breed, higher quality or specialty target market, outdoor rearing). The conventional systems (C-1 to C-5) were all common standard systems in their countries, but they have different conditions because of, for example, regulations, market, policies and climate. They commonly practiced indoor systems meeting minimum EU space requirements described in Council Directive 2008/120/EC (European Commission, 2008), a fully or partly slatted floor and 100% concentrate feeding. The adapted conventional systems

Table 1 *Size of the farming systems and* criteria used for categorising them

		Description criteria			
Systems	Size[1]	Breed	Market orientation	Outdoor index[2]	Resulting category
C-1	10^7	Conventional	Standard/quality	0	Conventional
C-2	10^7	Conventional	Standard	0	Conventional
C-3	10^7	Conventional	Standard	0	Conventional
C-4	10^7	Conventional	Standard	0	Conventional
C-5	10^6	Conventional	Standard	0	Conventional
AC-1	10^3	Conventional	Higher quality	0	Adapted conventional
AC-2	10^3	Conventional	Higher quality	0	Adapted conventional
AC-3	10^6	Conventional/Local	Higher quality	0	Adapted conventional
AC-4	10^4	Conventional	Higher quality	0	Adapted conventional
AC-5	10^6	Conventional	Higher quality	0	Adapted conventional
O-1	10^5	Conventional	Higher quality	3	Organic
O-2	10^5	Conventional	Higher quality	5	Organic
T-1	10^4	Local	Specialty	6	Traditional
T-2	10^3	Local	Specialty	2	Traditional
T-3	10^4	Local	Higher quality	3	Traditional

[1]Order of magnitude of the number of slaughters pig produced per year. No precise figures are given for reasons of anonymity.
[2]Outdoor index = sum of the scores given for the housing of sows, piglets and fatteners with 0 for indoor, 1 for semi-outdoor (indoor with access to outdoor concrete runs) and 2 for outdoor (access to pasture or forest).

differed from the Conventional with regard to specific claims, that is, claims for superior animal welfare (AC-1 and AC-4), meat quality (AC-2, AC-3 and AC-5) and on being environmentally friendly (AC-4). They had extra qualities like extra space for housing, special feed or took special measures to prevent environmental pollution and aimed at a special market segment. The organic production systems (O-1 and O-2) were both inspired by the organic principles stated by the International Federation of Organic Agriculture Movements (IFOAM, 2005) although one of them was not classified as organic according to the EU regulation for organic production No 834/2007 (European Commission, 2007). The traditional systems (T-1 and T-3) were systems aiming at preserving local breeds in a traditional environment and claiming special traits, and also aiming at special markets. They were small scale systems associated with specific regions of Europe and they used local breeds from small populations.

The tools used for sustainability evaluation

Detailed descriptions of the tools used for theme-wise evaluations are provided in the relevant companion papers (Breeding Programmes: Rydhmer *et al.*, 2014; Environment: Dourmad *et al.*, 2014; Market Conformity: Gonzàlez *et al.*, 2014; Economy: Ilari-Antoine *et al.*, 2014) or as Supplementary Material (Supplementary Material S1) for Animal Welfare, Animal Health, Meat Safety and Working Conditions. Briefly, each theme was assessed along one to six dimensions, as described in Table 2. For Animal Welfare, the five dimensions corresponded to the Five Freedoms (FAWC, 1993; Webster, 2001). For Animal Health, the four dimensions summarised the information provided by a questionnaire modified from the one developed by Berns (1996); Van der Wolf *et al.* (2004) and Mack (2007). The questionnaire for Breeding Programmes was based on a checklist for sustainable breeding schemes developed by Woolliams *et al.* (2005). When assessing farming systems using local breeds, questions about the characteristics of the breed were added to that list, based on Ruane's study (1999). The dimension Environment used the Life Cycle Assessment approach that is well adapted for the environmental evaluation of livestock farms and has been already widely used as reviewed by De Vries and de Boer (2010). For Meat Safety, the questionnaire was developed following the ideas of quality management (Stretch, 2005). The six dimensions of the questionnaire were designed following earlier reports (Von Borell *et al.*, 2001; Norrung and Buncic, 2008; Fosse *et al.*, 2009; Doyle and Erickson, 2012; Jenson and Sumner, 2012). Market Conformity was defined as the extent to which the quality of the carcasses and of the meat produced in the farms matched the requirements of the system's targeted market(s). Carcass and meat quality criteria were measured at slaughter. Acceptability benchmarks and market shares for each pork product category were obtained from the literature, from the specifications defined by the quality brands in some systems, and from personal communications with experts on the systems. The Economy dimension was assessed, using the economy part of the IDEA method (Indicateurs de Durabilité des Exploitations Agricoles = Farm Sustainability Indicators; Vilain *et al.*, 2003; Zahm *et al.*, 2008). The questionnaire on Working Conditions was designed specifically for the present study.

Most of the information was derived from interviews with farmers (with a total of over 500 questions asked to the farmers), with the following exceptions:

- The greater part of the information pertaining to Breeding Programmes was gathered from interviews with the nine

Table 2 *Dimensions considered within sustainability themes*

Themes	Dimensions
Animal welfare	Freedom from hunger and thirst
	Freedom from pain and disease
	Freedom to express natural behaviours
	Freedom from discomfort
	Freedom from fear and distress
Animal health	Preventive health management
	Disease status
	Parasite control
	Health status
Breeding programmes	Breeding goal and market
	Recording and selection
	Genetic variation
	Management of breeding organisation
Environment	Climate change per kg live weight pig
	Acidification per kg live weight pig
	Energy demand per kg live weight pig
	Land occupation per kg live weight pig
	Acidification per hectare
	Eutrophication per hectare
Meat safety	General
	Contact with outside environment
	Personal hygiene
	Cleaning and disinfection
	Vaccination management
	Verification
Market conformity	Market conformity score
Economy	Economic viability
	Economic specialisation
	Financial autonomy
	Reliance on subsidies
	Transferability
	Efficiency
Working conditions	Work load: automation score
	Work load: perceived lightness
	Work environment: facilities for personnel
	Work environment: perceived pleasantness
	Job satisfaction

breeding organisations that provided the genetic material to the farms included in the study, and a lesser part from interviews with farmers.

- The information on Market Conformity was derived from eight measurements at slaughterhouses and from the expertise of chain operators.

Within each of the 37 dimensions, the results obtained from the various questions or observations were aggregated in one primary indicator, which contributed to the integrated evaluation, as described in a study by Bonneau *et al.* (2014).

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Supplementary material

To view supplementary material for this article, please visit http://dx.doi.org/10.1017/S1751731114002110

References

Basset-Mens C and Van der Werf HMG 2005. Scenario-based environmental assessment of farming systems: the case of pig production in France. Agriculture, Ecosystems and Environment 105, 127–144.

Berns G 1996. Einbindung von Checklisten und mobile Analyselabor in Beratungskonzepte zur Erweiterung von Gesundheitsvorsorge- und Qualitätsmanagementsystemen in der Schweinefleischerzeugung. Thesis, Rheinische Friedrich-Wilhelms-University, Bonn, Germany.

Bonneau M, Antoine E, Phatsara C, Brinkmann D, Hviid M, Groes-Christiansen M, Fabrega E, Rodriguez P, Rydhmer L, Enting I, De Greef K, Edge H, Dourmad JY and Edwards S 2011. Diversity of pig production systems at farm level in Europe. Journal on Chain and Network Science 11, 115–135.

Bonneau M, Klauke TN, Gonzàlez J, Rydhmer L, Ilari-Antoine E, Dourmad JY, De Greef K, Houwers HWJ, Cinar MU, Fàbrega E, Zimmer C, Hviid M, Van der Oever B and Edwards SA 2014. Evaluation of the sustainability of contrasted pig farming systems: integrated evaluation. Animal, doi:10.1017/S1751731114002122.

Boogaard BK, Boekhorst LJS, Oosting SJ and Sørensen JT 2011. Socio-cultural sustainability of pig production: citizen perceptions in the Netherlands and Denmark. Livestock Science 140, 189–200.

De Vries M and De Boer IJM 2010. Comparing environmental impacts for livestock products: a review of life cycle assessment. Livestock Science 128, 1–11.

Dourmad JY, Ryschawy J, Trousson T, Bonneau M, Gonzàlez J, Houwers HWJ, Hviid M, Zimmer C, Nguyen TLT and Morgensen L 2014. Evaluating environmental impacts of contrasting pig farming systems with life cycle assessment. Animal, doi:10.1017/S1751731114002134.

Doyle MP and Erickson MC 2012. Opportunities for mitigating pathogen contamination during on-farm food production. International Journal of Food Microbiology 152, 54–74.

Edwards SA, Dourmad JY, Antoine E, Edge HL, Fàbrega E, de Greef K, Ilari E, Phatsara C, Rydhmer L, Bonneau M 2008. Tools for assessing sustainability of pig meat production systems. Proceedings of the 59th meeting of the EAAP, August 24–27, Vilnius, Lithuania, 7pp.

European Commission 2007. Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labelling of organic products and repealing Regulation (EEC) No 2092/91. Official Journal of the European Union L 189, 1–23.

European Commission 2008. Council Directive 2008/120/EC of 18 December 2008 laying down minimum standards for the protection of pigs. Official Journal of the European Union L 47, 5–13.

FAWC 1993. Second report on priorities for research and development in farm animal welfare. Ministry of Agriculture, Fisheries and Food, Tolworth, UK.

Fosse J, Seegers H and Magras C 2009. Prevalence and risk factors for bacterial food-borne zoonotic hazards in slaughter pigs: a review. Zoonoses Public Health 56, 429–454.

Gonzàlez J, Gispert M, Gil M, Hviid M, Dourmad JY, De Greef K, Zimmer C and Fàbrega E 2014. Evaluation of the sustainability of contrasted pig farming systems: development of a market conformity tool for pork products based on technological quality traits. Animal, doi:10.1017/S1751731114002146.

IFOAM 2005. The IFOAM norms for organic production and processing. Retrieved February 15, 2013, from http://www.ifoam.org

Ilari-Antoine E, Bonneau M, Klauke TN, Gonzàlez J, Dourmad JY, De Greef K, Houwers HWJ, Fàbrega E, Zimmer C, Hviid M, Van der Oever B and Edwards SA 2014. Evaluation of the sustainability of contrasted pig husbandry systems: economy. Animal, doi:10.1017/S1751731114002158.

Jenson I and Sumner J 2012. Performance standards and meat safety – developments and direction. Meat Science 92, 260–266.

Mack A 2007. Concept for the application of an integrated audit and document management system in the inter-organisational health management in meat supply chains. Thesis, Rheinischen Friedrich-Wilhelms-Universität, Bonn, Germany.

Mollenhorst H, Berentsen PBM and De Boer IJM 2006. On farm quantification of sustainability indicators: an application to egg production systems. British Poultry Science 47, 405–417.

Norrung B and Buncic S 2008. Microbial safety of meat in the European Union. Meat Science 78, 14–24.

Ripoll-Bosch R, Diez-Unquera B, Ruiz R, Villalba D, Molina E, Joy M, Olaizola A and Bernues A 2012. An integrated sustainability assessment of Mediterranean sheep farms with different degrees of intensification. Agricultural Systems 105, 46–56.

Ruane J 1999. Selecting breeds for conservation. In Genebanks and management of farm animal genetic resources (ed. JK Oledbroek), pp. 59–73. IDO-DLO, Lelystad, The Netherlands.

Rydhmer L, Gourdine JL, De Greef K and Bonneau M 2014. Evaluation of the sustainability of contrasted pig farming systems: breeding programmes. Animal, doi:10.1017/S175173111400216X.

Stretch T 2005. HACCP-based standard operating 585 procedures (SOPs), U.S. Department of Agriculture, Food and Nutrition Service & National Food Service Management Institute. University of Mississippi, Oxford, USA.

Van Calker KJ, Berentsen PBM, Giesen GWJ and Huirne RBM 2005. Identifying and ranking attributes that determine sustainability in Dutch dairy farming. Agriculture and Human Values 22, 53–63.

Van Cauwenbergh N, Biala K, Bielders C, Brouckaert V, Franchois L, Garcia Cidad V, Hermy M, Mathijs E, Muys B, Reijnders J, Sauvenier X, Valckx J, Vanclooster M, Van der Veken B, Wauters E and Peeters A 2007. SAFE – a hierarchical framework for assessing the sustainability of agricultural systems. Agriculture Ecosystems and Environment 120, 229–242.

Van der Wolf PJ, Mack A, Gymnich S, Schulze Althoff G and Petersen B 2004. Improving herd health through useful information. In Proceedings of the in-between congress of the International Society for Animal Hygiene, 11–13 October, Saint-Malo, France (ed. F Madec and G Clément), pp. 479–480. ISPAIA, Saint Brieuc, France.

Von Borell E, Bockisch FJ, Büscher W, Hoy S, Krieter J, Mueller C, Parvizi N, Richter T, Rudovsky A, Sundrum A and Van den Weghe H 2001. Critical control points for on-farm assessment of pig housing. Livestock Production Science 72, 177–184.

Vilain L 2003. La méthode IDEA – Guide d'utilisation, deuxième édition enrichie et élargie à l'arboriculture, au maraîchage et à l'horticulture. (The IDEA method, user's guide, second version enriched and extended to arboriculture, market gardening and horticulture). Educagri éditions, Dijon, France. 151pp. Retrieved October 15, 2013, from http://www.idea.portea.fr/26.0.html

Webster AJF 2001. Farm animal welfare: the five freedoms and the free market. Veterinary Journal 161, 229–237.

Woolliams J, Berg P, Mäki-Tanila A, Meuwissen T and Fimland E 2005. Sustainable management of animal genetic resources. Nordic Gene Bank Farm Animals, Norway. ISBN: 82-997123-1-9.

Zahm F, Viaux P, Vilain L, Girardin P and Mouchet C 2008. Assessing farm sustainability with the IDEA method – from the concept of agriculture sustainability to case studies on farms. Sustainable Development 16, 271–281.