Meat Science 109 (2015) 13–17

Contents lists available at ScienceDirect

Meat Science

journal homepage: www.elsevier.com/locate/meatsci

Animal welfare towards sustainability in pork meat production

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ARTICLE INFO

Article history:
Received 9 February 2015
Received in revised form 13 May 2015
Accepted 15 May 2015
Available online 21 May 2015

Keywords:
Animal welfare
Farm
Meat production
Pigs
Slaughter
Sustainability
Transport

ABSTRACT

Animal welfare is an important pillar of sustainability in meat production and is associated with other aspects of this concept, such as animal health, productivity, food safety, food quality and efficiency from a cost of production perspective. These interactions are present at all stages of the production cycle, from the beginning of the animals' farm life until their slaughter. On farm, some of the main welfare issues are related to neonatal mortality and low level of sensory input, which are likely to engender stereotypes and injurious behaviours, such as tail-biting. Pre-slaughter handling refers to the interaction between humans and animals prior to and during transport and at slaughter. Strategies to reduce pre-slaughter stress will benefit carcass and meat quality, being the training of stockpeople one of the most cost-effective policies to improve animal welfare. These strategies include also the implementation of standard monitoring procedures to detect signs of consciousness after stunning, before sticking and during bleeding until death occurs.

1. Introduction

Sustainable meat production is defined as a form of production 'ecologically sound, economically viable, socially just, and humane' (Appleby, 2004). It brings together aspects such as animal health, environmental protection, productivity, food safety, food quality, and efficiency from a cost of production perspective such that consumers perceive the product as 'good value for money' (Pethick, Ball, Banks, & Hocquette, 2011). Animal welfare is largely perceived as a 'public good' by European citizens (Miele & Evans, 2010) and it is considered a necessary element of sustainable animal production (Broom, 2010). The demand for "welfare friendly" products increases as public conscience and perception on livestock production systems grow. Animal welfare is not only a matter of ethics, but also an essential tool to gain and maintain markets, and any husbandry that benefits sustainability should maximize animal welfare and avoid its potential impairment. While addressing ethical aspects about the sustainability of meat production systems, developments in animal welfare should be based on a solid scientific background.

Animal welfare can be defined in a number of different ways, but there is a growing consensus that, whatever the definition, it has to include three elements: the biological functioning of the animal (the ability to cope with its environment), its emotional state and its ability to show normal patterns of behaviour (Manteca, Velarde, & Jones, 2009). The multifactorial nature of animal welfare requires that all its aspects should be considered. The Welfare Quality® (2009) project developed a standardised welfare assessment system that aimed to cover all its different aspects. It defined 12 welfare criteria, falling within 4 principles (good feeding, good health, good housing, and appropriate behaviour; Table 1) providing a very useful and exhaustive framework for understanding the components of animal welfare and identifying and assessing the main welfare issues at each stage of the production cycle. Meat production systems can only be considered as welfare friendly if all welfare criteria are fulfilled at all stages of the production cycle. Alternatives, such as 'natural' systems, are perceived by the consumers to provide good welfare. The lack of behavioural restriction in extensively managed animals is, in the minds of the general public, an important animal welfare benefit (Matthews, 1996), and often associated with natural products (Font i Furnols & Guerrero, 2014). It is true that these systems have incomparable advantages related to expressing normal or 'natural' behaviour, but they also are at a disadvantage when considering other aspects related to animal welfare. Animals in extensive environments may face a range of threats to their well-being, but principally those related to nutritional stress and inadequate water supply, parasitical diseases, climatic extremes, lameness, predators, degree of human care and supervision (Turner & Dwyer, 2007). Temple, Manteca, Velarde, and Dalmau (2011); Temple, Courboulay, Manteca, Velarde, and Dalmau (2012b); Temple, Courboulay, Velarde, Dalmau, and Manteca (2012a) compared the welfare on Iberian pigs in extensive and intensive conditions. Pigs kept extensively had a lower prevalence of severe wounds and abnormal behaviours, such as tail biting than pigs in conventional system. However, the authors also found that pigs in extensive systems presented the highest prevalence of poor body condition. Due to the

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http://dx.doi.org/10.1016/j.meatsci.2015.05.010
0309-1740/

Table 1
Welfare Quality®'s 4 principles and 12 criteria.

Principles	Criteria	
Good feeding	1	Absence of prolonged hunger
	2	Absence of prolonged thirst
Good housing	3	Comfort around resting
	4	Thermal comfort
	5	Ease of movement
Good health	6	Absence of injuries
	7	Absence of disease
	8	Absence of pain induced by management procedures
Appropriate behaviour	9	Expression of social behaviours
	10	Expression of other behaviours
	11	Good human–animal relationship
	12	Positive emotional state

increasing global demand for meat products, the last few decades of the 20th century animal production intensified enormously and farms became highly specialized on a specific type of production (Blokhuis, 1999). Conventional farms with concrete floors and relatively high stocking densities displaced more traditional systems and greatly predominate throughout Europe. This intensification enables a large increase in production volume and meat consumption, but also increases efficiency in the use of the available resources, productivity and food security (Miele, Blokhuis, Bennett, & Bock, 2013), and reduces the environmental footprint of livestock production. However, intensification might impair animal welfare, as the interactions of the animals with the environmental conditions (confinement, space allowance, flooring, feeding and drinking place, enrichment, etc.) play an important role on the animal welfare. More specifically, intensive housing may lead to problems, because animals cannot perform behaviour, for the expression of which they have an innate motivation. Furthermore, they may not be able to meet environmental challenges decisively different than those they face in their natural habitat.

This review will focus on the major welfare issues of the current intensive pig production system presented along the different stages (on farm, during transport and at slaughter). Welfare indicators and strategies to improve their welfare are also discussed, as well as their relevance in meat production sustainability. Any strategy intended to improve animal welfare must be shown to be practicable, robust, safe, affordable, easy to implement and in the long term interests of the animals and the farmer (Manteca & Jones, 2013) have to be met. If these requirements are not met, the strategy will be not adopted. Strategies involving the application of environmental, experiential, management and genetic improvements are likely to be the most effective (Boissy, Fisher, Bouix, Hinch, & Le Neindre, 2005).

2. Animal welfare on farm

On farm, some of the main welfare issues are related to neonatal mortality and low level of sensory input, which are likely to engender stereotypes and injurious behaviours, such as tail-biting (Manteca & Jones, 2013). The elicitation of injurious behaviours can also result in undesirable economic consequences, such as reduced productivity, product quality and profitability (Jones & Boissy, 2011).

2.1. Neonatal mortality

Neonatal mortality is the main welfare concern in piglets as well as an important economic and environmental burden. In the European Union, neonatal mortality averages 10–15%, and in most of the cases it occurs during the first 24–48 h of life. Mortality is mostly related to crushing of piglets, hypothermia and starvation. However, the death of a piglet is often the last consequence of a chain of events. In most cases the triggering factor is the level of a piglet's development and physical condition at birth (Edwards, 2002). Thus, most piglets that die during the first days of life are healthy piglets but too weak to suckle and, especially, to compete with the other piglets of the litter. Neonatal mortality is a complex multifactorial problem that involves several elements related to piglet vigour, the maternal behaviour of the sow and the characteristics of the physical environment (Baxter et al., 2008). In natural conditions, the days previous to farrowing sows separate from the group, choose a suitable isolated site, and build a nest. Domestication has hardly altered this behaviour, and similar patterns of nest building behaviour are shown by domestic sows kept in pens and provided with material. Typically farrowing crates, 2.0–2.4 × 0.6 m in size, are designed to restrict the movement and protect crushing of piglets. However, in farrowing crates, the presence of other sows, the restriction of movement, and the impossibility to perform normal nesting behaviour will negatively affect the sow's welfare. The first consequence is an acute stress response that increases plasma concentrations of cortisol and b-endorphin (Lawrence et al., 1994) that has an inhibitory effect on the release of oxytocin. In fact, inhibition of oxytocin release results in a prolonged farrowing duration, a delay in the secretion of colostrum and an increase in the percentage of false suckling events (i.e., those in which no secretion of colostrum or milk is produced although the sow lies down on her side and piglets suck the teat). Therefore, crating will disturb the farrowing progress, lactation and thermoregulation, and consequently survival and growth of the neonatal piglets (Algers & Uvnäs-Moberg, 2007).

Well designed loose-house systems to meet the needs of the sows and piglets during farrowing and lactation and in addition assuring good hygiene and easy access and inspection for the caretaker might have potential benefit for survival and growth of piglets (Baxter, Lawrence, & Edwards, 2011). Provision of nesting material in loose housing systems allows the sow to perform a complete repertoire of nest building behaviour. This shortens the duration and affects hormones responsible for lactation and good maternal behaviour (Yun, Swan, Oliviero, Peltonniemi, & Valros, 2015). Loose housing enables the sow to establish a thermally comfortable birth sited which reduces mortality (Malmkvist et al., 2006), and to move around and show protective behaviour during lying down which may prevent crushing of piglets (Damm, Forkman, & Pedersen, 2005). However, some studies reported higher mortality rates in loose housed sows than in crated sows, ranging between an increase of 2 to 8%-unit (Hales, Moustsen, Nielsen, & Hansen, 2014). Although the loose farrowing is not yet robust enough under commercial situations, the previous paper showed that a proportion of sows in pens had a level of piglet mortality similar to that of the sows in farrowing crates, indicating that the loose housing system has the capability to deliver the same performance as farrowing crates. The experience of both caretaker and the sows in the loose housing system may be important factors to reduce mortality in this system. Furthermore, the appropriate design of housing systems has to allow an immediate contact between sow and piglets shortly after birth in order to ensure an early intake of colostrum.

Additionally, the use of breeding goals for large litter size during the last two decades has challenged piglets even further during the critical neonatal phase. In Denmark, the litter size has increased from 12 to more than 17 total born piglets per litter, and the piglet mortality from approximately 2 to 4 (Pedersen, 2015). The major consequences of large litter size are increased duration of farrowing and lack of teats for all live born piglets (Rutherford et al., 2013). Thus, the colostrum per piglet is reduced (Devillers, Farmer, Le Dividich, & Prunier, 2007) and the competition between littermates is increased (Theil, Lauridsen, & Quesnel, 2014), reducing birth weight and increasing mortality. In addition, lack of space in the farrowing crate limits the free access to the sow's udder and access for piglets to rest on a comfortable and warm surface away from the sow. The Scientific Opinion Scientific Opinion of the Panel on Animal Health and Welfare (EFSA, 2007a) concluded that genetic selection for litter size should not exceed, on average, 12 piglets born alive.

2.2. Tail-biting

Pigs are strongly motivated to perform particular behaviour patterns, such as rooting. To satisfy this intrinsically motivated exploratory and (possibly) foraging behaviour, they have a need for manipulable materials (Studnitz, Jensen, & Pedersen, 2007). This becomes apparent when these materials are absent or inadequate and exploratory motivation is frustrated. In this situation, manipulation of other pigs and pen fittings and skin lesions, in particular tail-biting, increase and play behaviour reduces (Chaloupková, Illmann, Bartoš, & Špinka, 2007; Fraser, Phillips, Thompson, & Tennessen, 1991; Scott, Taylor, Gill, & Edwards, 2006b; Scott et al., 2006a; Van de Weerd, Docking, Day, & Edwards, 2005). Tail-biting is an animal welfare problem because of the pain and suffering experienced by the bitten animal, the stress caused to the group (restlessness) and the likely frustration of the biting animal (Scientific Committee on Animal Health & Animal Welfare, 1997).

The European Union Directive 2008/120/EC laying down minimum standards for the protection of pigs establishes that pigs must have permanent access to a sufficient quantity of material to enable proper investigation and manipulation activities, such as straw, hay, wood, sawdust, mushroom compost, peat or a mixture of such, which does not compromise the health of the animals. The opportunity to investigate novel aspects of environments is thought to have particular value for all animals (Mench, 1994). However, there is little evidence that the type and quality of the enrichment material offered affects animal welfare. For example, there is little evidence that provision of material such as chains, chewing sticks and balls can reduce the risk of tail biting (EFSA, 2007b). Some manipulable materials, although they meet pigs' behavioural needs, may also have adverse effects on other aspects of pig welfare. Materials which are of poor hygienic quality (e.g. through contamination) or which are injurious, may cause health problems and injuries (Tuyttens, 2005). The provision of straw to stimulate rooting behaviour may in a warm climate prove to have adverse effects due to humidity, attracting flies (EFSA, 2014).

The enrichment and tail-docking requirements of the EU directive have been inconsistently implemented in many Member States, and Food and Veterinary Office (FVO) missions have reported difficulties in compliance. The DG SANCO funded project 'EUWelNet' (www.euwelnet.eu) has developed an e-learning knowledge strategy to improve the consistency of such professional judgements and examined its suitability. Based on the current state of knowledge, EFSA (2014) proposed two simple tool-boxes for on farm use to assess the functionality of the supplied manipulable material and the presence and strength of risk factors for tail biting. However, tail biting has a multi-factorial origin (Moinard, Mendl, Nicol, & Green, 2003) involving extrinsic risk factors such as barn micro-climate, nutritional deficiencies, competition for resources, social instability and high stocking density and intrinsic factors, such as genotype and ontogeny (Taylor, Parker, Mendl, Edwards, & Main, 2012).

Tail docking which is carried out to prevent tail biting results in acute to chronic pain (Noonan, Noonan, Rand, Priest, Ainscow, & Blackshaw, 1994; Simonsen, Klinken, & Bindseil, 1991). Therefore, tail-docking practice is detrimental to the welfare of pigs. For this reason, the EU legislation (2008/120/EC) states that tail-docking must not be carried out routinely but only where there is evidence that injuries to other pigs' tails have occurred.

3. Animal handling from farm to slaughter

Humans are an important part of the pigs' environment, both directly when working with them or being in close proximity and indirectly via management decisions on the production process or on housing design (Waiblinger & Spoolder, 2007). The term 'stockmanship' covers the way in which animals are handled, the quality of their daily management (feeding, cleaning …), and the health care (e.g. how quickly and efficiently sick animals are recognised and treated) (Waiblinger & Spoolder, 2007). Three main factors contribute to the individual differences in the quality of stockmanship: stockperson's personality, attitude and behaviour (Hemsworth & Coleman, 1998). Personality is defined as the combination of traits that affects how a person interacts with the environment and it is relatively stable over time. Attitudes towards animals are learnt and may be modified through experience and education (Waiblinger & Spoolder, 2007). Most specifically, both personality and attitudinal factors influence the way that stockperson behave towards the animals during rearing, transport and slaughter (Hemsworth, Coleman, Barnett, Borg, & Dowling, 2002). The stockpersons' behaviour, which can vary from calm, gentle, frequent and 'friendly' to infrequent, rough and rushed, is a major variable determining animal's fear or confidence in humans and, hence, the quality of the human–animal relationship, stress responses and productivity (Hemsworth & Coleman, 1998).

Pre-slaughter handling refers to the interaction between humans and animals during the phases of preparation for transport, loading, transportation, unloading, lairage and moving to the point of stunning (Velarde & Dalmau, 2014). At slaughter, the combination of high slaughter speed, poorly designed and maintained handling infrastructures, and poor attitude of the stockperson lead to rough handling and excessive and inappropriate use of electric goads (Faucitano, 2001; Faucitano, Marquardt, Oliveira, Sebastiany Coelho, & Terra, 1998). Compared with using a board and a paddle and/or a compressed air prod, the use of an electric prod results in more falls, fewer stops and less turning around, more and longer vocalisations, greater heart rate, greater blood lactate concentrations at exsanguination, greater ultimate pH values and greater incidence of blood-splashed hams (Correa Correa et al., 2010). A large survey recorded behaviour and handling from unloading until stunning and that higher values of the mean noise level at unloading and increasing use of prods among other factors (the percentage of painting pigs and the spring and autumn season), resulted in a lower pH 30 min after slaughter (Van de Perre, Permentier, De Bie, Verbeke, & Geers, 2010). Fear during the unloading at the slaughterhouse could be assessed by means of reluctance to move and turning back behaviour, and human–animal relationship by means of high pitched vocalisations (HPV), defined as squealing or screaming, at group level when pigs are moved from lairage to the stunning area (Velarde & Dalmau, 2012). Exsanguination blood glucose, lactate, blood and ear temperature, as well as post mortem loin temperature and ultimate pH can be used also as indicators of pre-slaughter welfare (Guardia et al., 2004; Warriss, Brown, & Adams, 1994).

Training personnel of the abattoir on the behavioural principles of handling can greatly reduce the use of electric goads. The stockperson and others associated with animal pre-slaughter handling should have adequate knowledge and understanding of the species-specific behavioural patterns. For example, handlers must be aware that red meat animals have wide-angle vision but only have limited forward binocular vision and poor depth perception (Fig. 1). This means that they can detect objects and movements in front and beside them, but can only judge distances directly ahead. Therefore, animal movements can be affected by shadows, discontinuities on the floor and lighting. Animals have a tendency to move from a darker area towards a brighter area, but they will not approach blinding light. On the other hand, these animals can hear over a greater range of frequencies than humans and are more sensitive to higher frequencies (Velarde & Dalmau, 2014). Pens, passageways and races shall be designed and constructed to allow the animals to move freely in the required direction using their behavioural characteristics and without distraction. Pigs prefer to walk side by side for as long as possible (Grandin, 1997). At the point where passageways are reduced in width, this should be done by a means that prevents excessive butting of the animals. Solid-walled fences eliminate contact between pigs walking through the alleys and those held in pens and prevent stops due to distraction (Faucitano & Geverink, 2008). In the EU the slaughterhouse staff must have

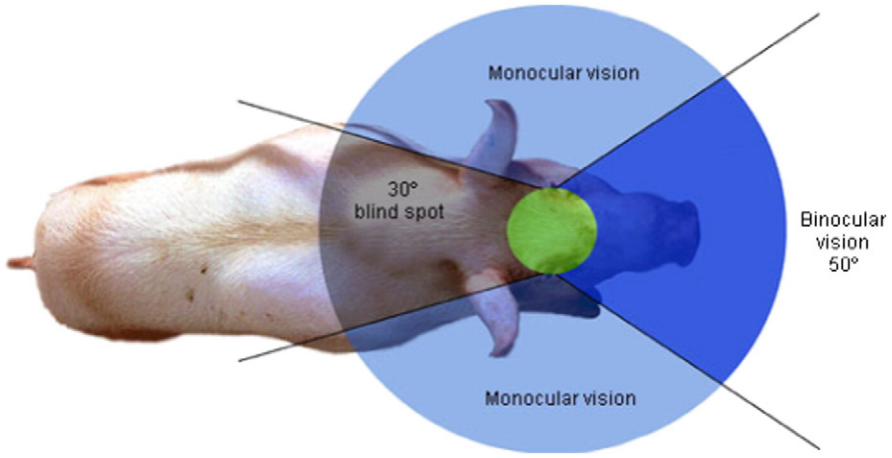

Fig. 1. Pig's vision.

specific training on these behavioural patterns (Council Regulation, 1099/2009).

4. Monitoring procedures at slaughterhouses

Pigs must be stunned before sticking according to the EU regulation (Council Regulation, 1099/2009). The purpose of this is to induce unconsciousness and insensibility to pain until death occurs through bleeding (McKinstry & Anil, 2004). Animal welfare during stunning can be challenged in two ways — the stunning process itself (pain and fear), and the effectiveness of the stunning process to ensure that the animal is unconscious during bleeding and post-slaughter procedures. To fulfil this requirement, the personnel performing stunning and/or bleeding must have the knowledge and skills to recognise the signs of both effective and ineffective stunning and, in the event of a failure, to re-stun the animal. Animals should be monitored regularly during the entire process, from stunning to bleeding, and ascertain that they do not show any signs of consciousness and also that death occurs before further carcase dressing operations or scalding begins. In order to ensure that the stunning processes are carried out in a reliable way, the aforementioned Council Regulation requires slaughterhouse operators to put in place and implement standard monitoring procedures (SOPs). Those checks shall be carried out on a sufficiently representative sample of animals and their frequency shall be established taking into account the outcomes of previous checks and any factors which may affect the efficiency of the stunning process.

The EFSA Panel on Animal Health and Welfare (AHAW) set out to develop toolboxes of welfare indicators for developing monitoring procedures at slaughterhouses for pigs stunned with head-only electrical method or carbon dioxide at a high concentration (EFSA, 2013). It proposed welfare indicators together with their corresponding outcomes of consciousness, unconsciousness or death, to be used at three key stages of monitoring: (a) after stunning and during shackling and hoisting, (b) during sticking, and (c) during bleeding. The panel concluded that, although it is traditional to look for outcomes of unconsciousness in pigs following stunning, the risk of poor welfare can be detected better if pig welfare monitoring is focused on detecting consciousness, i.e. ineffective stunning or recovery of consciousness. Regarding the frequency of checking, the opinion states that it differs between the roles of different people. The personnel performing stunning, shackling, hoisting and/or bleeding, will have to check all the animals and confirm that they are not conscious following stunning. For the Animal Welfare Officer, who has the overall responsibility for animal welfare, a mathematical model for the sampling protocols was proposed, taking into account the throughput rate (total number of animals slaughtered in the slaughterhouses) and tolerance level (amount of potential failures — animals that are conscious after stunning).

The EUWELNET project (www.euwelnet.eu) developed standard operating procedures (SOPs) for the assessment of effective unconsciousness following stunning at commercial slaughterhouses. The aim of these improved standard operating procedures (SOP) is to enable food business operators (FBO) and animal welfare officers (AWOs) to better implement the welfare at slaughter and to provide the competent authorities (CAs) and official veterinarians (OVs) with a method to assess compliance with the Regulation. The SOPs include recommendations on the objectives, responsibilities, control measures, monitoring procedures, corrective actions and records.

5. Conclusions

Animal welfare is an important pillar of sustainability in meat production. Intensive pig production increases efficiency in the use of available resources, productivity and food security. However, it might impair animal welfare. On farm, important welfare issues are related to neonatal mortality and low level of sensory input, which are likely to engender stereotypes and injurious behaviours, such as tail-biting. Future research should be carried out to assess the primary causes of piglet mortality in different types of farrowing systems as well as the benefits of loose house systems, taking into account both the piglet survival and the sow health and welfare. Short and long term consequences of large litter size need to be also addressed. The minimum requirement for manipulable material to express exploratory behaviour should be also addressed to eliminate the need of tail docking. Pre-slaughter handling refers to the interaction between humans and animals prior to and during transport and at slaughter. Strategies to reduce pre-slaughter stress will benefit carcass and meat quality, being the training of stockpeople one of the most cost-effective policies to improve animal welfare. These strategies include also the implementation of standard monitoring procedures to detect signs of consciousness after stunning, before sticking and during bleeding until death occurs.

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