Product quality attributes associated with outdoor pig production

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Abstract

Outdoor pig production offers animals increased environmental diversity and behavioural freedom but imposes challenges for breed adaptation, management control, biosecurity, and environmental protection. Each of these issues has potential implications for the real and perceived quality of the product. In most conventional Northern European production systems, only adult and suckling animals are at pasture. However, in traditional Mediterranean systems and in organic production systems, meat animals may be maintained outdoors throughout their lives. Major influences on organoleptic quality of product derive from the choice of breeds most appropriate to outdoor systems, modifications to growth rate, and the increased proportion of forage in the diet. Indirect consequences may also result from both positive and negative influences on physiological stress responses in the pre-slaughter period. Whilst some aspects of animal health and hygiene may be improved in more extensive conditions, exposure to parasites and to contact with wildlife may increase zoonotic infection risk. Perceptual attributes of product quality may be either positively or negatively influenced, depending on the ethical attitudes of consumers and the quality of management and husbandry in outdoor pig units which are visible to the public. The extent to which real and perceived differences in product quality are reflected in changed economic value is more a function of marketing than production system.

Keywords: Quality; Pig production; Outdoor systems; Genotype; Diet; Welfare

1. Introduction

Product quality can be defined as “the sum of the properties and characteristics of a product or of a service which confer on it the ability to satisfy implicit or explicit requirements” (see Edwards and Casabianca, 1997). This definition encompasses many aspects that, in the case of food from farm animals, include both real and perceived attributes of the product. Primary attributes of quality can be viewed as those that are directly and objectively measurable in the material produced; for example, physical, chemical, microbiological, and organoleptic measures. Secondary attributes of quality can be viewed as those which relate to consumer perceptions of the product but may not be measurable in the material itself; for example, animal welfare, environmental impact, cultural, socio-economic, and traceability/safety aspects of the production system. These have also been referred to as attributes of ‘product’ and ‘process’, respectively.

Outdoor pig production systems come in many forms. In some European countries, particularly UK
and France, there are significant numbers of outdoor herds contributing to conventional pig meat supplies. In the UK, it has been estimated that approximately 30% of the national sow breeding herd is housed outdoors (Sheppard, 1996) although this figure is lower in other European countries (Edwards, 1994). The popularity of outdoor production is a consequence of financial considerations linked to the low establishment and overhead cost of such systems (Edwards, 1996), as well as encouragement from retailers with a market for more extensively produced meat. These conventional outdoor production systems typically have highly selected genotypes, high stocking rates, and total reliance upon manufactured compound feed. However, they are seldom truly outdoor systems for the meat animals; they typically confine the progeny after weaning, sometimes in hut-and-run outdoor systems and more often in fully enclosed buildings. Finishing pigs are almost always housed, either in deep litter systems or in conventional controlled environment housing, with <0.5% of UK pigs being finished outdoors (Sheppard, 1996; Edwards, 1999b).

This conventional outdoor production contrasts with a small but growing population of farms producing pigs to organic standards (Edwards, 1999a; Kelley et al., 2001). These must be kept in accordance with the European Community standards for organic livestock and livestock products (Council Regulation EC 1804/1999 amending Directive EEC 2092/91), with additional requirements sometimes being imposed by individual Certification Bodies (e.g. Soil Association, 2000). It is a requirement of the Directive that breeding animals have access to pasture. In some certification schemes (e.g. Soil Association, 2000), it is also a requirement that finishing pigs be kept at pasture, although this is not universal and in many countries growing and finishing pigs are housed with an outdoor run area which may be of concrete.

The third major European outdoor system is the traditional Mediterranean silvopastoral system. This system involves indigenous breeds that are extensively pastured in natural forests for the production of high-value dry-cured hams (Dobao et al., 1988; Edwards and Casabianca, 1997). Typically, all phases of production take place outdoors, sometimes in extreme conditions in mountain zones. The animals reach their slaughter weight at an advanced age, conferring great maturity on the meat produced. In addition, the finishing takes place during autumn in forests of oak or chestnut and the animals convert large quantities of acorns or chestnuts into fat deposits.

There is thus no standard outdoor system for pig production, and generalisations about the quality of product from outdoor systems must be approached with great care. As in any system evaluation, multiple interacting components are involved in the final outcome and must initially be analysed individually to assess their likely contribution to the whole (Edwards, 2000).

2. Effect of genotype

One major difference usually present between indoor and outdoor systems relates to the genotype of pig that is typically used. Animals kept outdoors need to be of more robust constitution in order to withstand the rigours of the climate (either heat or cold), exhibit appropriate ranging behaviour, and deal with social competition for resources such as feed or shelter. In conventional outdoor systems, robustness is most commonly provided by incorporating genes from the Duroc breed into crossbreeding programmes with the Landrace and Large White breeds used in indoor production, to give a typical inclusion of Duroc genes of 12.5 to 25% in the slaughter generation (Edwards and Zanella, 1996). Because of its robust character, the Duroc breed experiences fewer welfare problems in extensive systems. In addition, it confers benefits on product quality through greater intramuscular fat (Blanchard et al., 1999a) and improved muscle fibre type. Thus, this breed has been associated in many studies with an increase in quality parameters of fresh meat, for example darker, redder muscle colour, increased fat firmness and increased tenderness (e.g. MLC, 1992).

In organic systems, emphasis is placed on using traditional breeds adapted to the local conditions and extensive production systems. A survey of UK organic herds in 1999 indicated that nine different traditional breeds were in use, with the most numerous being the British Saddleback (Kelley et al., 2001). Such breeds again are likely to experience
fewer welfare problems in extensive systems since they carry higher levels of body fat and, because of their lower lean tissue growth rate, are likely to be under less metabolic stress in situations of feed insufficiency or poor diet quality. They also have excellent maternal behaviour attributes. There has been some limited comparison of carcass and meat quality of pork from a range of such genotypes, including the British Saddleback and Tamworth (Warriss et al., 1996). The traditional breeds generally had greater backfat levels, increased fat firmness, produced meat which was darker, and lost less exudate during storage, but was not uniformly superior to modern breeds. Eating quality was highest in the Tamworth breed, followed by the Duroc and the Hampshire, and poorest in the Pietrain. Some of the reported superiority of traditional breeds may reflect the fact that these are genetically fatter animals with higher levels of intramuscular fat, associated with benefits in eating quality (e.g. Fernandez et al., 1999). However, it has also been suggested that improved eating quality might be a result of differences in fibre type between the genotypes, as the traditional breeds were observed to have a finer muscle grain. In a recently completed study of eating quality of pork and pig meat products of different breeds reared under organic conditions (Kelley et al., 2001), no consistent differences between progeny of traditional (Saddleback) and improved sows (Camborough 12) were detected (unpublished results).

Mediterranean silvopastoral systems are based on local breeds with slow rate of growth, great fatness and mediocre conformation (Casabianca, 1995), and a greater predisposition to deposit oleic acid (Gandemer et al., 1990). Their capacity to deposit mono-unsaturated fatty acids increases with age, as opposed to improved breeds which tend to deposit more saturated fatty acids (Girard et al., 1983). Crossing with the Duroc breed is often used to improve the productivity of the animals without greatly affecting their hardiness or reducing the level of intramuscular fat. This is particularly important for the processed products such as dry hams where marbling is recognised as a criterion of quality (Girard et al., 1986). The Duroc breed therefore plays a key role in all types of outdoor systems, where the organoleptic benefits conferred by its genetic predisposition to deposit intramuscular fat are widely recognised and valued.

3. Effect of diet

Pigs produced in outdoor systems have the theoretical potential to forage for a range of different foodstuffs (Edwards, 2003), and the nature of the diet might affect product quality. However, since most progeny from conventional outdoor systems are finished indoors on concentrate diets, they are unlikely to differ in this respect from progeny of indoor sows. This contrasts with the situation in organic production, where standards require the provision of roughage for all growing pigs. This may be in the form of grazed vegetation for animals at pasture, or provided as a supplementary feed (e.g. hay, silage or root crops) in shed-and-run systems. In both situations, animals fed ad libitum concentrate have very low forage intakes (<5% of daily dry matter intake; Edwards, 2003), although when concentrate feed is restricted, higher intakes of roughage can be achieved (up to 15%). Roughage intake can be beneficial to pig welfare, with bulky diets promoting satiety when food intake is limited. They may also beneficially influence health, both through promotion of a desirable gut microflora profile, and due to a reduced prevalence of gastric ulceration (Lee and Close, 1987).

Effects of herbage consumption on meat quality are still little explored. Herbage contains compounds with the potential to flavour pig meat, as well as unsaturated fatty acids and antioxidants. Pigs given access to pasture have higher levels of polyunsaturated fatty acids, n-3 fatty acids, and vitamin E in the muscle than indoor pigs (Nilzen et al., 2001; Hogberg et al., 2002). This gives the positive advantage of a meat product which can be considered more beneficial for human health, but which also has the potential for higher lipid oxidation in storage, with adverse effects on organoleptic quality. However, direct nutritional effects of herbage may be accompanied by indirect negative effects on total nutrient intake and growth rate associated with feeding of bulky diets. Research has consistently shown an improvement in tenderness and eating quality of pig meat from animals with high growth rate resulting from ad libitum feeding of diets...
which are relatively nutrient-dense (Blanchard et al., 1999b; Ellis et al., 1996). This may be associated with increased protein turnover rate, proteolytic activity in muscle, and reduced collagen maturity at slaughter. Reduced levels of concentrate feeding and ad libitum intake of roughage (either clover grass or clover grass silage) caused reduced daily gain in growing pigs, which caused increased lean meat content and reduced intramuscular fat and tenderness significantly (Danielson et al., 1999; Hansen et al., 2001). Hansen et al. (2001) found no significant effects on meat and eating quality between low concentrate rations including ad libitum intake of roughage compared with a 100% organic concentrate or 100% conventional concentrate, except for the composition of fatty acids. The polyunsaturated fatty acids in the meat of 100% organic fed pigs increased significantly by 2% compared with those fed 100% conventional concentrate. Feeding of restricted organic concentrate and ad libitum roughage further increased the amount of polyunsaturated fatty acids by 4% in comparison with the conventional concentrate feeding treatment. This increase may lead to healthier meat, but also rancidity and a WOF problem during storage and processing of the organic meat. In a recently completed study of eating quality of pork and pig meat products of organic pigs kept at pasture or in a shed-and-run system (Kelley et al., 2001), no consistent differences were detected as a result of access to fresh herbage (unpublished results). Because of the difficulty in sourcing dietary protein of high quality produced under organic conditions, it is more likely that organically-reared pigs will receive a reduced supply of the key essential amino acids. This regime has been shown to result in increased intramuscular fat content (2.9 versus 1.2%), and therefore possibly improved eating quality, under experimental conditions (Sundrum et al., 2000b). However, it has not yet been possible to replicate these results under farm conditions (Sundrum et al., 2000a).

Mediterranean silvopastoral systems have been associated with improved quality of pig meat when used for dry-cured ham production, due to the relatively high levels of intramuscular fat resulting from access of native pig breeds to acorns which are high in starch (Edwards and Casabianca, 1997). Cava et al. (1999) showed increased aroma and flavour, and less rancidity in dry-cured ham, by feeding acorns to pigs. Within a given genotype, many studies have been carried out to show how the characteristics of the fat are modified during the finishing regime, with eating quality particularly affected by the accumulation of oleic acid in the adipose tissue (Fallola et al., 1989). Genotype–environment interactions occur, since a Large White, even after acorn finishing, never exceeds 2.5% intramuscular fat, whilst a native pig of slow growth genotype subject to such finishing can reach 11% (Casabianca and Luciani, 1989).

4. Effect of climatic environment

Another major difference between pigs produced outdoors and indoors is the exposure to plentiful fresh air and greater extremes of climate. Such circumstances may influence both primary and secondary product quality attributes. The outdoor environment clearly has potential for both positive and negative effects on pig health and welfare (Edwards and Zanella, 1996). Plentiful space and fresh air will reduce infection pressure but, if ground conditions become poor as a result of high rainfall and unsuitable soil type, welfare may be seriously compromised. Energy requirements of outdoor pigs in Northern Europe are generally higher because of increased climatic energy demand, whilst protein requirements are relatively unaffected (Close and Poornan, 1993; Edwards, 2003). Conversely, at high ambient temperatures, voluntary feed intake can be reduced to the extent that it is inadequate to meet requirements for high production. If modified nutritional requirements in either situation are not met, both welfare and growth rate will suffer and these, in turn, can impact adversely on meat quality.

Exposure to cold can directly affect product quality, giving rise to shorter carcasses with a higher proportion of fat in subcutaneous rather than internal depots. There is an inverse relationship between the ambient temperature and the degree of unsaturation of subcutaneous fat, faster post-mortem pH decline in cold exposed pigs and lower ultimate muscle pH (Lefaucheur et al., 1991; Lebret et al., 2002). Such effects might give rise to seasonal quality differences in outdoor pigs. Exposure to plentiful fresh air may also benefit product quality in other ways. An important component of organoleptic quality is the
concentration of malodorous compounds in fat, such as skatole and indole, which cause unpleasant odor when cooking. These can be absorbed from excreta through the skin and respiratory tract, giving rise to impaired quality in pig meat from animals housed very intensively. However, lower stocking density, better air quality, and a diet with more fermentable fibre, such as might be obtained from natural foraging, will all reduce the risk of meat taint from this source (Hansen et al., 1994).

5. Effect of exercise

In comparison with housed animals, outdoor pigs generally have a large area over which to roam, and a more diverse environment providing greater stimulus for exploratory behaviour. Increased exercise can be important for animal welfare, as muscle tone and bone strength can be adversely affected by restricted movement, although increased activity can also result in a marked increase in the maintenance energy requirement (Edwards, 2003). However, the proportion of the day spent active does not appear to be greatly increased in outdoor conditions (Guy et al., 2002a), although this depends on level of hunger (Ewbank, 1974). The effect of exercise is unlikely to be important for primary meat quality differences between indoor and outdoor pigs, since forced exercise on a treadmill had no influence on muscle characteristics at slaughter or sensory qualities (Weiss et al., 1975; Essen-Gustavsson et al., 1988; Petersen et al., 1997).

6. Effect of environmental enrichment

The major animal welfare advantage of outdoor production is the greater space and environmental diversity, allowing expression of a wide range of behaviour patterns. Reduced space has been shown to be a social stressor, and a barren environment has been shown to give rise to greater abnormal and aggressive behaviours (Beattie et al., 1993, 1995, 2000). However, in many commercial outdoor units, the expression of natural foraging behaviour is considered undesirable, as it removes vegetative cover from the fields. To prevent this, it is common practice in conventional outdoor systems to nose-ring breeding pigs and, whilst this can preserve the pasture, the welfare implications are contentious (Horrell et al., 2001). Environmental enrichment of indoor-reared pigs has been shown to be important to alleviate behavioural problems such as tail biting. In addition to immediate effects of enrichment on behaviour, there are suggestions that it plays an important role in behavioural development. Comparison of pigs reared from birth to weaning in highly enriched environments or barren environments, which were subsequently both transferred to standard, relatively barren housing, showed long term detrimental effects of early impoverished housing. These included greater restlessness in the fattening and parturient periods, impaired social behaviour towards penmates and offspring, reduced growth rate and delayed puberty in subordinate animals, greater adrenal response to acute stress, and greater development of stereotyped behaviour in response to tethering (Schouten, 1986; de Jong et al., 1995, 1996). Pigs reared in enriched and barren conditions have also shown differences in ease of handling in later life, although results of such comparisons have not been consistent (Barton-Gade and Blaabjerg, 1989; Beattie et al., 1995).

Since early enrichment has been shown to modify the physiological response to stressors, and since stress physiology can have a very significant effect on meat quality (as either PSE or DFD muscle depending on the nature and duration of stress response), enrichment has the potential to exert a major influence on final product quality (Warriss, 1994). However, results have been equivocal. It has been suggested that pigs from more enriched environments are less stress susceptible and might therefore deal more adequately with transport and pre-slaughter handling. Barton-Gade and Blaabjerg (1989) observed that pigs reared outdoors were calmer and more easily handled at the abattoir than intensively-reared pigs, although muscle pH values were lower for these pigs. In another study, outdoor pigs showed a decrease in ultimate pH and in water retention capacity, suggesting that these pigs experienced greater pre-slaughter stress (Gandemer et al., 1990). Similarly, in more controlled experiments, environmental enrichment has sometimes resulted in reduced pig meat tenderness (Beattie et al., 1993), whilst on other occasions it has increased tenderness (Beattie et al., 2000). Differences in growth rate and
fatness may be a confounding factor affecting meat quality in such comparisons. It is interesting to note that pigs born outdoors, even when subsequently transferred to indoor rearing systems, show a lower growth check in response to weaning (Edwards and Rooke, 1999) and may have better lifetime growth performance and meat quality in some climatic conditions (Gentry et al., 2000b).

7. Primary attributes of meat quality from outdoor systems

Since many component factors that have been shown to influence pig meat quality can differ between indoor and outdoor systems, measurable differences between animals from such systems might be expected. However, evidence of any consistent effect is sparse. Eleven different published experiments reporting comparisons of meat quality in outdoor and indoor reared pigs have been reviewed (Warriss et al., 1983; Barton-Gade and Blaabjerg, 1989; Gandemer et al., 1990; van der Wal et al., 1993; Dufey, 1995; Enfalt et al., 1997; Sather et al., 1997; Nilzen et al., 2001; Jonsäll et al., 2002; Gentry et al., 2002a,b). The majority of studies where the measurement was reported (6/9 and 7/10) have shown no difference in juiciness or tenderness, respectively. Three studies reported reduced juiciness in outdoor pigs, one reported reduced tenderness, whilst two reported increased tenderness. Detrimental effects on meat quality have sometimes been linked with reduced growth rate and/or fatness. No experiments (0/7) showed a difference in (meat) flavour and only one (1/4) reported a difference in off-flavour or taint. A significant number (6/9), however, have reported reduced muscle pH and/or increased drip loss, suggesting greater susceptibility of outdoor pigs to pre-slaughter stress.

8. Secondary attributes of meat quality from outdoor systems

Whilst the primary attributes of product quality therefore do not appear to be consistently modified by outdoor production, the secondary attributes of quality cannot be ignored. In most studies, taste panel evaluations are scientifically conducted, with panelists unaware of the origin of the samples. However, it is known that sensory evaluation can be influenced by cognitive factors (beliefs and attitudes). Subjects with prior experience and a positive attitude towards ‘free range’ pork, rated this product less juicy but similar in most other attributes to conventional pork when unaware of the origin of the sample. However, when aware of the origin, they rated free range pork as more juicy, less bland, less tough, more tender, less dry, and more pleasant (Oude Ophuis, 1994). Consumers’ perceptions of the merits of a production system are therefore highly likely to influence their perception of the quality of product produced from such a system. This phenomenon is obviously highly relevant to marketing of pig meat from outdoor systems since, in general, consumers perceive outdoor systems to be more humane, environmentally friendly, traditional, and sustainable.

The extent to which such perceptions are scientifically supported is highly debatable (Edwards and Casabianca, 1997). Although the consumer generally perceives animal welfare to be enhanced in outdoor systems, this is not necessarily the case. In one study in which genotype was controlled, pigs finished outdoors grew better, and had lower skin lesion and stomach ulceration scores, than pigs in very intensive, slatted housing, although were not better than pigs in less intensive straw-bedded housing (Guy et al., 2002b,c). There is larger scale evidence that outdoor systems may be better for health in some respects, since veterinary and medicine costs per pig are 10–20% lower in outdoor than in indoor herds (Edwards and Zanella, 1996). However, parasitism may be greater in the outdoor situation, where worm eggs can remain viable in the soil for extended periods and constitute a source of reinfection. This is a particular issue in organic herds, where routine use of anthelmintics is prohibited. Outdoor pigs face other welfare problems, particularly in relation to thermal stress (as discussed previously) and social competition. Low ranking animals may be particularly disadvantaged in outdoor systems in comparison with the more controlled indoor situation, since they can receive only limited human assistance in attaining adequate access to resources such as shelter and food. Thus, when considered in the welfare framework of the Five Freedoms (FAWC, 1992), the following
conclusions about outdoor production systems can be drawn:

- Freedom from hunger and thirst—no effect, or possible negative effect if reliant on natural foraging.
- Freedom from thermal and physical discomfort—possible negative effect from climatic extremes.
- Freedom from injury and disease—positive effect from reduced infection intensity, but possible negative effect from reduced biosecurity and increased parasitic burden.
- Freedom from fear and stress—positive effect from greater space allowance and enriched behavioural development, but less human assistance for subordinate animals and possible negative effects at time of slaughter from unfamiliarity with confinement and handling.
- Freedom to express normal behaviour—clear positive effects, although nose-ringing of breeding stock is an issue.

Outdoor production is also often perceived to be more environmentally friendly, generating less smell and pollution than slurry-based intensive units. However this may not be the case, since feed efficiency may be poorer in climatic extremes, causing greater excretion of unutilised dietary nutrients. In conventional outdoor systems with high stocking rates, the deposition of unutilised nutrients per unit area can be higher than in any other form of intensive farming (Edwards, 1998). In summer, losses of nitrogen by gaseous emission can be high and, when autumn rainfall occurs, losses by leaching can also be substantial (Watson et al., 1998, 2003). This will be especially true if vegetative cover has previously been removed by foraging activity. In organic systems, where total nutrient loading of land is regulated, and in Mediterranean systems, where stocking density is much lower and woodland and pasture are maintained, environmental impact is less severe and better recycling of nutrients within the production system is achieved.

Outdoor production is often perceived as being a more sustainable, traditional, and family-based farming system. However, this is becoming less true of conventional outdoor systems, which may be large scale, corporately owned, and seldom operate in a self-sufficient, sustainable way. Although integration with an arable rotation is common, to benefit from home-grown cereals and straw and to utilise excreted nutrients as fertiliser, this is equally true for many indoor pigs units. Although recognised schemes which are based on principles of sustainability do exist (for example organic and conservation grade production), their share of the total (or outdoor) pig meat market is very small (MLC, 1987). In the Mediterranean systems, by contrast, outdoor pigs are important for management of the forest heritage. The ‘dehesa’ is a man-made ecosystem and, when abandoned, they rapidly become unproductive, due either to shrub growth, which limits the grazing and provokes risk of fire, or to disappearance of trees and desertification. Pig production in silvopastoral systems, even if the pasturage of animals is limited to the finishing period, is therefore of major significance in the conservation of landscape in Mediterranean areas.

Finally, consumers often perceive that meat produced in outdoor systems is more nutritious and safer, with lower use of feed additives and antibiotics. As previously discussed, forage feeding may indeed increase some health promoting aspects of pig meat (Nilzen et al., 2001; Hogberg et al., 2002). Chemotherapeutic medication use is also lower in outdoor herds, and they are not permitted as standard treatments in organic production systems. However, the reduced control of biosecurity in outdoor systems, and the threat of zoonotic infection from wildlife, may mean that microbiological quality of the carcass is actually poorer in some instances. For example, the carriage of Salmonella by birds moving between urban waste disposal areas and outdoor pig units poses a real risk. In both Danish and Dutch studies, the Salmonella seroprevalence has been shown to be higher in free-range finishing pigs than in those produced in conventional intensive systems (Wigstrøm et al., 1999; van der Wolf, 2000).

Thus, although outdoor production currently has a favourable consumer perception of secondary attributes of quality, this is difficult to objectively substantiate under present circumstances. It will be very important to ensure the validity of such quality attributes in the future, and to actively promote these, if a strong consumer satisfaction with, and demand for, pig meat from outdoor systems is to be preserved.
9. Conclusions

In general, primary attributes of pig meat quality have not been shown to be consistently influenced in a favourable way by outdoor production. However, some aspects of outdoor systems have the potential to benefit product quality and should be promoted. The role of genotype is of particular importance in this respect. Secondary attributes of quality can exert a strong influence on consumer perception. The benefits of outdoor production for animal welfare, environmental impact, socio-economic sustainability, and food safety are equivocal, but need to be strengthened and promoted in the future to guarantee a secure and profitable market.

References


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