# QUALITY ASSURANCE SCHEMES

J.D.WOOD[1], J.S.HOLDER[1] AND D.C.J.MAIN[2]
[1]Division of Food Animal Science,
[2]Division of Animal Health and Husbandry School of Veterinary Science,University of Bristol, Langford, Bristol, BS40 5DU, UK

## SUMMARY

This paper considers the consumer's changing definition of quality in relation to meat and the current development of Quality Assurance (QA) schemes to ensure that certain quality standards are met. The key ingredients of QA schemes are food safety, animal welfare and sensory aspects (meat quality) although the latter is not a major feature of many schemes at present. For each of these components, points in the production-processing chain where problems can arise should be identified and control procedures introduced. Monitoring is required to check the effectiveness of these. This approach is based on HACCP principles although best practice rules are the basis of most current QA schemes. The paper identifies key points on the farm and in the abattoir where food safety, animal welfare and meat quality can be compromised and shows how best practice procedures are introduced to reliably raise standards. There is some concern about the credibility of some QA schemes in relation to the standards set, the strictness of inspection and especially the impartiality of auditing procedures. This may be ensured in schemes within Europe which comply with EN 45011 standards. The move towards more tightly regulated QA schemes to raise consumer confidence could benefit some traditional products and organic meat production schemes which already operate with strict specifications.

## INTRODUCTION

The use of quality assurance (QA) schemes to satisfy consumers that products reach certain standards of quality is now common in various industries. In the meat industry, schemes are rapidly developing and are beginning to embrace all the aspects of quality that are important to consumers 'from farm to fork'. This paper considers the application of QA schemes to improve quality in relation to food safety, animal welfare and sensory aspects of quality (called meat quality here).

## DEFINITIONS OF MEAT QUALITY. THE NEED FOR QA SCHEMES

It is clear that the consumer's definition of food quality in relation to meat is now very wide and has been conditioned by changing attitudes in society generally, often amplified by the media. The list in Table 1 is not exhaustive but shows that quality not only includes sensory characteristics such as meat tenderness and colour but also views or perceptions about the conditions of animal production in relation to animal welfare, the impact of animal production on the environment and, of course, food safety. The emphasis on food safety in the UK is due in part to publicity surrounding the BSE saga and the rise in food poisoning notifications assumed to derive from animals and meat. In a recent outbreak in Scotland, 20 people died from consuming meat products contaminated with *E.coli* O157:H7 (Parliamentary Office of Science and Technology, 1997).

**Table 1. Factors in meat production contributing to the consumer's definition of quality, with examples**

| | |
|---|---|
| Food Safety | BSE |
| | *E.coli* O157 H:7 and other zoonotic bacteria |
| | Antibiotic residues |
| Animal welfare | Live animal transport |
| | Intensification (stalls and tethers) |
| | Animal slaughter procedures |
| Environment | Wastes from farms and abattoirs |
| Healthiness | Fat |
| | Saturated fatty acids |
| Taste | Tenderness |
| | Colour |
| Lifestyle | Preparation time |
| | Availability in convenient forms |

Many of the items in Table 1 have negative connotations for consumers who now have access to a wider array of foods than ever before. It is not surprising then that total meat consumption has been static or has increased only slowly in many countries in the last few years (Table 2) although the 'red' meats (beef and lamb) have faired worse than the 'white' meats (pork and poultry). In some other countries, for example in Asia where these issues are currently less acute, meat consumption is rising rapidly.

**Table 2. Changes in annual per capita consumption of meat in the EU 12 countries 1986-1995 (%)**

| | Beef and lamb |
|---|---|
| Beef and lamb | -7 |
| Pork and poultry | +10 |
| All meat | +4 |

Department of Trade and Industry (1997)

In order to strengthen the markets they presently have, the meat industry must be proactive and build quality into meat production systems. QA schemes should aim to provide assurance by defining the aspects of quality which are most important to consumers and in which variation causes the most dissatisfaction. Points in the chain where problems can arise must be identified and control measures implemented. Monitoring is required to check the success of these controls and the eventual result should be a system reliably producing higher and less variable quality. This approach is based on hazard analysis critical control point (HACCP) principles, more commonly applied to maintaining hygiene in food processing lines. The aim is to anticipate and avoid hazards rather than react to problems when they occur. The three arms of a possible QA scheme and indications where problems can arise to affect quality are shown in Figure 1.

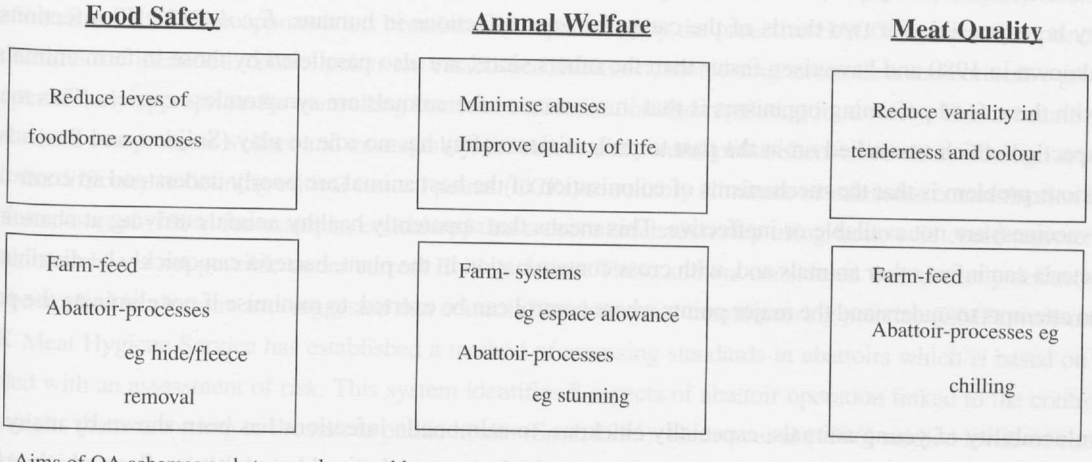


Figure 1. Aims of QA schemes and stages where problems can arise and be overcome.

The rapid development of QA schemes is being driven by other forces, for example the concentration of retailer power in many countries and their need for traceability. In the UK the Food Safety Act (1990) requires retailers to exercise due diligence in ensuring safe food. This requires detailed documented knowledge of the whole production process and the ability to trace meat cuts back along the chain to the abattoir or farm.

## INTERNATIONAL TRADE CONSIDERATIONS

The aspects of quality to be emphasised in QA schemes differ between countries and within countries. This may be because of consumer pressures in a particular country eg animal welfare issues are strongly emphasised in the UK QA schemes. The need to ensure high quality in export markets explains developments in some countries for example Denmark (Andersen, 1997) and Australia (Pointon and Hamilton, 1998). Within countries, a desire to differentiate products to suggest superiority in the market place explains why the emphasis in schemes may differ. However all of these variations can be accommodated when schemes operate to internationally recognised standards such as EN 45011 [European Accreditation of Certification, 1995]. Moves

towards harmonisation will lead to greater openness of international markets since the terms of trade will increasingly be bound by recognised scientific principles in the future (Pointon and Hamilton 1998).

Although international trade in meat has always been significant, it is likely to increase in the future as World Trade Organisation agreements progress, distribution technology improves and production costs widen between countries. For example although international trade in pork was only 3% of world production in 1997 this was a 10-fold increase on 1970. Gee (1997) pointed to the potential for large North American exports to Europe in the short term and those from Central European countries in the longer term. All these aspirants will have to satisfy demanding retailers in importing countries not least because of the counter claims from home-based producers. Strong QA schemes, certified and accredited to internationally recognised standards will be vital for exporters to demonstrate high standards and for importing countries to protect their own markets.

Another important consideration with respect to international trade is the provision within the General Agreement on Tariffs and Trades (GATT) which limits the ability of governments to bring in legislation that inhibits free trade. Animal welfare legislation in particular could be seen as a barrier to free trade. However, non-governmental organisations, which would include QA schemes are not bound by GATT. It would, therefore, seem likely that increasing consumer concerns will need to be addressed by QA schemes rather than national legislation.

## FOOD SAFETY ISSUES

A recent analysis of food poisoning in the UK (Parliamentary Office of Science and Technology, 1997) has shown that notifications of food poisoning to doctors increased five-fold between 1982 and 1996. At the same time the reported incidence of three bacteria also greatly increased ie campylobacter, salmonella, and *E.coli* O157:H7. Campylobacter is now the most common bacterium giving rise to food poisoning, salmonella incidents having plateaued in 1992. In each of these cases the upward trend in human reports is mirrored by that in farm animals. For example the increase in salmonella food poisoning is associated with 2 sub-types which have recently increased in farm animals: *S.typhimurium* DT104 common in cattle and *S.enteritidis* PT4 in poultry. Poultry is responsible for two thirds of the campylobacter infections in humans. *E.coli* 0157:H7 infections, which were virtually unknown in 1980 and have risen faster than the others since, are also paralleled by those in farm animals.

One problem with these food poisoning organisms is that in most cases the animals are symptomless carriers. This means that classical meat inspection which was relied on in the past to protect meat safety has no role to play (Snijders and Berends, 1996). Another, more serious problem is that the mechanisms of colonisation of the host animal are poorly understood so control measures on farms (eg vaccines) are not available or ineffective. This means that apparently healthy animals arriving at abattoirs which are 'shedding' bacteria can infect other animals and, with cross contamination in the plant, bacteria can quickly be distributed. This scenario has led to attempts to understand the major points where control can be exerted, to minimise if not eliminate the problems.

### Farm factors

The extreme vulnerability of young animals, especially chickens, to salmonella infections has been shown by many workers for example Mead (1996). Mead showed that if the guts of young chickens are colonised by adult-type flora which are salmonella-free, their resistance to salmonella infections is then considerably increased. This is termed competitive exclusion. Commercial mixed gut flora preparations are available and probiotics (1 or more named strains) can also be used for this purpose. However there has been mixed success. Campylobacter has yet to be controlled using competitive exclusion.

There has been much speculation about the use of antibiotics as growth promoters in animal production and the consequent emergence of resistant bacterial strains. For example, the rapid increase in food poisoning outbreaks resulting from *Salmonella typhimurium* is linked to the appearance of strains resistant to a range of commonly used antibiotics (Brisabois et al, 1997), suggesting (although there is considerable debate about this) that it has emerged by selection pressure caused by antibiotic usage on farms and in human medicine. This sort of concern has already led to bans on the use of growth promoters in QA schemes (Anderson, 1997) and this trend will continue.

Feed is potentially a major source of salmonella infections. Levels of bacteria in feed delivered to farms can be considerably reduced by instigating a programme of strict hygiene controls in feed mills including operation of the pelleting machine above 81$^{0}$C. Lillie (1995) reported that the use of these regulations in Danish feed mills had reduced the incidence of salmonella (% of mills where bacteria isolated) from 72 to 7 between 1990 and 1995.

The importance of the herd or farm unit as a source of infection has been reported by several workers. The success of all in-all out systems of pig production, rather than continuous stocking, followed by strict disinfection regimes to reduce salmonella infection was reported by Dahl and Wingstrand (1996). Stocking clean units with specific pathogen free (SPF) pigs was successful in a study reported by Weitjens et al (1996).

### Abattoir factors

In a study of 15 poultry flocks, 11 of which were initially contaminated with campylobacter, Mead et al (1995) showed that when the organism was present in caecal contents it was extremely difficult through the use of decontamination treatments to reduce the levels in the final product sufficiently such that risk to human health was eliminated. This was only possible when there was no initial infection, showing the importance of reducing live bird infections on farms. Similarly, Berends et al (1996) showed that pigs with salmonella in their faeces at the abattoir were 3-4 times more likely to have infected carcasses than those not carrying the bacterium. Hadley et al (1997) developed a scoring system for sheep fleece cleanliness and showed that those with score 5 (very dirty and wet) had 100% incidence of Enterobacteriaceae at the shoulder carcass meat site compared with 35% in those scored 1 (clean and dry).

A UK report into food poisoning showed that poor hygiene in abattoirs was a major causative factor (Parliamentary Office of Science and Technology, 1997). Faecal contamination of carcasses during skinning and evisceration occurs unless strict control of procedures is maintained and there are many ways that cross contamination can occur, for example from knives or gloves which aren't sterilised between animals and from contaminated environmental surfaces (Holder et al, 1997). However, some papers have noticed only small differences in microbial loads on carcasses between apparently 'clean' and 'dirty' abatoirs even when appropriate hygiene procedures are used (Hinton et al, 1998).

### Food safety in QA schemes

Traditionally, food safety quality control relied on end product testing which was retrospective, destructive and unable to take account of batch variation. This approach has been broadly superceded by the proactive HACCP system. The principles of HACCP, by which hazards are identified, control points are established, limits set, monitoring undertaken and corrective procedures established seem particularly appropriate for controlling bacterial contamination and regulating food safety. This is because, compared with the factors which compromise welfare and meat quality, the causes and control points seem more clear, although several authors have pointed to the difficulty in defining critical control points (CCPs) to reliably eliminate or minimise contamination in the fresh meat industry. Berends et al (1996) for example, considered that a decontamination step using lactic acid could represent a CCP but the use of such materials is not possible under current EU legislation. These authors considered that a strictly defined HACCP system could not be applied in abattoirs and suggested that controls based on good manufacturing practice (GMP) were more appropriate.

The UK Meat Hygiene Service has established a method of assessing standards in abattoirs which is based on HACCP principles coupled with an assessment of risk. This system identifies 5 aspects of abattoir operation linked to the control of contamination and weighs them according to the risk to public health (Soul, 1996). Hudson et al (1996) studied levels of carcass contamination in 11 beef abattoirs and showed generally good correlations between these and the Hygiene Assessment System (HAS) scores (Table 3). For this reason the HAS system for controlling abattoir hygiene is an important part of UK QA schemes eg British Quality Assured Pigs. Large differences in total viable counts between abattoirs was noted in the study of Hudson et al (1996), reflected in their HAS scores which are now published in a 'league table' and used by retailers to choose suitable abattoir suppliers.

Rules for GMP form the basis of the Danish scheme for controlling salmonella contamination in feed mills and the feed industry (Lillie, 1995). The Danish salmonella surveillance programme segregates pig herds into 3 groups with special slaughter arrangements required for high risk herds (Emborg et al, 1996). Both these systems are requirements of the national QA scheme for Danish pork.

The Pork Quality Assurance programme in the USA puts major emphasis on the prevention of antibiotic residues in meat and the maintenance of herd health. The principles of HACCP are used to ensure that medicine use is appropriate and regulated (Lautner, 1997). Regular monitoring of muscle tissue for antibiotic residues is also part of the Farm Assured British Pigs scheme (Gready, 1997).

In the Netherlands, the concept of Integrated Quality Control emphasises best practice in the whole production-processing chain (Snijders and Berends, 1996). One aim is to minimise the risk of infected material entering the food chain which will eliminate the need for expensive classical meat inspection. Other countries eg Australia are developing HACCP-based food safety assurance schemes which will also remove the need for current levels of meat inspection (Pointon and Hamilton, 1998).

**Table 3.Categories of red meat slaughterhouse operation scored by the UK Meat Hygiene Service using their Hygiene Assessment System (HAS) and correlations between HAS score and carcass microbial quality in 11 beef abattoirs found by Hudson et al (1996)**

| Category and main features within each category | Weighting (%) | Correlation: HAS vs total viable counts |
|---|---|---|
| Antemortem<br>Cleanliness of animals | 8 | -0.50 |
| Slaughter and dressing<br>Skinning<br>Evisceration | 37 | -0.68 |
| Personnel and practices<br>Training programme<br>Use of washbasins/sterilisers | 30 | -0.68 |
| Maintenance and hygiene of premises<br>Facilities<br>Maintenance programme | 15 | -0.19 |
| General conditions and management<br>Management | 10 | -0.34 |
| | 100 | |

## ANIMAL WELFARE ISSUES

Maintenance of good animal welfare is an increasingly important part of QA schemes in the UK and other countries. The 'five freedoms' as defined by the Farm Animal Welfare Council (FAWC; Table 4) are the principle framework for evaluating animal welfare in many QA schemes although FAWC does recognise that these are "ideal states rather than standards for acceptable welfare" (indeed some freedoms may be conflicting eg it may be impossible to prevent certain diseases without using vaccinations which cause distress associated with handling). The inclusion of animal welfare in most QA schemes is achieved by setting and enforcing standards based on a mixture of scientific research, legislation and advice from interested and experienced parties.

**Table 4. The 'Five Freedoms' which provide a framework for setting the welfare standards of food animals in QA schemes**

| |
|---|
| Freedom from hunger and thirst |
| Freedom from discomfort |
| Freedom from pain, injury or disease |
| Freedom to express normal behaviour |
| Freedom from fear and distress |

Farm Animal Welfare Council (1993).

### Farm factors

The Farm Animal Welfare Council produces regular reports on the welfare issues appropriate to each livestock sector. FAWC has reported significant problems in both intensive and extensive systems. For example, leg weakness in intensively-reared broiler chickens was identified as a significant issue (FAWC, 1992). However, lameness was also identified as a problem in the sheep and dairy industries (FAWC, 1994; FAWC, 1997).

Best practice rules in animal husbandry are often used to improve animal welfare, for example in relation to the maintenance of stable groups of animals or the provision of foraging materials for pigs. Standards can also define space allowances and prevent the use of practices considered unacceptable eg stalls and tethers for sows which confine movement. Problems arise when practices seem to compromise animal welfare but no suitable alternatives are available eg farrowing crates which restrict sow movement but prevent piglet crushing and tail docking which reduces tail biting in older pigs. Also, stockmanship has a critical role to play in maintaining good animal welfare but stockmanship qualities are difficult to precisely define.

Disease outbreaks can seriously compromise animal welfare and best practice protocols can be used to define control measures which prevent them. These should be supported by objective evidence of good practice eg accurate recording of medicine useage and production parameters such as growth rate. Ideally the internal management controls would meet the requirements of a standard such as ISO 9001.

A veterinary health plan (VHP) is a useful tool for demonstrating best practice with respect to health and welfare issues (Main, 1997). This establishes prevention and treatment protocols for the particular farm and is regularly reviewed by the producer and veterinary surgeon. For example, the use and extent of tail docking should be documented and justified in the VHP as should the use of all medicines including antibiotics. Strict adherence to withdrawal times should be clearly documented.

**Abattoir factors**

Transport and slaughter are potentially stressful events for food animals in which their 'freedom from discomfort, fear and distress' (Table 4) could be compromised. Some parts of these processes have been well researched and the standards recommended in some QA schemes are soundly based. These include transportation times and minimum stunning currents, where recommendations are based on physiological stress indicators measured in controlled experiments (eg Warriss, 1998; Anil et al, 1997). For others, a combination of scientific data and agreed best practice decides the standards. Polarisation is apparent between schemes on issues such as the use of live animal markets.

**Animal welfare in QA schemes**

In the UK, the Royal Society for the Prevention of Cruelty to Animals (RSPCA) have formed a company called Freedom Foods which implements welfare standards on farms and in abattoirs. The Freedom Food trademark can be used by farmers, hauliers and abattoirs who are inspected by Freedom Food assessors. Unannounced monitoring is done by RSPCA. The standards specified by Freedom Food for pigs are shown in Table 5. Some of these would be considered rigorous by some, for example the ban on stalls and tethers for dry sows is not implemented generally in the UK until 1st January 1999.

**Table 5. Welfare standards for pigs specified by RSPCA under their Freedom Food scheme**

**Food and water**
No mammalian-derived protein
Weaning must be >3 weeks of age
**Environment**
Space allowances:

| Live weight (kg) | Total area ($m^2$) |
|---|---|
| 20 | 0.225 |
| 60 | 0.55 |
| 100 | 0.75 |

Stalls and tethers not allowed for dry sows
Farrowing crates only allowed until suitable alternatives become available.
Pigs must be kept in stable groups and have constant access to straw
**Health**
Veterinary health plan drawn up and regularly updated
Castration not allowed if pigs slaughtered at <90kg live weight
Tail docking only allowed in certain circumstances and with agreement of veterinary surgeon
**Transport**
Pigs must not be sold through live markets
Training courses required for transport personnel
Ramps not >20% incline
Pigs should be slaughtered 'as close as possible' to point of rearing
Slaughter pigs not to be transported for >8 hours
Food should be withdrawn at least 4 hours before transport and fasting should not >18 hours
**Slaughter**
Abattoir must appoint an animal Welfare Office suitably trained (eg by University of Bristol)
Installation of CCTV in lairages recommended.
Stunning current not <1.3amp
Stun-stick interval not>15 seconds

Royal Society for the Prevention of Cruelty to Animals (1997).

In the scheme operated by Farm Assured British Pigs, welfare standards are as specified in Codes of Practice and inspection and auditing is done by Veterinary Surgeons. Both the Freedom Food and Farm Assured British Pigs schemes require abattoirs to employ a trained Animal Welfare Officer (AWO) to implement welfare policy. The University of Bristol has developed the first UK training programme for AWOs which is now a requirement of many QA schemes and processor-retailer partnerships.

Schemes between and within countries differ in the emphasis placed on the various aspects of animal welfare. For example the Danish QA scheme for pigs requires anti-skid rubber flooring in lorries but the use of stalls and sow tethers will be allowed up to 2006 other than on those farms supplying UK supermarkets (Andersen, 1997). The Freedom Food scheme does not allow the use of stalls and tethers now.

The public perception is that cattle and sheep are kept in a more 'welfare friendly' way than pigs and poultry but nevertheless QA schemes are required to ensure that abuse does not arise (Main, 1997). Under the Freedom Food schemes, calves over 14 days of age must have access to dry feed and forage. All sheep must derive 'the bulk of their nutrient requirements' from pasture during the grass growing season and lambs must not be weaned at less than 5 weeks of age. For both beef and sheep, mutilations including castration and tail removal can only be done in specific circumstances.

## MEAT QUALITY ISSUES

The increasing demand for quality in all its forms includes the eventual sensory quality of the meat purchased and consumed. There are many aspects of quality but tenderness and colour are probably the most variable and the most important to consumers. Much research has been done and it is possible to identify points in the food chain where these can be compromised or enhanced. However there have been few attempts to apply HACCP principles to the control of meat quality and meat quality is not central to most current QA schemes.

### Farm factors

Extreme paleness or darkness is sometimes found in pigmeat and beef, due to a combination of environmental and genetic factors. Animals which experience stress over a lengthy period (say >10 hours), usually because of mixing with unfamiliar animals or poor handling, deplete muscle glycogen stores and can develop high pH meat which is dark, firm and dry (DFD) and has poor keeping quality. Alternatively, in pigs, if the stress is experienced immediately before slaughter, muscle pH falls rapidly as anaerobic metabolism occurs and pale soft exudative (PSE) muscle results. Both of these conditions can be avoided on many farms by the application of good management. For PSE however, there is also a genetic cause. Animals inheriting a mutated version of the ryanodine receptor gene (halothane gene) will develop PSE even under good management. In this case the solution is to use a commercially available DNA test to eliminate the defective gene from breeding stock. Producers usually rely on breeding companies to supply halothane gene-free breeding pigs.

Proper control of pre-slaughter stressors could also lead to more tender meat because adrenaline may inhibit the calpain proteolytic enzyme system which tenderises muscle post mortem (Sensky et al. 1998). Tenderness is also higher when animals have grown quickly, especially in the period just before slaughter and this could be due to activation of the calpain enzymes (Blanchard et al, 1995).

### Abattoir factors

Events in the abattoir can affect colour slightly through their effects on muscle pH and temperature but the implications for tenderness are particularly marked. Rapid chilling so that the deep muscle temperature falls below $10^{0}$C within about 3 hours of slaughter reduces tenderness and this 'cold shortening' can be overcome by high voltage electric stimulation or pelvic suspension of the carcass (Taylor et al, 1995).

Conditioning of muscles, whereby proteolytic enzymes degrade the muscle structure at a temperature of about 1C, has a large effect on tenderness. In a recent study the comparative effects on tenderness of breed (Large White and Duroc), growth rate (produced by *ad libitum* and 0.8 ad *libitum* feeding) and conditioning time (1 or 10 days) were studied. Prolonging conditioning time had by far the biggest effect, increasing tenderness by 1 unit on the 1-8 scale and also increasing pork flavour intensity and overall liking (Wood et al, 1996).

Meat is increasingly being sold as processed or part-prepared rather than fresh. Marinades can be used to flavour and also tenderise the meat by penetrating the muscle structure which also increases water retention. In a recent study, Sheard et al (1998) showed that polyphosphate injection into pork increased tenderness by over 1 scale unit on the 1-8 scale, ie more than the effect of 10 vs 1 day conditioning.

### Meat quality in QA schemes

In the UK, the Meat and Livestock Commission (MLC) have published a 'Blueprint' for Quality British Pork' which describes best practices to achieve increased and less variable tenderness. Key stages in the pork chain which affect tenderness are described and control measures suggested. The Blueprint has been widely adopted in the meat industry. The relative effects of various factors on tenderness based on the MLC Blueprint and derived mostly from research at Langford are shown in Table 6. Combinations of factors often produce additive effects because the biological causes of variation are different and complementary.

**Table 6. Effects of single factors and combinations of factors on pork tenderness (griddled longissimus steaks) identified by research at Langford**

| | Units on 1-8 category scale for tenderness |
|---|---|
| Duroc effect: 0 vs 0.5 | 0.4 |
| Ad lib vs restricted feeding | 0.4 |
| Electrical stimulation (ES) vs none | 0.4 |
| Pelvic vs achilles carcass suspension | 0.4 |
| Conditioning: 4 vs 10 days | 0.4 |
| ES + 10d conditioning (vs no ES and 4d) | 0.8 |
| Pelvic suspension + ES vs rapid chilling | 1.0 |
| Low end point meat temperature after grilling (65 vs 80) | 1.0 |

From Taylor et al (1995), Wood et al (1995) and Wood et al (1996).

Control of on-farm factors might involve collaboration between feed and breeding companies. Key points in processing where tenderness can be compromised can largely be controlled by ensuring that times and temperatures are maintained within certain limits. These include lairage time, chilling time and temperature and conditioning time and temperature. These points are not strictly CCPs in that it is impossible to guarantee a reduction in toughness or reliably high tenderness resulting from remaining within the limits at each stage. A feature of much research and experience regarding tenderness is that day-to-day variation occurs and is not fully understood.

Measurement of meat quality itself, ie colour and tenderness, is required to monitor the collective effectiveness of the control points. Muscle pH is also a useful quality measure. Colour and pH can be measured on-line using automatic probes described by Kauffman et al (1993) and tenderness/toughness is assessed instrumentally or by taste panel. The industry needs reliable and simple procedures for routine testing which are not generally available at present.

As with food safety and animal welfare, the credibility of QA schemes for ensuring high meat quality depends on the standards achieved. Warkup (1993) demonstrated the benefits of following Blueprint procedures exactly compared with the normal retail product in terms of tenderness. Success will come to those groups who control their sources of variation most successfully.

## FUTURE DEVELOPMENTS

The need to improve quality through a comprehensive examination of practices at key points in the food chain is now recognised in many countries and QA schemes are developing quickly. Quality Assurance has been called the key issue of the 90s (Gready, 1997) and it is clear that there are many more developments to come. Some current issues can be summarised.

Standards of food safety, animal welfare and meat quality are not static and will change with time to reflect new market requirements and scientific evidence.

Consumer groups in the UK have recently highlighted confusion over the large number of QA schemes with their associated acronyms and uncertainty about the difference between them. Some rationalisation is required as is a clearer identification of inspection, certification and accreditation bodies, steps and procedures. In the UK it is proposed that the industry-run QA schemes such as Farm Assured British Pigs and Farm Assured British Beef and Lamb are rationalised under the umbrella of the certification body Assured British Meat. This separate organisation is seeking accreditation from the UK Accreditation Service (UKAS), a member of European Accreditation of Certification (EAC). Members of EAC apply the standards of EN 45011 which are recognised internationally.

An important aspect of EN 45011 is the requirement for impartial auditing. This is interpreted differently in various current QA schemes. Third party auditing seems the preferred approach, carried out by trained and qualified personnel. At the University of Bristol we are developing a course to train assessors of animal welfare on farms. These will not necessarily be veterinary surgeons.

The credibility of a particular scheme depends on the standards set, the stringency of inspection and auditing procedures and the actions taken over non-compliance, which might ultimately include rejection of membership. However, the primary objective is to ensure corrective action so that standards increase within the scheme.

The standards required are likely to differ between competing schemes, allowing 'differentiation' in the market place. For example one scheme may allow the use of live auction markets for marketing and another insist on deadweight marketing for welfare reasons.

The need to achieve a high level of traceability, down at least to the level of the farm, is clear. Electronic tagging is seen as a way to identify animals from the farm to the slaughter point and beyond and yet there are still important issues of reliability to be resolved before electronic identification devices are widely used (St%ork et al, 1998).

Some traditional meat products, eg Parma ham and Aberdeen Angus beef with good reputations for meat quality and controls governing production, seem ideally placed to take advantage of the new demands for quality assurance. Similarly, organic meat production schemes which already work to strict QA guidelines seem likely to benefit from the trend to tighter controls over production and processing.

## REFERENCES


Andersen, T. (1997). Quality assurance in Denmark. The Pig Journal 39, 23-28.

Anil, M.H., McKinstry, J.L. and Wotton, S.B. (1997). Electrical stunning and slaughter of pigs. Guidelines for good welfare assurance. Fleischwirtschaft International 1997, 8-13.

Barrow, P.A. and Duchet-Suchaux, M. (1997). Salmonella carriage and the carrier state. Salmonella and *Salmonellosis* Proceedings. Zoopôle, Ploufragan, France, pp. 241-249.

Blanchard, P.J., Chadwick, J.P., Warkup, C.C., Ellis, M. and Deans, G.A. 1995. The influence of rate of lean and fat tissue development on pork eating quality. Animal Science 60: 512.

Brisabois, A., Fremy, S., Moury, F., Casin, I., Breuil, J. and Collatz, E. (1997). Epidemiological survey on antibiotic susceptibility of salmonella *typhimurium* strains from bovine origin in France. Salmonella and *Salmonellosis* Proceedings. Zoopôle, Ploufragan, France, pp. 337-341.

Dahl, J. and Wingstrand, A. (1996). Salmonella reduction at the farm level. In Factors Affecting the Microbial Qualityof Meat. 1. Disease Status, Production Methods and Transportation of the Live Animal, editors M.H. Hinton and C. Rowlings, pp 9-18. University of Bristol Press, Bristol, UK.

Department of Trade and Industry. 1997. Foresight for Food and Drink-Meat. Department of Trade and Industry, London.

Emborg, H.D., Sorensen, L.C. and Bech-Nielsen, S. (1996). How the Danish Surveillance system for salmonella has influenced the microbial qualityof pig carcass meat. In Factors Affecting the Microbial Qualityof Meat. 1. Disease Status, Production Methods and Transportation of the Live Animal, editors M.H. Hinton and C. Rowlings, pp 51-56. University of Bristol Press, Bristol, UK.

Farm Animal Welfare Council. (1992). Report on the welfare of broiler chickens. FAWC, London.

Farm Animal Welfare Council. (1993). Report on priorities for animal welfare research and development. FAWC, London.

Farm Animal Welfare Council. (1994). Report on the welfare of sheep. FAWC, London.

Farm Animal Welfare Council. (1997). Report on the welfare of dairy cattle. FAWC, London.

Gee, D. (1998). Key changes in the global pork chain. Proceedings Langford Food Industry Conference. University of Bristol, Bristol, UK.

Gready, R. (1997). A whole industry approach to farm and quality assurance. The Pig Journal 39, 90-96.

Hadley, P.J., Holder, J.S. and Hinton, M.H. (1997). Effects of fleece soiling and skinning method on the microbiology of sheep carcasses. Veterinary Record 140, 570-574.

Hinton, M.H., Hudson, W.R. and Mead, G.C. (1998). The microbial quality of British beef. 1. The carcasses sampled prior to chilling. Meat Science. In Press.

Holder, J.S., Corry, J.E.L. and Hinton, M.H. (1997). Microbial status of chicken portions and portioning equipment. British Poultry Science 38, 505-511.

Hudson, W.R., Mead, G.C. and Hinton, M.H. (1996). Relevance of abattoir hygiene assessment to microbial contamination of British beef carcasses. Veterinary Record 139, 587-584.

Kauffman, R.G., Sybesma, W., Smulders, F.J.M., Eikelenboom, G., Engel, B., van Laak, R.L.J.M., Hoving-Bolink, A.H., Sterrenburg, P., Nordheim, E.V., Walstra, P. and van der Wal, P.G. 1993. The effectiveness of examining early post-mortem musculature to predict ultimate pork quality. Meat Science 34: 283-300.

Lautner, B. (1997). Quality assurance in the U.S. The Pig Journal 39, 29-36.

Lillie, A. (1997). Preventing zoonotic agents in domestic animals by proper feed hygiene. In Meat Quality and Safety as Affected by Primary Production, editors A.J. Moller, M.M. Mielche and P.A. Barton Gade, pp 195-201. European Consortium for Continuing Education in Advanced Meat Science and Technology, Utrecht, The Netherlands.

Main, D.C.J. (1997). Welfare-friendly lamb and the supermarkets. Proceedings of the Sheep Veterinary Society 21, 83-86.

Mead, G.C. (1996). Does the use of competitive exclusion and probiotics in poultry influence the microbial status of poultry carcasses? In Factors Affecting the Microbial Qualityof Meat. 1. Disease Status, Production Methods and Transportation of the Live Animal, editors M.H. Hinton and C. Rowlings, pp 33-40. University of Bristol Press, Bristol, UK.

Mead, G.C., Hudson, W.R. and Hinton, R.H. (1995). Effect of changes in processing to improve hygiene control on contamination of poultry carcasses with campylobacter. Epidemiology and Infection 115, 495-500.

Parliamentary Office of Science and Technology (1997). Safer Eating. Microbiological Food Poisoning and its Prevention. Parliamentary Office of Science and Technology, London.

Pointon, A.M. and Hamilton, D.R. (1998). Outcomes of a risk assessment of pig meat hygiene in Australia. Proceedings of International Pig Veterinary Society pp.

Royal Society for the Protection of Cruelty to Animals (1997). Welfare Standards for Pigs. RSPCA, Horsham, W. Sussex, UK.

Sensky, P.L., Parr, T., Scothern, G.P., Perry, A., Bardsley, R.G., Buttery, P.J., Wood, J.D. and Warkup, C.C. 1998. Differences in the calpain enzyme system in tough and tender samples of porcine *longissimus dorsi*. Proceedings of the British Society of Animal Science, 1998, 16.

Sheard, P.R., Nute, G.R., Richardson, R.I., Perry, A. and Taylor, A.A. 1998. Injection of water and polyphosphate into pork to improve juiciness and tenderness after cooking. Meat Science. In press.

Snijders, J.M.A. and Berends, B.R. (1996). A proposal for an alternative meat inspection system for fattening pigs. In Factors Affecting the Microbial Qualityof Meat. 1. Disease Status, Production Methods and Transportation of the Live Animal, editors M.H. Hinton and C. Rowlings, pp 141-147. University of Bristol Press, Bristol, UK.

Soul, P. (1996). The UK Hygiene Assessment System. In Factors Affecting the Microbial Quality of Meat 2. Slaughter and Dressing, editors M.H. Hinton and C. Rowlings, pp. 153-167. University of Bristol Press, Bristol, UK.

Stärk, K.D.C., Morris, R.S. and Pfeiffer, D.U. (1998). Comparison of electronic and visual identification systems in pigs. Livestock Production Science 53, 143-152.

Taylor, A.A., Perry, A.M. and Warkup, C.C. 1995. Improving pork quality by electrical stimulation or pelvic suspension of carcasses. Meat Science 39: 327-337.

Warkup, C.C. 1993. Improving meat quality: the blueprint approach. In: Safety and Quality of Food from Animals (eds. J.D. Wood and T.L.J. Lawrence). Occasional Publication No. 17 of British Society of Animal Production pp 63-67.

Warriss, P.D. (1998). Choosing appropriate space allowances for slaughter pigs transported by road: a review. Veterinary Record 142, 449-454.

Weijtens, M.J.B.M., Urlings, H.A.P., Van der Plas, J., Bijker, P.G.H., Keuzenkamp, D.A., Koster, D.S. and Van Logtestijn, J.G. (1996). Establishing a campylobacter-free pig breeding population: the top-down approach. In Factors Affecting the Microbial Qualityof Meat. 1. Disease Status, Production Methods and Transportation of the Live Animal, editors M.H. Hinton and C. Rowlings, pp 41-50. University of Bristol Press, Bristol, UK.

Wood, J.D., Brown, S.N., Nute, G.R., Whittington, F.M., Perry, A.M., Johnson, S.P. and Enser, M. 1996. Effects of breed, feed level and conditioning time on the tenderness of pork. Meat Science 44: 105-112.

Wood, J.D., Nute, G.R., Fursey, G.A.J. and Cuthbertson, A. 1995. The effect of cooking conditions on the eating quality of pork. Meat Science 40: 127-135.