

## **CONTRACT REVIEW**

### **MEAT QUALITY – HOW WELL DO WE MONITOR AND ASSURE QUALITY?**

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For the purposes of this paper I would like to define quality as 'fit for purpose' and I will, in the main, consider only table cuts of meat rather than all meat products. The arguments can however be applied across the full spectrum of products. I will not restrict myself to any particular species.

Quality, judged from the Consumers' viewpoint, is their expectation and experience. When they sit down to a meal with meat what do they expect? I believe they expect to experience the meaty aroma, perhaps tinged with those of herbs and spices and they expect to see a piece of meat that has the colour they associate with the degree of 'doneness' they have asked for or tried to produce. If they want a rare steak they do not expect it to be grey throughout, but want it showing the purplish red colour in the centre. Most do not want the meat to be oozing 'blood'. Then when they eat it they expect to experience the textural characteristics that match their expectations. If they are eating fillet they will expect a much more tender bite than they expect from rump steak. The textural characteristics include the hardness to bite and also the residue that must be swallowed. Juiciness is also expected because few like to eat something that is dry and mealy. Juiciness is not just expressed juice, but is a combination of the expressed juice and salivary stimulation. Consumers also expect to enjoy the flavour. This may be the flavour of the meat itself or the overall flavour of the meat with the spices, herbs and sauces. Some consumers may also be interested in the nutritional content of the meat and, often, whether it comes from an animal which has been given growth promotants.

How well do we monitor what the consumer experiences? If we judge quality as perceived by the customer, what is expected? I realise that there are many different types of customer but for this exercise consider the customer as the home person. What determines which piece of meat that person purchases? To some extent it will be driven by price, in part because of the notion that price reflects quality attributes. Fillet steak for example will be more expensive than crosscut blade steak and is generally regarded as having characteristics that many consumers consider as quality attributes. Fillet will be more tender, but within a cut type how do they judge quality? They judge by the source, packaging, colour, the amount of drip in the pack, the fat cover and the amount of bone. Some customers will add the information supplied into their own judgement of quality.

How well do we monitor what the customer experiences? Many of the supermarkets and retailers make their judgement of quality at the carcass stage. What do they consider as quality? In many cases they judge quality on basis of carcass weight, age of the animal from which the carcass came and the degree of fatness. Conformation might also be in their list of criteria but until recently there was no interest in any other characteristics which might provide a guide to ultimate quality.

How well do we monitor the delivery of quality to the retailer? A processor might judge quality by looking at the animal they purchase. Generally they are only concerned with conformation, weight, fatness and expected yield. Do they consider the 'quality' of the product they will produce? From a legal standpoint they will take account of the possibilities of disease, residues, presence of growth promotants and animal cleanliness.

How well do we monitor the quality perceived by the processor and how does it relate to the quality required by the consumer? The producer often considers his or her animals are the best. The criteria used to judge quality are growth rate, size, conformation, breed characteristics and perhaps temperament. How well do these characteristics indicate quality and how well do we monitor them? I believe we need to integrate the many facets of quality over all phases because the end purpose of all the production, processing and marketing, is delivery of a pleasurable eating experience to the consumer while ensuring the profitability of all necessary parts of the chain. Table 1 lists quality-related measurements that may be made and the overall purpose of those measurements.

**Table 1. Quality-related measurements of meat**

Location of measurement	Measurement	Purpose
Farm	Breed	
	Sex	
	Live weight	Predict carcass weight
	Fat cover	Predict grade
	Visual conformation	Predict yield
	Age	Grade
	Nutrition	
Processor	Carcass weight	Payment
	Yield	Payment
	Cleanliness	Penalties
	Fat thickness	Grade – payment
	Muscle colour	Market grade
	Fat colour	Market grade
	Muscle area	Market grade
	Marbling score	Market grade
	Muscle pH	Stress, colour, tenderness
	Microbiological counts	Hygiene
	Temperatures	Hygiene, process control
	Origin	Disease status, traceback
	Residue levels	Overall performance
	Cut weights	Yield
	Shear force	Tenderness
Wholesaler	Temperature	Hygiene
	Time	Inventory control
	Cut weight	Pricing
	Meat colour	Grade – some markets
	Fat colour	Grade – some markets
	Fat cover	Grade
Retailer	Weight	Pricing
	Fat cover	Yield
	Temperature	Regulations
	Microbiology	Safety
	Tenderness	
Customer	Weight	Payment
	Meat colour	Assess freshness
	Fat colour	Assess source and age
	Marbling	Fat content
Consumer	Aroma	Enjoyment
	Juiciness	
	Appearance	
	Texture	

Many measurements are made on the animal, its carcass and its products, for various purposes. Not all of these contribute to quality assurance but this does not mean they are unimportant. For example, measurements made as a basis for payment to producers may have nothing to do with ultimate product quality, but are vitally important economically. What do we measure along the complete production and marketing chain and how well do the measurements assist in the assurance of quality to the end user?

## WHICH MEASUREMENTS ARE IMPORTANT FOR ASSURANCE OF QUALITY IN THE CONSUMERS' EYES?

Measurements that assure food safety are critically important. However the question of which measurements assure the other quality attributes is more difficult to answer. Can a consumer obtain a 'high quality' steak if many of the measurements are not taken? The answer is probably yes, but not on a reliable assured basis. To assure the quality means that this must be delivered practically 100% of the time and not have a mere 50% chance of success. To assure quality it becomes important to minimize variability arising from any unmeasured or unmonitored factors.

By controlling processing it is possible to get the large proportion of product to meet a defined tenderness standard, but there will be the 15 to 20% that is still too tough. This has been achieved with New Zealand lamb processed according to the accelerated conditioning and aging (AC&A) specifications. However, even 15 to 20% unaccounted for variability will not assure quality. It is therefore imperative to take a Hazard Analysis Critical Control Point (HACCP) approach to tenderness. This approach becomes the Palatability Analysis Critical Control Point (PACCP) approach, conceived in the USA and recently discussed by Webster (1997). In taking this approach it makes sense to step through the process of raising an animal and taking that animal through the full processing and marketing sequence to the ultimate consumer. Where are the control points and are they critical to the delivery of product?

## ANIMAL CHARACTERISTICS

All of the major animal characteristics (Table 1) are considered by some to influence 'ultimate quality'. Some of the characteristics have been used to restrict the type of animal that can be used to supply certain markets. For example, in the UK, Marks & Spencer sell beef only from Angus and some Angus crossbreeds but not from the continental European breeds. There has been a continuing argument that Brahman animals are tougher than Bos taurus animals (Wheeler *et al.* 1990).

I do not believe that the animal conformation has any bearing on quality at the consumer end point, although it could be argued that the shape of a cut is influenced by the conformation of the animal. This would certainly be the case for the loin where a poor conformation can lead to a thin and narrow loin muscle, which is not what the customer expects of a top quality steak. What about fatness, live weight or carcass weight? Carcass weight is an important attribute as far as payment is concerned. It is a factor that can be measured early and provides a base from which to compare animals free from the complication of variable gut fill, common in cattle. I do not consider these are critical points in the assurance of end point quality especially if one considers lean grass-fed beef. However there are those who would argue that grass-fed beef and quality meat are oxymorons. They argue that it is impossible to have quality beef unless it has been grain fed! I do not accept that argument. In fact, there is plenty of anecdotal evidence of high praise being given to properly handled grass-fed beef.

Animal age has an effect on texture and tenderness and the effect is not uniform across all muscles. If one is concerned only with the loin it might be possible to ignore animal age, but if other hind and fore quarter cuts are of importance then age is important (Harris and Shorthose 1988). It is interesting that tenderness determined by shear force measurements may not totally reflect the age effects that are detected by a sensory panel (Wenham *et al.* 1973). The difference due to age is a result of connective tissue changes that occur as the animal matures. It is important to recognise that the connective tissue changes are correlated with physiological age, not necessarily chronological age. Mere acknowledgement of years since birth may not be much value in assuring quality. There also appear to be some subtle effects that may be age related or may be a reflection of environmental effects that have been confounded with animal age. There is anecdotal information that beef animals of the same age can be very different in tenderness if one group has overwintered whilst the other was killed before winter. Similar examples can be found for lambs that are born late in the season and are killed at ages similar to the normal throughput. They are likely to be tougher than expected.

As researchers get closer to understanding mechanisms of quality development, it is likely that there will be probes that can detect different characteristics which determine the end quality potential. It is important not to consider tenderness as the only quality parameter, but rather consider all of the quality characteristics. Tenderness is undoubtedly a major factor but as prices increase all attributes will need to be right to get the customers cash and then continue to get the repeat purchases.

There can be considerable between animal variability and, if we are to assure quality such variability should be minimized. It may be that tight specifications are required on animal categories that can meet specific end

product characteristics. I would like to think that it should be possible to tailor processing to account for raw material variability. If process A is appropriate to convert a young, well-grown animal into product of premium class, it may or may not be the process suitable to convert older well grown animals to the same quality product. These might require process B. We do not have the information that allows this form or level of selective processing to take place. Early identification of animal characteristics is essential to selectively process the carcasses. There is no measurement that will currently allow this and we do not know how much difference we can accommodate through selective processing.

## **PROCESSING**

What about the processor, do they measure the appropriate things and even if they do, do they control the process according to the requirements? Processors measure and/or record a lot of data from a wide range of variables. This is done to control processes, to determine what payments are required, to comply with regulations and sometimes to assure quality. Which of their measures are important and necessary to assure quality?

The processes that affect the product must be monitored. These start with the stress on animals imposed by handling. Then there is the time/temperature history of the product and its effect on microbial growth. It must ensure no toughening but the achievement of optimum tenderness and colour. Grading may provide some quality information but probably not to the degree that some processors and producers accept. Grade as normally judged, at least in the New Zealand context, is based on weight, fatness and to a small degree on conformation. For markets such as Japan there are also fat and meat colour scores and a marbling score. How do these affect quality? For the Japanese buyer, but not necessarily the end consumer, the fat and lean colour at time of grading is important but these change during storage, and therefore the colour at time of sale can be quite different (Powell 1997). The higher priced Japanese meat is certainly well marbled; in fact one wonders if it is meaty fat or fatty meat. However to the average New Zealander and Australian consumer the appearance of a heavily marbled steak is not synonymous with quality. If you placed a series of steaks on display ranging from no marbling through to heavily marbled, the average New Zealander and Australian would choose to purchase a steak close to the non-marbled end of the scale. However, if commenting on the juiciness of cooked steaks the same consumers are likely to favour some marbling. In assuring quality it is important to be sure what level of quality is being assured. There is no reason why there should not be different levels that are assured.

If the animal has arrived at the processing plant, what factors that affect quality can be controlled? These are especially important to monitor and control. Control may be in form of exclusion from a category, or a direction to use a modified process. The ultimate pH of meat has a pronounced effect on its keeping quality, colour, tenderness and waterholding capacity, and it is one measure that is often used to exclude product. In the Meat Standards Australia (formerly EQS) programme (Webster 1997), beef is expected to be within the pH 5.3 to pH 5.7 range. To qualify for the New Zealand Qmark, beef must have an ultimate pH less than 5.8 (Fraser 1997). Meat with ultimate pH above 6.0 is often excluded from the vacuum packed chilled meat trade.

Although a producer and processor may take all possible care with their animal handling, they may still have some carcasses exhibiting elevated ultimate pH levels. Nothing can be done about this once the animal has been slaughtered. There is a need for a method to measure the animal condition prior to slaughter and predict the ultimate pH. If an animal were identified as likely to give a high ultimate pH, it could be diverted to be re-fed and rested, and processed on a later day.

The stunning system used may exert an influence on the subsequent performance of the processing operations. In the New Zealand context, where electrical stunning of sheep and cattle is common and where there may be other applications of electricity during processing it is important that the full use be known and factored into tailoring the electrical stimulation of the carcass process for the individual animal. Captive bolt stunning systems may have a much lesser influence on the ultimate quality but this has been poorly researched. It is important that the performance of the stunning operation be monitored for humane reasons if nothing else.

Electrical stimulation of carcasses is widely used, but how many operators really know what they are doing or whether they are 'using a sledgehammer to crack the walnut'? Electrical stimulation is one of a series of tools that can be used in the quest for a better quality product. It is not, *per se*, 'the answer to the maiden's prayer' (Law 1972). How many processors monitor their electrical stimulation and know the current levels, the variability of response and the variability in end product? I suspect very few!

There is a number of characteristics of electrical stimulation that should be measured. The importance of the measurements increases as the voltage used decreases. The characteristics that I consider important are: time and muscle temperature at time of application, current level, pulse characteristics and frequency, and duration of stimulation. At low voltages, the current levels are extremely dependent on the contact resistance. A recent paper by Sparrey and Wotton (1997) stresses the importance of contact resistance and impedance of electrical stunning tongs. The same is equally, if not more true for stimulation systems. Many plants I have seen claim to be using electrical stimulation, yet have no idea of the current levels through the carcass or the effects they are expecting or are achieving. Effective stimulation is a valuable processing aid ensuring an increased uniformity of pH fall and a more uniform commencement of aging. However unless the stimulation is controlled it can increase variability because it fails to accommodate differences in electrical resistance and difference in animal response.

Throughout the dressing process the focus should be on measures that are used to control the hygiene of the operation. The cleanliness of the product, affected by both visual soiling and unseen microbiological contaminants, has a major affect on quality. It is of little value trying to control a process with assessments for which the answers are not available until several days later. There is need for immediacy if change is to be made on the basis of a measurement. For microbiological hazards it is more likely that monitoring the process control will have more affected than will end-product monitoring. This means that attention should be directed to ensuring that workers know why their operations must be carefully conducted, and that they use good hygienic operations for themselves and their implements. Mechanisation should allow more complete cleaning and sterilization of tools between operations. It is easier to wash and use high-pressure steam to sterilize a machine than it is to achieve the same level of hygiene with a manual worker. The New Zealand MAF have the philosophy that product should be kept clean by avoiding contamination, rather than allowing contamination but expecting removal of it before sale. This has benefited the New Zealand industry. However in trying to get to an even cleaner situation the use of a pasteurizing or sterilizing treatment might be required, even though some (Jay 1996) would argue that product can be too clean and provide no competition for some of the unusual 'nasties'. A quality product demands safety to be assured. To achieve this it is therefore important to use the appropriate methods to ensure production of a hygienic product, rather than control the subsequent processes to maintain that assurance.

Temperature, time, environment and available nutrients all influence microbiological growth rates. It is these factors that can be controlled for 'safety' of product, and product safety must be assured right up to the time of consumption. The extent to which a processor must go to ensure safety is a matter of debate, and even legal argument. At present it appears that the processor is liable should one of their products cause a problem. Food products are perishable and changes will occur from time of sale until time of consumption. Consider this scenario: I buy some minced beef from the local supermarket at 9am, I leave it on the back seat of my car for the day before taking it home. I season the meat and form it into a patty and grill it until it looks slightly brown in the centre. Who is responsible if I get food poisoning? Is it the supermarket? Is it the processor or am I responsible? I must admit I am inclined to absolve the supermarket and the processor from all responsibility *provided* they are able to assure me that the product their product at point of sale is assured safe until its used by date under reasonable handling practices.

Traceback of product is becoming important as a means of assuring customers that producers, processors and supermarkets know what they are processing and selling and can, in case of a problem, know where it originated. I am not convinced that it should be necessary to be able to trace every steak back to its animal of origin and thus back to its source, but there is definitely a push towards that position. The situation becomes more difficult if you expect the same for smaller animals. Perhaps the argument is that the larger animals are more likely to be traded more than once during their lifetime and be subjected to a range of operators, whereas chickens and pigs are likely to be handled as a group. Traceback is one factor that should have a role in assuring quality since it will allow identification of any producer not adhering to rules on handling of chemicals and animal remedies. The fact that they can be identified will encourage more producers to conform to the rules. There will be the few who, no matter what the rules and checks, will try to cheat the system. Traceback has some positive aspects in that it can be arranged so that the processor can track their product and have more information available to assist management of their operation.

The New Zealand QMark and the AC&A control procedures have set a tenderness standard that requires tenderness testing (using the NZ Tenderometer) of product where the process deviates from the defined procedures. This provides a measure of how well the processes are operating and a means for the regulators,

in this case the New Zealand Meat Producers Board, to approve different processes. The important end result is the target quality rather than the means of getting that quality. However, tenderometer testing is a slow and destructive process that cannot be applied to all product. It is not as costly as sensory testing but, within a given class of stock, is an effective check of performance. There is an increasing range of technologies allowing measurements on samples from the carcass to predict tenderness. Most of these have not been found to account for enough of the variability to make them very useful, but if they are being used to segregate carcasses into different classes they may be more valuable. Most have focussed on tenderness: NIR (Byrne *et al.* 1997), conductivity and impedance (Byrne *et al.* 1997), ultrasonics (Karam *et al.* 1997) but there is also a move to assess flavour, marbling and potential colour. More work is required before any of these are of value as on-line product monitoring devices, no matter where in the process they are used.

## **WHOLESALEERS**

The wholesaler must continue to be vigilant with respect to the time/temperature history of the product and to general hygiene to preserve safety. Time and temperature will also be important for the full development of tenderness and perhaps, at the extreme, the deterioration of flavour. In general terms the wholesaler is often not in a position to affect quality, though may do so if also cutting and repackaging the product.

## **RETAILERS**

Similarly the retailers must protect the safety of product. However they have a critical role in presenting the product in a way that appeals to the potential customer. Unless the product appears to have quality it will not be sold, and all the good work up to that point is wasted. The packaging, merchandising and pricing of the product will all affect the perceived quality. Do we really know what the customer expects and for what they are willing to pay? What does the retailer measure to know what they sell, or do they depend of the supplier? Tenderness measurement (eg by Tenderometer) and other quality assessments can be used to audit quality performance but are not control measures.

## **CUSTOMERS**

Customers purchase the product but do we know what they think of their purchase? Do we actually know the quality of the product they buy? Do we do anything to determine how satisfied they are with the meat they buy, or how the ultimate consumers reacted on being served the product? None of us would expect the same reaction from a customer served mince as one served up a fillet steak at a romantic dinner, but there are standards of quality that are expected in each case and the question must be: how well did we meet (meat) those expectations? The preparation of the product for consumption plays a part in the 'quality at consumption'.

I believe that we do not do a very good job of assuring quality through to the final customer, the consumer. We still need to take a more integrative approach and know exactly what drives variability in ultimate product characteristics. If we more fully understand what contributes to the variability we may then be in a position to tailor selection and processing to deliver a predictable product.

The initiatives to deliver quality to the consumer, eg The Australian MSA, the New Zealand Qmark, the UK Blueprints (Warkup 1997) and the USA initiatives for pork and beef (Miller 1997) are moving us forward but there still too much variability? Someone buying a packet of breakfast cereal expects and gets something that is the same as they purchased last month and will be the same when they repurchase next month. Can we say the same for meat or do we get something that does not even come close? I believe we still have a long way to go in the quest for guaranteed quality, but we are getting closer.

## MONITORING AND ASSURING QUALITY OF AUSTRALIAN PORK

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As a consequence of consumer demand for lean, tender and juicy pork products with acceptable flavour, the Australian pig industry is continuing to strive towards producing pork which meets these requirements. This paper will discuss quality problems facing the Australian pork industry and provide details of current industry initiatives focussed on improving eating quality by reducing the incidence of pale soft and exudative pork (PSE).

### PALE, SOFT AND EXUDATIVE PORK

Problems associated with inconsistent meat quality, particularly pale soft and exudative pork (PSE), have been shown to cost the Australian pig industry up to \$20 million per year (Whan 1993). Recent studies have identified that the incidence of soft, exudative pork in Australia was between 41 and 64%, with an average of 51% (Eldridge *et al.* 1995; King 1996). The pork quality defects of PSE and dark, firm and dry meat (DFD) can be determined on the carcass using objective measurements of muscle pH and colour.

The development of PSE meat results from a rapid pH decline post-slaughter while the muscle temperature is high ( $> 38^{\circ}\text{C}$ ). It is associated with a deterioration in the appearance of fresh pork due to higher drip loss, softer texture and paler colour than normal meat. Processing losses are also experienced when cooked, cured hams and bacon are manufactured from PSE rather than normal meat.

The recognition of the importance of the high incidence of PSE in the Australian industry led to the National Pork Quality Improvement Program. The aim of this initiative was to develop, refine, validate and implement standards of management of pigs and their carcasses to achieve a 50% reduction in the incidence and commercial impact of pale, soft, exudative meat in abattoirs that implemented and maintained these standards. Over a period of sixteen months, this program achieved an overall reduction of 38% in the incidence of soft, exudative pork in four participating abattoirs (Eldridge *et al.* 1995). Similar results were achieved in the State-wide programs which were run concurrently (Hofmeyr 1996). It was demonstrated in this Program that a reduction in the incidence of PSE could result from low-cost changes to pre-slaughter management of pigs and post-slaughter chiller management.

As the rapid rate of pH decline at a high muscle temperature is largely responsible for the production of PSE pork, several rapid chilling systems have been installed as a method of reducing its incidence. Warner (1997) presented results under Australian conditions and discussed the problem of rapid chilling to reduce PSE and improve colour resulting in unacceptably tough pork. Unfortunately, the impact of post-slaughter management strategies used to reduce PSE incidence have not been widely documented in terms of potential effects on tenderness of fresh pork. This issue is of particular importance as the industry continues its move towards producing leaner pigs to satisfy changing consumer requirements for lean pork products. Dikeman (1996) stated that reducing fat depth at the P2 site to less than 14 mm may result in cold-shortening, particularly when rapid chilling systems are used.

### TENDERNESS

The pork quality characteristics of tenderness, juiciness and flavour are used to describe the eating quality of fresh pork. Although many studies have documented the effects of PSE/DFD in terms of reduced acceptability, paler colour and increased drip loss, less attention has been concentrated on determining both the potential impact of these pork quality defects on eating quality and the variability in eating quality of fresh pork. A survey of tenderness of pork loins purchased from retail outlets in Melbourne from December 1996 to June 1997 found that 31% of all pork loins purchased would have been considered tough by consumers (Hofmeyr 1998). Furthermore, it was found that 65% and 58% of pork loins purchased in December 1996 and January 1997, respectively, recorded Warner-Bratzler values greater than 6 kg. Possible reasons for the high levels of tough pork found in this study are not clear. The incidence of PSE did not markedly differ between pork loins purchased over the seven month period. This is in contrast to Warner (1994) who indicated that PSE pork may be tougher and drier compared with normal pork. As stated by Hofmeyr (1998),

the high incidence of tough pork identified in the survey should be of considerable concern to the Australian pork industry, particularly with the introduction of the Australian Pork Industry Quality Program. As sensory evaluations were not conducted as part of this study, it is not known whether this product was acceptable in terms of juiciness and flavour.

## **JUICINESS**

Dikeman (1996) stated that selection and production of pigs with reduced levels of subcutaneous fat is likely to have negative effects on pork eating quality due to a reduction in intramuscular fat content. Bennett (1997) considered that eating quality problems with Australian pork are related to insufficient intramuscular fat. Strategies that include castrate production and the introduction of the Duroc breed into pig herds, to increase the intramuscular fat content of pigs without influencing subcutaneous fat levels or feed conversion efficiencies, are currently under investigation.

## **PORK FLAVOUR**

Flavour of pork, particularly from entire male pigs finished to heavy slaughter weights, is of major concern to the Australian pork industry due to boar taint. The term 'boar taint' refers to the undesirable, often intense, faecal, urine-like odour and/or flavour. Skatole and androstenone, the two causative compounds implicated in boar taint, appear to be synergistic in their contributions. Hennessy *et al.* (1997) found that the percentage of pigs with levels above the international thresholds of 1.0 mmg/g for androstenone and 0.2 mmg/g for skatole ranged from 6 to 18% in four piggeries in Australia and New Zealand. Due to their lipophilic nature, these metabolites accumulate in body fat, particularly of mature boars. Hennessy *et al.* (1997) stated that if the Australian pig industry wants to increase domestic consumption of pigmeat whilst simultaneously increasing pork exports, particularly to Asian countries, this issue of boar taint must be addressed. To this end, interest in the production of castrate males to overcome problems associated with boar taint is increasing. Additionally, although a vaccine for boar taint has been developed in Australia, commercialisation of the product is now necessary prior to its use in the Australian pig industry. This vaccine will chemically castrate entire male pigs when administered four weeks prior to slaughter, without adversely affecting growth.

## **PIG INDUSTRY QUALITY ASSURANCE**

The implementation of quality assurance systems into the Australian pig industry is a new initiative of the Pork Council of Australia, the Pig Research and Development Corporation and the Australian Pork Corporation. The Australian Pork Industry Quality Program (APIQP) is a three stage program involving the implementation and certification of a Hazard Analysis Critical Component Points (HACCP) system with the overall aim of assisting businesses involved in pork production to produce pork of the highest quality (Tidswell 1997). The three stages of this Program are: 1. To adopt the Pork Industry Quality Standards; 2. To implement and certify a HACCP plan; and 3. To upgrade to quality assurance. The implementation of a HACCP based system enables full documentation of all procedures and practices used by producers and transport operators. A total of 90 producers, to December 1997, have committed their businesses to APIQP and signed for Stage One of the Program, with one producer already at Stage Three level. This third stage of the Program requires an upgrade of the HACCP plan to a quality assurance system and it is recommended that producers and transport operators use the Safe Quality Food 2000 as a minimum standard, whilst ISO accreditation is also acceptable. One of the four standards in the APIQP relates to meat quality with the overall objective being 'To maximise pork meat quality by reducing the incidence of PSE/DFD'. This is primarily directed to improving pre-slaughter handling. It is noteworthy that whilst the introduction of such quality systems enable producers and transport operators to manage hazards and provide documentation demonstrating that procedures are in place to assure consistency of product, there are no mechanisms within this program for monitoring of eating quality. Therefore, this Program cannot guarantee that meat of a consistently high quality will be marketed as procedures used for slaughtering pigs and post-slaughter carcass management practices may differ between processors, wholesalers and retailers of pork. Current research in the PRDC Eating Quality Assurance Program will be focussed on determining suitable pathways, across the entire pork marketing chain, for the production of consistently high quality, tender pork using a 'Palatability Analysis of Critical Control Points' approach.

Monitoring of eating quality must occur as part of this quality framework. The four key factors identified in this paper to influence pork eating quality are PSE, tenderness, marbling and off-flavours due to boar taint.



Responsibility for these four factors must be carried by all sectors of the pork marketing chain to ensure consistently high meat quality. Monitoring of these factors is at present difficult; a method to measure taints is currently being developed, and a system for measuring marbling may also be possible in the future. Currently, muscle pH and colour are used to classify carcasses as PSE, normal or DFD but this is not conducted on-line at the abattoir as, ideally, it should be done at least 6 to 8 hours post-slaughter.

It is clear that further research is needed to determine whether this variability in tenderness of pork is impacting upon repeat purchases. Additionally, key factors influencing pork tenderness need to be determined, and research conducted, to ensure that strategies implemented to ensure high eating quality of pork do not adversely affect product safety or increase the incidence of PSE pork. Because the economic implications of consumer dissatisfaction with the eating quality of pork have not been determined in Australia, it is not known how inconsistent eating quality of pork influences consumer demand. Additionally, potential effects on eating quality associated with the increase in the average slaughter weight of pigs in Australia, being driven by production and processing efficiencies associated with heavier pigs, will also need to be ascertained.

In summary, an integrated approach across all sectors of the Australian pork industry focussing on quality rather than quantity of production is necessary in order to provide product suitable for both our domestic and export markets. The implementation of quality systems by producers and transport operators involved in the Australian Pork Industry Quality Program will assist in facilitating the industry drive toward improved eating quality of pork through a reduction in the incidence of PSE. Furthermore, the definition of critical control points which influence pork quality across the entire pork marketing chain will also assist in minimising variability in eating quality of pork.

## **BEEF QUALITY - AUSTRALIA 1998**

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The last few years have been a period of rapid change for the Australian beef industry. There have been demands for increased safety and improved quality from consumers and customers, and these are continuing. The Industry has responded through the introduction of quality assurance (QA) programs that are intended to meet these customer requirements and this process, the drive for quality to meet market requirements, is continuing.

The need to integrate QA procedures across all sectors of the Industry, from the farm to the consumer's plate is widely recognised. The catchcry is 'Quality from paddock to plate'. This paper provides a brief overview of systems being used to improve the safety and eating quality of beef.

## **BEEF SAFETY**

There are two aspects to the safety of meats that are of ongoing concern to consumers: contamination with chemical residues and with pathogenic microorganisms. Contamination of foods with chemical residues occurs largely, but not entirely 'on farm'. The cattle industry has addressed this issue by the introduction of 'Cattlecare'.

## **RESIDUES - CATTLECARE**

Cattlecare is an 'on farm' Quality Assurance 'Code of Practice' program for beef producers. Its introduction resulted from trade problems with residues. Thus it was developed in response to market requirements. It followed a chemical residue problem in a feedlot in 1993, which led to Cattle Council forming a Residue Management Group in 1994. Cattlecare is intended to be part of a paddock-to-plate approach to solving ongoing problems affecting beef production and marketing, and was set up to deal with problems at the source (Anon. 1996).

The purpose of the Cattlecare Code of Practice is to provide an industry specific standard to which cattle producers can produce beef. It is based on ISI 9002 and the Hazard Analysis Critical Control Point (HACCP) system. It represents the minimum industry standard for quality with respect to chemical residues, bruising and hide damage. It has the following elements or objectives:

- Damage to meat and hides minimised
- Branding and injections done with due care
- No metal shot used in mustering
- Cattle dehorned to prevent bruising and injury
- All animals to have clear property identification
- Persistent chemicals in soils strictly monitored
- Farm and ag-vet chemical dose rates and withholding periods strictly observed
- Cattle for sale shall not carry unacceptable residue levels.

Producers are accredited once they have achieved the required standard and adherence to the Code of Practice is audited by qualified external auditors. The outcomes and benefits of Cattlecare, and the rewards to the producer from it, are:

- Reduction of residue risk and hence protection of markets
- International recognition by customers
- Catalyst for new marketing opportunities such as product differentiation and branded product.
- Improved efficiency and professionalism
- Preferred supplier status

Cattlecare provides a framework for expansion of QA into other on farm areas including optimising meat quality and minimising the contamination of cattle with pathogenic microorganisms that originate on farm. These include the enteric bacterial pathogens such as *Salmonella* and *Escherichia coli*.

### **PATHOGENIC MICROORGANISMS**

Over recent years there has been an increased incidence of food-borne illness in many developed countries. To some extent this has resulted from improved epidemiology and more stringent reporting requirements. However new bacterial pathogens have emerged and the incidences of well-known problem organisms, such as *Salmonella*, have increased on some foods. Consumers are now more aware of potential health problems from pathogenic organisms in foods and are demanding improvements in food safety.

Most isolates of *E.coli* are non-pathogenic. This organism has been traditionally regarded as an indicator of faecal contamination and hence of the possible presence of enteric pathogens such as *Salmonella*. In recent years new pathogenic strains of *E.coli* have been identified and some of these may cause disease that can result in death.. Of particular concern are the enterohaemorrhagic (EHEC) strains such as *E.coli* 0157.H7, which was first identified in the USA in 1982. This organism is invasive and able to move from the intestine into the circulatory system where it can lyse red blood cells. This can result in kidney problems and renal failure, particularly in children, and death can result. Two particular outbreaks of food-borne illness resulting from EHEC strains of *E.coli* have had major impacts on public opinion and caused changes to hygiene operations in the food industries. In the USA in 1993, the 'Jack in the Box' outbreak, that was caused by under-cooked hamburgers contaminated with *E.coli* 0157 H7, resulted in some 70 people being affected and the deaths of three children. This led to significant changes to industry operational procedures in the USA. In Australia, there was an outbreak in Adelaide, caused by a related strain, that was traced to contaminated mettwurst. One young child died and others suffered renal damage requiring dialysis.

In response to consumer pressure, the US authorities introduced new, more stringent hygiene requirements in meat production. These were incorporated in the so-called 'Mega Regs' (Pierson 1997). The draft versions of these new rules posed major problems for industry implementation. For example, one proposed requirement was that, in abattoir operations, the surface temperature of the carcass or meat must fall

continuously to 4.4°F and never rise. Potential problems for the Australian meat processing industry included the need for altered chilling practices with more rapid rates of temperature fall. It was feared that these could result in an increase of boning problems caused by hard fat and of toughness problems resulting from cold shortening. However in the 'Final Rule' that was introduced in 1997, the draft rules were replaced by requirements for plants to determine and report the microbiological status of their product.

The Mega Reg shifts the emphasis from traditional meat inspection QC procedures to a QA system based on more relevant scientific data, and utilising HACCP principles. A major theme is the progressive development of a cohesive Paddock-to-Plate meat safety strategy addressing factors across all sectors of the industry. For all meat processing plants supplying the US market, Meat Safety Quality Assurance containing the following elements must be implemented:

- An HACCP-based QA program
- Standard Operating Procedures for Sanitation (SSOPs)
- Microbiological testing for generic *E.coli*
- Testing for *Salmonella*

In terms of the microbiological quality of the product, performance criteria, based on microbiological baseline surveys done in both the USA and Australia, are used to benchmark individual plants. All Australian export abattoirs are now testing for *E.coli* and *Salmonella* and the implication is that there should be continuous improvement, ie the standard will tighten over time. Carcass decontamination procedures are permitted but emphasis is in the prevention of contamination.

In Australia, the industry supplying the domestic market must now must comply with the new Australian Standard set by the Agricultural and Resource Ministers Council of Australia and New Zealand (ARMCANZ). Plants must now have in place QA systems based on HACCP with verification of microbiological quality of the end product. This Standard covers meat safety in abattoirs, boning rooms, secondary processing (smallgoods) plants, wholesaling operations and meat transportation. The introduction of HACCP into the smallgoods industry has recently been described (Kennedy 1998). A National Food Hygiene Standard is now being developed by the Australia New Zealand Food Authority to cover the remainder of the meat chain, namely retailers, catering establishments of all types, and all retail outlets. It is intended that this will complete the 'chain of protection' from the abattoir through to the consumer. For the cattle producer and the feedlot the following are, or will eventually be, required:

- Husbandry practices to achieve clean stock relatively free of faeces, ingesta and other dirt on the hide
- Minimal contamination by pathogens of animals on farm

For the cattle producer, transport operator and abattoir the following will be required:

- Post farmgate practices that minimise stress in order to limit cross infection and the opportunity for growth of pathogens in the intestine.

It is in the area of initial contamination where considerable research may still be required. What are the sources of these pathogens? What is their ecology on-farm and in the varied environments in which cattle are produced in Australia? Are they endemic in the herd or do they come into the herd from other animals or birds?

## EATING QUALITY

Eating quality requirements vary with the consumer and the market. The Australian beef industry exports to many countries and must meet a wide range of quality requirements determined by those markets. There are two stages in the process that leads to satisfied customers and repeat purchases of beef. Both of these involve the assessment of quality attributes by the customer. Those of importance to Australian consumers are shown in Figure 1.

There have been a number of studies to determine how current product meets the requirements of Australian consumers. Most quality attributes are being met. For example, there are minimal complaints with respect to lean meat colour and fat colour. Overwhelmingly Australian consumers are looking for two things,

<i>At purchase</i>	Amount of fat	<i>At eating</i>	Tenderness
	Distribution of fat		Flavour
	Fat colour		Juiciness
	Lean Meat colour		Cooking aroma
Portion size is also important but is not a quality factor			

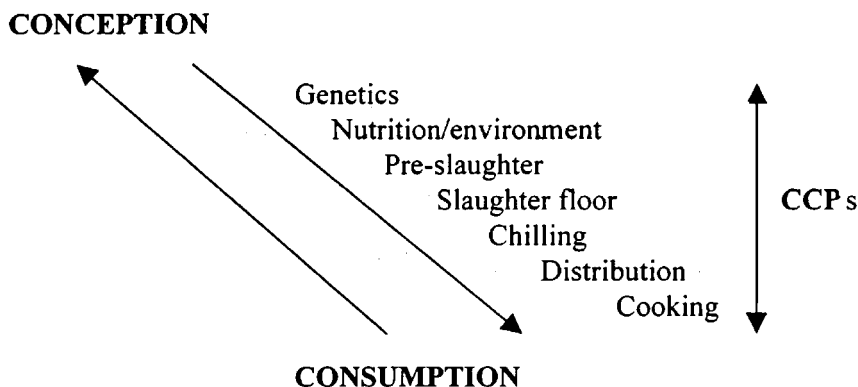
**Figure 1. Attributes of beef quality**

the desired amount and distribution of fat, and a product that is consistently tender. Consumers understand the differences in tenderness of various cuts, but for any one cut they have an expectation of its eating quality, particularly its tenderness. Currently that expectation is not being met consistently enough.

Several studies have shown that consumers purchasing steaks for home consumption are seeking the minimum amount of fat. There should be almost no visible marbling fat and selvage fat should be trimmed to no more than about 3 mm (Hearnshaw and Shorthose 1992). Interestingly, recent studies have indicated that marbled steaks (score 2 to 3) provided cooked in a restaurant environment have a high acceptability. In other words, if the consumers are not aware of presence of the marbling fat, the eating quality of marbled steaks is rated as high.

The expected eating quality is directly related to the liking of the appearance of a steak. Unfortunately there is little relationship between the appearance of raw beef and its eating quality, and this poses a challenge for the industry. Currently, meat is described in Australia using the AUS-MEAT system. This describes some live animal traits, and the characteristics of the carcass and meat from the animal. It enables the processing industry to sort carcasses and meat in terms of the requirements of a wide range of markets. AUS-MEAT is not a grading scheme as such. It does not sort product into quality ranges or grades, and in this way Australia differs from some other major beef producing countries which have grading schemes based on quality and yield. Of particular note in this regard are the USA and Japan. The American grading scheme appears to produce a more consistently tender product than is available in Australia, but still has a failure rate claimed by US scientists to be at least 15%. In addition, the much more diverse nature of the production system in Australia means that the US grading scheme would have a much lower success rate here.

In response to falling demand for beef and customer complaints, the Australian industry has moved to introduce a grading scheme to improve the consistency of eating quality. A scheme is currently being trialed in Brisbane. It is being driven by an industry organisation, Meat Standards Australia (MSA), with funds from the industry through the Meat Research Corporation.



**Figure 2. Elements of a pathway for achieving consistent eating quality**

## **MSA GRADING SCHEME**

The grading scheme being tested is based on the concept that achieving consistent eating quality requires a 'pathway approach'. A pathway encompass industry operations from 'conception to consumption' or from 'paddock to plate'. Not all operations are critically important. There needs to particular attention to certain critical control points (CCPs). These can occur at any stage of a pathway. The key stages that form a pathway and their relationship are shown in Figure 2.

The introductory specifications, 'Consistent Eating Quality of Beef - Introductory Specification for Consumer Satisfaction Released', for the grading scheme trial were announced in February 1997 and these claimed to specify the safe minimum requirements for three eating quality groups for beef on the domestic market. It is not possible to detail those specifications in this paper, or to record the history of the trial that is currently underway, but a number of points can be made.

Australian meat scientists are generally supportive of the MSA approach and of the need for a pathway based system. Australian meat scientists have long pointed to the improvements in tenderness that can be made by optimising the in-works processing technology to the cattle and the post farmgate environment. MSA has put considerable effort into this area. For example, pathways that include tenderstretching ( pelvic hanging of the carcass) have been tested with considerable success and are now approved for use in certain works. Similarly there is general agreement that the generation of the grades should be based on consumer evaluation of eating quality, ie palatability. MSA is currently engaged in massive consumer evaluation of beef produced using a variety of commercial pathways. This also has scientific support because it is adding a new dimension to consumer studies. Researchers do not have access to the resources to undertake extensive consumer experimentation of this type.

Although the number of retail outlets selling graded beef is limited at present, the product appears to a success with consumers, and premiums are being paid for '3 Star Beef' over ungraded beef on sale in the same outlet, and for 4 Star over 3 Star.

The CRC is evaluating the carcasses and meat quality of some 8,000 cattle over a period of six years. Meat quality attributes are being measured objectively using laboratory procedures. The CRC is supporting MSA with scientific backup, and is providing meat samples from about 1,000 of its cattle for evaluation by MSA consumer panels. This will produce a valuable correlation between the objective measurements of tenderness, eg peak force, and the evaluation of beef by Australian consumers of the late 1990s.

## **SUMMARY**

There is overall agreement in the three papers that the meat industries are making concerted efforts to improve product quality, and to meet the expectations of consumers and the requirements of markets. The various sectors of industry are now more united in this drive for quality and there is more integration of effort than ever before. To a significant extent these efforts are being driven by regulatory requirements, sometimes imposed by overseas customer countries. However there is agreement that industry generally is more prepared than ever to take control of its own destiny and that many persons involved in industry are, or want to be, increasingly proud of their products.

The presented papers say little about branded product. Fresh meat is still largely sold and generally regarded as a generic commodity. In the case of beef in Australia, when lack consistency of tenderness is no longer a problem, we are likely to see increased diversity in the market, with grass fed and grain fed segments, and with branded product increasingly available.

Quality can only be assured to the consumer if we can control the raw material (the animal) and control the processes used to convert the raw material into the ultimate product. There is still a long way to go before meat quality can be as predictable as that of a bowl of cereal. Do we want to get to that level or would it be too boring?

New systems approaches, such as critical control point based QA systems, will only lead to continuing improvements provided there is commitment from the personnel involved. To maintain this will require trading systems that are responsive and that reward effort.

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