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THE MEAT WE EAT: NOTIONS OF QUALITY FOR TODAY AND TOMORROW

DAVID LISTER
Division of Animal Sciences and Health
CAB INTERNATIONAL
Wallingford, Oxon OX10 8DE, UK

SYNOPSIS

Perceptions of meat quality are changing dramatically. Though they may be capricious, new considerations are not simply those which allow us to enjoy the meat eating habit but could determine whether some people will continue to eat meat at all. Though this is unlikely to be of catastrophic consequence for the meat industry worldwide, elements of these will need to be incorporated into our thinking about the quality of meat in its widest sense if it is to continue to be enjoyed and to contribute to the improved nutrition of the world's peoples.

WHY EAT MEAT?

Though early man probably used meat as a supplement to a vegetarian diet, the ancient Greeks and Romans saw meat as an important component (Waterlow, 1989). And healthy their diet must have been if it allowed them to achieve as much as they did in the 30–35 years of life expectancy. That they should have died so young was more likely to have been through war and infectious diseases than malnutrition. There is evidence, for instance, from the North East and Mediterranean region that 12000 years ago when the transition from hunting and gathering to agriculture and animal husbandry occurred that meat could stave off certain skeletal pathologies (Ulijaszek, 1991). Meat is now well recognised as a rich source of protein, energy and many other nutrients (Ashwell and Lambert, 1991); it contains e.g. protective omega 3 polyunsaturated acids, and only when consumed to excess does it seem to spawn the atherogenesis and cancers which have, of late, tended to tarnish its image (Ashwell, 1991).

Until the last 200 years or so people must have been more concerned about getting enough meat of whatever quality than achieving the finer gustatory pleasures from eating it, though this certainly would not have prevented both cooks and consumers from having views about what was required in a carcass or cut of meat (Tannahill, 1973).

Moreover, needs have changed over the centuries. In many primitive communities the yield of edible components from an animal's dead body was, and still is, only part of the equation. A dead seal, to an Eskimo, provides everything from gourmet eating to clothing, lamp oil and ropes. The industrial revolution of the 18th and 19th centuries was lubricated with animal fats and oils and the yield of tallow from carcasses for industrial use was just as important as that of edible calories to fuel the industrial work force.

So it was that fat became an early desirable component of meat and justified both for its apparent contribution to the cooking process and, to the succulence of the cooked meat. Game species, on the other hand, have always been recognised for their leanness and enjoyed for other attributes. These animals may traditionally be eaten shortly after the kill or after a prolonged period of hanging/maturation when a degree of autolysis has developed both to tenderise the meat and give it new flavours. In the days before refrigeration, unless animals were eaten within a short period of slaughter most meat from larger animals would automatically develop these characteristics which would have to be enjoyed as they were or disguised with spices and herbs.

MEAT IN THE WORLD'S DIETS

Quality of life, which seems largely to be a prerogative of the developed world, carries with it the expectation that the people's diets will incorporate a significant content of meat. About 1/3 of the world's meat is produced in developing countries which reflects, to a large extent, the poor availability of surplus cereal grains; the potential global output of meat from grazing land is 25% of the total. Thus the consumption of meat is a measure of economic success and increasing affluence is marked by increasing meat consumption (Unnevehr & Ruppel, 1991), which creates pressures for structural changes in meat production technology, feed ingredient supply and marketing to which the response is slow and the gap in meat production between developed and developing countries is still substantial (see Table 1).

Meat provides about 34% of the dietary energy and 59% of protein consumed by rich nations but only 6% and 15% in diets in developing countries. There is also a difference in preference for different species of meat animal. Beef is enjoyed by rich and poor nation alike whilst sheep and goat meat are more popular in developing countries. Poultry and pigmeat are of growing importance in all economies and even in Europe and the USA poultry meat accounts for much of the rise in total meat consumption which otherwise has changed little over many years (Table 2) unlike in Asia where, in the 1980s, meat production expanded by 56%.

Table 1. Production of meat ($\times 10^6$ tons). Contribution (%) to total production

	World	UK[a]	Percentage contribution	
			Developed countries	Developing countries
Beef	47	1	24	11
Sheep and goat	7	0.25	2	3
Pig	51	0.9	25	14
Poultry	28	0.75	15	6
Total	133	2.9	66	34

[a]Meat and Livestock Commission 1982
Source: Food and Agriculture Organisation 1980

Table 2. Daily consumption of meat (g)

	UK			USA[a]
	1965	1975	1985	1979
Beef and veal	30	31	26	47
Mutton and lamb	24	18	12	<1
Pork	12	12	14	21
Poultry	15	24	28	75
Total	81	85	80	153

[a]Olson 1981
Source: National Food Survey 1990

DIET AND HEALTH

One of the reasons for the continued growth of sales of poultry meat, apart from its price advantage and product variety, is its promotion as a 'healthy' food. The notion of a 'prudent' diet which will promote good health and contribute to the prevention of specific diseases is reflected in the sets of dietary goals which have been formulated since the late 1960s by medical and government-appointed committees in a number of Western countries. Of these, the US 'dietary goals' proposals (Harper, 1981), the UK Committee on Medical Aspects of Food Policy, COMA, (DHSS, 1984), and the National Advisory Committee on Nutrition Education (NACNE, 1983) were in the vanguard. Though the specific recommendations have been tempered over the years since their announcement, those proposing that the intake of all fats should be reduced still hold, rather more because of their energy density and propensity to effect weight gain than for any pathogenic features such as might arise from, say, the specific fatty acids they may contain. These committees also advocated the need for greater intakes of dietary fibre. Stopping smoking is perhaps as important an action as any to avoid the more notorious maladies.

These dietary recommendations tend however, to conform with what people were eating 50-60 years ago and people are reluctant to partake of such a prudent diet (Marks, 1985) in place of the variety of rich foodstuffs available today. There is, moreover, a body of opinion which declares it naive to consider that a primary dietary constituent, fat, carbohydrate or protein is responsible for atherosclerosis, although demographic studies in China (Peto, 1990) recognise important links between the consumption of animal products, blood cholesterol and cardiovascular disease.

Barker (1992), however, draws the conclusion from lifetime information on defined populations that vulnerability to cardiovascular disease owes much to the physiological insults which individuals may suffer in early life. These setbacks not only retard foetal and early growth but also augment the consequences of many of the known risk factors for mortality from cardiovascular diseases. Moreover, this increased risk persists irrespective of the social class in which individuals are born and reared.

Changing life style, which will include a combination of dietary modifications, taking more exercise and stopping smoking seems to be more beneficial to health than consuming a prudent diet on its own. But there is no doubt that awareness of the possible hazards of eating so called 'unhealthy' diets has caused consumers to question the place of meat in theirs and with it the range of features of meat which they expect to be encompassed within the term quality. For example, some consumers are becoming increasingly concerned about the systems for producing meat and possible interactions with other elements in the chain to the consumer. Some of these have direct implications for health and satisfaction of the consumers; others are more philosophical in nature but nevertheless impinge on the overall acceptability of meat.

PERCEPTIONS OF MEAT QUALITY

First and foremost it has to be recognised that in the developed world meat is eaten to be enjoyed, not just for any nutritional value. As Dr Douglas Rhodes once put it - " Meat scientists and technologists should consider themselves to be part of the entertainment rather than the food industry"! Given that, any feature of meat - whether in its production, processing or preservation - which offends may also prejudice the enjoyment of that meat. Quality attributes may then encompass a wider array of features than were evident hitherto. How, for example, can caring individuals 'enjoy' meat from animals raised or slaughtered in a manner which is offensive to them?

Nutritional value, wholesomeness and safety of foods were listed by the American Association of Cereal Chemists (AACC, 1984) as customer concerns about food buying and in this way the wider area of perceptions of quality in food items was recognised. But it was price that headed the list.

Sales of meat suffer or benefit when the price of it is only marginally changed. In economic terms, meat is a demand elastic commodity. But price is influential only in part. It must be related to perceived quality thus making 'value' the more appropriate term. Unacceptable quality may become acceptable at the right price. Value is also important in relation to the price of alternative commodities and products and is especially important in today's markets with their wide variety of new meats and meat products. Value has never been more important in determining sales and customer satisfaction and should be considered against all aspects of quality.

The questions of whether it is right to eat meat; whether meat is safe to eat; whether it is nutritionally valuable and whether it is affordable and good value against alternatives are appropriate notions of quality within the ISO (1986) definition that quality 'represents the totality of features and characteristics of a product that bear on its ability to satisfy stated or implied needs'. Quality interpretations vary also from product to product, between and within communities and thereby contribute to our ideas of choice and, hence, value.

Any attempt to fix quality in meat animals must go hand in hand with scientific and technological progress in their breeding and husbandry, and this has been of consequence only within the last 100 years or so. Hammond's book, 'The growth and developmentof mutton qualities in the sheep' (Hammond, 1932) was a milestone in attempts to recognise the scientific basis of quality, but it must be said that it did more to give

scientific credibility to the culinary dogma of the time than to establish objective criteria *de novo*. There is, for instance, no reference to a taste panel anywhere in the book. The dawn of meat science and technology was not to appear for another 20 years and then more as a consequence of developments in our understanding of the fundamental physiology and biochemistry of muscle in the early period post mortem and the chemistry of fats. The role of connective tissue was hesitatingly tackled even later. But more of this later.

Sentiments prior to purchase

Ethical and moral

• Production systems and animal welfare

It has to be said that whilst vegetarianism is a much vaunted option of the chattering classes, in reality fewer than 5% of the populations of Western Europe choose it and the numbers involved grow only slowly. There is also a distinct gap between those who purport to subscribe to the philosophy and those who will routinely cut meat from their diets (Harrington, 1995). But there is a growing concern amongst vocal, thinking people about the conditions under which meat animals are raised, transported and slaughtered, which is becoming a serious impediment to animal and meat production (Waran, 1995).

One of the most significant features of world animal production over recent decades is the move towards fewer production units with higher capacities. The poultry industry made the first moves and today the bulk of the world's commercial poultry flocks are bred by a handful of international breeding companies. The trend is apparent for the pig sector too and even to some extent, for beef. Production of poultry, pigs and beef, in astonishingly large units is becoming commonplace and with it the voicing of those concerns referred to earlier. Increasing the size of units almost always brings about an increase in intensification which increases the risk of spread of any disease contracted to large numbers of animals and the possible focus for widespread infection of human populations unless the necessary husbandry and management procedures are adopted.

Intensive systems of production often suffer greatest criticism, however, from the viewpoint of animal welfare. Once animals were housed, managed and fed to meet the highest levels of efficiency of production without concern necessarily for their welfare. Good stockmen have traditionally had the welfare of their charges at the forefront of their outlook; the worry today is that this outlook cannot be left to individual altruism and indeed, it is difficult to adhere to in very large units. In some countries welfare guidelines are established by government. In the UK, the Farm Animal Welfare Council has been established for about 20 years; its job is to advise government Ministers and recommend codes of practice on all aspects of the welfare of farm animals, including such practices as the tethering of breeding pigs, the stocking of battery cages for laying hens or the transport and despatch of animals at slaughter. Some of the guidelines become law.

The European Union also has concern for the welfare of animals but it is clear that the different Member States have different attitudes towards animal welfare and consensus about these matters is difficult to establish. Even within those countries where animal welfare legislation receives a sympathetic hearing, arguments are often voiced that meeting recommended codes of practice or installing appropriate equipment will be prohibitively expensive and certainly damage competitiveness. Other opinions suggest that meeting the requirements will create higher prices for food which consumers will not wish to pay. There is a view (Harrington, 1995) that producers will, in any case, have to meet animal welfare criteria as a normal production cost, for customers will simply not pay if there is a significant cost implication for what they believe to be a necessary condition of the production process. Failure of the meat sector to recognise this could have profound consequences, for the alternative, which consumers may choose, might simply be to stop eating meat.

Product safety

• Food borne pathogens

It is well recognised that the health of nations owes more to public health measures than to the development of drugs by the international pharmaceutical industry. The incidence of TB in populations had been declining steadily long before the introduction of para amino salicylic acid and streptomycin. Cholera, typhoid and paratyphoid became a rarity as urban sewage systems were established and milk-borne diseases such as bovine tuberculosis and brucellosis were diminished after hygienic practices and pasteurisation became commonplace in the dairy industry. Improved methods of husbandry have eliminated many of the helminth parasites which also infected man. The outcry which follows any outbreak of meat-borne disease today identifies how much reliance we place on good, safe, practices in the production and preparation of meat. Risk of consumers contracting a food-borne disease is an Achilles heel of the meat industry and the industry strives via various means to overcome this perceived weakness. Even so the track record is not particularly good.

In the UK during the 1980s (though the situation was remarkably similar elsewhere in the developed world) there were dramatic increases in the reported numbers of outbreaks of salmonellosis and *Campylobacter* infections (Galbraith, 1990). Though cattle numbers and reported *S. typhimurium* outbreaks in man rose in the mid-1980s, more cases of *Salmonella*, especially *S. enteriditis,* and *Campylobacter* infections were linked to the contamination and consumption of poultry meat (Figures 1 and 2).

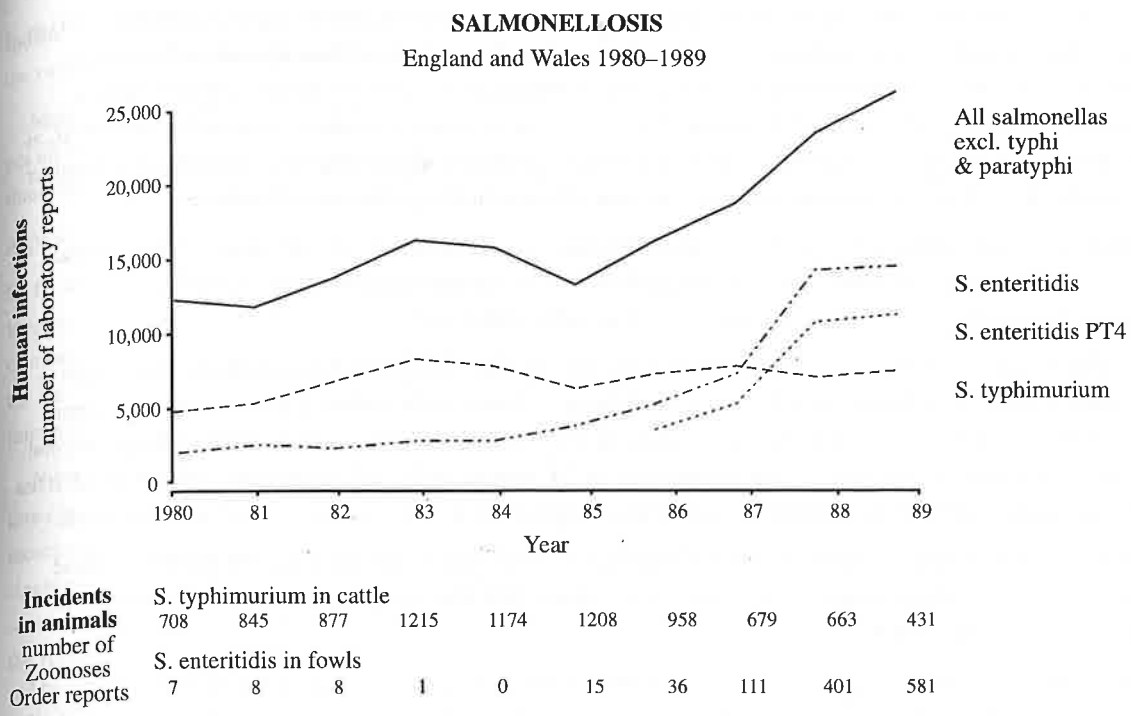

Figure 1 Trends in Salmonella infection (Galbraith, 1990)

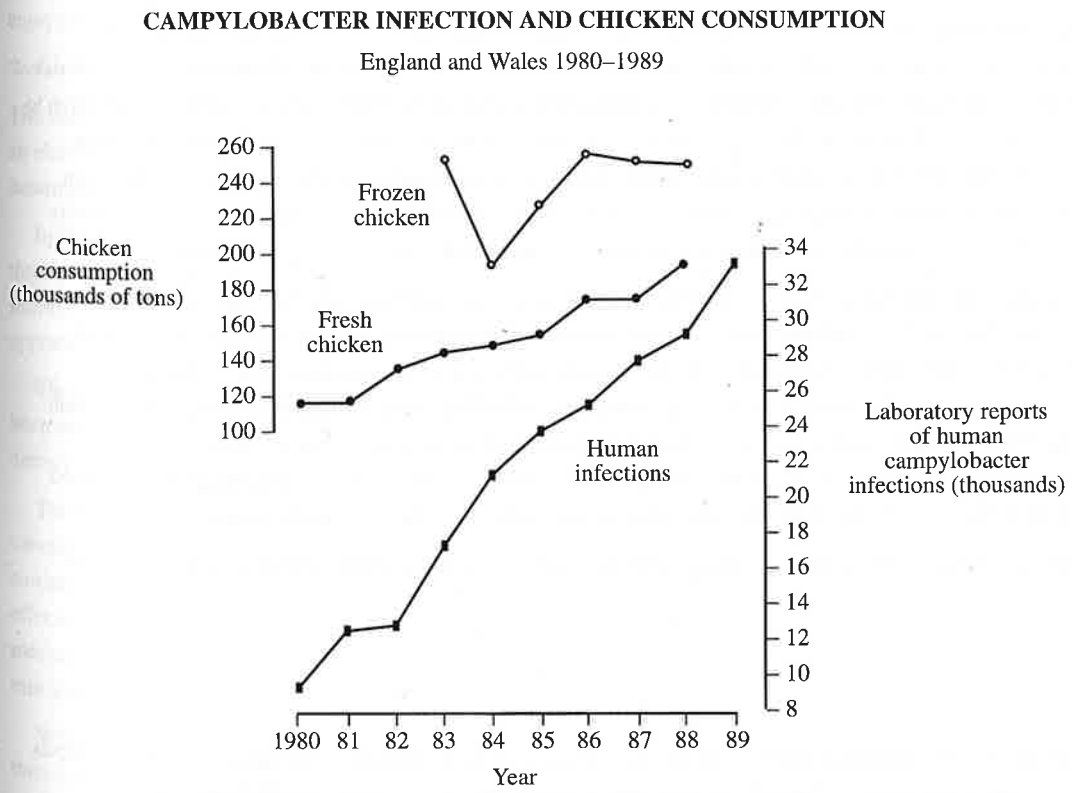

Figure 2 The relationship between chicken consumption and human Campylobacter infections (Galbraith, 1990)

There is no doubt that good hygiene practice (especially the use of HACCP procedures - see Johnson, Hinton and van Logtestijn, 1991) in the cold chain and thorough cooking of meat and meat products could substantially reduce the incidence of these diseases in the human population and public education to this effect could be enormously valuable. The elimination of the causative bacteria presents a greater problem, especially in the production sector (van Logtestijn and Urlings, 1995). Feeds and the production environment can be 'cleaned up', as the Norwegians and Swedes have shown, to reduce *Salmonella* contamination in pork and poultry meat and hygienic measures post slaughter can maintain this improved quality. It is not so easy, however, to achieve the same effects with *Campylobacter* contamination.

Most recently bacterial mutations or adaptations in *E. coli, Yersinia* and *Vibrio* have caused particular concern because of their unusual pathogenicity which has caused deaths amongst those infected. *E. coli* (strain 0157/H7) has caused outbreaks of gastroenteritis and haemorrhegic uraemia syndrome and *Yersinia enterocolitica* also produces a heat-stable enterotoxin.

The most sinister spectre of the last decade is the newly identified disease of cattle - Bovine Spongiform Encephalopathy. It is thought to have been introduced into cattle via feed protein derived from Scrapie infected sheep. A change in the rendering system for sheep carcasses destined for use in animal feeds or a contemporaneous adaptation in the organism itself seems to have allowed it to develop interspecific oral infectivity. (Human populations have been consuming scrapie infected sheep in the UK without apparent harm for more than 200 years). It has not been possible to demonstrate this principle outside ruminants though similar encephalopathies have been recognised in mink and cats.

The fear for humans is in the risk of contracting a similar condition, Creutzfeldt-Jakob disease, (CJD) which is a rare but widely spread scrapie-like neurological disorder. Though CJD possesses features similar to scrapie and BSE there is no medical or scientific evidence to suggest that BSE is a zoonotic disease (Taylor, 1989).

The consequence of all this is, firstly, a massive impact on sales of beef in the UK and on exports; secondly, the withdrawal from sale and use of nervous and other tissues from both healthy and infected stock for human consumption or incorporation in animal feeds, and thirdly, the initiation of a major research effort on the aetiology, transmission and control of the disease.

The disease risk from beef is, however, taken by some as yet another disquieting aspect of modern animal production. There is no doubt that the recent experiences have cast a shadow over the perceived safety and wholesomeness of meat, and severe damage to national and international trading in the affected commodities.

• Residues

Apart from the array of toxic and poisonous materials that have found their way into the feed and tissues of animals historically, many biologically active materials are now used to promote growth and other production benefits in meat animals. Not all of these are without risk (Moats, 1994) When antibiotics began to be important in the cure of diseases and infections during the 1940s there was little thought given to the possibility that their continued use might lead to the development of resistant strains and types of pathogens in both human and farm animal patients. The widespread use of antibiotics for growth promotion and to improve feed utilisation efficiency in meat animals began eventually to raise concerns about the effects that these drugs might have once they were a continuing feature of the food chain. Eventually legislation was drawn up in many countries to control the use of these agents in animal husbandry most extremely in Sweden.

Of late, however, the use of hormones and anabolic agents to promote lean growth in meat animals has been the centre of controversy. Although these drugs may have had the desired effects (which otherwise could only be achieved through generations of classical animal breeding) their use has raised ethical doubts and moral uncertainties in people's minds and fear that the consumer might be harmed. The precedent of Diethyl Stilboestrol (DES) which was approved for use as a growth promoter in farm animal before its carcinogenicity in man was established, is difficult to shrug off and though a case against the natural and synthetic steroid hormones has not been proven, the European Union has yet to approve their use. Many people believe that free choice should be exercised and so long as the products derived from treated animals are labelled to that effect, and their safety assured by experts, then they should be made freely available.

Quality is not normally impared by anabolic agents but some e.g. beta agonists, may induce toughness in the meat of treated animals (see Wood and Fisher, 1990).

Attraction to purchase

Presentation

A walk along the 'meat' displays of any supermarket clearly demonstrates a move away from the traditional presentations of the standard cuts and joints of fresh meat towards a predominance of pre-packaged, portion controlled items and an abundance of added value, speciality products. There are many sound marketing reasons for this as the poultry industry was quick to discover. Attractive packs of legs, wings and breast meat capitalise on the high value components of a carcass and result in more sales of poultry meat. Taking these and, perhaps, cheaper portions of the carcass, adding seasonings and dressings and cooking them contribute substantial added-value when they are sold as, say,

Indian, Asian and Oriental dishes. Presenting meats like this also dissociates the item from the farm animals from which they are derived and the twilight zone of concern between farm and factory.

Meat and meat products so offered are, like toothpaste and cornflakes, subject to a different range of quality notions. When the product is not on view the appeal of the packaging, magazine advertising or the TV commercial may provide the impetus to purchase rather than the direct appeal of the displayed product. Frozen products may also need an entirely separate presentational approach and marketing strategy.

Appearance

So far as fresh meat is concerned consumers look for colour and fluid retaining characteristics and fat content of meat in the hope that they will indicate the eventual enjoyment of the meat when it is eaten. Steenkamp and van Trijp (1988) and Hoffman (1990) have presented categories of meat quality attributes which extend these basic properties to include all those which have interested meat scientists and technologists for the last 20-30 years. Of these PSE and DFD of pork and comparable conditions in the meat from other species have been of paramount importance (see Tarrant, Eikelenboom and Monin, 1987; Fabiansson, Shorthose and Warner, 1988).

None of these characteristics of fresh meat is new to the meat world, but there have been signs that their incidence has increased in recent times in association with changes in performance and production characteristics (fast, feed efficient lean growth especially amongst mesomorphic animals) and the handling of animals prior to slaughter. In pigs the PSE condition is most closely associated with the effects of a single gene - the so called 'Hal' gene whose presence can now be diagnosed using a DNA probe and hence offers hope for its elimination. A second single gene effect has been identified by French researchers. The Rendement Napole (Rn) gene appears to be confined to individuals in the Hampshire breed and leads to poor processing characteristics of hams (Monin *et al* 1992).

The DFD or dark cutting condition is mainly, though not exclusively, a feature of beef from some entire males and is almost always associated with behavioural problems either induced through poor handling prior to slaughter, or which occur spontaneously in individual animals.

Appreciation when eaten

Having persuaded potential consumers of meat that it is ethically and morally acceptable for them to eat it and that it is an attractive commodity to purchase, we can examine the quality criteria which should be met to ensure continued, repeat purchasing and the consistent enjoyment of meat in the diet.

Sensory qualities

The traditional view was that animals had to be 'finished' i.e. fattened, ready for slaughter if the meat was to be of the best eating quality, and an element of this still resides in our grading and classification systems for meat today. There is scientific evidence to support a role for fat in determining the final enjoyment from eating meat; the question nowadays is - how much is enough?

In the US and Canada, beef carcasses tend to be graded on the principle that a minimum of fat thickness promotes an acceptable palatability through the avoidance of cold toughening which an insulating layer of fat provides against the more zealous refrigeration practices, and intramuscular/marbling fat supposedly gives succulence, flavour and, perhaps, tenderness to the meat. Similar, though less formal and defined approaches are used for assessing sheep carcasses.

The same qualities were sought traditionally for judging the suitability of both live animals and carcasses in Europe. However, there have been major efforts over the last 15–20 years to assess the quality of carcasses in terms of their leanness and classification schemes have been agreed in order to do this (de Boer, 1983).

This has been brought about primarily because of developments in pig production and marketing. It is fortunate that most of the fat in a pig carcass is subcutaneous fat, and any measure of this, in animals of the same weight, gives a good indication of the lean content of their carcasses and the basis for a scale of payment based upon lean meat yield. The classification schemes thus devised have resulted in dramatic effects on pig production efficiency and carcass composition. In the UK for example the fat thickness over the last rib - the so-called P2 measurement - is now about 11 mm in the average slaughter pig of 60-80 kg, though many with 5 mm and less are seen. Twenty years ago 22 mm would have been the average (MLC, 1994).

What has been achieved for pigs through breeding and improved nutrition is seen as a goal for producers of the other meat species. Of late, therefore, the tendency has been to introduce more breeds of cattle and, even sheep, of the large, lean late maturing types.

All of this has gone some way towards meeting recommendations emanating from the diet/health debate about leaner meat and reduced fat intake. There is, however, concern in some circles that palatability and succulence of the meat from ultra lean animals is beginning to be affected (Wood, Wiseman and Cole, 1994).

The amount of marbling fat required to give optimal eating pleasure is seen best as a threshold value higher than which further benefits are marginal. A figure of 2–3% is often suggested - much higher than the <1% often found in UK pigs. Even so, much of the research to confirm the value of higher levels of intramuscular fat has been equivocal and at best their influence has been only small. There is evidence that meat from Duroc pigs which contains more intramuscular fat than UK white breeds is more juicy, though not more tender, and is less acceptable overall than that from Landrace pigs (Cameron *et al.*, 1990). The notorious fatness of Chinese Meishan pigs seems not to confer any specific advantage in terms of their overall eating quality (Ellis and McKeith, 1995). On the other hand pigmeat containing <0.8% extractable lipid may suffer in palatability (Wood *et al.*, 1991), and the concentration of unsaturated fatty acids and the polyunsaturated: saturated fatty acid (P:S) ratio will be increased in muscle tissue but thereby improving the 'healthiness' of the meat.

Lipid is also an important source of meat flavours (and off flavours through peroxidation induced rancidity) from volatiles containing carbonyls. Lean meat, therefore, may lack the source of carbonyls and some flavour, though the flavour components from water soluble constituents and products of browning reactions during cooking will still contribute (Bailey, 1988).

Tenderness was an early casualty of the need to alter the technology of modern high speed slaughter lines. A significant factor affecting throughput is the time taken to cool carcasses and the holding space which must be available for the completion of *rigor mortis*. Rapid/blast chilling and freezing techniques were seen as a means of increasing throughput and reducing evaporative loss from carcasses. It was quickly discovered, however, that accelerated cooling could produce a 'cold shortening' of the muscle and toughness of the meat (Locker and Hagyard, 1963). Identification of the interrelationships of time, temperature and the rigor process not only provided an explanation for the phenomenon but the means to avoid it. If muscles are allowed to develop *rigor* at temperatures below 10°C, their sarcomeres may shorten by 30% or more from the rest length and toughen the meat. An even more dramatic thaw contracture and toughening may occur if meat is frozen *pre rigor*. The rule of thumb to prevent the worst effects of refrigeration on tenderness is for lamb carcasses not to be refrigerated below 10°C within 10 hours of slaughter. Beef carcasses should not be exposed to air below 5°C and faster than 1 m/sec within 24 h of slaughter. Pig carcasses on the other hand show much faster *rigor* development and are at risk to cold shortening with only the most aggressive refrigeration practices. Poultry meat suffers its worst shortening within minutes of slaughter and will become most tender as it is chilled or even after freezing and thawing.

The level of risk of cold shortening in pig muscle is therefore, relatively small, though not unknown, because *rigor mortis* is usually completed within 10 hours and occasionally within minutes of death when the greater risk is for PSE meat to result.

Knowledge about the interrelationships between the cooling characteristics of the carcass, the pH fall and loss of ATP in the muscles which differ between and within muscles and how they might be manipulated (Bendall, 1979) has provided the means to develop post slaughter technology to speed the refrigeration process without inducing the toughening which otherwise might result. It has long been known that the application of an electrical voltage to an excised muscle could cause it to contract and stimulate the glycolytic process within it. Applied to whole carcasses shortly after slaughter, both low (~ 25v) and high (~ 750v) voltages can induce significant effects and allow even beef carcasses to be cooled at a more rapid rate than would otherwise be possible without damaging effects on eating quality. It will be clear that this technique is almost irrelevant for use in poultry and a possible means of inducing PSE in pigmeat.

Stretching muscle and hence sarcomere length during the rigor process may also further improve the tenderness induced through electrical stimulation. To do this may require novel suspension procedures for the carcass such as at the pelvis or Achilles tendon (Taylor, 1990).

It has always been felt that because gristle i.e. connective tissue, is what we find most unacceptable in a piece of meat and what we would spit out, then it might well contribute the background toughness of meat via the fine network of connective tissue which is distributed microscopically within the muscle. It has nevertheless proved difficult to reveal any strong direct correlation between connective tissue content and tenderness of muscle, even with the refinements provided by knowledge of its constitutional cross-linking structure, its solubility and phenotypic variability (McCormick, 1994). Velleman and Racela (1994) have suggested that the second component of the extra cellular matrix, the ground substance (proteoglycan), through its role in the assembly of collagen fibrils and elsewhere, may be a better candidate ultimately to affect meat quality.

Dransfield (1992) has looked to the biochemical constitution of muscle and especially the calpains and calpastatin components to identify a widely relevant basis for the tenderness of meat. This would apply to physiological attributes of the growing animal and interrelate with conditions present in muscle in the early post mortem period and during the maturation/ageing of the carcass, and even in the cooking process. Establishing this mechanism would create a significant leap forward in our understanding of the fundamental basis for improving the tenderness of meat at any stage between its conception and consumption.

THE FUTURE FOR MEAT

So long as the opening of another McDonald's restaurant in Beijing or Moscow shares the headlines with matters as momentous as the fall of communism in the USSR or the opening up of relations with China, no one can seriously doubt the future for meat globally. The mature markets for meat in the western world are, however, a greater concern which relates as much to perceptions of quality that can be attached to meat, as about its nutritional value. That meat must be safe, wholesome and healthful to eat is the minimum expectation; that it should be presented attractively to invite purchase, and guarantee consistent, uniform and enjoyable experience to the consumer when it is eaten, is becoming equally important. The technological challenge for all these is being met by animal and meat scientists throughout the world and there is expectation that all will be delivered at selling prices which purchasers of meat will consider to be of good value. Any clouds on the horizon stem from the ethics and morality of meat eating and the systems of animal production and slaughter which economic forces increasingly dictate and modern biotechnological advances permit.

'Is it right to eat meat if we jeopardise the welfare of animals destined to supply it?' could well be the question for the cusp of this and the next century. Scientists, farmers, industrialists and educators must recognise that this is a problem for which they must find solutions and promulgate them to ensure that meat continues to occupy its traditional place in feeding and providing social enjoyment for people and, in so doing, provides a necessary component for the mixed sustainable farming that will secure all our futures.

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