CONTRACT REVIEW

HIGH QUALITY CONTAMINANT-FREE PIG MEAT

INTRODUCTION

*C.P. McPHEE**

The pig industry has led the livestock industries in the objective measurement of carcase quality and in basing payments to pig producers on these (NPF 1988). Until now these measurements have been of sub-cutaneous fat depths in recognition of their association with lean content of the pig carcase. There has *been* a steady evolution in the instruments used from a simple scale through an optical probe to an electronic probe.

In recent times greater sophistication of meat retailing has enabled messages to be passed back to the processor and producer of consumer preferences for pig meat, not only with a high lean content but with preferred colour' and texture characteristics as well. There has also been rising concern over chemical residues in meat and national safety levels have been set and monitoring programmes implemented.

The papers in this contract describe techniques used for the measurement of meat characteristics and the means by which growth and development of the pig can be manipulated to achieve a desirable outcome. The first paper compares the accuracy of a variety of slaughter line instruments for assessing the lean content of carcases and the less well defined lean quality traits, The second paper examines the influence of nutrition and genotype on carcase quality. The third paper outlines the techniques currently in use to detect residues in pig meat of pesticides and anti-microbial agents. The fourth paper reports the results of a study of microbial contamination of pig carcases during the slaughter and cutting up processes.

OBJECTIVE MEASUREMENT OF PIG MEAT QUALITY

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Objective description of carcass and/or meat quality is central to value based marketing of swine. The overall perception of pigmeat quality embraces a number of factors, all of which are important in a complete evaluation. This paper is directed at the measurement of lean quantity and also the detection of meat quality factors such as PSE/DFD pork.

Estimation of carcass lean yield

The functional relationship between caudal rib measurements of fat depth *over* the *m. longissimus* and the quantity of carcass lean has been effectively utilised within pork carcass classification schemes throughout the world. These measurements are taken using the manual Danish Introscope (IS) or by the more operationally efficient, automatic probes. These probes utilise either the difference in electrical conductivity (Meat Fat Automatic MFA-Denmark) or light reflectance [Hennessy Grading Probe (HGP; New Zealand); Fat-O-Meter (FOM; Denmark); Destron PG100 (DST; Canada)] between the tissues to obtain measurements of fat and *m. longissimus* depth. The results of several studies

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comparing the accuracy (residual s.d.) of these instruments are summarised in Table 1. The precision of each technique is based on the best combination of measurements.

Table 1 Comparative accuracy (r.s.d.) of difference probes for predicting the percentage of carcass lean yield

Probe	Trial			
	Fortin *et al.* (1984)	Cook *et al.* (1989)	Lothje *et al.* (1988)	Ferguson (1988)
IS		2.31#		2.60#
HGP	1.84	2.37		
FOM	1.87	2.18		
DST		2.55		
MFA			1.80	
CC			1.63	

Adjusted for hot carcass weight (kg)

Whilst small differences in predictive accuracy have been observed, it is generally considered that there is a similar level of precision between these probes. Also shown are the results of Lothje *et al.* (1988) which provides an indication of the predictive accuracy *of* the Danish Pig Classification Centre (CC). The CC utilises robotic technology to automatically record 17 probe measurements on the carcass and is currently being evaluated in several Danish abattoirs.

Alternative technologies such as image Real Time (RTU) and non-image ultrasound (Velocity of Sound VOS) and total body electromagnetic scanning (TOBEC) are currently being evaluated in this application, Ferguson (1988) and Forrest *et al.* (1988) have shown the accuracy of RTU carcass measurements to be comparable in predictive accuracy to those recorded by automatic probes. Probably the most promising of these alternative technologies is TOBEC and the results by Forrest *et al.* (1958) and Kuei *et al.* (1989) certainly confirm the potential of TOBEC.

Detection of PSE and DFD pork

The ultimate pH of meat and the interaction between post-slaughter muscle temperatures and rate of pH fall determine the occurrence of pale, soft, exudative (PSE) and dark, firm, dry (DFD) pork. Both aberrant quality conditions affect the technological properties of pork for manufacturing, the aesthetics of the sensory traits and the appearance and shelf-life of the product. Thus the development of techniques for detection of PSE and DFD on the intact carcass is a priority in many pig producing countries.

The most researched technique has been to measure internal meat reflectance using a fibre optic probe. Several carcass grading probes have been fitted with extra software to provide a meat quality readout, eg., HGP, Destron PG100 and FOM. Probes such as the Bristol Fibre Optic Probe (FOP) or the more recent Canadian Colormet, have been developed specifically to measure meat quality.

The relationship between paleness and softness/exudate in PSE meat is quite variable (Warriss and Brown 1987), thus evaluations of meat quality should provide a measurement of both colour and structure. The prediction of ultimate meat quality is less accurate from measurements made at 45 min post-slaughter compared to those at 24 h – only about 50% of pig carcasses that develop PSE meat, and few DFD carcasses, can be detected on the slaughter-floor (Wariss *et*

al. 1989; Fortin and Raymond 1987). In Swedish abattoirs, measurements of internal reflectance using the HGP on the slaughter floor are used to monitor pre-slaughter stress problems such as leaving animals in the V-restrainer during breaks in slaughter (Lundstrom *et al.* 1985 and pers. comm.).

Generally, the measurement of the internal reflectance of meat predicts meat lightness or colour more accurately than drip loss (Wariss *et al.* 1989; Eikelenboom and Nanni Costa 1988). Probe measurements at 24 h have been reported to explain up to 80% of the variation in colour (Murray *et al. 1989)* but only account for 50–60% of variation in drip loss (Wariss *et al.* 1989; Murray *et al.* 1989). Drip loss is economically and visually important but its accurate prediction from on-line measurements on the pig carcass does no seem to be possible with present technology. Future research will hopefully address this problem.

In the pursuit for more accurate and reliable technology for assessing either the quantity or quality of carcass lean, there will be a strong preference *for* those techniques which lend themselves to automation. In addition, it is highly likely that more efficient carcass identification systems will be required to link the quantity and delayed quality assessments of carcass lean.

EFFECT OF NUTRITION ON PIG CARCASS QUALITY

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Introduction

Pig carcass price in Australia is dependent on P_2 backfat thickness with price penalties for P_2 in excess of a premium thickness or grade and no additional payments for improved meat or fat quality. This payment system encourages pig producers to reduce average consignment P_2 in order to obtain more than 50% of carcasses in the premium grade, without regard to meat or fat quality.

This dependence of carcass price on P_2 has also encouraged the use of genotypes with reduced fatness and the marketing of intact males rather than castrates. In an industry where *ad libitum* feeding is widely adopted, the trend in pig nutrition has been towards low-energy density diets fed to finisher pigs and research into nutrient requirements and food additives which will reduce backfat thickness.

Reports from several countries (Wood *et al.* 1988) have associated a decline in backfat thickness with a reduction in meat and fat quality and increasing research attention is now focussed on carcass quality as well as carcass fatness. This paper considers some of the recent nutrition studies on pig carcass quality with emphasis on fat thickness and fat quality.

Genotype/nutrition effects on fat thickness

It is now clear from Australian studies (reviewed by the Standing Committee of Agriculture, 1987) that the relationship between energy intake and backfat thickness is influenced by live weight, sex and genotype. Assuming that protein intake is not limiting, the relationship is curvilinear – decreasing (convex) during the grower phase (up to 50 kg live weight). In contrast to the grower phase, the increased energy intake during the finisher period (50 to 90 kg live weight) when fed *ad libitum,* is likely to exceed maximum protein deposition and result in a linear increase in fat thickness, Females will be

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fatter than intact males at all energy intakes because females have a lower rate of protein deposition. Improved genotypes not only have less backfat thickness at the same energy intake when compared to average genetic strains of pigs but demonstrate the convex energy intake – backfat response throughout the grower and finisher phases.

The implications from these findings are:

(a) backfat thickness is relatively insensitive to changes in energy intake when grower pigs and improved genetic strains of finisher pigs are fed energy intakes approaching *ad libitum;*

(b) some form of food restriction, such as reduction in energy density of the diet is necessary during the finisher phase to avoid excess fatness, particularly in females;

(c) because excessive food restriction decreases growth rate and may decrease food conversion efficiency, a level of energy intake at which protein deposition reaches a maximum will be the most profitable during the finisher phase; and

(d) because of the genetic variation in the energy intake – backfat response, simple on-farm trials involving several energy intakes will establish for individual producers the optimal energy intake for their strain of finisher pig.

Energy intake and fat quality

Wood *et al.* (1988) highlighted the relationship between reduced fat thickness and increased fat softness and the problem *of* carcasses which will not set when chilled and fat tissues which separate from one another and from lean.

Unlike rodents, fat synthesis in the pig occurs within adipose tissue and not in the liver. This has two implications. Firstly, as glucose is the precursor of fat synthesis in the pig, any reduction in glucose supply will reduce fat synthesis; and secondly, dietary fat sources will be incorporated directly into adipose tissue. As glucose supply is restricted the ratio of saturated to unsaturated fat deposition decreases and fat tissue becomes softer. Therefore any restriction in fat thickness (e.g. use of lean genotypes, intact males) or decrease in glucose supply (e.g. feed restriction) will lead to fat softness. Wood *et al.* (1988) further suggested that 10 mm P_2 is the critical point below which fat softness becomes a serious problem, particularly in intact male carcasses.

The ratio of saturated fatty acid (stearic acid) to unsaturated fatty acid (linoleic acid) provides the best measure of fat softness in pig carcasses. It is widely accepted that increases in dietary linoleic acid, such as the use of plant oils, will increase fat softness. In addition, reduction in fat thickness through the use of improved genotypes and intact males will also increase linoleic acid concentration in fat tissue.

Growth promotants

A large amount of pig research around the world is currently investigating the action of growth promotants such as porcine somatotrophin (PST) and repartitioning agents known as beta agonists, e.g. ractopamine (RAC). To summarise Australian studies (Campbell *et al.* 1989a) and the 60 abstracts presented to the recent 1989 meeting of the American Society of Animal Science (ASAS), Lexington, Kentucky, it now appears that PST administration to growing pigs reduces lipogenesis independently of any increase in protein deposition which in turn relies on increased protein (amino acid) intake. PST

administration eliminates differences in growth and *carcass* composition between intact males, females and castrate males. In addition the response to PST is similar for different genotypes. PST administration at 6 mg/day to finisher pigs reduced carcass fatness by 29% for boars and 49% for gilts (Campbell *et al.* 1989b).

There was general agreement from the ASAS meeting that RAC improves food conversion, loin area and decreases backfat thickness from 10 to 15%. It was also demonstrated that RAC and PST have additive effects on growth and fatness in finisher pigs. A recent review of Australian and overseas studies (Thornton and Shorthose, 1989) highlighted the effect of PST and repartitioning agents to reduce carcass fatness without detrimental effects on pig meat or fat quality. However, Warriss (1989), in a report to the British Society of Animal Production warned that beta agonists cause fat softness and reduced tenderness in pig meat. It is now apparent from recent research studies that PST and RAC have a dramatic effect in reducing carcass fatness in growing pigs. Adoption of this technology will allow producers to abandon current management practices such as restrictive feeding and the growth of intact males.

Conclusions

Australian studies in the last decade have shown that the relationship between energy intake, protein deposition and carcass fatness varies with liveweight, genotype and sex. This knowledge has provided pig producers with the ability to describe these relationships and maximise profitability for their strain of finisher pig using a simple on farm trial. Recent research studies into the action of growth promotants (growth hormone and beta agonists) on carcass fatness have provided the potential to reduce pig carcass fatness without the use of restrictive feeding practices. The use of this technology now requires the development of delivery devices, registration of the compounds and consumer acceptance. Insufficient attention has been given to the effects of these *growth* promotants on fat quality such as fat softness. There is a need for an objective method of measuring fat softness on the slaughter line and payment systems which reward carcass quality as well as carcass leaness.

PESTICIDE AND ANTIBIOTIC RESIDUES IN PIG PRODUCTS – CURRENT MONITORING METHODOLOGY AND RESULTS

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The significance of chemical residues in food, in relationship to human health, and the threat to export markets, have been headline news over the past two years. Testing of primary produce is carried out nationally through the Australian Quarantine and Inspection Service (AQIS) and the Bureau of Rural Resources (BRR). State government bodies also have monitoring programs in place.

Pesticide assay

The pesticides of concern which form persistent residues are mainly organochlorines (OC's) and organophosphates (OP's), which concentrate in fat. Assay methods and Maximum Residue Limits (MRL's) *are* therefore based on fat. Any of the fat depots in the body may be sampled as these pesticides are uniformly distributed throughout the fat of the body (our unpublished data). However, renal fat is usually preferred.

There are some forty accredited laboratories Australia-wide which routinely assay animal fat samples for the presence of pesticide residues. Thirty-eight

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use the method of sweep co-distillation as developed by Storherr and Watts (1965) and improved by Dingle (1975). The operation is similiar for each laboratory, with minor differences arising from optimization to suit specific requirements. The figures in parenthesis in the following summary indicate the range of conditions used. A measured aliquot (0.89–2.00 g) of rendered, molten fat is injected through a gas-tight septum into a glass extraction tube either empty *or* filled with glass beads. This glass extraction tube is electrically heated (220–270°C). Nitrogen gas is passed through the tube (220-1000 ml/min). Volatile organics, including the pesticide residues, are carried out of the tube and trapped in a short detachable chromatography column packed with Florisil (0.5–2.0% water deactivation). Pesticides are eluted from the column, usually with a mixture of diethyl ether and hexane (10–20% ether). Detection, identification and quantitation is by gas liquid chromatography (GLC).

All forty laboratories participate in the Extended Organochlorine Testing Program based on the Technical Requirements of AQIS. To ensure confidence in the results the Australian Government Department of Primary Industries and Energy (DPIE) instituted the National Pesticide Residue Proficiency Testing Program, designed in consultation with the National Association of Testing Authorities. Clean rendered fat is spiked by the addition of solutions of OC's and sub-samples are sent to participating laboratories. Assay results are then collated and analysed statistically. Continuing accreditation depends on satisfactory performance.

Antibiotic assay

Antibiotics include a wide range of chemical compounds, generally not fat soluble and not stored in the body. Residues may be present in muscle and organs for two to three weeks after administration. Antibiotic residues pose problems for the analyst, since there is most often too little information for selection of appropriate specific methods. This calls for less specific, all round screening methods able to demonstrate a wide range *of* antibiotics whose only common characteristic is toxicity to micro organisms, Screening tests generally will not distinguish between antibiotics. In Australia the Microbial Inhibition Test (MIT) is most common. A swab or disc saturated with kidney, liver or muscle fluid or urine is placed on an agar plate inoculated with a sensitive bacterium (usually *Bacillus subtilis*). The plate is incubated overnight and inhibition of growth around the sample is a positive result.

The Queensland Department of Primary Industries has a thin layer chromatography (TLC)/bioautography method in place. Antibiotics are separated by TLC and the developed TLC plate is placed face down on an inoculated agar plate. After incubation the migration zones of any antibiotic residues are revealed by the area of bacterial inhibition. For confirmation of identity and quantitation the specific methods favoured are high performance liquid chromatography, GLC, GLC/mass spectroscopy, TLC and electrophoresis.

Monitoring programs and traceback

Australia-wide testing is part of the Commonwealth Department of Primary Industries and Energy's National Residue Survey (NRS). The projected sampling regimen for pigs for 1989/90 is as follows: OC's and OP's in fat, 3300 (includes 300 feral pigs); synthetic pyrethroids in fat, 300; antibiotics in kidney, 1200; chloramphenicol in muscle, 300; sulphonamides in liver, 600. From- 100–600 samples will also be tested for heavy metals (As,Cd,Hg): cyromazine, dimetridazole, levamisole and stilbenes.

The NRS should be regarded as quality assurance rather than quality control. However, should routine monitoring reveal any problem, stringent quality

control measures such as the Extended Organochlorine Testing Program could be implemented until the problem is defined and corrected.

All samples collected at slaughter are identifiable to allow tracing of unacceptable residues back to the farm of origin, Corrective measures vary from extension measures to the imposition of quarantine. 'Traceback' investigations include collection of biopsy samples (taken surgically) from other stock on the property and environmental and feed samples. Once the source of contamination is located it is either removed or isolated and strategic management programs initiated to minimize residues in the future.

Results

The Level of Reporting (LOR) is the lowest level of the analyte which will be reported for a particular method. It is set by the analyst, taking into account factors such as the limit of detection, reproducibility and confidence intervals. In a monitoring exercise, the LOR is usually set at about ten percent of the MRL where possible, method restraints allowing. As an example, a meaningful LOR for dieldrin, where the MRL is 0.2 mg/kg, would be 0.02 mg/kg.

A) The National Residue Survey for the period 1.1.89 to 22.9.89 Of the 2599 samples analysed in the NRS for OC's and OP's, 112 contained more than the LOR and three (Dieldrin two, BHC one) contained over the MRL. Of the 1455 samples analysed for sulphonamides, 230 (all sulphadimidine) contained more than the LOR and 42 (all sulphadimidine) contained over the MRL. Of the 1382 samples tested for bacterial inhibition two gave a positive response.

B) The Sulphonamide Testing Program in place in Queensland One in every 300 pigs is sampled at slaughter in such a way as to ensure every piggery is sampled at least once *every six* months. Of the 401 samples analysed in the Queensland survey for sulphonamides, 56 (sulphadimidine 53, sulphamerazine one, sulphadiazine one, sulphathiazole one) contained more than the LOR and 19 (all sulphadimidine) contained over the MRL.

The compliance figure (99.9%) for pesticide residues in pig meat fat is highly reassuring and is an indication of the efficacy of the regulatory control and extension measures in place and the increased awareness of the problems of pesticide residues over the past two years.

The compliance figures (97% NRS, 95.3% Qld.) for sulphonamide residues are somewhat less reassuring. All residues greater than the MRL are sulphadimidine and State Government officers involved in traceback investigations believe it is a problem related to medicated feed, which could be solved by extension and management programs.

There is now a high degree of confidence in results for pesticide residue analysis. The same cannot be said for antibiotic and sulphonamide testing. It would seem an opportune time to implement a program such as the National Pesticide Residue Profiency Testing Program in the area of veterinary drug residue analysis.

MICROBIAL CONTAMINATION ON SPOILAGE OF PIG MEAT

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The keeping quality of meat is largely determined by the numbers and types of micro-organisms present on carcass surfaces after slaughter, and the temperature of storage (Ingram 1972; Sheridan 1982).

Roberts (1980) noted that bacterial levels on pig carcasses are usually higher than those on sheep and cattle. One of the reasons for this is the process for removal of hairs from the hide, which remains on pig carcasses whereas with sheep and cattle the hide is totally removed. In the scalding process, faeces escape from the anus and blood oozes from the sticking wound. These excretions contribute to the biological and bacterial load of the scalding water whose temperature may be insufficient to destroy many bacteria. Our studies have shown, however, that increasing bacterial concentrations in the scald tank water did not appear to be reflected in increasing levels of bacterial contamination on carcasses at the end of the slaughterline. Bacterial contamination of scald tank water may be more important as a source of contamination for deep muscle tissues as a result of residual heart action circulating scald tank water, ingested through the stick wound, throughout the circulatory system. (Jones *et al.* 1979, 1984)

Dehairing machines also contribute to the bacterial load on carcasses by recontaminating them with faeces and blood which continues to leak from carcasses as they are rubbed and buffeted together. The singeing process can also influence the bacterial flora on pig carcasses (Rasch *et al.* 1978). We have confirmed that carcasses produced in abattoirs using tunnel singeing ovens have lower bacterial levels than carcasses which are singed with hand-held gas torches.

We found that the final washing of carcasses produced only minor decreases in the bacterial levels on carcasses. Effective carcass washing needs an adequate water pressure and effective direction otherwise bacteria may only be moved from *one* site to another on the carcass *(Nortje et al.* 1979). Hot water, at a temperature of at least 80°C, is also needed to reduce bacterial numbers on carcasses (Kelly *et al.* 1981). It has been suggested by *Nortje et al.* (1979) that low degree singeing of carcasses prior to chilling might be used as an alternative to washing as a method of reducing bacterial numbers on carcasses.

On completion of slaughter and dressing, carcasses are stored at temperatures between 0°C and 4°C to minimise the growth of bacteria on carcasses. Initial chill storage should aim to rapidly bring the internal temperature of the carcass down to the chill temperature (Rosset 1982). This may take several hours because of the thickness of the carcass and the insulating effect of the skin and sub-cutaneous fat on carcasses. High volume air movement within the chiller is used to effect the temperature drop and this also promotes drying of the carcass surface which can further inhibit the growth of bacteria. Our observations have shown that in the initial 24 hours of chill storage, bacterial numbers on carcasses are reduced.

However, when carcasses are stored for periods longer than 24 hours, the selection of bacteria able to grow at low temperature, makes the initial drop in bacterial numbers a temporary phenomenon. Our observations show that there is a marked change in the composition of the bacterial flora on pig carcasses when they are stored longer than 24 hours, with Pseudomonads becoming the dominant flora. Pseudomonads are usually the fastest growing bacteria on the surfaces of chilled meat because their growth rate is less affected by low

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temperatures than that of their competitors (Rosset 1982). They are also the principal causative agents of spoilage on fresh meat.

The storage life of beef is inversely proportional to the levels of the initial surface bacterial contamination, and a similar pattern is observed with pig carcasses, Thus for prolonged storage of pig carcasses, without early spoilage, it is necessary to ensure that carcasses placed in chiller storage have the lowest achievable bacterial levels on their surfaces.

The boning room is also a source of contamination for pig meat. Gardner (1973) demonstrated that substantial increases in bacterial counts on bacon sides after their production from whole carcasses. Our studies have also shown that the boning operation causes substantial increases in bacterial levels on pig meat (Fig. 1). The significance of the boning operation to premature spoilage is underlined by the qualitative change in the bacterial load post boning. While the increase in total viable bacterial count was generally less than one log following boning, the increase in Pseudomonad counts was consistently much greater (Fig. 1). Thus, boning operations effectively disseminated the organisms responsible for spoilage of pork.

It has been demonstrated that muscle pH has a direct effect on bacterial growth on raw meat surfaces by altering the availability of specific nutrients necessary for growth (Newton and Gill 1981). High pH meat, and products made from it, spoils more rapidly than normal meat (Nicol *et al,* 1970). Shay and Egan (1986) demonstrated that vacuum packaged pork of normal pH (5.4 – 5.8) had a storage life of 6 weeks at 0°C, but in contrast vacuum packaged pork with a meat pH greater than 6.0 often spoilt after 3-4 weeks of storage.

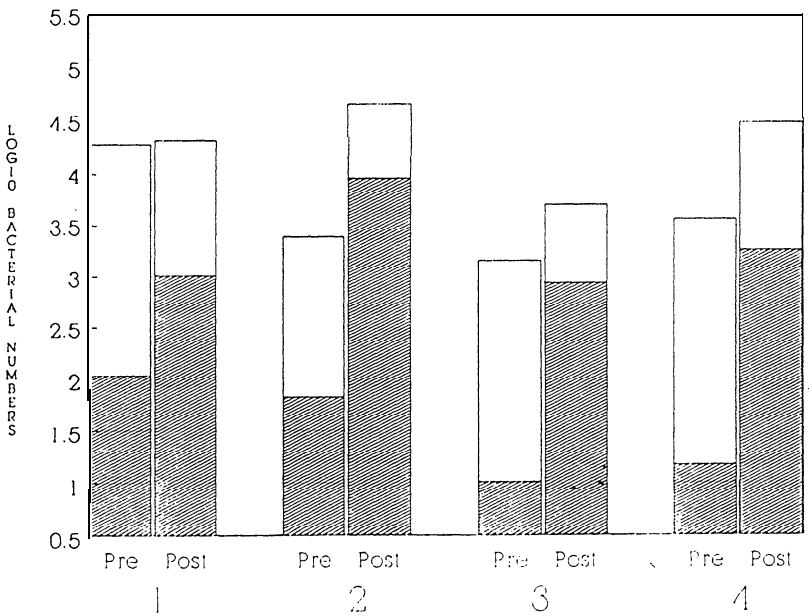

Fig. 1. Effect of the boning process on bacterial numbers on pork. Results are presented as total (dotted bar) and Pseudomonad (hatched bar) counts for four abattoir visits.

CONCLUSIONS

C.P. McPHEE

The contract papers detail procedures used in Australia to ensure the consumer is provided with pig meat which is nutritious, palatable and free from deleterious agents.

There has been a considerable advance in the prediction of carcase lean using slaughter line probes which measure the depth of subcutaneous fat and sometimes muscle thickness. Current emphasis is on the automation of these probes, the most sophisticated being the Danish Robotic probe which takes 17 simultaneous measurements. The probes currently in use account for up to 80% of the variance in lean content. Further improvements in prediction are likely with electromagnetic scanning equipment. Interest is being shown in the prediction of carcases which develop the DFD (dry, firm, dark) and PSE (pale, soft, exudative) conditions as a result of stressful handling conditions for pigs between farm and slaughter. The most promising predictor is internal reflectance measured by probe 24 h after slaughter. An accurate slaughter line predictor has yet to be developed.

Much is now known of treatments which can be applied during growth to attain the desired amount of lean in the carcase. The relationship between energy intake and lean deposition has a linear increasing phase approaching a maximum response. The slope of the linear phase and the energy intake at maximum lean deposition depend on live weight, genotype and sex. A single gene, the halothane gene, has been found in pigs which increases the lean yield of carcases at the expense of increasing the incidence of PSE meat and death when conditions are stressful (McPhee *et al.* 1979). Repartitioning agents such as porcine somatotropin and B-agonists have been shown to increase lean growth at the expense of fat by around 30%. This effect appears to be independent of genotype but reduces the difference between the sexes, There are problems in consumer acceptance, difficulty in applying treatment and a suggestion of reduced eating quality of meat from pigs treated with these agents,

Chemical residue testing of pig meat has been implemented throughout Australia. Safe levels have been set by the National Health and Medical Research Council and trace back and correction programmes backed by quarantine *powers* are implemented by State Governments. Pesticides assayed for are mainly organochlorides (OC) and organophosphate (OP), both of which concentrate in fat depots. Renal fat is the preferred tissue for assay, A screening test carried out on kidney, liver and muscle fluids detects the presence of antimicrobial agents but is unable to distinguish between antibiotics. In a recent national survey, 0.1% of samples contained levels of OCs and OPs higher than the set limits and 4.7% contained sulphonamide residues above the limits.

The processes of scalding, dehairing and washing after slaughter all contribute to microbial contamination of pig carcases. Modification of these processes which could significantly reduce this contamination are high temperature and pressure of washing water, the use of tunnel singeing ovens, high volume air movemnet during chilling and the maintenance of optimum muscle pH levels during storage.

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