

# **MEAT EATING QUALITY – A WHOLE CHAIN APPROACH**

## **Factors Affecting Pigmeat Eating Quality**

**Final Report to SEERAD from**

**SAC**

**University of Bristol**

**University of Newcastle**

**BioSS**

**SFQC**

**In collaboration with QMS**

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## **Final Report: Pigs**

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## Executive summary

The aim of this work was to investigate factors affecting the eating quality of pigmeat produced in Scotland and, in particular, to evaluate the consequences of increasing slaughter weight to obtain more cost-efficient production.

A total of 16 farms, all conforming to current best practice defined by the Scottish Farm Assurance Scheme, produced contemporary pigs of either heavy (~90 kg deadweight) or conventional (~75 kg deadweight) weight at slaughter. From each farm, 8 pigs were selected at the abattoir to give full representation of a factorial design including slaughter weight, gender and carcass selection criteria (based on fatness and muscle pH). Selected carcasses were split to provide a within-animal comparison of Enhanced processing (hip suspension and 10-day conditioning) against Basal processing (achilles suspension and 5-day conditioning).

256 meat samples from 128 pigs were subject to assessment by a trained sensory panel. 64 meat samples from 32 pigs, derived from a representative subset of 4 of the 16 farms, were also subject to assessment by a consumer panel in take home studies.

Key findings are:

- The precise experimental design was effective in detecting, as statistically significant, differences of 0.1-0.2 units in eating quality attributes of pigmeat on the 1-8 scale used by the trained sensory panel. The trained panel achieved a greater separation between the different objective sensory attributes than the take home panel, who appeared to score all hedonic attributes according to a more generalised liking of the sample. Tenderness was much more important than juiciness in determining overall consumer liking.
- The pork samples evaluated in this project were of good quality, as indicated by an average score of 6 on a 1-8 scale by the consumer panel for overall acceptability.
- In pigs of an appropriate genotype, and with good nutrition and management, increasing slaughter weight to a mean of 90 kg deadweight had no detrimental effect on eating quality attributes and did not significantly increase risk of boar taint. The trained sensory panel detected no differences in intensity of quality attributes, whilst the consumer panel scored eating quality of meat from heavy pigs significantly more highly. Thus, increasing slaughter weight under carefully controlled conditions can be expected to improve consumer perception of eating quality of the product and may also improve perception of value for money with a larger portion size.
- Relatively few sampled pigs showed post mortem muscle pH changes which would be indicative of reduced meat quality (PSE or DFD). This reflects the careful management applied during transport and lairage under current Scottish Farm Assurance guidelines.
- Selection of carcasses post-slaughter according to quality thresholds for fatness and muscle pH resulted in samples differentiated primarily by fatness, as a result of the consistently good pH results in the source population. The 4mm difference in fatness resulted in small but significant improvements in texture and flavour, as assessed by a trained sensory panel. In consumer panel assessments, significant benefits for eating quality were counterbalanced by higher levels of perceived fat, which were viewed as undesirable. Selection for a minimum threshold of carcass fat would therefore appear to offer some possibilities for potential niche marketing of higher eating quality pigmeat, but only if combined with fat trimming of the product. This negative perception of fatness would also need to be carefully screened if increases in slaughter weight were associated with greater changes in carcass fatness when applied across a more diverse population of pigs.

- Enhanced post-slaughter processing, comprising a combination of hip suspension and prolonged ageing, gave conflicting outcomes for objective sensory attributes assessed by the trained sensory panel, with enhanced tenderness but reduced juiciness. However, the consumer panel scored positive benefits for all hedonic attributes of eating quality. In view of these very positive results, the relative contributions of hip suspension and prolonged ageing to these beneficial effects justify further evaluation, since both incur a carcass processing cost which could be reduced if either procedure alone could give all, or the majority, of the benefit.
- Although the design of the investigation was optimised to precisely define the effects of Processing, Gender, Weight and P<sub>2</sub>, the implication of the results of the further analyses is that differences in husbandry (breed type, housing and feeding system) between farms were not sufficiently large to consistently affect eating quality attributes. The effect of slaughter date was of greater significance than the farm effect. This effect may be attributable to the combined effect of a wide variety of both the pre- and post-slaughter conditions, which can differ between individual days of slaughter.

## **BACKGROUND**

A pilot study to gather information on current practices for the production and supply of red meat in Scotland and to identify potential enhanced practices was carried out by MLC and QMS in 2002. This study involved discussions with industry and consumers, and a review of the scientific literature to provide descriptions of the current and enhanced practices to consistently deliver meat that will satisfy consumer demands for quality and eating experience.

To improve the eating quality and consistency of pigmeat, research indicates that pigs should achieve a rapid rate of growth in the finishing period and have adequate P<sub>2</sub> backfat thickness at slaughter. Whilst most of the on-farm factors identified as enhancing meat quality are already standard commercial practice, variability in pigmeat eating quality is still a problem and the reasons for this are poorly understood. Particular uncertainty exists about the effect of increasing slaughter weight on eating quality. This is a current development within the Scottish industry which is highly desirable to reduce cost of production by spreading overhead costs between more kg of saleable meat per carcass; a 10% increase in slaughter weight can reduce cost of pigmeat production by 3-4p per kg deadweight. However, such a strategy means that pigs will be older at slaughter, which carries uncertainties about the risk of increased toughness and boar taint. Consequently, there is a need for data from current commercial genotypes and production systems to address this concern.

In targeting a market for branded pigmeat of high eating quality, there may also be beneficial strategies for adoption in carcass selection and post-slaughter management. These also require evaluation under current Scottish commercial conditions.

These questions were addressed within the pigmeat component of an overarching research project on the improvement of eating quality in the Scottish red meat sector.

## **OBJECTIVES AND EXPERIMENTAL DESIGN**

The objectives of the trial were:

1. To examine the effect of increasing slaughter weight on eating quality.
2. To obtain a better understanding of other pre- and post-slaughter factors affecting eating quality.

To achieve these objectives, the pigmeat production chain was monitored on farm, through the transport and slaughter process, and during the management of the product post slaughter. At different points in the chain, the following structured comparisons were made:

On farm:	comparison of two slaughter weights and two genders.
At slaughter:	comparison of carcasses which met or failed to meet specific thresholds for fatness and muscle pH.
During processing:	comparison of an Enhanced v Basal processing regime incorporating different hanging techniques and maturation times.

Each of 16 farms supplied 16 different pigmeat samples from 8 pigs for sensory evaluation according to a balanced experimental design, comprising 2 weights (W) x 2 sexes (G) x 2 carcass categories (C) x 2 processing treatments (P). Comparisons of the effects of weight, gender and carcass category were carried out between animals, whilst comparisons of processing treatment effects were carried out between different sides of the same animal.

## METHODS

### On-farm

A total of sixteen farms provided pigs for the study. All participating farms were checked to ensure that they conformed with the criteria identified as enhancing eating quality in the earlier MLC/QMS report. Key points in this review were as follows:

- Entire male and female pigs from all breeds and crosses in current commercial use in Scotland were acceptable, but lines which carry the halothane gene were excluded because of their greater stress susceptibility at the time of slaughter which impairs meat quality.
- The pigs must have been fed *ad libitum* on diets which allowed them to achieve their lean growth potential, as faster growing pigs produce more tender meat.
- The target age at slaughter was less than 180 days.
- The finishing diet could not contain excessive levels of particular raw materials that are known to increase risk of taint in the meat (e.g. fishmeal) or soft fat problems (e.g. high linoleic acid).

Each participating farm produced two different groups of pigs with different target carcass weights (~75 kg deadweight and ~90 kg deadweight). A trials officer from SFQC visited the farm approximately 4 weeks before the planned slaughter date to check that the production standards for enhanced farm quality were being met and to identify groups of pigs which should reach the correct age and liveweight in the designated week of slaughter (See Appendix I). The pigs for the study were identified, weighed and tagged with individually numbered ear tags (double tagged for security). Each farm was asked to produce ~20 pigs in each weight category (10 males and 10 females) for slaughter on a single agreed day. Slaughter dates were divided equally between two seasons - spring (April/May) and summer (July/August).

During the farm visit the trials officer noted the genotype, housing system and feeding system of the pigs. He also took full details of the diets being used and a sample of feed for archiving.

### Transport and slaughter

On the day of slaughter (or day before, for early morning despatch) the trial pigs were weighed and individually slap marked on both shoulders. The slap number was recorded against the ear tag on the record sheet provided. Pigs were not mixed in the 7 days prior to despatch to avoid pre-slaughter stress which might affect meat quality. For the same reason, loading was carried out with minimal stress and pigs were given a space allowance of at least 0.42 m<sup>2</sup>/ 100 kg liveweight on the lorry (0.42 m<sup>2</sup> per pig for light pigs, 0.5 m<sup>2</sup> per pig for heavy pigs). The time of departure from the farm, time of pig arrival and unloading time at the abattoir were recorded. The journey distance, ambient temperature (measured in the shade outside the lairage) and temperature in the centre of the lairage, three feet above a group of pigs, were recorded.

While in the lairage, animals had access to adequate fresh potable water in clean, draught-free pens with well drained, insulated and non-slip floors. Pigs were held in lairage for the minimum period necessary to complete paperwork. They were then moved to the stun area, with the time noted, and electrically stunned according to normal abattoir practice.

## **Carcass processing**

Pig carcasses were divided into two categories according to whether or not they met a set of carcass criteria defining parameters known to affect eating quality (see Appendix II). To qualify for the quality selection group, carcasses had to meet the following criteria:

- a P<sub>2</sub> backfat thickness above 12mm
- a muscle pH not below 6.00 at 45 minutes post-slaughter, and not above 5.80 at 24 hours. (these values are indicative of Pale Soft Exudative meat, and Dark Firm Dry meat respectively).

From slaughter weight groups within each farm, one male and one female carcass which met the quality selection criteria, and one of each gender which failed the quality selection criteria were identified to provide samples for subsequent sensory evaluation. These were selected by taking the first animals on the slaughter line within the farm batch that met the specified criteria. These carcasses were hung such that one side was hip suspended, immediately after dressing and before removing to the chiller (Enhanced carcass processing), whilst the other side of the same carcass remained Achilles hung (Basal carcass processing) in such a way that the weight of the head produced equal tension on each side of the carcass. This enabled subsequent assessment of the effect of processing treatment to be carried out within animal, giving greater precision.

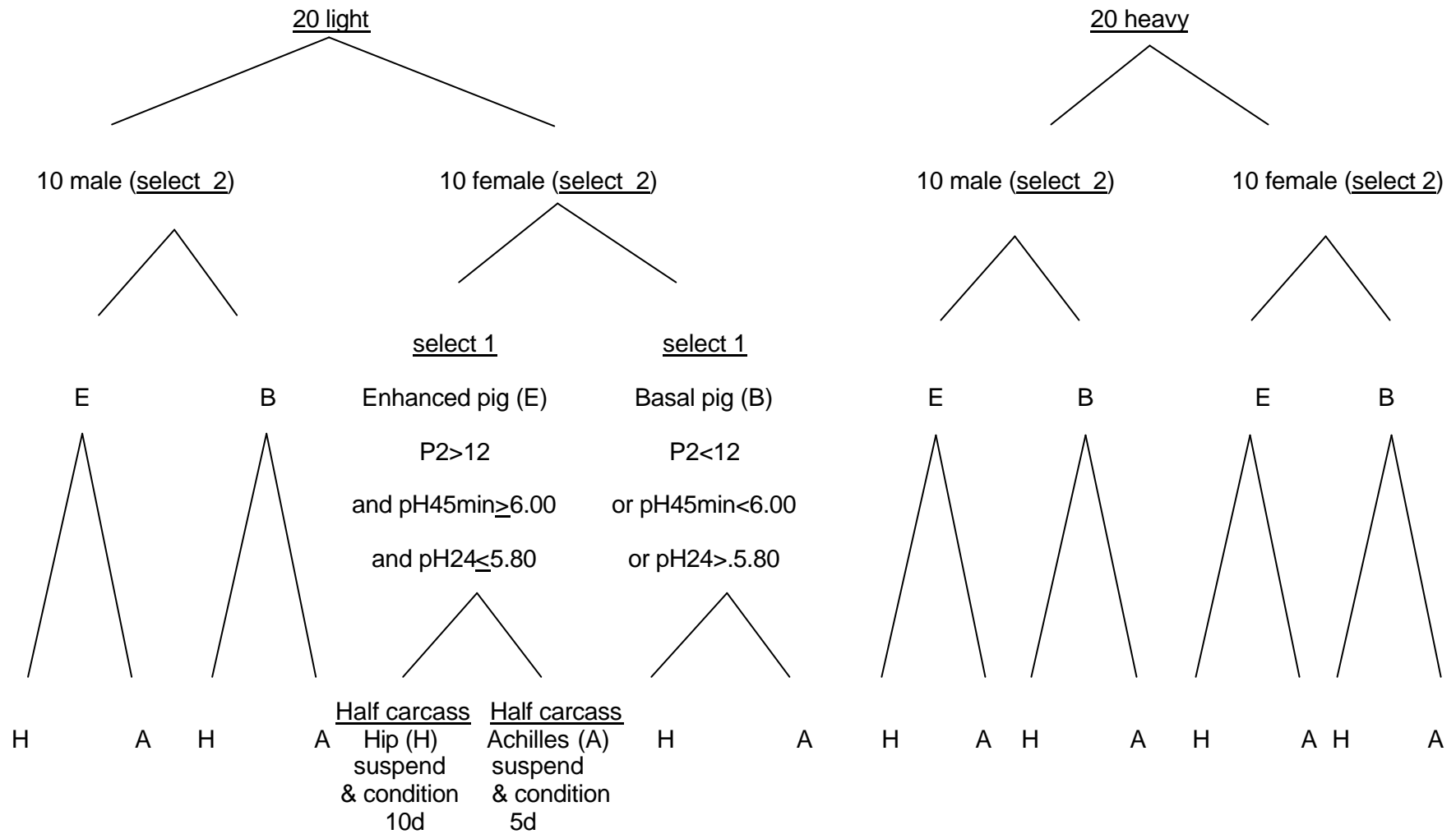
The selected carcasses were cut into primals at 24 hours. A sample joint comprising a minimum of 30 cm of loin from both sides from the anterior (head) end of deboned loin was taken. The whole loin was taken from those carcasses to be used for consumer testing. These de-boned loin primals were aged for a total period of 5 days (Basal processing) or of 10d (Enhanced processing) post-slaughter in vacuum bags. The Enhanced carcass processing treatment therefore comprised a combination of improved hanging method and prolonged conditioning, with these two factors being tested as a package against the Basal processing treatment. The 5 and 10 day conditioning periods represented 2 and 7 days from day of kill plus 3 days average time for retailing and consumption. Primals were delivered to Bristol University within 4d of kill so that conditioning finished in Bristol. At the end of the conditioning period, samples were frozen and stored at -20°C until sufficient samples had been accumulated ready for sensory analysis. Frozen loins were bandsawn to give 20mm loin steaks.

A diagrammatic representation of the full experimental design is shown in Figure 1. Each of the 16 farms thus supplied a sample of ~40 pigs, divided between the two target slaughter weights. At the abattoir, 8 pigs per farm were selected to give one representative of each combination of gender, weight category and carcass selection category (as in Figure 1). The carcasses from all of these selected pigs were then split to give a detailed within-animal comparison of Enhanced and Basal processing treatments.

## **Assessments of eating quality**

Two different assessments of eating quality were made within the study. The first involved assessment by a trained sensory panel in controlled facilities at Bristol University, whilst the second involved assessment by a consumer panel in a take home study. These two panels serve different functions, with the sensory panel trained to objectively evaluate specific properties of meat in isolation of each other, whilst the consumer panel reports on the extent of liking of different attributes of the meat. When comparing sensory and consumer results, it is therefore important to qualify the conditions under which results are obtained. Firstly, the questions for the sensory panel are, “directional”, by this we mean that increases in the intensity of an attribute should, if above the threshold of detection, elicit increases in the response. Assessors are effectively asked to quantify the intensity of the attribute. Consumers are using an “hedonic” scale whereby they are asked how much they like a particular attribute.

**Figure 1. The trial design indicating the sampling strategy for pigs from each individual farm**



The conditions under which the two sets of data are collected are also very different. A trained panel is conducted in a controlled environment, with no discussion or vocalisation between assessors when the panel is in progress. Samples comprising only lean meat are presented in specific orders and, in this case, appearance factors are masked by red light. The tests therefore offer a direct comparison between samples. A take home study supplies just one sample per visit and therefore the comparison is with the experience of the consumer against their perception and expectation of how the meat should taste. Individual family members may well influence other members in the household. The differences between the two panel types are summarised in the following table.

<b><i>Attribute</i></b>	<b><i>Sensory Panel</i></b>	<b><i>Consumer Panel</i></b>
1. People difference	Assessors of known sensory acuity. Trained to assess each attribute independently.	Unknown sensory acuity. Untrained, may be influenced by one attribute when scoring a second.
2. Health	Assessors fit and well. Free from colds, hay-fever. No dentures or dental problems. No medication being taken that could influence assessments.	Unknown.
3. Test environment	No communication between assessors during sessions.	Family members may influence each other at the dinner table*
4. Design constraints	Direct comparison between samples during the test.	Monadic presentation, no direct comparison. Tests often 1 week apart.
5. Questionnaire difference and Psychological task difference.	Intensity scales used for texture, flavour, juiciness e.g. how tough? extremely tough. How tender? extremely tender. These scales are directional, because an intensity of a stimulus is being measured.	Hedonic scales used, degrees of liking. Texture liking?, like extremely. These scales are non-directional because a preference or liking is being measured, so some people might prefer meat with, “bite” whilst others prefer meat that is easy to chew.
6. Environment & technology	Test takes place under controlled conditions, separate panel booths, red light, direct entry of results into a computer	Domestic conditions, distractions, results entered on panel forms.
7. Technology	Highly controlled cooking to a set endpoint temperature thus reducing bias caused by different endpoint temperatures. 7 <sup>0</sup> C difference will affect sensory attributes.	Steaks cooked for a time based on experience to achieve a level of doneness preferred by the family.
8. Presentation	Section of lean muscle served, trimmed of all fat and connective tissue. Lean tasted in isolation.	Each family member receives a whole steak/ chop. Steak/ chop tasted as part of a meal, so other flavours (apple sauce, mustard) Succulence providers (Gravy, juices from vegetables, sub-cut fat from the meat) present and may influence juiciness.

\*Variations in liking are less among individuals within a household than between households and reduced as the number of individuals in a household increased [Dransfield, E., Martin, J-F., Fisher, A., Nute, G.R., Zygyiannis, D., Stamatari, C., Thorkelsson, G., Valdimarsdottir, T., Piasentier, E., Mills, C., Sanudo, C and Alfonso, M. 2000. Home Placement Testing of Lamb Conducted in Six Countries. *Journal of Sensory Studies*, 15: 421-436]

## Sensory panel (trained taste panel)

### *Cooking*

Prior to the morning of sensory assessment, pork samples were removed from the freezer, initially thawed at room temperature and then stored overnight in a refrigerator set at 4°C. Pork loin steaks were cooked, turning every 3 minutes, on a griddle (Lincat Model GS7, Lincat Ltd, Lincoln, UK) until the internal temperature of the pork, as measured by a hand held thermocouple, reached 72.5°C in the geometric centre. The pork was then placed in a holding oven set at 60°C. The pork was then sub-sampled and cut into samples approximately 2 x 2 x 2 cm sections. These sections were wrapped in pre-coded aluminium foil and served to individual assessors. At each session, assessors received 2 samples of pork from the same pig, one sample having received basal processing and the other enhanced processing. In the course of a morning 8 sessions were run comprising 4 blocks of two adjacent sessions, such that 2 blocks were all gilt meat and 2 blocks were entire males, i.e. 16 samples per morning. The animal treatments of weight and P<sub>2</sub> were balanced within blocks. Pork was assessed from only one farm in a morning.

### *Sensory Assessment*

Sensory assessors were screened and selected on the basis of their ability to discriminate and describe a list of attributes. The initial screening followed the recommendations given in British Standard BS7667, Part 1 [Guide to the selection, training and monitoring of selected assessors]. Further training in the assessment of pork followed the procedures outlined in Wood & Nute (1995) [The Effect of Cooking Conditions on the Eating Quality of Pork. *Meat Science* 40 127-135]. Additional training in the recognition and detection of androstenone and skatole used the triangular test method [BS5929, 1984, Methods for sensory analysis of food. Triangular test].

Ten assessors (all female, age range 25 – 60) formed the panel. Previous investigation has indicated that there are no significant gender differences in the sensory assessments made [Jellinek G. (1985) General testing conditions, Test subjects. In: *Sensory Evaluation of Food, Theory and Practice*. Ellis Horwood, Chichester, England. p24], with the exception that female panellists show greater sensitivity to some abnormal flavours and odours. In pork there are differences in the ability to detect androstenone. Basically, men are less sensitive than women and require a much higher concentration of androstenone before reaching recognition threshold. However, when they do, the perception and description of the stimulus is similar. It is important to remember that the criteria used to select sensory assessors are based on their ability to achieve a standard of taste sensitivity and odour recognition. The thresholds used in these tests have been based on physiological experiments investigating the sensitivity of taste and odour, and are documented in the British Standard BS7667, Part 1:1993, also adopted by ISO 8586-1:1993.

The panellists were asked to rate samples on an 8-point scale for:

- texture (1= extremely tough to 8=extremely tender),
- juiciness (1=extremely dry to 8=extremely juicy),
- pork flavour intensity (1= extremely weak to 8 =extremely strong),
- abnormal flavour intensity (1= extremely weak to 8 =extremely strong).

All assessments were completed in a purpose built panel room, illuminated with red light, comprising individual booths each fitted with a sensory computer that facilitated direct entry of results by the assessors. The order of sample presentation was structured to reduce the influence of first-order carry over effects.

### Consumer Testing - Take home panel

Families living in the area surrounding Bristol were asked to take part in the trial. They were told they would receive samples of vacuum packed frozen loin at intervals over a four-week period. Data were collected on family composition, educational status and the importance (0-10 scale), for each family member separately, of 12 attributes when purchasing and eating meat (see Appendix III). Participants were given instructions on how to thaw the pork; i.e. remove from the freezer 24 hours before cooking and place in a domestic refrigerator. Families were asked to grill the pork and serve as part of a meal and to ensure that they used the same cooking procedure over the four weeks. The person preparing the meat (“Cook”) was asked to answer questions on the Visual and Cooking quality of each sample of meat (0-10 scale). Each family member was asked to complete a questionnaire which contained four, 8point category scales covering tenderness, juiciness, flavour and overall acceptability, where 1=dislike extremely to 8=like extremely.

A total of 48 families, comprising 143 Family members completed the tests. Two families consisted of 5 people, 10 of 4, 21 of 3 and 15 of 2. The Age and Gender distribution of family members was:

Gender	Male	Female
Age (years)		
<25	17	13
25-35	8	5
35-50	27	28
>50	19	24
Total	71	70

Non-respondents 2

Their educational status was:

	Number
School to 16	58
School to 18	37
Graduate	45

Non-respondents 3

Family members were asked about frequency of consumption of meat and fish.

Meat/Fish	Pork	Beef	Lamb	Chicken	Fish
Frequency:					
Weekly	25	57	20	108	51
2-3 times/month	63	46	51	25	44
Once/month	24	20	41	3	19
<once/month	23	13	20	3	17
Never	4	3	7	0	8
Total	139	139	139	139	139

Non-respondents 4

Family members were asked to rate each of the qualities given below on a 0-10 scale. The qualities are ordered by mean preference, with higher scores being a greater preference.

Quality	Average Score
Brand	2.79
Packaging	3.12
Store	4.99
Liquid in cooking	5.62
Butcher	5.76
Price	6.45
Liquid in package	6.68
Colour	7.05
Visible fat	7.59
Flavour	8.10
Juiciness	8.32
Tenderness	8.67

### Statistical design and analyses

It is important that the conclusions from this study can be applied across a range of farming and processing conditions, each of which will be slightly different. This study was carefully designed to achieve robust results. Careful design of the study also maximised the information available and thus ensured the resources were used to maximum effect.

There are three main design elements. The first of these is the identification of suitable live animals for processing; the second the design of the processing of the animals to give samples for evaluation and the third the design of the sensory testing of the samples. A proportion (25%) of the samples tested together in the blocks of the sensory design were evaluated by families of the take-home panel.

Taking each of these levels of design in turn:

1. Two different farms were selected to supply pigs for processing on each of 8 Kill dates (4 in Spring and 4 in Summer). Using information collected about the 16 farms, they were categorised by housing system (slats v no slats), feeding system (liquid, home-mix, compound pellets) and proportion of Duroc genes in the dam breed (0 v 25%).
2. Each farm supplied pigs of both genders and at two different weights. At slaughter the carcasses were categorised as conforming to the “enhanced” specification or as “basal” by a requirement to have a P<sub>2</sub> of 12mm or more as well as a suitable pH at 45 minutes and at 24 hours post-slaughter. The aim was to get 8 carcasses, one with each combination of gender, weight and P<sub>2</sub>/pH specification. The carcasses were then split and one half received basal processing and the other half enhanced processing. Thus 16 samples derived from 8 animals were sourced from each farm.
3. The sensory laboratory evaluated the samples from each farm on different days. Two samples were cooked together and served to the sensory assessors at a time. The order of evaluation was determined independently for each assessor so that each sample was evaluated first by half the assessors. The samples tested together were from one animal, one sample being from basal processing and one sample from enhanced processing. This process was repeated 8 times in the sensory day. Adjacent pairs of samples were grouped together into “Blocks” and balanced combinations of Weight and P<sub>2</sub> class were allocated to pairs within blocks. Each block consisted of samples from animals of the same gender. Thus the degree of precision in

comparison was greatest for post-slaughter processing method, then for Weight and P<sub>2</sub> class, then for gender, and least precise for farm comparisons.

4. One constraint of take-home panels is that all the family must test the same sub-samples at the same time. Also from a logistical viewpoint, in order to minimise the amount of meat required, and to control the amount of resources required to prepare samples for testing, they must be drawn from as few carcasses as possible. Accordingly the samples for the take-home panel were drawn from 2 of the 8 Kills. A retrospective check was carried out to ensure that the Kills from which these samples were derived were typical of the overall population for the categories which they represented. This confirmed that they did not differ significantly from the source population in terms of animal, carcass or sensory panel characteristics. Samples from a Block of the sensory design provided sub-samples for take-home testing by several families. Thus all meat tested by a family was from animals of the same gender.

Clearly simple analysis of such a complicated data set would not do justice to the quality of the data, which were collected with meticulous care. More importantly, simple analysis would run the risk of coming to misleading conclusions.

There are many advantages in developing a one-stage analysis that allows both design aspects from the measuring process and from the source of the samples to be integrated. This form of analysis, which is known as meta-analysis, is widely used in clinical trials in human and veterinary medicine. In agriculture it is used to integrate data from variety trials carried out at different centres in the UK and in different years. It is only comparatively recently (since approximately 1990) that such techniques have become widely available in specialised statistical packages.

#### *Sensory panel*

A model with several random (error) terms, together with fixed terms was fitted using Residual Maximum Likelihood (REML). The statistical program Genstat was used for this purpose.

The Fixed model was

Order (of testing) + Processing \* Gender \* Weight \* P<sub>2</sub>

and the random model

Assessor/Day/Block/Session/Order+Kill/Slap/Sample

The random model was shown to be justified by the data using tests of differences in deviances.

#### *Take-home panel*

As with the sensory data, a model with several random (error) terms, together with fixed terms was fitted using Residual Maximum Likelihood (REML).

The fixed model was:

Order (of testing) + Kill + Processing \* Gender \* Weight \* P<sub>2</sub>

For both the “Visual and Cooking Quality” and “Eating Quality” data the random model was:

Household+Sample

More complicated random models, with a term for family member, were tested for the Eating Quality data, but were not found to be justified using a test of differences in deviance.

## RESULTS

In this section, tabulated results are given for three different populations of pigs. The *source population* refers to all pigs allocated to trial groups on farm (N=675 pigs across 16 different farms). From these pigs, a subset of 128 animals (8 per farm) were selected at the abattoir according to the criteria shown in Figure 1 to supply pigmeat *samples for sensory analysis* by the trained taste panel. A subset of these pigs (32 animals from 4 farms) was then further selected to also supply pigmeat samples for *consumer assessment in a take home panel study*.

All results presented in the tables are derived from the composite statistical analysis in which all factors in the experimental design were simultaneously included, as detailed in the methods. However, for simplicity of presentation, the main effects of treatment factors and first order interactions of interest are shown sequentially in separate tables.

### Effects of slaughter weight

Table 1a shows the characteristics of the pigs sampled for sensory analysis in each of the slaughter weight categories. The results show that on average the sampled pigs matched the target values of 75 and 90 kg deadweight. As expected, heavier pigs had a higher level of fat and better killing out percentage. On-farm performance prior to slaughter was not statistically different in terms of liveweight gain. The light pigs were 2 weeks younger at slaughter and the ages, calculated from the birth weeks identified by the source farm, indicate very good growth rate throughout their lifetime.

**Table 1a. Characterisation of the animals supplying pigmeat samples for sensory analyses according to slaughter weight category**

	Light	Heavy	Sed	Sig
N	64	64		
Final liveweight (kg)	100.9	122.3	1.17	***
Carcass wt (kg)	73.4	90.9	0.79	***
Backfat (mm P <sub>2</sub> )	11.22	12.62	0.265	***
Liveweight gain pre-slaughter (g/d)	820	861	29.5	ns
Killing out %	72.85	74.37	0.352	***
Age at slaughter (days)	139.4	154.8	3.50	***

Sed = standard error of difference; Sig = level of significance

\*\*\* = P<0.001; \*\* = P<0.01; \* = P<0.05

The extent to which the sampled pigs were representative of the source population produced on the collaborating farms is shown by the values for all pigs which were initially tagged on farm (Table 1b). Comparison of Tables 1a and 1b indicates that the sampled pigs gave good representation. It is worthy of note that the increase in backfat thickness associated with increasing carcass weight was 2mm per 20kg. This is at the lower end of previous estimates, with 1mm per 5 kg often taken as a rule of thumb, and suggests that the pigs were of high genetic quality. This is an important criterion when assessing suitability of a farm for heavier pig production, since excess fat is viewed adversely by consumers (see later).

**Table 1b. Characterisation of the source population of trial animals according to slaughter weight category**

	Light	Heavy	Sed	Sig
N	331	344		
Final liveweight (kg)	101.5	120.7	0.51	***
Carcass wt (kg)	74.3	89.6	0.40	***
Backfat (mm P <sub>2</sub> )	11.05	13.07	0.214	***
Liveweight gain pre-slaughter (g/d)	838	824	14.1	ns
Killing out %	73.12	74.21	0.175	***

*Effects of gender and their interaction with slaughter weight*

Comparison of pigs of different gender in the sample for sensory analysis showed that females tended to be fatter and slower growing in the month prior to slaughter, but had higher killing out percentages. The effects of gender were the same at both slaughter weights, as indicated by the lack of any significant statistical interaction (Table 2a).

**Table 2a. Characterisation of the animals supplying pigmeat samples for sensory analyses according to gender (G) within slaughter weight (W) category**

	Light		Heavy		Sed	Sig	
	Male	Female	Male	Female		G	G.W
N	32	32	32	32			
Final liveweight (kg)	101.8	100.1	124.2	120.4	1.66	*	ns
Carcass wt (kg)	73.6	73.3	91.7	90.1	1.12	ns	ns
Backfat (mm P <sub>2</sub> )	10.81	11.62	12.69	12.56	0.374	ns	ns
Liveweight gain pre-slaughter (g/d)	872	769	921	801	41.7	***	ns
Killing out %	72.43	73.28	73.84	74.89	0.498	**	ns

Once again, these differences in the sample for sensory analysis were representative of the population as a whole (Table 2b).

**Table 2b. Characterisation of the source population of trial animals according to gender (G) within slaughter weight (W) category**

	Light		Heavy		Sed	Sig.	
	Male	Female	Male	Female		G	G.W
N	161	170	172	172			
Final liveweight (kg)	102.4	100.6	122.2	119.3	0.70	***	ns
Carcass wt (kg)	74.4	74.2	90.0	89.3	0.55	ns	ns
Backfat (mm P <sub>2</sub> )	10.74	11.36	12.78	13.36	0.294	**	ns
Liveweight gain pre-slaughter (g/d)	874	802	857	791	19.4	***	ns
Killing out %	72.62	73.63	73.64	74.77	0.241	***	ns

The overall effects of slaughter weight on eating quality, as assessed by a trained sensory panel, are shown in Table 3a. The trained sensory panel assessments are designed to highlight relative differences in intensity of various sensory attributes between treatments, and do not indicate that

samples are good or bad in absolute terms. It is usual for means for texture and juiciness to be between 4 and 5 on the sensory scale that is adopted. Increasing slaughter weight did not have any negative effects on sensory attributes of the meat.

**Table 3a. The sensory characteristics of pigmeat, assessed by a trained sensory panel, according to slaughter weight category**

	Light	Heavy	Sed	Sig.
N	64	64		
Texture (1-8 scale, high = more tender)	4.33	4.22	0.082	ns
Juiciness (1-8 scale, high = more juicy)	4.47	4.43	0.081	ns
Pork flavour (1-8 scale, high = stronger flavour)	3.73	3.77	0.038	ns
Abnormal flavour (1-8 scale, high = stronger flavour)	2.98	3.07	0.077	ns

Table 3b shows the effects of slaughter weight on eating quality, as assessed by consumers in the take-home panel. The take home panel are asked to make judgements about acceptability while the experienced sensory panel make analytical judgements free of considerations of acceptability, which are undoubtedly influenced by both experience and personal preferences. In addition the sensory panel receive a portion of lean only from the meat cooked in a controlled way, whereas the take home panel cook the meat at home in less controlled conditions, and by a diversity of methods, prior to making their eating quality assessments on a portion comprising both lean and fat.

The take-home home panel noticed the greater steak size and amount of fat of samples from the heavier pigs and also greater liquid release when cooking. However, they clearly preferred the eating quality of meat from heavier pigs, scoring this significantly more highly for all attributes. Both categories had mean scores in the upper half of the 1-8 scale, indicating good quality. The differences in favour of meat from the heavier carcasses were relatively large, at 0.5-0.7 points on an 8-point scale.

The significantly higher preference of the consumer panel for the meat from Heavy pigs may reflect a favourable predisposing influence from the perception of greater steak size, and a greater beneficial effect of the higher fat level under home cooking conditions and when the lean and fat are eaten together in the portion. It is also possible that, since bigger chops take longer to cook, there may have been less chance of them being 'overcooked'. It is known that, as the cooking temperature increases, then abnormal flavour decreases but tenderness also decreases.

**Table 3b. The sensory characteristics of pigmeat, assessed by a take home panel, according to slaughter weight category**

	Light	Heavy	Sed	Sig.
N	16	16		
<i>Visual and Cooking Quality – Cook</i>				
Size of steak (0-small, 10-big)	4.55	5.91	0.322	***
Colour of lean (0-light, 10-dark)	4.74	4.93	0.338	ns
Colour of fat (0-white, 10-yellow)	4.06	3.80	0.337	ns
Amount of Visible fat (0-small, 10-large)	5.06	6.77	0.393	***
Acceptability of Amount of Visible fat (0-unacceptable, 10-acceptable)	5.31	4.82	0.457	ns
Liquid released in packaging (0-none, 10-very large amount)	4.14	3.87	0.469	ns
Uncooked Odour (0-weak, 10-strong)	2.62	2.90	0.365	ns
Cooking Odour (0-weak, 10-strong)	3.58	4.30	0.401	ns
Odour Liking (0-unpleasant, 10-pleasant)	5.84	5.86	0.304	ns
Amount of Liquid released whilst cooking (0-small, 10-large)	3.92	5.35	0.522	*
<i>Eating Quality – Family</i>				
Tenderness (1-8 scale, high = more likeable)	5.72	6.31	0.178	***
Juiciness (1-8 scale, high = more likeable)	5.40	6.10	0.184	***
Flavour (1-8 scale, high = more likeable)	5.84	6.33	0.173	*
Overall acceptability (1-8 scale, high = more acceptable)	5.72	6.30	0.188	**

Table 4a shows the effects of gender within slaughter weight category as assessed by the trained sensory panel. Males gave meat which was rated as more tender and more juicy than that from females. It had a stronger pork flavour, at heavier slaughter weights. Meat from males had a higher score for abnormal flavour, although the mean value was low in absolute terms. This was true at both slaughter weights, suggesting that the risk of boar taint had not been significantly increased in the heavy slaughter weight group. Overall, 5 pigs out of the 128 pigs were identified as showing some boar smell in the kitchen during cooking. These came from 5 different farms, and comprised entire male pigs with carcass weights ranging from 80.5 to 95.0 kg. Four samples from these pigs (2 sides from each of 2 pigs) were identified during panelling as having higher abnormal flavour. Overall, 6 pigs (from 5 different farms) were detected by the trained sensory panel as having high abnormal flavour (raw score of >4 on the 1-8 scale). These comprised 4 entire males (carcass weights of 70.0, 77.5, 81.5 and 95.0 kg) and 2 females (carcass weights of 76.0 and 77.5). Examination of the data failed to show any association of high values of Abnormal Flavour with any other measured factor.

**Table 4a. The sensory characteristics of pigmeat, assessed by a trained sensory panel, according to gender within slaughter weight category**

	Light		Heavy		Sed	Sig.	
	Male	Female	Male	Female		G	G.W
N	32	32	32	32			
Texture	4.44	4.21	4.31	4.13	0.116	**	ns
Juiciness	4.66	4.27	4.54	4.32	0.115	***	ns
Pork flavour	3.72	3.74	3.86	3.68	0.056	ns	**
Abnormal flavour	3.10	2.86	3.10	3.03	0.110	*	ns

Table 4b shows the effects of gender within slaughter weight category as assessed by the take home panel. Meat from males was perceived as fatter (although  $P_2$  was not significantly higher) and had greater liquid release in packaging and during cooking. It had significantly stronger odour, both before and during cooking, and this odour was rated as less pleasant than the odour from gilt meat. However, on an absolute scale, both gilts and boars scored above the mean value for pleasantness of cooking odour (>5 on a 0-10 scale). These effects of gender on odour were generally independent of slaughter weight, the only exception being cooking odour, which was similar for boars in both weight categories but stronger for the heavy gilts than the light gilts. This has no clear explanation, although it is possible that higher stocking rates at heavier weights might lead to increased skatole in the samples. There was therefore no suggestion of an increase in boar taint odour from heavier entire male carcasses. In contrast to the trained sensory panel results, there was no significant difference between the genders in any attribute of eating quality assessed by the take-home panel, nor was there any interaction between gender and slaughter weight.

**Table 4b. The sensory characteristics of pigmeat, assessed by a take home panel, according to gender within slaughter weight category**

	Light		Heavy		Sed	Sig.	
	Male	Female	Male	Female		G	G.W
N	8	8	8	8			
<i>Visual and Cooking Quality -Cook</i>							
Size of steak	4.33	4.77	4.92	4.90	0.431	ns	ns
Colour of lean	4.96	4.52	4.74	5.12	0.440	ns	ns
Colour of fat	4.31	3.80	3.79	3.80	0.448	ns	ns
Amount of visible fat	5.38	4.75	7.27	6.27	0.529	*	ns
Acceptability of amount of visible fat	4.94	5.68	4.45	5.19	0.572	ns	ns
Liquid released in packaging	4.78	3.49	4.49	3.25	0.602	**	ns
Uncooked Odour	3.27	1.98	3.27	2.53	0.473	**	ns
Cooking Odour	4.29	2.87	4.43	4.16	0.521	*	*
Odour Liking	5.34	6.34	5.59	6.13	0.411	*	ns
Amount of Liquid released whilst cooking	4.04	3.80	6.07	4.64	0.583	*	ns
<i>Eating Quality -Family</i>							
Tenderness	5.67	5.76	6.32	6.30	0.256	ns	ns
Juiciness	5.33	5.47	6.11	6.08	0.260	ns	ns
Flavour	5.76	5.93	6.30	6.35	0.242	ns	ns
Overall acceptability	5.57	5.86	6.30	6.30	0.253	ns	ns

Comparing the results of sensory and consumer panels, the sensory panel detected significant effects of gender on texture and juiciness, and significant interactive effects for pork flavour with respect to carcass weight category, which were not detected by the consumer panel. Meat samples from male pigs showed increases in sensory texture of 0.23 and 0.18 respectively in light and heavy pigs. These may reflect the higher growth rates of male pigs in the pre-slaughter period. The consumer results imply that although a highly trained panel can detect these small differences they are not sufficiently large to be detected by consumers when tasted at home. A similar scenario occurs for juiciness where the sensory differences between genders were 0.39 and 0.22 for light and heavy pigs respectively. However, it must be borne in mind that pigs of different gender were not compared within family, since the statistical design gave more priority to precision of comparison of other treatment effects.

### Effects of carcass selection

The characteristics of the selected carcasses that met the post slaughter quality criteria (in terms of backfat thickness and muscle pH) are shown in Table 5a. The majority of carcasses identified as not conforming were attributable to low P<sub>2</sub> value, although a few failed to meet the pH criteria. In the population as a whole, 14% of 639 carcasses had a pH<sub>45</sub> which was <6.0. A quarter of these occurred on one particularly hot day which, if excluded, reduced the overall prevalence to 12%. This is towards the lower end of typical industry values of between 10-20%. There was almost no occurrence in sampled carcasses of a pH<sub>24</sub> which was >5.8. The mean carcass pH values therefore did not differ significantly between the selection criteria groups, or between animals of different weight or gender. Conforming carcasses had a 4mm greater average P<sub>2</sub> fat thickness, but this was accompanied by only a small increase in tenderness and a stronger pork flavour when assessed by the trained sensory panel; juiciness was surprisingly unaffected.

**Table 5a. The carcass and sensory characteristics of pigmeat, assessed by a trained sensory panel, according to carcass quality category after slaughter**

	Not meeting criteria	Meeting criteria	Sed	Sig
N	64	64		
Carcass weight (kg)	81.0	83.3	0.79	**
Backfat (mm P <sub>2</sub> )	9.78	14.06	0.265	***
pH1	6.34	6.35	0.040	ns
pH2	5.64	5.63	0.013	ns
Texture	4.19	4.36	0.082	*
Juiciness	4.49	4.41	0.081	ns
Pork flavour	3.69	3.81	0.037	***
Abnormal flavour	3.02	3.02	0.077	ns

Figure 2 shows how these P<sub>2</sub> values related to the population as a whole. The median values for the light and heavy slaughter weight source populations are not dissimilar to those of the selected carcasses which met, or failed to meet the carcass selection criteria for fatness. However, it must be borne in mind when interpreting trial results on the effects of slaughter weight that the experimental design evaluated effects of slaughter weight independently from those of carcass selection criteria (and hence such large differences in fatness). The apparent under-representation of heavy pigs with a P<sub>2</sub> of 12mm has no logical explanation and is likely to just be a result of sampling variation.

**Figure 2. The source population distribution of carcass backfat (mm  $P_2$ ) according to slaughter weight category**

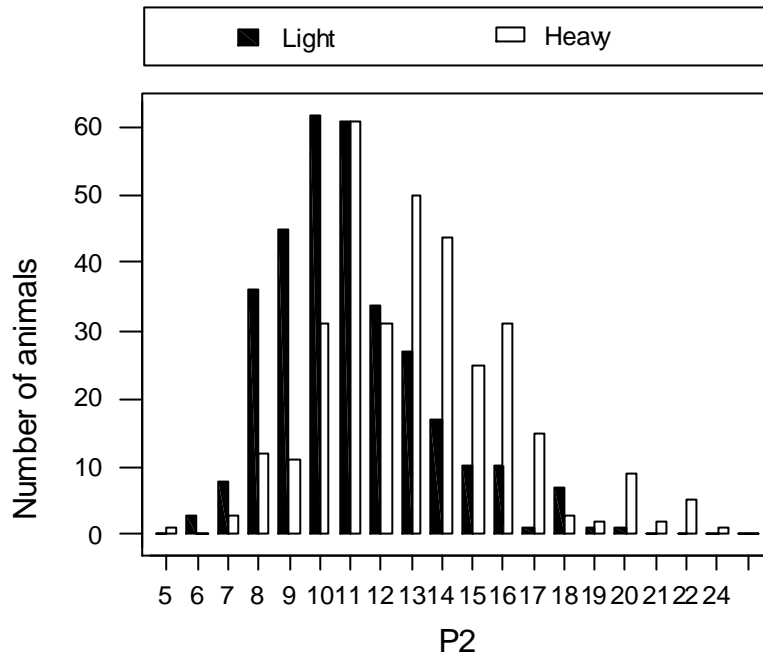


Table 5b shows the effects of carcass selection criteria on quality assessments made by the take-home panel. Carcasses selected for a minimum  $P_2$  level after slaughter were perceived as fatter, and this fatness was less acceptable. However, there were significant improvements in scores for tenderness, juiciness and overall acceptability of 0.3-0.4 units on the 1-8 scale.

Comparing the results of the sensory and consumer panel, both groups reported similar increases in texture with greater fatness. The implication is that a measured increase in sensory texture, i.e. more tender, was reflected by the take home panel preferring more tender meat derived from the fatter pigs. The sensory panel did not find differences in juiciness, whereas the take home panel detected a clear beneficial effect of greater fatness. This may reflect a greater beneficial effect of the higher fat level under home cooking conditions and/or when the lean and fat are eaten together in the portion. The sensory panel detected differences in pork flavour intensity but, whilst the take home panel also reported a difference of similar magnitude in liking of flavour, this was not statistically significant with the greater variance.

**Table 5b. The carcass and sensory characteristics of pigmeat, assessed by a take home panel, according to carcass quality category after slaughter**

	Not meeting criteria	Meeting criteria	Sed	Sig
N	16	16		
<i>Visual and Cooking Quality - Cook</i>				
Size of steak	5.26	5.20	0.233	ns
Colour of lean	4.78	4.89	0.210	ns
Colour of fat	4.12	3.74	0.209	ns
Amount of Visible fat	5.03	6.80	0.306	***
Acceptability of Amount of Visible fat	5.60	4.53	0.330	***
Liquid released in packaging	3.98	4.02	0.320	ns
Uncooked Odour	2.85	2.68	0.227	ns
Cooking Odour	3.92	3.96	0.248	ns
Odour Liking	5.94	5.75	0.206	ns
Amount of Liquid released whilst cooking	4.58	4.69	0.323	ns
<i>Eating Quality - Family</i>				
Tenderness	5.85	6.18	0.139	*
Juiciness	5.56	5.94	0.137	**
Flavour	5.97	6.20	0.128	ns
Overall acceptability	5.86	6.15	0.137	*

### Effects of post-slaughter processing

Since the experimental design allowed effects of post slaughter carcass processing to be compared between the two sides of the same carcass, these have a high degree of precision. The effect of post slaughter carcass processing (hip suspension and prolonged ageing as an enhanced quality treatment) on assessments made by the trained sensory panel is shown in Table 6a. Enhanced post slaughter treatment resulted in more tender meat with a better pork flavour, but surprisingly also significantly reduced juiciness. There was no significant interaction between carcasses selected for quality attributes after slaughter and the effect of subsequent processing method.

**Table 6a. The sensory characteristics of pigmeat, assessed by a trained sensory panel, according to post slaughter processing treatment**

	Baseline	Enhanced	Sed	Sig
N	128	128		
Texture	4.14	4.40	0.053	***
Juiciness	4.52	4.37	0.044	***
Pork flavour	3.70	3.80	0.031	***
Abnormal flavour	3.03	3.02	0.042	ns

Table 6b shows the effects of post slaughter processing treatment on quality assessments made by the take-home panel. There were no significant differences in visual or cooking quality characteristics, but meat which had received enhanced processing was rated as more tender, more juicy and of higher overall acceptability (by 0.4 points on a 1-8 scale).

**Table 6b. The sensory characteristics of pigmeat, assessed by a take home panel, according to post slaughter processing treatment**

	Baseline	Enhanced	Sed	Sig
N	32	32		
<i>Visual and Cooking Quality -Cook</i>				
Size of steak	5.27	5.19	0.242	ns
Colour of lean	4.88	4.79	0.224	ns
Colour of fat	3.80	4.05	0.224	ns
Amount of Visible fat	5.93	5.90	0.315	ns
Acceptability of Amount of Visible fat	4.93	5.20	0.342	ns
Liquid released in packaging	3.95	4.05	0.338	ns
Uncooked Odour	2.63	2.89	0.244	ns
Cooking Odour	3.71	4.17	0.265	ns
Odour Liking	5.76	5.93	0.216	ns
Amount of Liquid released whilst cooking	4.55	4.73	0.344	ns
<i>Eating Quality-Family</i>				
Tenderness	5.83	6.20	0.142	**
Juiciness	5.61	5.89	0.142	*
Flavour	5.97	6.20	0.132	ns
Overall acceptability	5.81	6.21	0.141	**

Comparing the results for the sensory and consumer panel, both show significant increase in texture for the enhanced over the baseline pigs. The implication is that a measured increase in texture (i.e. more tender) was reflected by the take home panel preferring more tender meat derived from the enhanced treatment. In terms of juiciness an interesting scenario exists whereby the trained panel showed that pigs from the enhanced treatment were significantly less juicy than baseline pigs whilst the take home panel showed the reverse, although at a reduced level of significance. It is likely, although this cannot be confirmed, that this can result from either cooking effects and/or the difference in perception when the lean and fat are eaten together in the portion.

## Further analyses

### *Farm effects*

Further statistical analyses were carried out to investigate the effect of individual farm of origin on eating quality, and the factors which might contribute to farm differences. When the individual farm of origin was entered into the model of eating quality, it was apparently significant. However, further investigation showed that it was a Slaughter Date (Kill) effect rather than a true Farm effect; i.e. there was no difference between Farms within a Kill. Grouping the Kills into Spring and Summer showed no convincing effects of Season. Comparison of genotype (% Duroc genes) on the farm showed no significant effects. Likewise comparison of housing and feeding systems showed no significant effects. This would suggest that, under good management conditions which prevailed on the participating farms, on-farm factors exert a relatively small influence on pigmeat quality in comparison to effects associated with the immediate pre- and post slaughter period.

*Individual factors associated with eating quality – trained sensory panel*

The statistical analysis was repeated using in turn Daily Liveweight Gain, Age at Slaughter and Fatness (P<sub>2</sub> level) as covariates. None proved to be significant. However the range seen in the data may be too small for these effects to come through.

The analysis was also re-run using a reclassification of the P<sub>2</sub> levels according to thresholds used in previous experimental studies (≤8, 9-12, > 12 mm), and Weight data according to the threshold for taint testing of entire male carcasses (<85, ≥85 kg). The results are shown in Table 7, and indicate only a small improvement in tenderness and pork flavour in the highest P<sub>2</sub> category.

**Table 7. The sensory characteristics of pigmeat, assessed by a trained sensory panel, according to carcass weight and P<sub>2</sub> category**

Carcass Weight	<85 kg			≥85 kg			Sed	Sig		
	≤8mm	9-12mm	>12mm	≤8mm	9-12mm	>12mm		W	P <sub>2</sub>	W.P <sub>2</sub>
P <sub>2</sub>										
N	13	34	23	2	25	31				
Texture	4.26	4.18	4.60	4.18	4.17	4.23	0.215	ns	*	ns
Juiciness	4.51	4.45	4.50	4.82	4.46	4.34	0.224	ns	ns	ns
Pork flavour	3.68	3.64	3.76	3.48	3.80	3.85	0.105	ns	*	ns
Abnormal flavour	3.15	2.93	3.02	2.89	3.05	3.09	0.208	ns	ns	ns

*Relational Analysis*

For the 64 samples from 32 animals used in the take home study, it is instructive to determine the correlations between sample estimates obtained from the take home panel data. The results given in Table 8a show that all four attributes are closely linked in the family members evaluations. This implies that the panel members are not clearly differentiating between different components contributing to hedonic scores, but rather scoring all of them according to a generalised liking of the sample. (see Table page 10 attribute 1. Sensory panels are trained and are less influenced when scoring one attribute by the score they gave for an earlier attribute)

**Table 8a. The correlations between the different attributes of eating quality scored by members of the take-home panels.**

Texture	1.00			
Juiciness	0.89	1.00		
Flavour	0.72	0.75	1.00	
Overall acceptability	0.90	0.89	0.87	1.00
	Texture	Juiciness	Flavour	Overall acceptability

In contrast, for the same samples, the correlations of the sample estimates of the sensory attributes for the trained sensory panel are shown in Table 8b. These demonstrate that the trained panel achieved a greater separation between the attributes than the take home panel. They have clearly dissociated the different objective sensory characteristics, as they have been pre-selected and trained to do. (This highlights the points 1, 4 and 5 in the Table on page 10 comparing consumer and sensory panels)

**Table 8b. The correlations between the different attributes of eating quality scored by members of the trained sensory panels.**

<i>Texture</i>	1.00			
<i>Juiciness</i>	0.50	1.00		
<i>Pork Flavour</i>	0.39	-0.01	1.00	
<i>Abnormal Flavour</i>	-0.11	-0.11	0.06	1.00
	<i>Texture</i>	<i>Juiciness</i>	<i>Pork Flavour</i>	<i>Abnormal Flavour</i>

Using this same dataset, partial Least squares (PLS), with 2-dimensions, was used to produce robust equations of estimation of consumer eating quality values from sensory values of the trained panel (Table 9). This allows exploration of which objective sensory attributes are most influencing the scores for liking which are given by the consumer panel.

**Table 9. Prediction Equations for Consumer ratings of eating quality from Sensory ratings of the trained panel.**

<b>Consumer Eating Quality</b>	Constant	<i>Texture</i>	<i>Juiciness</i>	<i>Pork Flavour</i>	<i>Abnormal Flavour</i>
<b>Texture</b>	2.9000	0.6029	-0.2509	0.5434	-0.1200
<b>Juiciness</b>	3.0533	0.5706	-0.3568	0.5883	-0.1131
<b>Flavour</b>	4.2615	0.3732	-0.2058	0.3677	-0.0741
<b>Overall acceptability</b>	3.5499	0.5428	-0.3907	0.5914	-0.1074

It is interesting that the equations give equal and high positive weights for all eating quality scores of consumers to sensory *Texture* and *Pork Flavour* and lower negative weights to sensory *Juiciness* and *Abnormal Flavour*. This would suggest that, as in other studies of consumer perception of pigmeat eating quality, tenderness is much more important than juiciness in determining overall consumer liking.

## CONCLUSIONS

- The precise experimental design was effective in detecting, as statistically significant, differences of 0.1-0.2 units in eating quality attributes of pigmeat on the 1-8 scale used by the trained sensory panel. The trained panel achieved a greater separation between the different objective sensory attributes than the take home panel, who appeared to score all hedonic attributes according to a more generalised liking of the sample. Tenderness was much more important than juiciness in determining overall consumer liking.
- The pork samples evaluated in this project were of good quality, as indicated by an average score of 6 on a 1-8 scale by the consumer panel for overall acceptability.
- In pigs of an appropriate genotype, and with good nutrition and management, increasing slaughter weight to a mean of 90 kg deadweight had no detrimental effect on eating quality attributes and did not significantly increase risk of boar taint. The trained sensory panel detected no differences in intensity of quality attributes, whilst the consumer panel scored eating quality of meat from heavy pigs significantly more highly. Thus, increasing slaughter weight under carefully controlled conditions can be expected to improve consumer perception of eating quality of the product and may also improve perception of value for money with a larger portion size.

- Relatively few sampled pigs showed post mortem muscle pH changes which would be indicative of reduced meat quality (PSE or DFD). This reflects the careful management applied during transport and lairage under current Scottish Farm Assurance guidelines.
- Selection of carcasses post-slaughter according to quality thresholds for fatness and muscle pH resulted in samples differentiated primarily by fatness, as a result of the consistently good pH results in the source population. The 4mm difference in fatness resulted in small but significant improvements in texture and flavour, as assessed by a trained sensory panel. In consumer panel assessments, significant benefits for eating quality were counterbalanced by higher levels of perceived fat, which were viewed as undesirable. Selection for a minimum threshold of carcass fat would therefore appear to offer some possibilities for potential niche marketing of higher eating quality pigmeat, but only if combined with fat trimming of the product. This negative perception of fatness would also need to be carefully screened if increases in slaughter weight were associated with greater changes in carcass fatness when applied across a more diverse population of pigs.
- Enhanced post-slaughter processing, comprising a combination of hip suspension and prolonged ageing, gave conflicting outcomes for objective sensory attributes assessed by the trained sensory panel, with enhanced tenderness but reduced juiciness. However, the consumer panel scored positive benefits for all hedonic attributes of eating quality. In view of these very positive results, the relative contributions of hip suspension and prolonged ageing to these beneficial effects justify further evaluation, since both incur a carcass processing cost which could be reduced if either procedure alone could give all, or the majority, of the benefit.
- Although the design of the investigation was optimised to precisely define the effects of Processing, Weight, P<sub>2</sub> and Gender, the implication of the results of the further analyses is that differences in husbandry (breed type, housing and feeding system) between farms were not sufficiently large to consistently affect eating quality attributes. The effect of slaughter date was of greater significance than the farm effect. This effect may be attributable to the combined effect of a wide variety of both the pre- and post-slaughter conditions that can differ between individual days of slaughter.

## **Appendix I. On- farm protocol**

# **MEAT EATING QUALITY – A WHOLE CHAIN APPROACH**

## **Pig Farm Protocols**

**SAC/BioSS/University of Bristol/  
University of Newcastle/SFQC/QMS**

**4 March 2003**

### **Contents**

#### 1. Pig plans and protocols:

- 1.1 Farmer collaborator's guide to the trial
- 1.2 Farm data collection sheet and guidance notes

## 1.1 Farmer collaborator's guide to the pigmeat eating quality trial

To improve the eating quality and consistency of pigmeat, research indicates that pigs should achieve a rapid rate of growth in the finishing period and have adequate P<sub>2</sub> backfat thickness at slaughter. Some uncertainty still exists about the effect of increasing slaughter weight on eating quality, although this is highly desirable to reduce cost of production. Whilst most of the on-farm factors identified as enhancing meat quality are already standard commercial practice, variability in pigmeat eating quality is still a problem and the reasons for this are poorly understood.

The objective of this experiment is

1. to examine the effect of increasing slaughter weight on eating quality
2. to obtain a better understanding of what other pre- and post-slaughter factors affect eating quality

### Farm standards for enhanced quality

Entire male and female pigs from all breeds and crosses in current commercial use in Scotland are acceptable, but lines which carry the halothane gene must be excluded from the enhanced quality specification because of their greater stress susceptibility at the time of slaughter which impairs meat quality. The pigs must be fed *ad libitum* on diets which allow them to achieve their lean growth potential, as faster growing pigs produce more tender meat. The target age at slaughter should be less than 180 days, but it is accepted that the data on this subject relate to pigs of lighter slaughter weight. The effect of age at heavier slaughter weight will be explored in the study, since a 180 day target with very heavy slaughter weights may not be easily achieved. The finishing diet should contain limited levels of raw materials which might cause a taint in the meat or soft fat problems (as under present QMS guidelines), and a high level of vitamin E (100 IU/kg) is desirable to enhance shelf life of the meat.

Each participating farm will produce two different groups of pigs with different target carcass weights (~75 kg deadweight and ~90 kg deadweight). To ensure high eating quality, a trials officer from SFQC will visit approximately 4 weeks before the planned slaughter date to check that the production standards for enhanced farm quality are being met and identify groups of pigs which should reach the correct age and liveweight in the designated week of slaughter. The pigs will be identified as a group, weighed and will each receive individual numbered ear tags (double tagged). A deadline slaughter date and minimum carcass weight will be set, allowing for variation within the group. Pigs falling outside this target will be excluded from the enhanced specification group. Each farm will be asked to produce 20 individually identified pigs in each weight category (10 males and 10 females) for slaughter on the same agreed day. Slaughter dates for the different individual farms will be staggered over several weeks in the spring (April/May) or in the summer (July/August).

**1.2 Farm data collection sheet and guidance notes**

Trial organiser to assist in data collection  
 (copy to be retained by trial organiser and 2<sup>nd</sup> copy to be left with farmer)

**FARM DATA COLLECTION SHEET: HEAVY PIGS**

(~90 kg deadweight/ 120 kg liveweight at slaughter)

**Farm Name:**

**Date of first weight:**

**Date of final weight:**

**Date of despatch:**

Identity of pigs logged onto trials (**heavy slaughter weight** category)

	<b>Pen location</b>	<b>Tag number</b>	<b>Sex</b>	<b>Age</b>	<b>Live weight at start</b>	<b>Live weight at slaughter</b>	<b>Slap No.</b>
1			G				
2			G				
3			G				
4			G				
5			G				
6			G				
7			G				
8			G				
9			G				
10			G				
1			B				
2			B				
3			B				
4			B				
5			B				
6			B				
7			B				
8			B				
9			B				
10			B				

**FARM DATA COLLECTION SHEET: LIGHT PIGS**

(~75 kg deadweight/100 kg liveweight at slaughter)

**Farm Name:**

**Date of first weight:**

**Date of final weight:**

**Date of despatch:**

Identity of pigs logged onto trials (**light slaughter weight** category)

	Pen location	Tag number	Sex	Age	Live weight at start	Live weight at slaughter	Slap No.
1			G				
2			G				
3			G				
4			G				
5			G				
6			G				
7			G				
8			G				
9			G				
10			G				
1			B				
2			B				
3			B				
4			B				
5			B				
6			B				
7			B				
8			B				
9			B				
10			B				

How is age determined? .....

**TRIAL ORGANISER CHECKLIST on farm enhanced practice**

Farm name:

Date of visit:

Tick box

Confirm all pigs bred from lines excluding halothene gene  
(confirm with breeding company if necessary)

Confirm all light pigs will be under 180 days at slaughter and age at  
slaughter known for heavy pigs

Planned slaughter date

...../...../.....

**Heavy slaughter group (carcass weight ~90 kg)**

Target liveweight

..... kg

Current liveweight

.....to ..... kg

Target liveweight gain

..... g/day

**Light slaughter group (carcass weight ~75 kg)**

Target liveweight

..... kg

Current liveweight

.....to ..... kg

Target liveweight gain

..... g/day

Confirm diet details obtained (and separate table completed)

Finishing diets **equal or exceed** minimum specifications

Finishing diet **does not** contain >2.5% fishmeal

Finishing diet **does not** contain >1.6% linoleic acid

Note Vit E level of Finishing diet

.....

Confirm finishing diets are fed ad libitum with adequate trough space

Confirm that pen hygiene is good and pigs are in clean condition

Confirm that selected groups are showing no signs of clinical disease

Confirm that handling and loading facilities are adequate

**Details of diets used**

For home mixed diets obtain ingredient composition. For purchased diets obtain supplier name and diet identification

Production stage	Weight when fed	Diet name	Home-mix or supplier	Full composition details obtained	DE (MJ/kg)	Total Lysine (g/kg)	Digestible lysine (g/kg)
Weaner 1	..... to ..... kg						
2	..... to ..... kg						
3	..... to ..... kg						
Grower 1	..... to ..... kg						
2	..... to ..... kg						
3	..... to ..... kg						
Finisher 1	..... to ..... kg						
2	..... to ..... kg						
3	..... to ..... kg						

***Take a representative sample (~1kg) of finishing feed in case of any unusual farm result. This should be labelled with farm id, sampling date and initials of sampler.***

### Trial organiser's guide to completion of Stage 1 documentation – pigs

The farm will be visited at approximately 28 days pre-slaughter. The objective is to ensure that there is in place a production system appropriate to meet the enhanced quality specification (in terms of breeding, housing and feeding) and that effective records are in place to identify the age and weight of the stock.

1. Identify appropriate groups of finishing pigs, with adequate representation of both genders, to reach target weight for age at slaughter for the two carcass weight categories.
2. Check that the finishing groups are identified by tag numbers. As a guide, the weight range within the selected pigs should not be more than 3 kg either side of the mean wherever possible.
3. Weigh the pigs and record on the form.
4. Estimate the minimum liveweight at slaughter (use 76% killing out unless better data exist from the specific farm).
5. Calculate the target age and minimum weight at slaughter using the information in Table 1 or better information on growth rates from the specific farm if this exists.

Table 1. Guideline minimum weight for age and minimum liveweight gains during finishing for enhanced quality specification. Note: these are minimum targets which should be achievable by most people, not challenging targets to which only the best herds can aspire.

Age (weeks)	Target liveweight (kg)	Minimum liveweight gain in preceding period (g/day)
4	8	
8	19	400
12	34	550
16	54	700
20	76	800
24	101	900
26	114	900

6. Obtain details of all diets fed to the growing pigs and confirm that these are appropriate to permit optimal lean tissue growth rate (see guidelines in table 2). Check the ingredient composition and specification of the finishing diet, consulting a project nutritionist as required.

Table 2. Minimum diet specifications to ensure optimal lean tissue growth

Pig liveweight	Minimum DE (MJ/kg)	Minimum ileal digestible lysine (g / MJ DE)
15-30	14	0.8
30-50	13.5	0.7
50-70	13	0.65
70-90	12.5	0.6
90-110	12	0.6

7. Confirm that diets are fed ad libitum to finishing pigs and that trough space is adequate (see guidelines in table 3).

Table 3. Guidelines for minimum trough space allowances for ad libitum feeding

Pig liveweight (kg)	Trough space for ad libitum feeding (mm/pig)		
	Pelleted diet	Meal diet	Wet fed
50	26	43	19
70	29	48	21
90	32	53	23
110	35	58	25

8. Observe pigs in the finishing building at different weights and confirm that pen hygiene and pig cleanliness are satisfactory.
9. Confirm handling and loading facilities are appropriate for minimal stress during loading. Loading ramp angle should not exceed 20 degrees.



### Notes on farmer checklist

- (1) SSSFA approved hauliers to be used only (includes farm transport that has been assessed).
- (2) Animals to have high glycogen reserves at dispatch. Normally fed animals will have adequate glycogen reserves to see them through a normal (mainland) Scottish transport to abattoir. Glycogen reserves can be depleted by stress, excitement and hard physical exercise, eg prolonged fighting between mixed batches. High glycogen reserves in the muscle provide the energy source for the development of the correct ultimate pH in the muscle. This is achieved by glycogen breakdown following slaughter to form lactic acid within the muscle ensuring good keeping quality. The higher the glycogen reserves the better as this reduces the chance of getting dark cutting meat and gives a haulier/abattoir more flexibility to cope with unprecedented factors such as traffic jams or mechanical breakdowns.
- (3) The aim is not to stress the animal as this can result in deleterious changes in the muscle after slaughter which give pale, watery meat.
- (4) Normal meat hygiene rules apply.
- (5) This information can be used to sum up the total handling/transport time so that, where appropriate, over-stressed animals can be appropriately rested by abattoir staff.
- (6) To protect welfare and avoid stressing animals, all those responsible for handling and transporting stock should have been trained and management should regularly check to assure high welfare standards/good practice.
- (7) To comply with the enhanced scheme specification, pigs must be slaughtered before the deadline date and at minimum target weight.

**Appendix II. Abattoir protocol**

**MEAT EATING QUALITY – A WHOLE CHAIN APPROACH**

Pig Abattoir Protocols  
19/03/03

**SAC/BioSS/University of Bristol/  
University of Newcastle/SFQC/QMS**

### ***Collaborator's guide to the pigmeat eating quality trial***

To improve the eating quality and consistency of pigmeat, research indicates that pigs should achieve a rapid rate of growth in the finishing period and have adequate P<sub>2</sub> backfat thickness at slaughter. Some uncertainty still exists about the effect of increasing slaughter weight. Whilst most of the on-farm factors identified as enhancing meat quality are already standard commercial practice, variability in pigmeat eating quality is still a problem and the reasons for this are poorly understood.

#### ***Farm standards for enhanced quality***

Entire male and female pigs from all breeds and crosses in current commercial use in Scotland are acceptable. Pigs will be fed *ad libitum* on diets that allow them to achieve their lean growth potential so that they do not exceed 180 days of age at the time of slaughter and have a target P<sub>2</sub> of 12 mm. The finishing diet will contain 100 IU/kg of vitamin E to enhance shelf life of the meat. Farms will produce two different groups of pigs with different target carcass weights ( $\leq 70$  kg deadweight and  $\geq 85$  kg deadweight). The pigs will be identified as a group by a range of individual tag numbers and will be slap marked before sending to the abattoir.

#### ***Abattoir practices for improving quality***

At the abattoir pigs will be divided by weight group for ease of experimental processing. Carcasses will be split to the head and one side removed from the heads so that it can be hip suspended. P<sub>2</sub> and pH (removal of PSE and DFD carcasses) will be recorded. Carcasses for meat sampling will be identified overnight and the next day final pH will be recorded as a final selection. A 12in section of boneless loin from each selected carcass will be cut from the anterior (head) end from the point of division from the shoulder, vacuum packed, labelled and despatched to Bristol to arrive within four days of slaughter. Further ageing will be carried out at Bristol.

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**Consortium Pork Protocol** –through abattoir.

Area of concern	Procedure- enhanced	Procedure - standard
Unloading and lairage	<p>Time of pig arrival and unloading time at the abattoir will be recorded. Transporters must be unloaded promptly</p> <p>While in the lairage animals must have access to adequate fresh potable water in clean, draught-free pens with well drained, insulated and non-slip floors.</p> <p>Careful handling is essential at all stages from farm to slaughter to maintain optimum animal welfare.</p> <p>Goads (electric) must not be used and the use of other sticks, pipes, wires or hard blunt equipment is not recommended.</p> <p>All lairage areas must have water sprinklers but only used if the environmental temperature is above 10°C, shown advantageous above 15°C – not to be used &lt;5°C</p> <p>Keep pigs in lairage for a minimum period necessary to sort paperwork,</p>	As left
Stunning and slaughter	<p>Captive bolt and electrical stunning are acceptable.</p> <p>Abattoir staff must adopt practices that ensure stress is minimised</p>	Ditto
Carcass classification	Enhanced pigs will only be accepted with a P <sub>2</sub> above 12mm	Any fat cover, P <sub>2</sub> preferably <12mm, recorded
Post-stun carcass treatment	Hip suspension of one side freed from head immediately after dressing and before removing to the chiller – preferably hung with Achilles hung other side	Achilles hung other side
pH window	pH not below 6.00 in the first 45min post-slaughter, pH not to be above 5.80 at 24h.	Monitor pH, no restrictions
Boning	Samples from carcasses meeting above criteria decided overnight, cut into primals at 24h	Ditto.
Conditioning/Maturation	<p>For a total of 10d* post-slaughter in vacuum bags post-quartering as a boneless loin primal. Delivered to Bristol within 4d of kill so conditioning finishes in Bristol</p> <p>* this includes 7d from day of kill plus 3d average time to retail and being eaten by consumer</p>	<p>For a total of 5d* post-slaughter in vacuum bags post-quartering as a boneless loin primal. Delivered to Bristol within 4d of kill so conditioning finishes in Bristol</p> <p>* this includes 2d from day of kill plus 3d average time to retail and being eaten by consumer</p>

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Points to be monitored by technician monitoring slaughter having received farm sheet from haulier

Farm name (as on scheme)..... Date.....

Time of lorry arrival at abattoir/distance travelled	
Ambient temperature – to be measured in the shade outside the lairage (pH probe has a temperature probe)	
Temperature in lairage centre	
Time lorry fully unloaded	
Average number of animals in each section	
Time brought up to stun pen	
Any fractious or difficult animals observed – is it possible to identify its position in the slaughter line?	
Did any pigs fall off the processing line and get out of sequence?	yes/no
Was this corrected or was the pig ignored?	Corrected/ignored

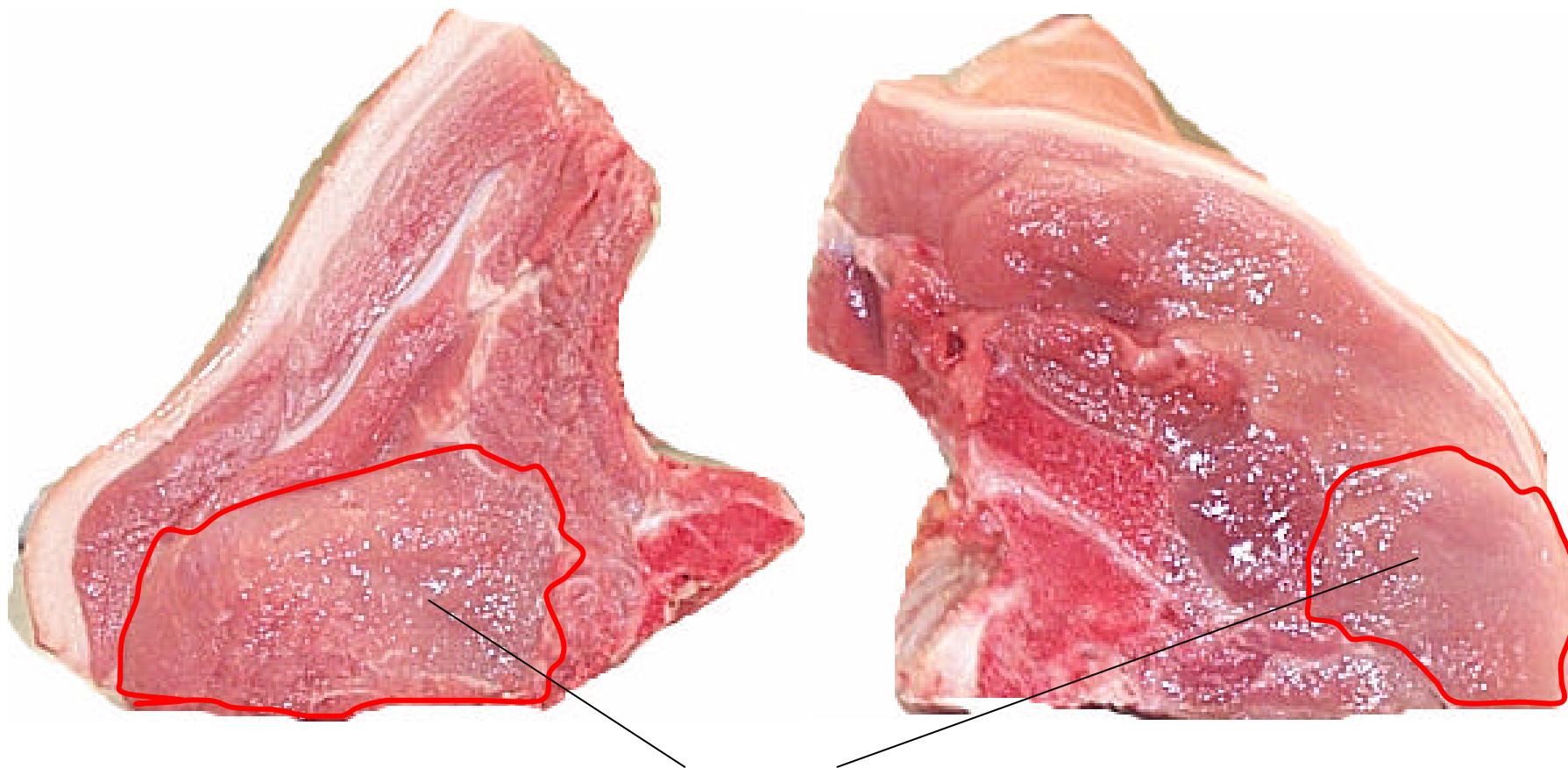
*Consortium staff procedures in abattoir*

- On arrival at plant ascertain when pig batches will be delivered.
- Obtain data sheet from haulier
- Monitor outside air temperature, record weather and middle of lairage temperature
- Observe pigs being brought up to stun pen and record time
- Read tag numbers and slap marks at convenient point post-bleeding and record order of pigs – record sex
- Watch through scald tank and record any pigs that drop off gambrel or become out of order
- At end of line mark both sides (on rear leg) of experimental pigs with kill No/tag No.
- All pigs to be Achilles suspended right side, left side hip suspended, extra gambrel used to ensure carcasses hang evenly.
- Carcasses moved to one line of chiller away from rest of production and pH, time and temperature measured at last rib both sides
- Order of pigs, tags and other identification marks checked
- Overnight, decide on pigs to be sampled with a few reserves.
- Measure final pH, make final decision on Enhanced and Basal specification pigs and apply blue tag with U-o-B number, to centre of loin area that will be sampled, both sides with allocated sample number
- Follow pigs through boning and ensure that blue tags are not removed. Obtain 12in of loin from both sides from anterior (head) end of deboned loin.
- As loins are put in vacuum bag replace blue tag with correct (by U-o-B number) laminated label, write down its allocation against pig data on recording sheet.
- Label should be on skin side, coded side up.
- Count all samples for Bristol and put in delivery crates or boxes. There should be 16 samples from each farm, 32 samples per day if we manage to do 2 farms at a time. 2 sexes x 2 weights x 2 groups (fit enhanced protocol pH 45 min, P<sub>2</sub> and pH 24h, versus don't fit this criteria) = 8 pigs selected. You then have 2 sides for each pig (hip or Achilles suspended) which = 16 samples (see flow chart)
- Check procedure is in place for sending samples to Bristol.
- Within the week enter all collected data onto computer spread sheet and send electronic copy to Tony Hunter and Ian Richardson and store a hardcopy in file. Ian needs to know samples codes and treatment allocations within 3 days of slaughter so he can allocate to correct ageing periods

**Pork loin right side – we want whole section + skin without bone to avoid vacuum bag punctures**

**Head end**

**Tail end**



Loin eye muscle – select head end  
as muscle bigger for sensory panel









## Project Contacts

<b>Name</b>	<i>Role</i>	<b>Contact details</b>
Geoff Simm (SAC)	Project manager	0131 535 3209
John Vipond (SAC)	Beef and sheep protocols	0131 535 3215
Sandra Edwards (University of Newcastle)	Pig protocols	0191 222 8350
Ian Richardson (University of Bristol)	Abattoir protocols	0117 928 9291 Office 0117 928 9654 ian.Richardson@bristol. ac.uk
Tony Hunter (BioSS)	Statistician	0131 650 4896
Kim-marie Haywood (QMS)	QMS project facilitator	0131 472 4040
Santiago Avendaño (SAC)	Assistant to project manager	0131 535 3212
Jim Fraser (SAC)	Abattoir sampling team co-ordinator	0131 535 3207
Aileen Bearhop (SEERAD)	SEERAD project manager	0131 244 6403

**Appendix III - Take Home Panel Questionnaire**

**HOUSEHOLD No.**

1. What is the total number of persons in your household?
2. Please, indicate these characteristics for each person in your household:

	NAME	AGE	GENDER	EDUCATION		
				School to 16	School to 18	University degree
Person 1						
Person 2						
Person 3						
Person 4						
Person 5						
Person 6						

3. Which cooking method do you normally use for (up to two choices per species):

	Pork	Beef	Lamb
Barbeque	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Fry	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Grill	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Roast	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Stew	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other (specify):	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

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HOUSEHOLD No.

NAME

4. How often do you eat the following meats at home (*please, mark the most appropriate alternative for each meat, do not include processed meats, eg., sausages, bacon...*):

	Never	< once a month	Once a month	2-3 times a month	Weekly
<b>Pork</b>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Beef</b>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Chicken</b>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Lamb</b>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Fish</b>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

5. How important for you are the following factors in terms of the satisfaction you expect from pork meat? Assign 0 (*low importance*) to 10 (*high importance*) to each factor and your personal preference for each characteristic. Please, do not discuss your opinions with other members of your family and do not let them influence your view.

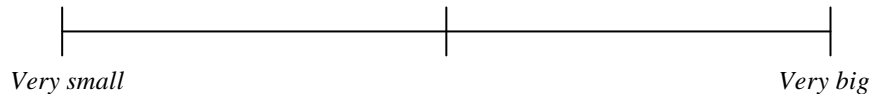
Characteristics	Points (0 to 10)	Prefer
<i>Eg. Type of cheese</i>	7	<i>Mature Cheddar</i>
Brand		
Packaging		
Butcher		
Store		
Colour		
Amount of visible fat		
Amount of liquid in the package		
Amount of liquid released while cooking		
Price		
Tenderness		
Juiciness		
Pork flavour intensity		

**HOUSEHOLD No.**

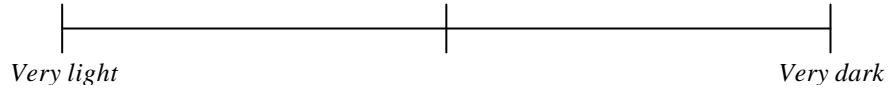
**SAMPLE**

If you are the cook, what do you think about the following characteristics? Tick on the line.

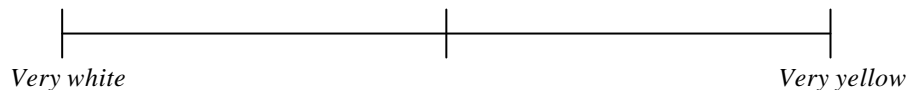
**SIZE OF PORK STEAK**



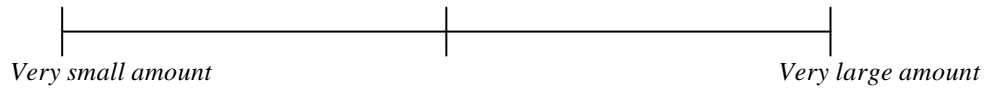
**COLOUR OF LEAN**



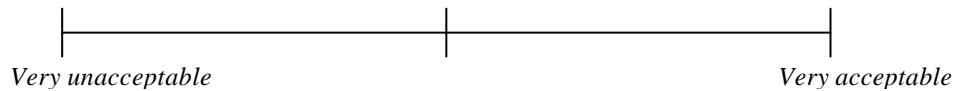
**COLOUR OF FAT**



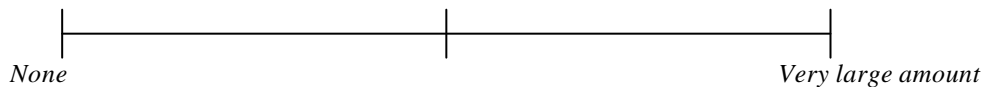
**VISIBLE FAT**



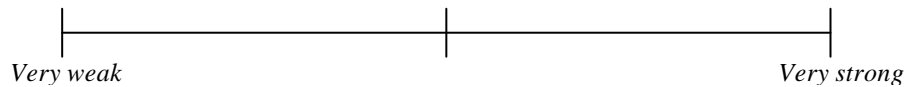
**AMOUNT OF VISIBLE FAT**



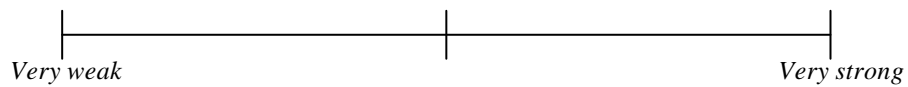
**LIQUID RELEASED IN PACKAGING**



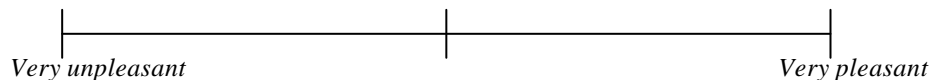
**ODOUR OF UNCOOKED PORK**



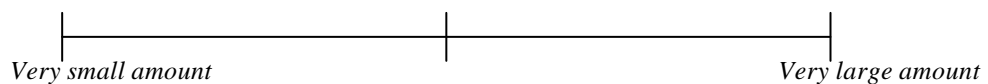
**ODOUR OF PORK WHILST COOKING**



**ODOUR LIKING**



**LIQUID RELEASED WHILST COOKING**



<i>DATE</i>
<i>TIME</i>

**HOUSEHOLD no**

**SAMPLE no**

**NAME**

For each one of the four attributes below, mark the alternative that best represents your opinion on the sample that you have just tasted. Please, do not discuss your opinions with other members of your family and do not let them influence your score.

	<b>TENDERNESS</b>	<b>JUICINESS</b>	<b>FLAVOUR</b>	<b>OVERALL</b>
				<b>ACCEPTABILITY</b>
Like extremely	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Like very much	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Like moderately	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Like slightly	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Dislike slightly	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Dislike moderately	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Dislike very much	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Dislike extremely	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>		

**OBSERVATIONS:**