SESSION 2: POST-SLAUGHTER HANDLING

A STUDY OF THE PRACTICAL & ECONOMIC CONSIDERATIONS ASSOCIATED WITH HIGH VELOCITY AND LOW TEMPERATURE AIR STREAMS FOR THE COOLING OF BEEF

UNION INTERNATIONAL CONSULTANTS & ASSOCIATES

A series of tests, to determine the practical requirements for and the economic advantages of the ultra rapid chilling of beef sides was made:-

- to determine the optimum blast chill condition with relation to temperature, air velocities and time and to reduce shrinkage by moisture losses to a practical minimum;
- to determine the refrigeration load during the blast chill period on an hour by hour basis;
- to determine the yield benefit in additional trimmed meat that could be obtained by blast chilling compared to current facilities;
- determination of a practical design for a large meat works and the analysis of additional capital costs against additional revenue possible.

In this test series the following information was obtained.

(a) The optimum refrigeration cycle was:
- 1 hour at -15°C air velocity 2 metres per second;
- 3 hours at -12°C air velocity 2 metres per second;
- 17 hours without applied refrigeration or air movement for temperature equalisation.

(b) The total refrigeration load, per body of 250 kgs average weight, as used in the final works design was: 1st hour 19.1 MJ; 2nd hour 13.3 MJ; 3rd hour 9.6 MJ; 4th hour 8.4 MJ.

c) Shrink during refrigeration was 0.7% of the hot washed carcass weight 0.2% of the unwashed weight: (good modern conventional chillers give about 1.4% shrink).

d) In a separate test boning yield of commercially trimmed meat was: on a cold meat basis; blast chilled 67.6%, conventionally chilled 68.0%; on the hot meat basis 66.8% and 66.1% respectively; the respective shrinks were 1.2% blast chill 2.8% conventional chill.

e) For a kill of 1000 head per day it was estimated that additional expenditure for blast chilling facilities over conventional chillers would be £480,000. Additional revenue would be £1,570; additional energy costs £340; net benefit £1,230. This represents a return on additional capital of 51% p.a. based on 200,000 head per year (80% utilization).

Developments in the freezing of meat products in the 'Torry' Continuous Air Blast Freezer

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The purpose of freezing meat is to lower the temperature and thus slow down spoilage so much that when the product is thawed after cold storage it is virtually indistinguishable from fresh meat. The recommended storage temperature for frozen meat is -18°C and it is advisable to lower the average temperature of the meat to this value during the freezing process.

In practice, in a blast freezer with a mean air temperature of -35°C, this means lowering the temperature of the warmest part of the meat, usually the centre, to -10°C, so that the average temperature of the product entering the cold store is then at or below the desired -18°C.

The 'Torry' Continuous Air Blast Freezer was initially developed for the individual quick freezing (IQF) of fish and shellfish products up to 50mm thickness. Currently there has been an increasing interest in the freezing of various meat products of a similar size range to processed fish products. Many of the features of the 'Torry' make it eminently suitable for these meat products and, in order to exploit this possibility, it was necessary to establish design parameters for individual products.

The 'Torry' freezer is a single-pass in line continuous freezer which incorporates a sheet stainless steel band conveyor. It is designed for rapid freezing and this is obtained by blowing both over and under the belt at a velocity of approximately 10 m/s. The product may be placed on the conveyor either manually or automatically and it is removed automatically at the outlet.

It is particularly suitable for products which require to be fed automatically, such as hamburgers, and where it is important that product is not marked during the freezing process.

An experimental programme was undertaken to determine the freezing time and loading density for a wide range of meat products. Weight loss during freezing was also established for unwrapped products. Products investigated included sirloin steaks, braised steaks, both vacuum packed and unwrapped, minced beef, liver and kidney packs, a range of sausages of different weights, meat pies and pork chops.

It was possible to establish that the freezer was equally suitable for meat products as for fish. The necessary design parameters for a range of meat products have been established.

The use of the 'Torry' continuous freezer will thus enable processed meat products to be frozen more rapidly and eliminate much of handling and delays which are an essential part of batch freezing processes.

2:3

Freezing of meat with hydroaerosol pre-chilling

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The technological process of freezing sides of beef and pork with hydroaerosol pre-chilling was investigated. Two versions of the process were studied: two-stage technology (hydroaerosol chilling for 3 hours and freezing in air at -30°C, air velocity 0.8 m/sec) which was compared with the conventional freezing of hot sides in air with the same parameters; and three-stage technology (hydroaerosol chilling, air chilling at air temperature 0°C and velocity 1 m/sec., and freezing) which was compared with the conventional technology consisting of air chilling of meat and its subsequent freezing. 1,200 beef sides and 500 pork sides were used in commercial-scale experiments for the determination of meat weight losses.

It was found that using hydroaerosol chilling led to a reduction of weight loss during cold treatment by 0.20 - 0.52% for beef and 0.26 - 0.31% for pork. During subsequent storage the weight losses of experimental and control sides were similar. In laboratory experiments the influence of hydroaerosol pre-chilling on organoleptic qualities, changes in the colour characteristics of the meat and the state of the lipid system was studied by the content of lipoperoxides and the composition of neutral lipids. Also the effect on the microflora was judged by total counts of aerobic mesophiles and psychrotrophs.

No significant differences in the indicated parameters between meat samples frozen after hydroaerosol chilling and by commercially accepted methods were found.

2:4

An acoustic method of investigation and its application to evaluation of the structural changes occurring in meat during refrigeration, processing and storage

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The principles and application of an acoustic method of investigation of the changes occurring in meat are considered. The development of acoustic equipment for studying muscle tissues by means of an impulse echo- and transmission method is described. Some peculiarities of the dissemination of elastic waves in muscle tissues depending upon their frequency and pattern temperature are considered. It is shown that an increase in frequency and lowering of the freezing temperature result in an increase in the velocity of dissemination of elastin waves in muscle tissues. The influence of continuous storage of meat upon the velocity (V) of ultra-wave dissemination in muscle tissues depending on the degree of pattern deformation ε is considered. The relationship $V = f(\varepsilon)$ for fresh-killed meat is found to be less variable than for meat in the state of rigor mortis. The investigation carried out showed that the acoustic method of investigation is an efficient means of studying structural changes in meat depending on the conditions of heat treatment during processing and storage.

2:5

The prediction of freezing and thawing times of mutton carcasses

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Due to the seasonal production cycle more mutton is being frozen for long term storage and then thawed before boning and processing, but little data are available on freezing and thawing times. To provide these data, 34 chilled mutton carcasses (weight range 25 to 50 kg) were frozen under 3 conditions (-30°C, 0.5 m/s; -30°C, 4 m/s; -20°C, 0.5 m/s) either unwrapped or wrapped in stockinette cloth. After freezing the carcasses were stored for between 3 and 28 days under typical commercial conditions of -30°C, 1 m/s. Twenty-nine frozen carcasses were then thawed in air at 10°C, 0.5 m/s, 85% RH.

A numerical predictive method based on a cylindrical model was developed to extend the experimental results. The relationship was determined between the freezing and thawing time of cylinders of material having the thermal properties of meat, over a range of cylinder diameter for the experimental conditions of air temperature and heat transfer coefficient used experimentally. The best linear fit between carcass weight and experimental freezing time was then chosen from the six freezing conditions and compared with the predicted relationship between cylinder diameter and freezing time. This enabled the relationship between carcass weight and cylinder diameter to be established, which was then used to predict freezing and thawing times for the other conditions. The values of heat transfer coefficient used in the prediction were calculated from the literature and ranged from 30 $W.m^2°C$ for unwrapped carcasses in air at 4 m/s, to 8 $W/m^2°C$ for wrapped carcasses at 0.5 m/s.

From the results it was concluded that for freezing, any condition more severe than -20°C, 0.5 m/s, would attain a 24 hour cycle with unwrapped carcasses, but at -20°C, 0.5 m/s, heavy wrapped carcasses would require 30 hours. To guarantee an overnight (15 to 16 hour) freezing cycle for wrapped carcasses, conditions more severe than -30°C, 4 m/s would be required. To thaw unwrapped mutton carcasses completely, a thawing cycle of at least 36 hours would be required and a minimum of 2 days for stockinette-wrapped carcasses. A matched-pairs T test showed that the shoulders took significantly longer ($P<.001$) to thaw than legs from the same animals, the difference being greater for wrapped than unwrapped carcasses.

When predicted freezing and thawing times were compared with the experimental data, average absolute errors of 12.1% for freezing and 16.4% for thawing were obtained.

2:6

Thawing meat blocks using microwaves under vacuum

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Even using the fastest conduction based thawing method, condensing steam under vacuum, over 13 hours are required to thaw unwrapped 15 cm thick meat blocks to a centre temperature of 0°C. With cartoned material air thawing is the only practical method and the minimum thawing time for similar blocks is extended to 22 hours. Many investigations have been carried out on the use of electro-magnetic thawing methods, predominantly micro-waves, to overcome problems caused by the poor thermal conductivity of meat and meet industrial requirements for considerably shorter thawing times. Existing microwave systems can successfully temper meat blocks i.e. achieve centre temperatures in the range -5 to -2°C. However attempts to completely thaw 15 cm thick blocks result in uneven absorption of energy and localised cooking in surface layers.

Using relatively low powered microwaves on frozen material contained in a chamber at a vacuum pressure between 16 to 26 mbar offered a theoretical solution to the problem of run-away surface heating. During thawing, free water at the surface of the meat would boil at a temperature between 15 and 25°C. The large amount of energy absorbed by the boiling process should reduce the likelihood of over-heating.

A prototype plant, was designed and constructed to investigate practical problems of applying such a solution. In initial trials an exact amount of microwave energy calculated from the enthalpy change required was supplied over periods ranging from 0.5 to 2 hours. No over-heating was observed but the resulting material was significantly under-thawed. When the total energy supplied was increased by a factor of 2.5 total thawing to above 0°C was achieved. Fifteen cm thick meat blocks inside solid fibre board cartons thawed in either 1 or 2 hours had maximum surface temperatures ranging from 14.9 to 26.7°C. The average weight loss over the 1 and 2 hour cycles were 6.5 and 8.2% respectively.

These experiments have demonstrated that the combination of microwaves with the vacuum overcomes previous problems. However, the energy requirements and capital cost of an industrial system are high and limit potential applications.

2:7

Energy consumption and weight loss in industrial pig chillers

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New pig chilling processes are often designed using low air temperatures and high air velocities to reduce weight loss. However, these conditions can only be obtained by increasing the power requirements of the refrigeration plant. In the United Kingdom it was impossible to calculate the economics of introducing such processes because no information was available on the amount of energy used, its cost and the financial losses due to evaporative weight loss in existing chilling systems. Measurements have therefore been carried out, initially at five abattoirs, to obtain this basic data.

All five abattoirs used a 24 hour batch chilling system in which pigs that had been slaughtered on one day were chilled overnight and cut and/or transported on the following day. Four of the abattoirs used a single stage chilling process with air at a nominal temperature between 1 and 6°C. In the fifth system pigs were initially placed for 1 hour in a pre-chiller using air at -5°C before being transferred to a main chill room set at a nominal temperature of 3°C.

An analysis of the data obtained shows that the specific energy used during pig chilling varied between 97 and 360 kJ/Kg, with a current average energy price of 1P/MJ this produced costs of 0.1 to 0.36 p/kg. The average weight loss at the abattoirs ranged from 1.85 to 3.5% of hot weight which resulted in a financial loss, assuming a wholesale price of 80p/kg, of between 1.5 and 2.8 p/kg.

It was clear that a large percentage of the difference in specific energy consumption between abattoirs was due in part to the extent to which the maximum capacity of the chillroom was utilised. When the data was adjusted to take into account this factor there were still substantial differences in total specific energy consumption and weight loss. The results indicate that reducing the average air velocity in existing chillrooms, especially in the latter stage of chilling, would reduce both weight loss and energy consumption. In two systems the average air velocity was reduced after the majority of the heat had been removed by switching off a proportion of the evaporator fans. The specific energy consumption of the evaporator fans over the 24 h period may be a useful indicater of this.

The difference in consumption and weight loss between abattoirs shows that there is considerable scope for improvement by transferring existing technology between abattoirs while also providing a basis for new comparisons. Since the loss in value due to weight loss is approximately 10 times that of the energy used, even modest improvements in yield would on purely economic grounds, justify large increases in the energy expended.

2:8

Decision making in slaughterhouses with an extended direct costing system

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Absorption costing systems (i.e. non-itemised) as currently applied in slaughterhouses no longer meet the requirements of a modern cost accounting system, i.e. making basic cost elements available for managerial decisions in the areas of planning, pricing and control. The appropriate management tool which provides the 'relevant cost' in decision-making situations in slaughterhouses can only be a cost accounting system which differentiates between the fixed and the variable cost elements. This is the case with direct (marginal) costing systems and extended systems. The basic concept of such an extended direct costing system is presented, special emphasis being given to the development of a hierarchy - adapted to real slaughter operations - in which all costs are allocated according to their specific hierarchy level as so called 'single' costs. As a result of such an extended direct costing system the profit contributions of the specific hierarchy levels are obtained which form the basis for the following managerial decisions:

1) Which is the maximum price level for buying livestock?
2) Buy half carcasses or prepare own?
3) Slaughter: yes or no?
4) Which grade is most profitable?
5) How should carcasses be cut?
6) Is processing of by-products profitable?

As a result of such an extended direct costing system the operational decisions become clear in terms of their profit contribution, thus offering decision-making aids for efficient management.

2:9

Electrical stimulation efficiency and distribution of electric potential and electric field along lamb carcasses

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The efficiency of electrical stimulation, indicated by the pH-drop post mortem, increases with the value of the electric field until it reaches a maximum depending on the duration of stimulation, for values higher than two volts/cm. This research focused on factors limiting its efficiency as applied to muscles situated in various areas of the carcass.

The object of this study was to examine the distribution of the electric potential and the electric field in the carcass arising from the applied stimulation voltage.

The experiments were carried out on eight male Limousin lambs of 15 to 17 kg carcass weight. Stimulation voltages were applied twenty minutes post mortem, after dressing, by placing electrodes:
- either at each end of the lamb carcass (shoulder and leg). The electric potential was then measured at several localized points on the line joining the electrodes:
- or at the severed neck muscles and the Achille's tendon, and the electric field measured at the localized level of several muscles.

The results showed:-

1. A sudden drop in the electric potential in the vicinity of the electrode; because of the polarization and the contact electrode-muscle tissue, only fifty per cent of the applied voltage is actually effective.
2. A heterogeneous distribution of the electric field exists in the carcass.
3. High values of electric field were measured in the m. Longissimus Dorsi, and very low values, three to four times lower, in the shoulder muscles, m. Supraspinatus and m. Triceps Brachii.

A better distribution of the electric field should therefore be developed by seeking the optimum positions for the electrodes. For this purpose, our study of the electric field was carried out by making a cast of a lamb half-carcass, filled with a uniformly conducting salt solution. It was found advantageous to use several electrodes (one being at the hook at the backlegs) to obtain a good distribution of the electric field.

The differences in the geometry and the electrical resistivity of the different parts of the carcass on the one hand, combine with the phenomenon of electrical contact between electrode and muscle tissue on the other, to modify the intensity and the distribution of the electric field.

2:10

Tenderness variability in muscles from bulls at standardized weight, age, slaughter and cooling conditions

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The effect of different animal or carcass characteristics or treatments on the tenderness of meat has been the subject of many investigations. Probably because of differences in animal characteristics, but also in carcass-handling, cooling-rate, method(s) used to asses tenderness, muscle(s) chosen, etc., the results of such investigations are often very different from each other and even contradictory. The investigation of the influence of a single animal or carcass characteristic on meat tenderness seems to be possible only if all other factors influencing tenderness are held constant or, are at least recorded in order to quantitate their eventual effect.

Two experiments were done to find out if conditions could be standardized in such a way that the effect on tenderness is as constant as possible so that similar animals would give similar tenderness ratings. For reasons of standardization and ease of working, Warner-Bratzler peak shear force was chosen as (objective) tenderness measurement. In addition to this main investigation target, the predictor (expt. 1) and indicator (expt. 2) value of Myofibrillar Fragmentation Index (MFI) determined on raw muscle for peak shear force measurements on cooked muscles was studied. For the first experiment 26 bulls of two different breeds of exactly 1 year old (mean values $\pm$ SE for live weigth : 457 $\pm$ 6 kg and dressing-% : 64.5 $\pm$ 0.2 %)were slaughtered in the slaugherhouse of our laboratory on 5 different days and for the second experiment 34 bulls of two different breeds of exactly 1 year old (mean value $\pm$ SE for live weight : 487 $\pm$ 6 kg and dressing-% : 59.0 $\pm$ 0.3 %) were slaughtered on 6 different days. Slaughtering was done after captive bolt stunning in a reproducible manner and carcasses transported to a cooling room (4 $\pm$ 2°C) after exactly 68 $\pm$ 1 min p.m.(expt. 1) or 64 $\pm$ 1 min p.m.(expt. 2). For both experiments temperatures of two muscles (Longissimus dorsi 8th toracic rib and Semitendinosus) of the right hand carcass halves were recorded continuously in a standardized way until 24 h p.m.. Both muscles were removed between 24 and 28 h p.m., vacuum packed and stored at 4°C until 8 days p.m..

For both experiments temperature measurements indicate that cooling rates were nearly identical for all carcasses, which was one of the objectives of the experiments. In spite of this standardization a great variability in peak shear force values was still observed not due to breed differences. For expt. 1 peak shear force values (determined at 8 days p.m.) ranged from 25.1 to 81.9 N and from 33.9 to 57.6 N for Long. dorsi and Semitendinosus respectively. For expt. 2 these values (determined on samples frozen at 8 days p.m. and preserved at -20°C for $\pm$ 1.1/2 months) ranged from 22.7 to 59.6 and 25.4 to 55.9 N respectively. Reasons for this variability will be discussed.
Although MFI and peak shear force values were significantly correlated, peak shear force could not be predicted reliably from MFI measurements.

2:11

Effect of extra low voltage electrical stimulation on sheep carcasses

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The effect of extra low voltage electrical stimulation (5V supplied by a commercially available electrical stimulator) on merino lamb carcasses was studied.

Three lots were prepared: 1) held for 24 hours at 15 ºC; 2) quick chilled; 3) electrically stimulated and quick chilled. All the lots were stored for 11 days at 2 ºC.

The toughness of the meat was measured with an Instrom texturometer, Kramer shear for semimembranosus muscle and Warner-Bratzler shear for semitendinosus muscle, as well as by a taste panel served biceps femoris muscle.

The Kramer shear values obtained indicate that muscle held for 24 hours at 15 ºC underwent an increase in tenderness during the storage period greater than that for muscle that was quick chilled; no differences were found between stimulated and unstimulated muscle. After the sixth day of storage, the tenderness of the quick chilled meat increased somewhat in both the stimulated and unstimulated lots.No similar results are reflected by the Warner-Bratzler shear values and the sensory scores.

2:12

Effect of extra low voltage electrical stimulation on the tenderness of bovine sternocleidomastoid muscle

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In order to optimally define the parameters for electrical stimulation, an experiment was designed to demonstrate the effect of extra low voltage stimulation (20 V direct current, 14,3 Hz, for 120 sec) on the tenderness of sternocleidomastoid muscle from one-year-old bovines.

Three lots were prepared: 1) held for 24 hours at 15 ºC; 2) quick chilled; 3) electrically stimulated and quick chilled. All the muscle used in the experiment was stored at 2 ºC for ten days, and, in each of four analyses, the shear values were measured and a taste panel assessed the toughness.

The results indicate significant differences ($P < 0,01$) between the shear values for samples from lot 1 and those for samples from lots 2 and 3, but no significant differences were found between the values for lots 2 and 3. The taste panel analyses of toughness produced similar findings. The results obtained therefore suggest that electrical stimulation had no effect on the tenderness of sternocleidomastoid muscle in the conditions tested.

2:13

The effect of early post mortem storage conditions on sensory and bacteriological quality of electrically stimulated hot boned beef longissimus.

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Six approximately 13 month old meat bulls of the Meuse Rhine Yssel (MRY) breed were stimulated electrically within 5 min post mortem (p.m.) (85 V, 14 Hz, 30 s). Within 1½ h p.m. both left- and right-hand longissimus muscles were hot boned and sampled for bacteriological examination. The caudal part up to the 3-5th rib was divided in equal "cuts" of approximately 10 cm thick which were sampled for sarcomere length assessment. The cranial parts were cut into 2 cm thick chops, which were run through a culture of bacteria prepared from scrapings of cutting tables, in an attempt to simulate a high degree of cross contamination. Cuts and chops of each animal were vacuum packaged and randomly distributed to water baths of 0, 10, 15, 25 and 35°C in which they remained for 3.5 or 7 h. A rough estimate of the rapidity of glycolysis was obtained by monitoring pH and temperature fall of one single longissimus cut per bath, fully submerged in an open vacuum bag. After conditioning, cuts and chops were stored on open racks in a chilling room at 3 ± 1°C for 8 days. At day 9 cuts were unpacked and tested for colour, drip loss, sarcomere length and, after cooking to an internal temperature to 70°C, for cooking loss and Instron Warner Bratzler shear force. In addition cuts and chops were examined bacteriologically.

The 5 h/15°C conditioning period produced meat with the highest sarcomere length and the lowest drip loss and shear force. Temperatures of 0 and 35°C resulted in "cold-" and "heat-shortening" respectively. The concomitant increase in drip loss indicate a certain relationship between muscle shortening and water binding. Hunter L, a and b colour values increased with increasing temperatures. Cooking losses were not significantly different for the various treatments.

Bacteriological examination showed, not surprisingly, that conditioning at 0 and 25°C resulted in the lowest and highest colony counts respectively. Temperatures of 10-15°C resulted in an increase in aerobic colony counts (at 30 and 4°C) from 2-3 log cfu/cm² at day 1, to approximately 5 (cuts) - 6 (inoculated chops) log cfu/cm² at day 9. Colony counts of mesophilic Enterobacteriaceae and Lactobacillaceae, both being under their limits of detection at day 1, increased to approximately 3 (cuts and chops), and 2.5 (chops) - 5 (cuts) log cfu/cm² respectively at day 9.

These findings indicate that early post mortem conditioning of electrically stimulated and hot boned beef should be conducted at 10-15°C, to meet both sensory and bacteriological quality requirements.

2:14

A comparison of the yield of saleable meat from hot and cold boned beef carcasses

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Hot boning is a procedure which has been promoted as a potential means for meatworks to reduce costs and increase the yield of saleable meat. Researchers have claimed that much of the weight lost during chilling of beef sides can be saved if the carcasses are boned out as soon as possible after slaughter.

This work describes the results obtained in a number of trials undertaken to determine if the yield of saleable meat from hot boned beef was significantly different from that from cold boned beef, when conventional boning procedures as currently practised by the Australian meat industry were used.

Results showed that an increase of 1.4% in meat yield was obtained for manufacturing grade cows (aged cows with an average dressed weight of 153 kg) when the carcasses were hot boned, as compared with cold boned. No significant difference in yield was found for domestic trade steers (young steers (0.2 tooth) with an average dressed weight of 233 kg and fat depth of 9 mm at the 12/13th rib)

The varying performance of the boning teams appeared to have as great an influence on the yield as the method of boning (hot or cold).

2:15

Rapid processing systems for pork

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The University of Georgia has been investigating the development of rapid processing systems for pork during the past three years. These studies have focused on the production of boneless, vacuum packaged, whole muscle cuts. During this time period, four major studies have been completed and the results of these studies will be presented. These studies were developed to investigate the effects of boning time postmortem, electrical stimulation, conditioning temperature, chilling temperature and length of storage on the sensory and physical properties of primal cuts. More specifically, Study I was developed to evaluate the effects of conditioning time (4, 6 and 8 h) at 17°C on the sensory and physical properties of boneless loins and shoulders. In addition, the effects of brine and conventional chilling systems were evaluated. In Study II, boneless loins and shoulders were obtained from carcasses conditioned for periods of 1, 2, 3 and 4 h postmortem at 17°C. The subcutaneous adipose tissue was removed from the loin on the left side of each carcass in order to evaluate the effects of fat cover on the physical and sensory properties of hot processed pork loins. Study III was concerned with the effects of electrical stimulation (ES) on both the physical and sensory characteristics of boneless loins and shoulders. In this study, carcasses were pulse stimulated (550 V) for 105 seconds. The loins and shoulders were deboned approximately 30 min postmortem, vacuum packaged and chilled using a brine system. Study IV consisted of two conditioning and two ES processing systems. The conditioning systems evaluated were 11°C for 5 h and 17°C for 3 h. Electrical stimulation systems consisted of pulse stimulation 550 V within 10 min postmortem followed by deboning within 1 h or 24 hr postmortem. All hot processed cuts were vacuum packaged and chilled in a glycol chiller to an internal temperature of 5°C. Conventionally processed carcasses were chilled at 10°C for 24 h prior to processing. In each of the four studies, mean values for percentage purge, thaw loss and cook loss were determined. Loin chops were evaluated by trained sensory panels for flavor, juiciness and tenderness. The major findings of these various studies are summarized by the following conclusions. In general, whole muscle cuts conditioned at 11°C for 5 h and cuts from carcasses conditioned at 17°C for 3 h were either "equal to" or "superior to" conventionally processed cuts in every trait evaluated. Electrically stimulated (ES), hot deboned cuts were observed to be similar to conventionally processed cuts. ES, cold deboned (muscles excised 24 h postmortem) primal cuts appear to be an undesirable method for rapidly processing pork.

2:16

Effect of high and low voltage stimulation on tenderness of muscles from slowly cooled beef sides

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The possibility of early tenderisation of beef when ES is followed by slow cooling has been investigated. One side of each of 5 beef carcasses was stimulated using 700 v (HES) and the opposite side taken as unstimulated control (CON). Another 5 carcasses were stimulated using 85 v (LES) immediately after sticking and one side from each included in the experiment. All sides from each of the 3 treatments were held at 15°C for 7 hours before being put in a chillroom at +1°C until 48 hours post-slaughter. This cooling procedure was designed to avoid cold-induced toughening.

The M. semimembranosus (Sm), M. longissimus dorsi (LD), M. triceps brachii (TB), M. pectoralis profundus (PP) M. serratus ventralis (SV), were removed at 48 hours, vacuum packed and held at +1°C until 3, 7 or 10 days post-slaughter.

At 1 hour post-slaughter, the pH averaged 6.44 for all muscles from HES sides compared with 6.93 from CON sides. Muscles from LES carcasses had an average pH, at the same time, of 6.14. Corresponding ultimate pH values at 48 hours were 5.63 (HES), 5.62 (CON) and 5.67 (LES).

Drip loss from all muscles at all three assessment times averaged 2.2% (HES), 2.0% (CON) and 3.0% (LES). Cooking losses were unaffected by ES, being 37.3%, 37.7% and 36.2% respectively.

The colour attributes (saturation, hue and lightness) of all muscles at all 3 assessment times were measured after 1 hour's exposure to air; ES had no effect.

Texture of cooked samples was measured instrumentally. When classified into toughness groups, "tender" (mechanical shear value <0.15 J), "intermediate" (0.15 to 0.25 J) and "tough" (> 0.25 J), CON carcasses had 6% of measurements "tender" and 27% "tough" at 3 days. Frequencies for LES were 13% and 12% respectively and for HES were 27% and 10%. At 10 days CON measurements were 21% "tender" and 9% "tough". Frequencies for LES were 26% and 11% respectively and for HES were 37% and 2%. High voltage stimulation was therefore more effective than low voltage in improving tenderness.

Tenderness of CON samples at 10 days was achieved in 7 days with LES and 3 days with HES.

2:17

The relationship of bloom to washing, bacterial numbers and animal type (cows, heifers, steers) in beef carcasses

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The term bloom is used in the fresh meat trade to describe the appearance of freshly killed sides of beef. This is a visual assessment made by buyers and for some years now the beef processing industry in Ireland has been concerned with attempts to clearly define bloom in absolute terms. This interest arises mainly from the fact that where bloom is judged to be poor, buyers may downgrade carcasses in price.

The present study was designed to determine the effect of spray washing with warm water (40^{o}C), on carcass bloom. The carcasses were stored in a commercial chill for 9 days and the relationship of bloom to bacterial numbers was also examined. The final part of the investigation was used to observe differences in bloom between carcasses from cows, heifers and steers, immediately post slaughter and after 36 hours in chill.

The results showed that washing beef carcasses had no effect on bloom. There was no difference in washed or unwashed sides after 9 days storage in a chill. Bacterial numbers were similar on washed and unwashed carcasses and there was no correlation between bacterial numbers and bloom.

When cows, heifers and steers were assessed for bloom, the cows were significantly different ($P<.001$) from the other two types. Heifers and steers had similar bloom scores. There was no difference in bloom scores at 0 time and after 36 hours in chill. Age difference was considered a possible factor in the inherently poorer bloom of the cow carcasses.

2:18

Non-destructive method for early detection of dark, firm, dry meat

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When carrying out hot-boning it is important to know if the meat carcasses are or are not originating from animals that have undergone prolonged stress, and which are likely producers of DFD-meat (dark, firm, dry). Especially when vacuum-packing, it must be determined as early as possible if the ultimate pH of the meat is to be normal.

It is known that the ultimate pH in meat is sometimes not reached until 48 hours post mortem. This may happen when there are certain temperature conditions and the meat has not been electrically stimulated effectively.

A method for estimating the ultimate pH only two hours post mortem is said to be needed (Buchter, 1982). Using the method described below it is possible to tell within 10 - 30 minutes post mortem, depending upon the slaughter speed, whether or not the meat will develop DFD-quality characteristics.

This method is based upon a "local" electrical stimulation in the Longissimus muscle immediately after dehiding by pulses applied by use of a Scancontrol apparatus equipped with two specially designed electrodes. This stimulation of the muscle section is followed by a pH measurement. Other convenient muscles may be used (eg Supraspinatus, either entire or in part.

The fact that the pH in the electrically stimulated muscle section falls rapidly, because the voltage "over" the section is relatively high, is used to advantage. When the carcasses are passing the weigh-point, the pH values in the Longissimus muscles in those carcasses which are not producing DFD-characteristics, have already fallen below the limit (in Norway) of pH 6.0.

Methods and criteria of practical ways of PSE determination in pork meat and the principles of its technological processability

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The occurrence of PSE meat is a world-wide problem. It is a result of intensive hybridizing programmes aiming at an increase in meat production. It concerns meat from animals sensitive to stress factors and is congenitally predisposed. Meat from such animals has an atypical course of ripening and has unsuitable technological properties. From the veterinary point of view, a part of such meat is classified as lower quality meat causing economic losses. It is therefore in the interest of the society to follow the incidence of such meat through the chain of agricultural production and the processing industry, as well as the technological suitability in the meat industry.

Objectives of the research and study were: researching the level of occurrence of PSE and DFD meats according to the four seasons of the year; the choice of suitable evaluation methods on the overall evaluation; criticism of limits of characteristics of PSE and DFD meats and a proposal for their arrangement; testing of PSE and DFD meat processing in assorted technologies of the meat industry and in assorted meat products. Meat was judged according to the criteria of the Czechoslovak national breeding industry, GDR standard TGL24704/28 and the criteria of the Research Institute of the Meat Industry in Magdeburg. For identification and evaluation of PSE and DFD meats, the following indicators were used: pH_1, pH_{24}, WBC, remission, consistency, percentage of losses by dropping and pressing, and sensory evaluation according to criteria included in the Czechoslovak veterinary regulations. Technological suitability was tested: in the case of packed meat in pieces and slices, in different foils, in normal atmosphere, and in vacuum; in the case of products with fine and coarse structure, ham and cured anatomical pieces.

Results of the study: largest amount of PSE meat occurred in the Spring (11%) and lowest amount in the Autumn (0.5%); the largest amount of DFD meat occurred in the Autumn (22%), the lowest amount in the Spring (4.8%); most suitable method of evaluation seem to be by pH, but it is not sufficient (objective evaluation requires at least three criteria - pH, colour, losses), sensory evaluation is insufficient; neither PSE, nor DFD meat is suitable for packing, for ham and products with gross structure and for producing cured anatomical pieces; processing of DFD meat for meat product is not limited; PSE meat is recommended for fine ground salami; it is suitable to combine PSE meat with DFD meat.

It is recommended to decrease the internationally acknowledged limit for PSE from 5.8 to pH 5.6 and to use the following scale for evaluation: low, medium, high manifestation of PSE values.