PPI

Functional properties of Australian beef
M.221

Prepared by:
JA Boles & J E Swan

Published: May 1995

MEAT & LIVESTOCK
AUSTRALIA

Executive Summary

A survey of American meat processors identified two U.S. market sectors interested in buying beef ingredients on the basis of improved functionality: sausage manufacturers and roast beef manufacturers. The former did not offer as much promise as originally thought as they are very price driven and unlikely to pay extra for graded meat. Roast beef manufacturers wanted closely trimmed, weight-ranged cuts, and would welcome guidelines on handling Australian meat to get the best performance. Developing standards for the AUS-Meat Handbook and increasing technical support to this market sector would be advantageous.

A survey of Australian packers found that they were more interested in research on meat functionality than on weight-ranging cuts for the U.S. market and also were interested in ways of getting around the import quotas existing at that time. A second survey in the U.S. determined the raw material characteristics desired by roast beef manufacturers and surveyed roast beef manufacturing methods.

Initially, laboratory studies examined the functionality of seven Friesian cow cuts (rib trim, chuck, hindshank, brisket, silverside, striploin, thick flank) for sausage and patty manufacture. Due to the results of the first U.S. survey, the focus changed to studying processing factors that affect cook yields and quality of roast beef. The following results were obtained:

Meat cut and functional properties: Rib trim and chuck from cows had higher pH values and produced darker, redder sausages than the other cuts. Sausages from striploin, rib trim, hindshank or chuck had higher sensory scores, and patties from thick flank and striploin had better sensory and cooking characteristics.

Cap muscle: About 25-30% of the cap-on inside was cap muscle (gracilis) and associated fat removed before roast beef manufacture. Roast beef manufacturers prefer to buy cap-off insides. Insides from British (*Bos taurus*) breeds had proportionately more cap muscle than insides from Brahman (*Bos indicus*) or Brahman x breeds (28.7, 25.9, 26.5% respectively).

Purge: Purge (drip loss) from insides was not affected by breed or animal age but was significantly higher for thawed meat than for meat stored chilled. Extending frozen storage at -20°C for up to 20 weeks increased purge slightly. Insides with higher pH had less purge on thawing. For vacuum-packed frozen insides, purge is minimized if the meat is thawed in water rather than in air and is processed immediately after it is removed from the package. Chill-stored (-1.5°C) flats had less purge and higher cook yields than insides.

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1. Introduction

The United States is Australia's largest market (although decreasing in proportion) for beef and for frozen boxed meat. Most of this meat is used for manufacturing patties and sausages. Adding value is a strategy of the Australian meat industry, although adding value may involve only a gradual upgrading of products rather than a radical change in the types of products produced. Added-value products can be targeted at three major end markets: retail, manufacturing, and the hotel, restaurant and institutional (HRI) sector. Information about manufacturing grade meats can lead to new market opportunities as well as provide technical assistance to current customers.

Many food manufacturers in Europe, Japan, and American want to establish effective, direct relationships with their suppliers. As well, many of these manufacturers have dramatically reduced the number of meat suppliers they deal with, and buy from only those suppliers whose product consistently meets specification. Becoming one of a few preferred suppliers has considerable benefits. For example, production can be planned and joint product specifications can be developed. Direct contact allows for better communication of requirements, and therefore food manufacturers can obtain products that better meet their specifications and quality requirements (Archibald *et al.*, 1994), and raw material specifications could be modified as required. Direct relationships would help those food manufacturing companies wanting to co-develop products with Australian companies. Such alliances between food manufacturers and suppliers would greatly reduce the risk and cost of product development. Information on Australian meat is needed to meet these changing trends.

The initial objectives of the programme were:

- To survey U.S. market requirements and quality criteria for manufacturing beef and to survey Australian meat processors' research needs.
- To determine the most appropriate methods for measuring meat functionality that would provide the information required by the end-users.
- To measure the functionality of Australian manufacturing beef, and determine how factors such as breed, gender, cut and post-slaughter conditions affect this functionality.
- To transfer the information to the Australian industry.

strategy for round cuts in the U.S., and whether the company would use an algorithmic tool to assist planning for supplying weight-ranged roasting cuts to the export market. As well, suitably located packers were asked if they would supply specially selected cuts for MIRINZ trials on roast beef functional properties. The data from this survey were used to identify the opportunities for developing products not subject to the U.S. voluntary restraint agreement (VRA), and ways of transferring the results of this project to the Australian meat industry (List, 1993b).

A list of companies in the U.S. involved in producing beef products was compiled from a directory of meat processors (List, 1994a). Companies were chosen if they primarily were processors or further processors of meat, if their major products included further processed beef, and if their general products included cooked meat.

In a second survey, ten U.S. roast beef manufacturers were visited in October/November 1993 to obtain process and product details for manufacturing roast beef products suitable for the U.S. market, to obtain information on raw material qualities required to manufacture roast beef to U.S. specifications, and to identify opportunities for beef preparations that may circumvent the VRA on beef cuts being exported to the U.S. at that time. The information was summarized in a confidential report (List, 1994b) and used to develop the methodology for laboratory trials on how meat cut, meat characteristics, storage and processing conditions affect roast beef quality.

2.2 Literature Survey

Before any research was done, the scientific literature from 1960 to present day was searched, both on-line and manually, for methods of measuring meat functionality. The information was summarized in a confidential report (Reid, 1993a).

2.3 Raw Material

Effect of meat cut on sausage and patty quality (Milestones 2 and 4)

The effect of beef cut on the yields, tenderness and cook loss of sausages and patties made from cow was studied. This type of animal was chosen as being representative of manufacturing beef. Thick flank, silverside, brisket (point end, seamed), chuck, hindshank and striploin were taken from twelve Friesian cows (carcass weight 170-214 kg) that had been slaughtered at the MIRINZ research abattoir. Rib trim was also obtained from six of the animals. The carcasses had been electrically stimulated and stored in a 5 °C chiller for 24 h before being boned. The cuts were placed into plastic boxes and transported to the processing laboratory.

-20°C for 2 weeks. Meat that was to be stored chilled was obtained 2 weeks after the meat to be frozen and was held in a -1.5°C chiller for 1 week before freezing. Thus, chilled and frozen cuts had been aged for the same amount of time.

Effect of cut and chilled storage time on roast beef quality (Milestone 12)

Prime steer insides and flats were obtained from a New Zealand export beef processing plant. Steers were electrically stunned and carcasses were electrically stimulated. The beef sides were stored in a 4°C chiller for 18 h before being boned.

Insides and flats were removed from 40 carcasses and trimmed to 1 cm external fat. The cap muscle was removed from all insides, and all cuts were vacuum packaged in non-shrink barrier bags [stated OTR of <70 ml m^{-2} 24 h^{-1} atm^{-1} at 23°C; W.R. Grace (N.Z.) Ltd, New Zealand)]. Packed cuts were transported within 2 h to MIRINZ under refrigeration (7°C), where they were placed in a -1.5°C chiller.

Effect of thawing rate, cooking rate and final internal temperature on roast beef quality (Milestone 14)

Insides were obtained from market weight steers at a New Zealand export beef processing plant. Steers were electrically stunned and carcasses were electrically stimulated. The beef sides were stored in a 4°C chiller for 18 h before being boned.

Cuts were transported to MIRINZ under refrigeration (4°C). All insides were then vacuum packaged in barrier bags [stated OTR of <70 ml m^{-2} 24 h^{-1} atm^{-1} at 23°C; W.R. Grace (N.Z.) Ltd, New Zealand]. After packaging, cuts were blast frozen (-35°C, air velocity 2-3 m s^{-1} for 48 h) and then stored at -20°C for 5 weeks.

Effect of breed, gender and frozen storage time on roast beef quality (Milestone 15)

Insides were obtained from steers (1-2 yr) and cows (≥ 3 yr) typical of animals being processed at two different export beef plants in Australia (Melbourne and Brisbane). Animals were electrically stunned and carcasses were electrically stimulated. The beef sides were stored in a 4°C chiller for 18 h before being boned.

Cuts were vacuum packed in shrink barrier bags [stated OTR of <70 ml m^{-2} 24 h^{-1} atm^{-1} at 23°C; W.R. Grace (N.Z.) Ltd, New Zealand]. Insides designated for frozen storage were frozen immediately; chilled product was held in a -1.5°C chiller until being air-freighted to New Zealand. Product was transported from the airport to MIRINZ under refrigeration (4°C). Frozen product was stored at MIRINZ at

NaCl solution were blended for 1 min at 16 000 rev min^{-1} in a Sorvall Omni-mixer with a six-bladed assembly. After blending, 1.5 ml of the meat slurry was centrifuged at 16 000 x *g* for 5 min. The protein content of the extract was determined by the Biuret method (Gornall *et al.*, 1949).

2.5 Meat pH

Minced meat samples were homogenized with distilled water and the pH was tested using an Orion pH metre, model 230A (Watson Victor Ltd., New Zealand). The measurements were made in duplicate and the mean was used for statistical analysis. The pH of whole meat cuts was determined using an Ingold stab probe.

2.6 Product Preparation

Sausage batters

Batters with the same protein, fat and moisture content were made for each cut using minced meat and fat, which had been tempered overnight at 0°C. A formulation typical of finely comminuted sausage products was used, with the amounts of lean beef, fat and ice being adjusted to produce batters with 13.5% protein, 25% fat and 59% water. All batters contained 2% added salt. Batch size was 2.5 kg.

To make the batters, lean beef, salt and ice were comminuted in an Adjutant table top bowl chopper (MADO, Germany). After 2.5 min chopping, the minced beef fat was added. Chopping continued until a total of 5.5 min had elapsed. After chopping, approximately 1 kg of batter was removed from the bowl and vacuum packaged. The vacuum bag was cut at one end and placed hole down in a manual sausage stuffer that fed the batter into five stainless steel tubes (internal diameter 19 mm, length 270 mm). Each tube was lightly oiled with 'Chef Mate' (S.C. Johnson and Sons Pty. Ltd., New Zealand), an aerosol containing soya bean oil. The the ends of the tubes were tightly sealed with rubber end-caps held by hose clips. The tubes were heated for 30 min at 50°C and then for 45 min at 70°C in two separate water baths. Immediately the heat treatment was complete, tubes were cooled on ice and then held overnight at 4°C before functionality tests the next day.

Patty manufacture

Meat and fat were thawed before use by holding at 10°C for 24 h. Meat, fat and table salt were weighed to ensure the patties contained 20% fat and 0.8% salt. The meat, fat and salt were mixed in a model A200 Hobart mixer (Hobart Corp., Troy, OH) fitted with a paddle blade on speed 2 for 30 sec. Batch size was 3 kg. The mixture was removed and minced through a 3-mm plate, then loaded into a patty cylinder, and the volume of fat and water released was measured. Fat and water losses were calculated as those volumes expressed as a percentage of the original weight of batter in the tube.

Cook yield and shrinkage of patties

The weight and total length plus width of six raw patties were recorded. The patties were then cooked simultaneously on a Hayman hotplate (Model PG30, Dishmaster Manufacturing Ltd, New Zealand), set at 165°C, for 2.5 min on the first side and 1.5 min on the second side. Immediately after being cooked, the patties were blotted gently on each side with paper towels, then reweighed and remeasured while still hot. The cooked weight and difference in dimensions was expressed as a percentage of the uncooked patty weight or dimension (cook yield and shrinkage)

Water-holding capacity of raw meat

The filter-paper press method developed by Grau and Hamm (1953, 1957) was used to measure the amount of water expressed from a raw patty held under pressure. Between 500 to 800 mg of the patty mix was placed on a filter paper with a defined moisture content (Whatman No. 2 qualitative stored above a saturated solution of potassium chloride) and pressed to a thin film (>40 kg pressure) between two plexiglass plates. The amount of water released by the meat (area of moisture ring around the meat film area) was expressed as a percentage of the meat weight. This value is inversely proportional to the meat's water-holding capacity (WHC). Results reported are the means of two determinations.

Torsion tests for batters

In torsion testing, shear stress and true shear strain at failure (referred to as "stress" and "strain" in this report) are measured. Shear stress is a measure of gel strength and is sensitive to protein concentration, processing characteristics and ingredient variables (Hamann, 1988). Shear strain is a measure of the deformability of the gel. Hamann and Lanier (1987) and Hamann (1988) reported that shear strain is influenced mainly by protein quality and is not as sensitive to protein concentration or processing characteristics as shear stress.

Torsion tests of cooked sausage batter were performed as described by Kim *et al.* (1986). For each treatment, one tube of batter that had been cooked for 30 min at 50°C and then for 45 min at 70°C in two separate water baths, was used for torsion testing. Immediately after cooking, the tubes were cooled in ice-water, then held for about 1.5 days at 3°C before testing. The cooked batters (gels) were then carefully extruded from their tubes and cut into 28.7-mm lengths, taking care to

2.8 Colour Evaluation

Colour measurements were done using a D25A-2 Hunterlab Tristimulus Colorimeter (Hunter Associates Laboratory, Inc., Reston, VA), a Hunterlab Miniscan (Hunter Associates Laboratory, Inc., Reston, VA), or a Gardner Spectrogard reflectance spectrophotometer (Pacific Scientific, USA). Instruments were set for Hunter ***L*** (lightness), ***a*** (redness) and ***b*** (yellowness) with a D65 illuminant at 10 degrees.

Colour of sausages and the seven raw cuts

To measure cooked sausage colour, four 25-mm long samples were taken at random along the 270-mm length of the sausage used for determining fat and water losses. Samples were placed under a pre-cleaned 1.0-1.2 mm thick glass microscope slide (Lomb Scientific and Co., Sydney, Australia) to prevent the sample surface becoming convex under pressure from the circular viewing aperture.

Surface colour of the raw meat was measured when the cuts arrived at MIRINZ. To measure cooked colour, whole-tissue samples, 20 mm thick and at least 30 mm in diameter, were heated to an internal temperature of 62°C in a 75°C water bath.

Colour of beef insides

To measure raw colour, a 1.3-cm slice from the anterior end of each raw cut was placed on a polystyrene tray and over wrapped with stretch film (D-film with a stated OTR of >2000 ml m^{-2} 24 h^{-1} atm^{-1} at 23°C; Printpac-UEB Ltd, New Zealand). The slices were placed in a single layer in boxes to exclude light and allowed to bloom in a 4°C chiller for 4 h before measurement. The mean of the three measurements taken at different locations was used for statistical analysis.

To measure cooked colour, a 1.3-cm slice from the middle of each cooked roast was packaged the same way as the raw slices. Colour measurements were taken at three locations per slice at 1, 15, 30, 60 and 120 min after slicing. The mean of the three measurements was used for statistical analysis.

2.9 Sensory Evaluation

Sausages

Fifteen untrained panellists used a 7-point hedonic scale to score the visual attributes of smoothness (particle size) and lightness (colour) of sausages made from each of the seven meat cuts. To assess the sausages' texture, six random 25-mm long samples from sausages that had been used for the cook yield tests were equilibrated

The following sensory characteristics were evaluated on a six-point structured scale: juiciness, dryness, tenderness, toughness, beef flavour intensity, off-flavours, "would you buy this product", and overall acceptability (Appendix 1). At the start of each session, panellists were also asked to score these attributes for their "ideal" beef roast, and to fill out the biographical information sheet to obtain the panellist group profile. Panellists then scored two randomly selected cubes of each sample. Room temperature water and unsalted saline crackers were available so panellists could cleanse their palates between each sample.

2.10 Factors Investigated

In Milestones 2 and 4, the effect of beef cut (thick flank, silverside, seamed point-end brisket, chuck, hindshank and striploin) on sausage and patty quality was determined. The trial was replicated six times (six carcasses per trial).

To investigate the effect of cut, storage condition and thawing regime on roast beef quality (Milestone 9), the pH of each individual cut was determined on arrival at MIRINZ. The cuts were then weighed, randomly assigned to the treatment conditions, vacuum packaged and blast frozen (-35°C, air velocity 2-3 m s^{-1} for 48 h). The following factors were investigated, with treatments being replicated twice:

- **Storage** — Chilled (4°C for 3 d) or frozen (5, 10 or 20 weeks at -20°C)
- **Cap muscle** — Stored with cap on or cap off
- **Thawing regime** — Meat was thawed at 4°C in either water or air for 48 h
- **Holding time** — Thawed meat was then held at 4°C in air for a further 24 h, either in the package or unpacked

The following factors were investigated to determine the effect of pH and storage condition on roast beef quality (Milestone 10). The trial was replicated five times.

- **Meat pH** — Normal <5.6; high ≥6.0
- **Storage** — Chilled (-1.5°C) for 1 week, then frozen -20°C for 2 weeks; chilled (-1.5°C) for 1 week

To investigate the effect of cut and chilled storage time on roast beef quality (Milestone 12), cuts were removed from chilled storage at various times and

2.11 Statistical Analysis

Data from Milestones 2 and 4 were analysed as a completely random design with six cuts evaluated from six cows. There were three replicates for each test, except for data from the filter-paper press tests (two replicates).

The experimental data from the roast beef functionality trials were analysed as follows:

- Data from Milestone 9 were analysed as a 4x2x2x2 factorial with five replicates.
- Data from Milestone 10 were analysed as a 2x2 factorial (two meat pH groups, two storage conditions) with five replicates.
- Data from Milestone 12 were analysed as a 2x7 factorial (two cuts and seven storage periods) with five replicates.
- Data from Milestone 14 were analysed as a 2x2x2x2 factorial (two thawing regimes, two unpackaged times, two cooking regimes and two final internal temperatures)
- Data from Milestone 15 were analysed as a 3x2x4 factorial (three breeds, two age/genders, four storage times) with five replicates.
- Data from Milestone 18 were analysed as a 2x2x2 factorial (two countries, two breeds, two shipping conditions) with four replicates.

Data were evaluated using Genstat (Rothamsted Experimental Station, U.K.) simple analysis of variance. Means were separated using least significant differences.

3. Results and Discussion

3.1 U.S. Manufacturer Survey (Milestone 3)

Manufacturers' preferences

Nine of the companies interviewed derived all or a substantial part of their business from grinding beef for patties. Other processors manufactured patties for smaller food service outlets and school lunch programmes.

There were two types of patty manufacturing processes. Companies processing for Burger King were allowed to use up to 50% imported frozen beef, which was manufacturers. Salami formulations often contain bull meat because it is redder and thought to improve product colour.

Roast beef manufacturers inject round cuts to reduce cooking losses. After being injected, the cuts are massaged, bagged, roasted, cooled and sliced to various specifications. Manufacturers were interested in knowing whether chilled Australian cuts would give higher cook yields and better bind than U.S. beef, especially in processes where customers demand less or no injection. The Food Service clients of roast beef manufacturers usually specify the meat cut that can be used. These specifications are becoming increasingly more specific (for example, weight-ranged cap-off inside rounds). Therefore, manufacturers would like Australian exporters to provide greater volumes of highly trimmed cuts.

Beef used for Mexican food is ground and cooked in a bean and sauce mix before being put into a tortilla or taco. Processing lines are very sophisticated but the demands for meat functionality are lower than for meat used for patties. Consequently, these manufacturers were interested in buying beef only on CL.

Fajitas, a Mexican stir fry mix including beef, chicken or seafood served on a hot skillet, are used in food service. Beef pieces (traditionally from skirts), are cut, massaged in marinade and three-quarters cooked away from the point of sale. The consumer in the food service outlet fills tortillas with the stir fry. Fajita manufacturers would welcome improved moisture binding during cooking but are not actively seeking other improvements in meat functionality. They, however, would like improved availability of trimmed cuts. Current manufacturers believe that more food service operators will increasingly become interested in meat strips as a base for dishes other than fajitas.

Pizza topping is an 180,000 t/y market. About half of this is formulated from low CL beef, with pepperoni, beef pieces and mince being major contributors. Pepperoni manufacturers have similar requirements to salami manufacturers, whereas manufacturers of beef pieces and cooked mince have similar concerns to Mexican food and fajita manufacturers.

It is not cost effective to use long processing times to extract protein to make restructured roasts. Consequently, restructured roasts are frequently bound using added emulsion rather than by massaging pumped meat. These manufacturers' concerns about functionality in beef are closer to those of sausage manufacturers ratio is usually calculated by dividing the meat's moisture content by the crude protein (percent Kjeldahl nitrogen x 6.25) content. Domestic beef has values of 3.6-3.75. Although manufacturers do not have to achieve a minimum protein content in sausage products, using meat with a low moisture:protein ratio means that there is more protein per unit volume. The increased protein can help the bind without requiring high levels of other ingredients. Every advantage is sought when making stable emulsions containing high moisture.

Theories on how meat binds moisture or fat and then forms stable emulsions include the influence of factors such as pH and rigor state, and type and content of protein and fat. Processing variables affecting bind that are controlled by meat processors and exporters pre-slaughter animal handling procedures, and storage condition (chilled or frozen, storage time, type of packaging).

Meat processing often has steps where the meat is size reduced (ground, diced or chopped) and the meat particles are then bound together by processes that may involve forming, extrusion and/or heat setting. Meat size reduction and particle binding are important in the following products that the companies interviewed were manufacturing: hamburger patties, hot-dogs, salamis, bologna, restructured roasts, burrito and taco fillings, pizza toppings and fritters. Many of these products are cooked and are susceptible to shrinkage, so manufacturers are interested in the ability of meat ingredients to bind fat and moisture, especially when the products are heat treated before sale.

The manufacturers interviewed were primarily focused on new opportunities in food engineering and the processing variables that increase particle bind and reduce product shrinkage. These included factors such as meat particle size; processing time/speed; packaging atmosphere; processing temperature profile; volumes and process capacities; using ingredients with pH or ionic effects (e.g. salt, phosphate) or emulsifying ability; adding fillers or stabilizers; the order of unit operations, and temperature of ingredients (frozen or chilled).

Manufacturers often select meat that has been supplied in different formats by exporters. The manufacturers do not generally purchase meat ingredients according to biochemical variables of the different cuts. Sausage manufacturers showed the most interest in understanding the biochemical bind quality of meat ingredients. However, they do not want meat individually graded for pH, protein type, processing variables, etc. More than one factor affects bind, so grading meat for the wide range of factors that affect bind strength would have limited value.

values of 6.0-6.5. However, although these manufacturers believed that there may be applications for high pH meat, they were concerned that quality and supply would be too variable. Some large manufacturers with R&D units were prepared to co-operate with Australian organizations to trial this type of beef.

Salt-soluble proteins are extractable proteins that aid binding in processed meats. The proteins form tight bonds between meat particles and in emulsions during heat setting. Manufacturers acknowledged that cuts with lower salt-soluble protein and higher collagen contents (such as briskets) do not restructure as well. However, because salt-soluble protein content is only one factor affecting binding ability, manufacturers were uncertain whether they would benefit if cuts were graded on this characteristic. Although collagen content is an important specification for McDonald's manufacturers in France and Germany, it is not a specification issue for American manufacturers.

The companies interviewed had strong opinions on how meat colour influences acceptability. They considered that consistent colour as well as the colour itself is important for cuts being used in meat products. Consumers do not like speckled cuts. Manufacturers have found that domestic grain-fed steer cuts with higher internal fat contents oxidize faster. They also found that the grey colour of sirloin cuts after one day's exposure to the atmosphere makes them unsuitable for manufacturing beef roasts. Top rounds have lower internal fat and can be exposed for up to 3 days without detrimentally affecting cooked colour. The lower internal fat content of range-fed (Australian) beef cuts may give manufacturers extra flexibility.

Manufacturers reported that thawed cuts that had not been vacuum-packed are unsuitable in formed products (such as Philadelphia sandwich fillings) because the surface of the cuts oxidizes and becomes grey. Bulk-packed meat cuts lose colour for certain processes. The cooked colour of roasts made from chilled cuts that had been stored for more than 2 weeks in vacuum packaging is an unacceptable grey. Flap and blade meat (rose-meat) are used for certain roast beef specifications because of their lighter colour. During cooking, shank meat gains a cooked colour more slowly than other cuts.

Frankfurter colour development takes longer in the smokehouse if frozen product is used. Whole-tissue products made from older animals can be unacceptably dark. However, dark meat is preferred for some sausages and salamis. Defatted beef hearts can be added to increase the colour of these products.

interest in trimmed range-fed cuts because of the increased demand for lean whole-tissue meat products.

The final CL in a patty is a function of blend of ingredients in the mix. If an error is made when using the algorithm to calculate patty CL, the ground meat must be re-blended with meat of the appropriate CL. This additional blending can increase meat temperature and allow bruising (disruption of the cells). This bruising can create quality problems when the patty is broiled, as the patty can seal too quickly. Because the juices cannot escape, swelling occurs. Because of increased quality assurance and new food engineering systems, this problem has decreased. On-line CL measurement and weight control is becoming more accurate, and more manufacturers are using CO_2 to cool the blend. The latter process reduces the reliance on tempered meat to cool the blend. Manufacturers would like to identify cuts with greater bruise resistance. However, this is of academic interest and unlikely to influence manufacturers' buying behaviour.

Briskets are suitable for pot roasts and corned meat as they have the long muscle fibres required. However, there is no point in grading for this characteristic as it is only a small market share for Australian beef, and American manufacturers have already identified the most suitable cuts for these products.

Marketing issues

Much of the scepticism large U.S. manufacturers had about new, functionally improved beef ingredients was related to supply. Interviewees were concerned that developing products that rely on functionally improved cuts would be counter-productive if the raw meat ingredients were unavailable for up to 4 months each year (which could happen if the quota is exceeded), if there were a 6-8 week lead time at other times of the year, and if supplier technical support were poor. Some manufacturers stipulate that their R&D departments do not propose new products that rely on a small selection of cuts. This avoids the risk of the cut becoming too expensive because of its new popularity. For example, the price of skirt meat increased when fajitas became popular.

In the U.S., beef is continuing to lose market share as a protein ingredient in sausages. Strong lobby groups encourage consumers to eat less beef because cattle convert grain to protein less efficiently than poultry. Sausage manufacturers focus on the unit price of protein in their formulations, and beef protein costs almost double the unit price of other major meat ingredients (Table 2). Because poultry

3.2 Australian Survey (Milestone 5)

Situation (August 1993)

Results obtained when surveying selected Australian beef packers are discussed in terms of the situation in the U.S. at that time. The signing of the GATT agreement in 1994 has changed the situation substantially. The quota of beef that individual countries could export to the U.S. was regulated by provisions in the Meat Import Law (MIL, 1979). Australia's VRA entitlement in 1993 was 315,000 tonnes, compared with 372,000 tonnes in 1992. This put extreme pressure on Australian exporters.

Round cuts were still being shipped to the U.S. in 1993. These generally were second-quality cuts, mainly from cow or lower-grade steers, that were more highly discounted in the Japanese market. One Australian packer interviewed was strongly committed to supplying specific companies in the U.S., but most companies were not. Two Australian packers had developed or were developing a good market for beef cuts with U.S. end users. However, because of the reduced VRA quota, they had abandoned these clients. Most Australian packers interviewed did not believe it was worth developing new business for beef cuts with U.S. end users until the quota issue was resolved. This was because it was becoming more difficult to provide constant service to U.S. end users, and because a large proportion of each packer's VRA quota had been used by exporting trimmings to U.S. grinders. (The price for trimmings was significantly higher in the U.S. than in other markets. In 1993, flats were significantly discounted in non-U.S. markets, whereas round and loin cuts could be sold easily in other markets.) The volumes of most round cuts sold to the U.S. could increase only if a loophole could be found in the MIL (1979) for certain products, or if the law was changed or rescinded.

Functionality research

The AMLC has received complaints for some time from U.S. end users about the functional properties of cuts for manufacturing beef roasts, and had commissioned the CSIRO to examine factors that give excessive purge and cook loss from frozen Australian product. The findings of the October/November 1993 MIRINZ market survey in the U.S. confirmed the AMLC's information that U.S. roast beef manufacturers had concerns about Australian beef. MIRINZ proposed a more comprehensive project to examine this than the AMLC-commissioned project.

The 1993 VRA constraints made researching the functional properties of cuts suitable for beef roasts more important. Cuts from lower-grade steers and cows, and meat from *Bos indicus* breeds raised in Queensland, are considered less tender commodity-style specifications. This was because many packers cannot predict, or have insufficient control over, the type and weight of stock they process. This is particularly applicable in Queensland, where large numbers of cattle are range-reared on large areas, then collected and sent to be slaughtered. South Australian and Victorian packers often have a more flexible relationship with stock agents, so requests for specific stock can be met. Some packers already sort by carcass weight. They believe that they are not penalized in the market place if cuts are not graded into weight bands. Provided cuts in the pack are similar in size, the end user is satisfied.

Some packers believe the market will not pay for the extra costs incurred by weight-ranging. The boning room operation would become more complex and inventory control costs would increase if weight-ranging is applied to the twelve to fourteen cuts taken from a carcass. Buyers, especially those in the U.S., do not appreciate this and will not compensate packers. Some packers believe that exporters will not compensate packers for yield losses on non-commodity-style cuts such as inside round (cap-off). As the cap muscle is 65-75 CL, it downgrades trimmings. Because the cap muscle is over 30% of the cut, packers want at least a 40% increase in returns for cap-off insides over cap-on insides. This premium is difficult to obtain.

Some packers would weight range round cuts only if the end user takes all the products (or at least 80% if the user insists on a certain minimum or maximum weight). This reduces the packer's need to predict the proportion of cuts falling into individual weight bands for marketing purposes. End users currently accept this practice or are not serviced.

Importers, who purchase most of the Australian beef going to the U.S., are often resistant to serving end users with anything but basic commodity specifications. This is part of their insurance strategy because they incur risk if the end user does not buy the meat that is being shipped. Non-commodity cuts are more difficult to sell quickly. The importance of this factor will diminish if the role of the importer declines in the future.

Packers usually resent recommendations by outsiders on new trimming or grading specifications. Exporters strive to establish their own brand identity in the market place, which involves their own unique product descriptions and specifications. While this attitude creates variability in the specifications of Australian meat products, it should give exporters the incentive to improve the service and specifications they individually offer their customers.

bars are expensive to operate, which is reflected in the retailers' mark-up. However, the medium-rare roast beef presentation at the point-of-sale is superior to that of the well-done pre-packed roast beef. For many Californian consumers this quality justifies the premium. However, the preference for purchasing rare (pink) roast beef from deli bars may not be so marked in other regions of America.

The specific plant, process and product of U.S. roast beef manufacturers must be registered and meet the Code of Federal Regulations, Title 9 (CFR, 1993). The Code is reprinted annually with all amendments, additions and deletions, and its provisions are too comprehensive to summarize easily. Ingredients permitted are in 9 CFR 318.7, time/temperature processing profiles are in 9 CRF 318.17, and cooked meat definitions are in 9 CRF 319.81. Many other important provisions ensuring quality are included in 9 CFR.

After several recent food poisoning incidents implicating food manufacturers and retailers, the United States Department of Agriculture's (USDA) Food Safety and Inspection Service (FSIS) published reviewed guidelines for internal cooking temperatures for meat and poultry products (Anon., 1993). The USDA assumes that microorganisms in ground products are evenly distributed throughout the patty during manufacture, so the minimum end-point temperature for this type of product was increased. The minimum end-point temperature for whole-tissue products in the guidelines did not change. This is because microorganisms on the outside of preparations such as beef roasts should be killed by the relatively high surface temperatures. However, this does not overcome the possibility that microorganisms could be transferred to the meat's interior during injection.

Although there have been publicity campaigns and mandatory food safety labelling for meat cuts destined for cooking, the U.S. roast beef manufacturers interviewed did not report any consumer backlash against roast beef. Similarly, deli operators in California (historically a sensitive market for consumer issues) reported that sales of medium-rare roast beef had not been adversely affected. Per capita beef consumption in the U.S. has fallen from a high of 40.3 kg in 1976 to 28.8 kg in 1991. Over the same time, per capita poultry (chicken and turkey) consumption has increased from 16.1 kg in 1976 to 26.2 kg in 1991 (AMI, 1992). This suggests that the long-term issues confronting beef consumption are about generic preference rather than due to health concerns, as poultry has been associated with as much bad publicity as beef.

Water thawing is much faster than air thawing; large cuts can thaw in less than a day. Packaged cuts are removed from cartons and placed in large stainless steel bins, and water at ambient temperature is continuously passed over the product. Although one interviewee had investigated water-thawing cuts in unsealed bags, this method is appropriate only for vacuum-packed cuts. Companies water-thawing cuts in unsealed bags report unacceptably high thaw losses.

One company microwaves the beef in a Raytheon for 10 min to raise the meat's temperature from -18°C to -6°C. The product is then left in a chiller for a further 3 days. This company reported a 10-12% purge from thawing Australian cap-on insides, none of which was being recovered. The management thought that the high purge (about twice what there used to be) was due to the systems they used. However, if the problem is not solved quickly, the company may return to using only domestic product for manufacturing roast beef.

Cap-on insides should not have more than ⅛ inch (3 mm) of fat covering. The cap should be under pressure when being cooked so it does not fall away during slicing. The cuts are usually put in a tight casing and then into a cooking bag or netted. The latter is more difficult to remove but usually leaves an attractive webbed finish on the surface of the cut.

Mandatory requirements for cooling beef roasts are in 9 CFR 318.17 (10 to 12). Chilling must begin within 90 min of the cycle being finished, and the product must be cooled from 120°F (48.8°C) to 55°F (12.7°C) in no more than 6 h. The meat cannot be packed until it has reached 40°F (4.4°C). The regulations also have instructions on how to reprocess the product if the temperature/time conditions are not met.

There is a wide scope within 9 CFR for the cooling regimes that can be used. The following systems were observed during the survey: spray chillers incorporated in ovens, cold water baths, chilling tunnels, evaporative coolers, and combinations of these methods.

The standard food ingredients added to roast beef are salt, phosphate and dextrose. However, other permitted ingredients may also be used such as sodium lactate, hydrolysed plant protein and other flavour enhancers, carageenan and caramel colouring.

The preamble to Chapter 2 defines processed meats as size reduced meat (with qualifications). VRA and 10% duty (*ad valorem*) applied to processed meats in 1993. Chapter 2 also describes a category called high-quality beef cuts, which are cuts specially trimmed for retailers. This category was not included in the VRA in 1993 and attracted only 4% duty. However, cuts had to be graded USDA Prime or Choice by a USDA inspector (which is not the practice in Australia).

Chapter 16 of the HTS covers preparations of meat, fish or crustaceans, and molluscs or other aquatic invertebrates not prepared or preserved by processes specified in Chapters 2 or 3. The main provisions for meat cover homogenized meat preparations (with qualifications for the end use), fully cooked meat preparations, and flavoured preparations. Depending on packaging and the exact specification, the tariff on these preparations was 3-10% in 1993, but no VRA was applicable. While homogenization is defined in the HTS (1993) and cooking is defined in 9 CFR, the definition of flavouring is not straightforward. Australia could use the HTS clause on flavoured meat to export pre-injected meat to the U.S. for roast beef manufacture.

At the time of the surveys, the most satisfactory procedure for ensuring that a meat preparation would be exempt from the VRA was to ask U.S. Customs for a binding ruling. Although the exporter could do this, using a trade organization representing packers abroad (such as the AMLC) was a better option. For a ruling, U.S. Customs need samples of the product, packaging and details of the process, specifications and intended final use. This submission is additional to the prior label and process approvals that must be granted by the USDA for meat preparations. It can therefore take a long time for a new product concept to get full access to the U.S. market. Resubmissions are often necessary. Under the auspices of the programme, MIRINZ collaborated with an Australian company to develop a protocol for getting access for a pre-injected product into the U.S. However, changes in the VRA made the project redundant.

U.S. Customs have been slow to make binding rulings on the percentage and distribution of flavouring they would accept. Characteristics that allow an ingredient to be classified as a flavour are also not straightforward (Tradenz, Washington, D.C., pers. comm.). Previous applications to U.S. Customs indicate that large cuts, lightly sprinkled with salt and pepper (as the provision reads), would be categorized into Chapter 2 (AMLC, New York, pers. comm.).

slightly higher fat content of the chuck when compared with the other cuts (other than rib trim) used in this study is probably due to the intermuscular fat between the many smaller muscles that make up the chuck. The silverside, on the other hand, is made from two large muscles, the biceps femoris and the semitendinosus, with little intermuscular fat. These muscles are also relatively lightly marbled. Other data (McKeith *et al.*, 1985) also show that the biceps femoris and semitendinosus of the silverside have significantly less fat than the infraspinatus muscle of the chuck and the rib portion of the longissimus dorsi muscle.

Table 3
Mean values and least significant differences (LSD) for composition (% wet weight) of trimmed cuts from Friesian cows (carcass weight 170-214 kg).

	n	Water	Protein	Fat	Ash	Collagen	SSP	pH
Forequarter								
Brisket	12	74.6	20.7	3.1	1.0	1.8	8.0	5.80
Chuck	12	75.1	20.6	2.6	1.0	2.1	8.3	6.03
Rib trim	6	71.6	21.7	5.7	1.0	2.6	8.5	6.03
Loin/back								
Striploin	12	74.5	21.7	2.4	1.1	1.5	8.4	5.87
Hindquarter								
Hindshank	12	74.6	21.9	2.4	1.0	2.4	8.0	5.92
Silverside	12	74.9	21.9	2.0	1.1	1.4	7.6	5.77
Thick flank	12	75.4	21.7	2.0	1.1	1.2	8.3	5.86
LSD (5%)		1.4	01.0	1.4	0.04	0.7	0.6	0.10

Cuts from the forequarter and the hindshank had significantly ($P<0.05$) higher collagen contents than the loin, silverside and thick flank (Table 3). Forequarter cuts have a greater number of smaller muscles so they have more epimysium (external layer of connective tissue with high collagen content) than cuts with larger muscles. The hindshank has large tendons and many smaller muscles, which will increase its collagen content. The four long, thin muscles in rib trim have a high surface area to volume ratio, which would increase collagen content.

Collagen has a marked effect on meat texture and eating quality (Berry *et al.*, 1986). High levels of collagen, especially as gristle, reduce the eating quality. However, processed meat products require some collagenous tissue to improve bite and cohesion (Schmidt, 1987). If they are made without an optimum level of connective tissue proteins, these products can be soft and rubbery and can lack cohesion. Although connective tissue can bind water below 60°C, it often breaks down to gelatin when heated above 62°C. Pockets of fat and jelly (water and hydrolysed

Table 4
Mean values and least significant differences (LSD) for functional characteristics of cooked batters made from trimmed Friesian cow cuts.

	Torsion test		Cook loss, %	
	Stress, kPa	Strain	Water	Fat
Forequarter				
Brisket	47.7	1.24	6.4	1.6
Chuck	54.7	1.30	3.5	1.2
Rib trim	48.6	1.34	2.5	0.9
Loin/back				
Striploin	56.2	1.28	3.2	0.9
Hindquarter				
Hindshank	52.6	1.31	4.1	1.3
Silverside	52.5	1.20	5.5	1.2
Thick flank	49.5	1.24	4.9	1.2
LSD (5%)	3.6	0.05	1.5	0.5

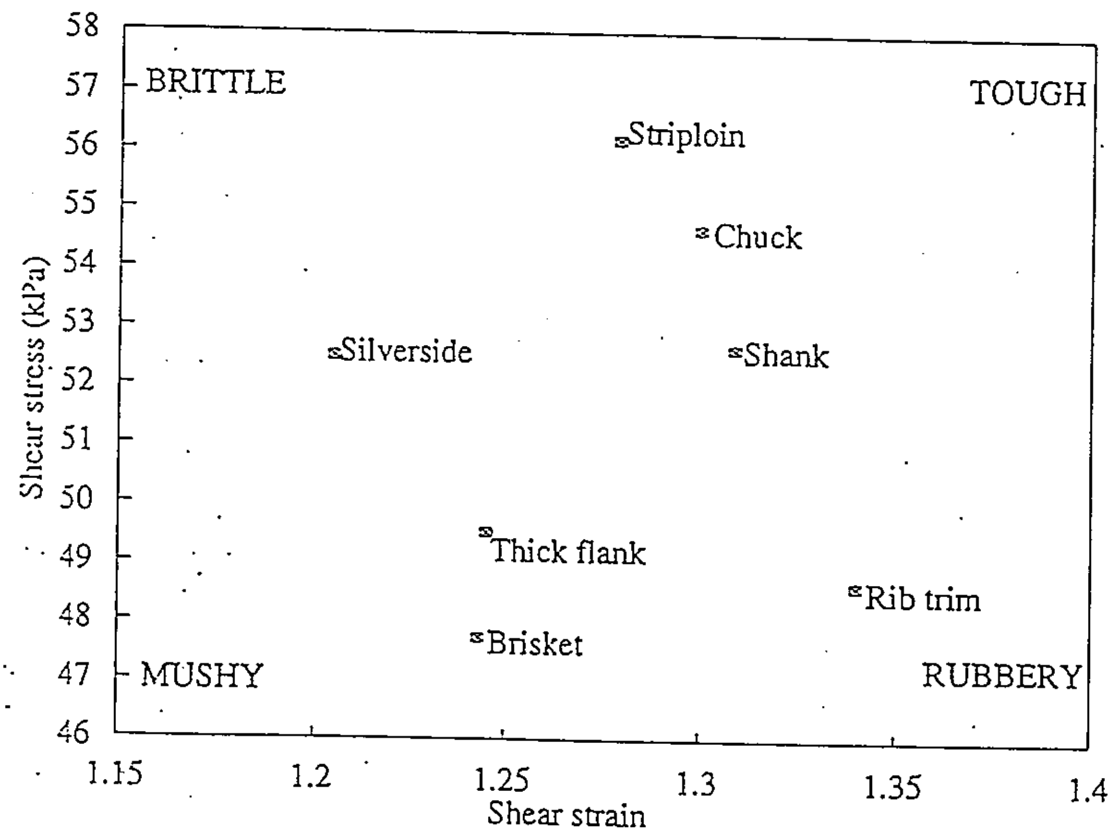

Figure 1
Textural map of shear stress and strain values of batters made from seven Friesian cow cuts, with some common sensory terms (after Lanier *et al.*, 1991).

Table 5
Mean values and least significant differences (LSD) for colour of raw and cooked slices from trimmed Friesian cow cuts.

	Raw slices					Cooked slices			
	L	*a*	*b*	Saturation	Hue angle	*L*	*a*	*b*	Saturation
Forequarter									
Brisket	30.0	9.2	5.2	10.7	59.7	44.5	6.0	10.8	12.5
Chuck	29.8	9.4	5.7	11.0	58.7	45.1	6.4	10.6	12.6
Rib trim	27.1	10.4	5.3	11.7	62.8	40.1	7.4	10.9	13.4
Loin/back									
Striploin	27.0	8.4	4.6	9.7	60.9	44.2	7.8	12.0	14.5
Hindquarter									
Hindshank	27.8	9.0	4.8	10.3	61.4	42.7	8.1	11.0	13.8
Silverside	31.3	8.6	5.7	10.4	56.4	42.9	6.1	11.4	13.0
Thick flank	30.4	8.1	5.2	9.8	56.4	46.5	6.8	12.6	14.5
LSD (5%)	1.6	1.0	0.4	0.9	4.5	ns	ns	0.9	1.4

Cooked batters made from chuck or rib were was significantly ($P<0.01$) lighter and redder than batters made from other cuts (Table 6). There were no significant correlations between most colour attributes of raw cuts and batters, although batter L values were weakly correlated with raw cut L values. Cooked batter a values were weakly correlated with fat content and pH of the raw cut, and there was a weak correlation between cooked batter L value and water loss on cooking.

Table 6
Mean values and least significant differences (LSD) for colour of cooked batters made from trimmed Friesian cow cuts.

	L	*a*	*b*	Hue angle
Forequarter				
Brisket	43.1	2.5	9.8	14.1
Chuck	40.9	3.1	9.5	18.0
Rib trim	41.1	3.1	9.7	17.8
Loin/back				
Striploin	43.9	2.4	9.8	13.9
Hindquarter				
Hindshank	43.1	2.5	9.8	14.6
Silverside	43.8	2.3	9.8	13.3
Thick flank	42.7	2.5	9.6	14.7
LSD (5%)	0.9	0.2	ns	1.2

Table 7
Mean values and least significant differences (LSD) for visual and textural attributes of cooked batters made from trimmed Friesian cow cuts. Visual attributes were rated on a 7-point hedonic scale where 1 = light or smooth and 7 = dark or coarse. Sensory attributes were rated on an open-line scale where 0 = minimum rating and 149 = maximum rating.

	Visual		Texture				
	Lightness	Smoothness	Hardness	Cohesion	Fracturability	Springiness	Chewiness
Forequarter							
Brisket	4.0	4.0	86.5	75.1	73.2	62.1	68.9
Chuck	5.1	4.1	90.6	81.4	78.7	80.9	
Rib trim	4.9	4.5	81.7	78.7	80.6	77.8	78.2
Loin/back							
Striploin	3.3	2.9	90.7	89.0	80.0	78.5	72.8
Hindquarter							
Hindshank	4.1	4.1	103.8	96.2	91.3	82.6	87.6
Silverside	3.4	3.0	88.6	71.0	78.4	65.6	67.1
Thick flank	3.6	3.0	83.8	66.9	69.0	60.8	57.0
LSD (5%)	0.8	0.5	ns	14.1	ns	13.5	12.8

Table 8
Mean values and least significant differences (LSD) for cook loss and shrinkage of patties made from trimmed Friesian cow cuts.

	Cook yield, %	Shrinkage, %
Forequarter		
Brisket	67.4	16.3
Chuck	70.3	17.1
Loin/back		
Striploin	74.7	14.2
Hindquarter		
Hindshank	71.6	17.7
Silverside	70.4	15.3
Thick flank	74.7	13.3
LSD (5%)	4.1	3.0

Although there was a correlation between the SSP content and water and fat loss for cooked batters (a fine emulsion with 2% salt), there was no correlation between the SSP and cook yield for patties. However, the cook yield for patties made from striploin or thick flank (which had high SSP contents) was significantly ($P<0.05$) higher than that from patties made from the other cuts except hindshank, suggesting that SSP content can affect cook yield from coarse-ground products. Hindshank meat (which had the highest collagen content) had an average cook yield, suggesting that a high collagen content may assist fat and water binding in cooked patties.

When heated above their denaturation temperature (>55°C), actin and myosin gel, form permanent bonds, and contract to various degrees. Collagen fibres from mature animals contract at about 65°C. Thus, patty shrinkage during cooking will be affected by both the gelation of actin, myosin and other meat proteins and the contraction of the collagenous fibres present. Cut significantly affected patty shrinkage (Table 8). Thick flank and striploin patties shrank the least (and had the lowest cook loss), while patties made from hindshank (which had a high collagen content) shrank the most. However, there was no correlation between shrinkage and any other variable measured in the trial, suggesting that no single attribute was responsible for shrinkage.

WHC and texture analysis of patties

Data for WHC and texture were skewed and were therefore subjected to log transformation before being statistically analysed. The WHC (which is inversely related to the expressed moisture) of raw patties made from brisket or chuck was significantly ($P<0.05$) lower than for patties made from the other cuts (Table 9).

Some researchers (Jones *et al.*, 1985; Beilken *et al.*, 1991) have found high correlations between punch and die data for raw patties and the sensory attributes of crumbliness, coarseness and chewiness. Any significant differences detected by mechanical measurement were usually also detected by the sensory panellists.

Average punch and die peak force values for cooked patties were less variable than those for raw patties (Table 9) and similar to the range reported by Beilken *et al.* (1991). The peak force for cooked patties was greater than that for raw patties from the same cut. This is because the gel that forms when the patty is cooked tends to increase patty "toughness". Cut type had a significant effect on the peak force values of the cooked patties: patties made from striploin or thick flank were the most tender, whilst those from chuck or hindshank were the toughest. Peak force data for raw and cooked patties were directly correlated ($P < 0.001$). Also, the higher the cook losses from the patty, the tougher the cooked patty ($r = 0.73$; $P < 0.001$). This is because the patty becomes more solid as water and fat are lost and the myofibrillar proteins gel on cooking (Jones *et al.*, 1985).

To reduce variability, Warner-Bratzler (WB) peak force data were subjected to a log transformation. Cut type had a significant effect on the WB peak shear force values of the cooked patties (Table 9). Cooked patties made from silverside and thick flank were the most tender, whilst those from chuck and hindshank were the toughest. This toughness may be due to the relatively high collagen content of the chuck and hindshank, which resists the movement of the WB cutting head. There is no explanation for the anomalous result that the WB data indicate that patties made from striploin were not the most tender of the patties made. The range of 0.77 kg for thick flank to 1.00 kg for chuck is less than the 1.0-5.0 kg range reported by Beilken *et al.* (1991). However, these researchers used carbohydrate in some formulations, and also used a larger sample diameter (15 mm versus 10 mm in the present study) for the test.

Beilken *et al.* (1991) found that WB peak force data are highly correlated with the sensory attributes of adhesion, rubberiness and crumbliness. However, although the punch and die and WB data in the current research indicate that patties made from chuck and hindshank were tough, data for the other cuts did not correlate well. The two tests may measure different degrees of fibre strength and matrix cohesiveness; thus they will not always rank tenderness in the same way.

structure, thus reducing fluid loss. Alternatively, water may have leaked through holes in the packaging and been adsorbed by the meat.

The cap muscle may protect the muscle from tissue damage during freezing/thawing; cuts stored with the cap muscle had 1.9% purge whilst those stored without the cap had 3.4% purge (Table 10). However, percent pump, percent tumble or cook yield was not affected by storing the meat with or without the cap muscle. The higher purge from meat stored without the cap muscle may make shipping cap-off insides less attractive to buyers. When looking at the economics of the system, the costs of shipping extra meat and having the trimming done by the end-user will need to be compared with the costs of shipping meat without a cap and having a higher purge and thus a lower product yield.

Table 10
Effect of freezing, frozen storage time, thawing regime, cap muscle and unpackaged holding time on the processing characteristics of roast beef from steer insides.

	Purge, %	Pump, %	Tumble, %	Cook yield, %
Storage				
Fresh	-	110.8	110.1	91.3
Frozen	-	111.8	111.3	96.9
LSD (5%)	-	0.9	0.9	1.6
Storage time, weeks				
5	2.3	111.2	110.6	96.4
10	2.4	112.0	111.4	96.9
20	3.1	112.2	111.9	97.5
LSD (5%)	1.0	1.1	1.1	2.0
Thawing regime				
Air	3.6	111.9	111.4	97.7
Water	1.8	111.8	111.2	96.2
LSD (5%)	0.9	1.0	0.9	1.8
Cap muscle				
On	1.9	111.6	111.1	95.6
Off	3.4	111.5	110.9	95.7
LSD (5%)	0.9	0.8	0.6	1.4
Holding time, h				
0	3.2	111.3	111.0	95.5
24	2.2	111.5	110.9	95.7
LSD (5%)	0.8	0.8	0.8	1.9

slices varied greatly and results were probably confounded by slight differences in cooking (that is, doneness). Colour values between treatments were similar in the first 15 min after the slice had been cut, but statistically significant differences occurred as exposure time increased (Table 12). However, differences were small and would not affect the consumer's perception of meat colour.

Table 11
Effect of freezing, frozen storage time, thawing regime, cap muscle and unpackaged holding time on the colour of raw steer insides.

	Hunter values		
	L	*a*	*b*
Freezing			
Fresh	32.6	15.1	7.9
Frozen	32.2	14.1	7.9
LSD (5%)	1.0	0.9	0.6
Storage time, weeks			
5	32.1	14.3	7.7
10	30.9	14.5	8.2
20	33.6	13.6	8.0
LSD (5%)	1.3	1.2	0.7
Thawing regime			
Air	32.1	13.5	7.6
Water	32.3	14.7	8.3
LSD (5%)	1.2	1.1	0.7
Cap muscle			
On	32.3	14.7	8.0
Off	32.3	14.1	7.9
LSD (5%)	0.9	0.8	0.5
Holding time, h			
0	31.8	14.5	7.9
24	32.7	14.2	8.0
LSD (5%)	0.9	0.8	0.5

Cooked slices of roast beef made from meat that had been frozen had higher Hunter *L* values (i.e. they were lighter), lower Hunter *a* values (i.e. they were less red) and lower Hunter *b* values (i.e. they were less yellow) than slices made from meat that had been processed fresh. The mechanism for the peak in redness (higher Hunter *a* values) and minimum values for lightness (Hunter *L* values) for slices made from meat that had been frozen for 10 weeks is unknown. Storage time at -20°C had little effect on the lightness of cooked roast beef slices, but there was a small consistent decrease in yellowness (Hunter *b* values) as storage time increased.

Roasts from insides thawed in water were consistently darker (lower Hunter *L* values) and slightly redder (higher Hunter *a* values) than roasts from insides thawed in air. There was also a slight consistent increase in red colour for insides stored frozen without the cap muscle, and for insides without cap muscle that had been held unpackaged 24 h before being processed. Hunter *b* values were similar for the factors investigated and were not consistently affected by treatments.

3.7 Effect of pH and Storage Condition on Roast Beef Quality (Milestone 10)

Processing characteristics

Bull insides in the normal pH group had an average pH of 5.5 ± 0.09, and those in the high pH group had an average pH of 6.5 ± 0.09. The cap muscle comprised 26.2% (n=20) of the inside, which was lower than the value of 30% obtained for steer insides (Section 3.6).

Bull insides stored chilled (-1.5°C) had negligible purge (Fig. 2), regardless of meat pH. A later trial (Section 3.8) found up to 3.7% purge from chilled steer insides (pH of 5.4-5.7) after 1 week of chilled (-1.5°C) storage.

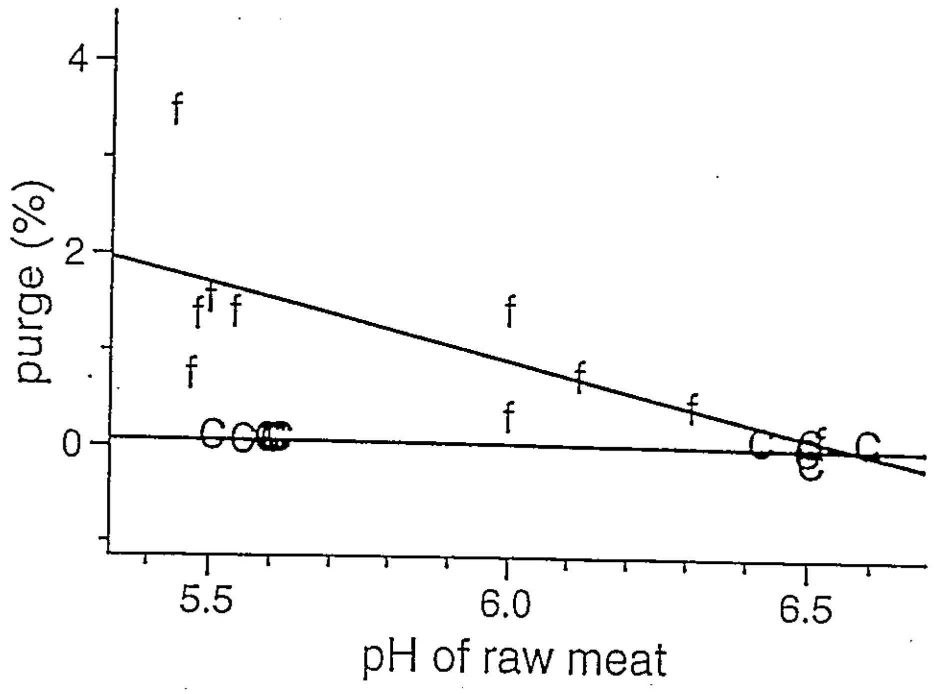

Figure 2
Effect of raw meat pH and storage condition (c = chilled storage at -1.5°C for 1 week; f = chilled storage at -1.5°C for 1 week, then frozen storage at -20°C) on the percentage purge of bull insides.

bulls. The darker colour of high pH meat results from a combination of effects. High pH meat has a more compact muscle structure, which limits oxygen diffusion and light absorption (Seideman *et al.*, 1984). The high pH also reduces the rate myoglobin is oxygenation to oxymyoglobin (which has a bright red colour). Thus, the meat appears to be dark red.

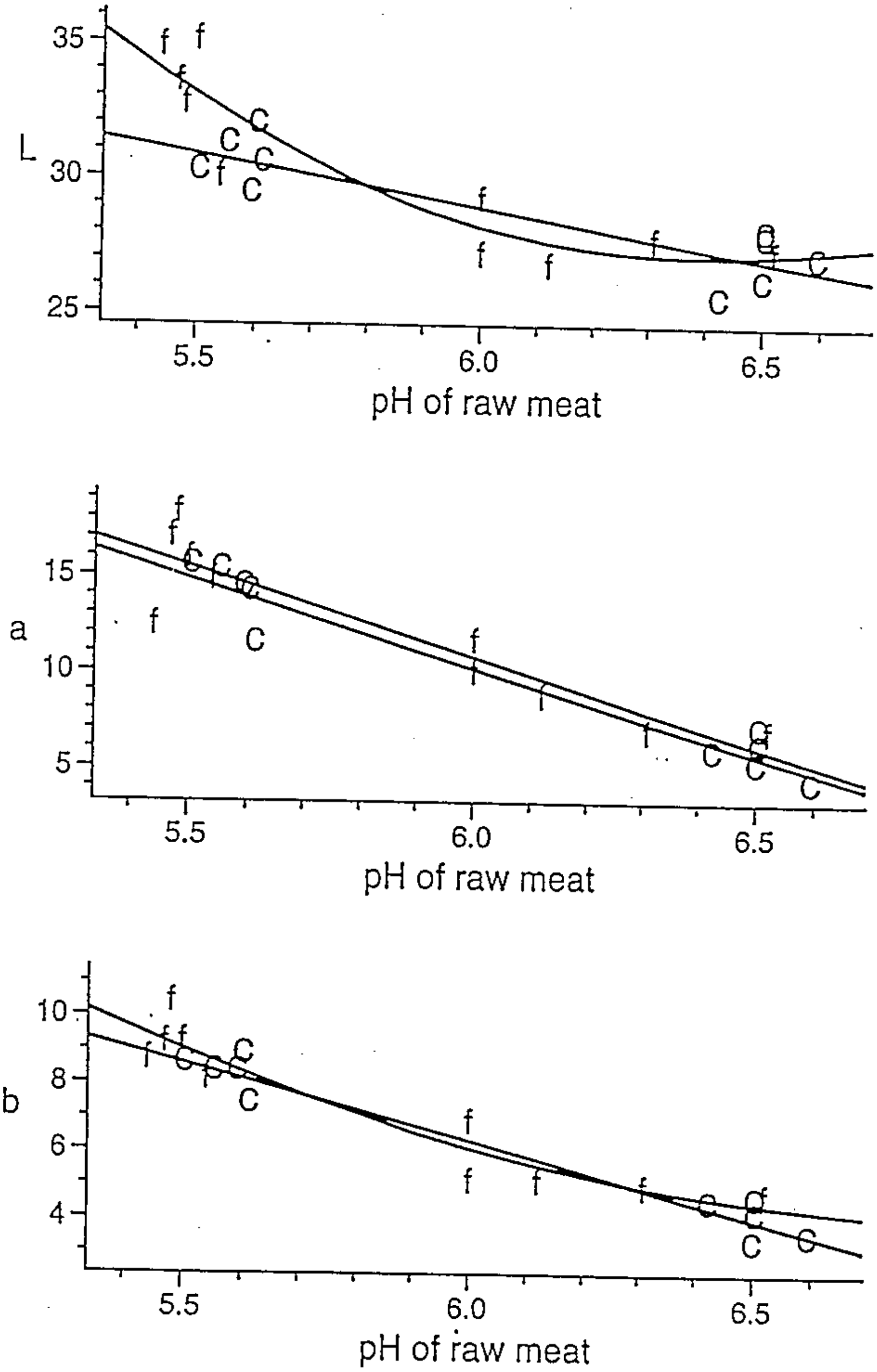

Figure 3
Effect of storage condition (c = chilled; f = frozen) and meat pH on the colour of raw bull insides.

Freezing bull insides did not significantly affect the colour of the thawed meat. Data from an earlier trial (Section 3.6) showed that freezing steer insides also did not affect *L* and *b* values, but had a slight effect on the *a* values.

- Cooked slices

Cooked meat was lighter (higher Hunter *L* values), less red (lower Hunter *a* values) and more yellow (higher Hunter *b* values) than raw meat (Table 14). Freezing had little effect on the cooked meat colour but cooking reduced the large effect that pH had on the colour of raw meat. Roasts made from high pH bull insides were significantly redder (higher *a* values) than normal pH roasts and the difference became greater as the time from cutting increased. The difference in Hunter *a* values is probably due to the high pH roasts having a higher concentration of undenatured myoglobin than roasts made from meat with a normal pH. Trout (1989) showed that less denatured myoglobin was formed in ground meat patties as meat pH increased. The high pH would have protected myoglobin during cooking, so roasts had a less cooked appearance at the same internal temperature than meat of normal pH. Therefore, high pH meat must be cooked to a higher internal temperature than normal pH meat to get the same visual doneness.

3.8 Effect of Cut and Chilled Storage Time on Roast Beef Quality (Milestone 12)

Processing characteristics

There were significant interactions between cut and chilled storage time for the following dependent variables: raw muscle pH, percent purge and cook yield. Individual means are given in Table 15. Because there were no significant interactions between cuts and storage time for percent pump and percent tumble, only the main effect means for these processing characteristics are given (Table 16).

In general, muscle pH increased with storage time, and the increase in pH was slightly greater for steer insides than steer flats (Table 15).

Flats had significantly less purge than insides (Table 15). The increased purge with chilled storage time was less for flats than insides. The amount of purge and its increase with storage time differ from the results of Parrish *et al.* (1991), who found little or no purge from vacuum packaged USDA Choice cuts stored at 0 to 1°C for up to 4 weeks. O'Keeffe and Hood (1980), however, reported 11-22% purge for vacuum packaged beef semimembranosus (insides) stored at 0°C for 1 week. Hodges *et al.* (1974) also reported significant differences in purge from vacuum packed beef cuts stored at 3 ± 2°C, with arm chucks and rounds have the greatest

Cut significantly affected the percent pump but not retention of brine (percent tumble). Insides had a significantly higher pump (Table 16). Chilled storage significantly affected both percent pump and percent tumble: as storage time increased, both percent pump and retention of brine on tumbling decreased.

Colour evaluation

- Raw cuts

Individual treatment means for Hunter colour values are given in Table 17. There was a significant interaction between storage time and cut for all raw colour measurements. Storage time had less effect on the Hunter *L* values (lightness) for flats than for insides. Flats showed a steady increase in lightness with storage, whilst the lightness of insides peaked at 3 weeks. Hunter *a* (redness) and *b* (yellowness) values of both insides and flats increased and then decreased with storage time. The data for insides were more variable than those for flats. The significant differences in raw colour observed were small and would have no practical effect on colour perception of the consumer as indicated by the colour panel scores, discussed below.

Table 17

Colour and mean panel colour scores for raw slices from vacuum-packed steer insides and flats stored at -1.5°C. Panellists scored colour on a 5-point scale where 5 = bright red, excellent colour and 1 = brown or other off colour.

Storage time, weeks	*L*		*a*		*b*		Colour scores	
	Insides	Flats	Insides	Flats	Insides	Flats	Insides	Flats
0	33.5	34.4	17.6	13.0	7.9	6.1	4.7	4.1
1	37.8	35.5	23.5	19.6	10.8	9.1	4.8	4.5
2	35.9	36.6	19.3	18.3	9.3	9.0	4.9	4.9
3	36.7	37.0	20.8	18.0	9.7	9.1	4.8	4.9
4	38.8	35.8	22.3	19.6	11.0	9.4	5.0	4.7
6	35.2	36.6	18.8	17.6	8.8	8.4	4.6	4.8
8	34.1	36.2	16.5	16.2	7.8	8.6	4.7	4.8
LSD (5%)	2.1		1.9		1.1		0.2	

Almost all the colour panel mean scores for flats and insides were above 4.5 on the 5-point scale, with the colour of insides being scored slightly higher than that of flats. Storage time had no consistent effect on the colour scores of the raw cuts. Miller *et al.* (1985) also reported that chilled storage (14 days aging) had no effect on the overall appearance score of beef strip steaks.

Table 18
Effect of cut (steer) and storage time at -1.5°C on colour of cooked roast beef slices on display.

	Exposure time, minutes											
	1			30			60			120		
	L	*a*	*b*	*L*	*a*	*b*	*L*	*a*	*b*	*L*	*a*	*b*
Cut												
Flats	44.5	9.9	8.8	42.3	10.9	9.7	41.0	11.1	9.5	40.9	10.0	9.7
Insides	42.2	11.7	9.9	41.3	11.1	10.2	40.6	10.9	9.8	39.9	10.4	9.9
LSD (5%)	1.2	1.1	0.6	1.4	1.1	0.5	1.4	1.1	0.3	1.3	0.9	0.2
Storage time, w												
0	41.9	12.8	9.9	39.9	13.0	9.8	39.5	12.7	9.6	39.1	11.4	9.8
1	42.9	10.3	9.9	41.8	10.3	10.3	39.7	11.1	9.7	40.6	10.5	9.9
2	42.8	11.0	9.3	42.1	11.1	9.5	39.9	11.6	9.9	39.7	10.6	9.2
3	42.9	10.5	9.4	42.0	10.0	9.7	42.0	9.6	9.3	41.9	8.8	9.4
4	45.0	9.4	8.8	42.7	10.2	9.9	42.8	10.3	9.8	40.5	9.5	10.1
6	44.3	11.1	8.9	42.1	11.5	9.9	41.6	10.9	9.8	40.6	10.4	9.7
8	-	-	-	-	-	-	-	-	-	-	-	-
LSD (5%)	2.1	1.9	1.0	2.5	2.0	0.8	2.4	2.0	0.6	1.1	0.8	0.3

\- no data

inherent juice in the meat because of the increased purge, so more charged areas are available to hold the added liquid (Hamm, 1986).

Cook yield was not significantly affected by cooking method, although yield for roasts cooked more rapidly (constant temperature) was 10% greater than that of roasts cooked by the slower delta T method (Table 20). It took 6 h for the centre of the roast to reach 63°C in constant temperature cooking compared with 12 h for delta T cooking.

Cooking to a higher internal temperature decreased the cook yield, although the difference is not significant (Table 20). Ritchey and Hostetler (1965) and Hearne *et al.* (1978) reported large decreases in cook yields as final internal temperature increased. Hearne *et al.* (1978) observed that most of the loss was from cook drip but evaporative losses also increased as the internal temperature increased. Laakkonen *et al.* (1970) also showed that cook yield decreased with increased cook time and temperature, and Beilken *et al.* (1986) reported that cook losses increased with time when cooking at a single temperature. Most of these cooking losses can be attributed to the changes occurring in the muscle proteins due to heating (Seideman and Durland, 1984).

The results of this trial suggest that thawing method and cooking procedure together affect the overall yields of roast beef. Thawing steer insides in water reduced purge but cook yields were higher from insides that had been thawed in air. Therefore, either thawing method can be used for preparing frozen insides for processing into beef roasts. Rapid cooking (at a constant temperature) tended to increase yields of roast beef and shortened the cooking time.

Colour evaluation

- Raw slices

Thawing method and unpackaged holding time did not significantly affect the colour of raw steer insides (Table 21), although meat thawed in water tended to have slightly higher Hunter *a* values (it tended to be slightly redder). Data from earlier trials (Section 3.6) showed that both redness (Hunter *a*) and yellowness (Hunter *b*) increased when steer insides were thawed in water.

Table 22

Effect of thawing and cooking regime and exposure time on the cooked colour of roast beef slices made from steer insides.

	Exposure time, minutes											
	1			30			60			120		
	L	*a*	*b*	*L*	*a*	*b*	*L*	*a*	*b*	*L*	*a*	*b*
Thaw method												
Air	45.2	6.9	7.6	43.2	7.6	8.1	42.6	6.7	8.1	42.4	6.1	8.3
Water	45.6	7.7	8.3	43.7	8.2	8.5	43.0	7.2	8.7	43.1	6.3	8.5
LSD (5%)	1.2	0.7	0.5	1.7	1.4	0.6	1.3	0.8	0.6	1.4	0.7	0.5
Holding time, h												
0	45.3	7.2	7.7	43.6	7.8	8.2	42.8	7.0	8.4	42.7	6.1	8.3
24	45.5	7.5	8.2	43.4	8.1	8.5	42.8	7.0	8.4	42.8	6.2	8.4
LSD (5%)	1.2	0.7	0.5	1.6	1.4	0.5	1.3	0.7	0.5	1.3	0.7	0.5
Cooking procedure												
Fast	45.9	6.8	7.7	43.5	8.1	8.1	42.6	7.4	8.4	42.1	6.4	8.3
Slow	44.9	7.7	8.2	43.5	7.8	8.5	43.3	6.6	8.4	43.5	5.9	8.5
LSD (5%)	1.2	0.8	0.6	2.0	1.7	0.7	1.5	1.0	0.7	1.6	0.9	0.6
Final internal temperature												
63°C	43.9	10.2	9.1	40.6	11.9	9.7	39.9	10.3	9.8	39.8	9.0	9.7
80°C	46.9	4.5	6.8	46.3	4.6	6.9	45.7	3.7	7.1	45.7	3.3	7.0
LSD (5%)	1.4	0.7	0.5	1.6	1.4	0.5	1.3	0.8	0.6	1.3	0.7	0.5

Table 24
Treatment means for the breed by storage interaction for processing characteristics of beef insides stored at -20°C.

Breed	Brahman			Brahman x			British			LSD (5%)
Storage, weeks	0	5	20	0	5	20	0	5	20	
pH	5.68	5.70	5.63	5.70	5.66	5.64	5.70	5.56	5.60	0.08
Pump, %	114.0	112.4	112.3	109.4	113.2	113.0	112.1	112.9	115.7	2.0
Tumble, %	113.0	112.9	111.6	107.3	112.7	112.4	111.7	112.6	114.3	1.6
Cook yield, %	98.0	97.6	96.0	97.5	99.6	99.2	96.9	101.9	99.0	2.4

Table 25
Effect of breed, age/gender and storage on the Hunter values for colour of slices from raw beef insides.

	L	*a*	*b*
Breed			
Brahman	35.1	13.5	8.1
Brahman x	33.8	12.1	7.5
British	32.9	13.6	7.4
LSD (5%)	1.3	1.1	0.8
Age/gender			
Steer (2 yr)	34.1	13.9	7.9
Cow (≥ 3 yr)	33.7	12.2	7.3
LSD (5%)	1.1	0.9	0.7
Storage at -20°C, weeks			
0 (2 weeks chilled)	36.5	15.9	8.7
5	31.9	11.4	7.0
20	33.4	11.8	7.2
LSD (5%)	7.1	1.0	0.7

- Cooked slices

There were significant interactions between breed and age/gender for Hunter *L* and Hunter *a* values, but not Hunter *b* values. Therefore, data for the former are presented in Table 26 and for the latter in Table 27. The colour values observed in this trial were similar to those reported in earlier trials on steer (Tables 12, 18, 22) and bull (Table 14) insides.

Table 26
Effect of breed x age/gender interaction and exposure time on Hunter *L* and *a* values of slices from cooked beef insides.

	Exposure time, minutes							
	0		30		60		120	
	L	*a*	*L*	*a*	*L*	*a*	*L*	*a*
Brahman								
Steers	44.9	11.2	44.7	10.5	43.4	10.7	44.5	9.1
Cows	47.1	9.9	46.3	10.2	45.9	10.1	46.3	9.1
Brahman x								
Steers	42.3	13.0	42.1	12.5	41.7	12.5	41.8	10.9
Cows	45.1	9.7	44.9	9.4	43.9	10.1	44.7	8.8
British								
Steers	43.3	11.1	42.2	10.8	41.7	10.5	42.8	9.5
Cows	42.3	10.1	40.9	10.3	40.7	9.7	40.6	9.4
LSD (5%)	2.4	1.6	2.2	1.5	2.3	1.4	2.2	1.3

This agrees with data reported by Carpenter *et al.* (1961) and Norman (1982). There were no significant effects of breed or storage time on peak energy data (total energy required to break the sample).

Table 28
Breed x by storage interaction for mean Warner Bratzler shear measurements of beef insides.

Breed	Frozen storage time, weeks	Peak shear force, kg	Energy to break, kg mm^{-1}
Brahman	0	4.0	278.0
	5	5.1	-
	20	3.8	302.5
Brahman x	0	4.9	312.6
	5	5.1	369.7
	20	4.1	327.9
British	0	3.8	333.0
	5	3.7	295.8
	20	4.3	337.2
LSD (5%)		0.6	64.0

- insufficient data.

3.11 Effect of Country, Breed and Storage Condition on Roast Beef Quality (Milestone 18)

Processing characteristics

The US Customs impounded the plane (including the passengers and cargo) on which the meat was being air-freighted from Australia. During this time, the meat was not stored in freezers or chillers. Information from the data loggers indicated that the temperature of the frozen meat reached -2°C and that of the chilled meat reached 4°C, which are above the optimum holding temperatures. Overall, the meat took 7 days to reach Iowa State University rather than the 2-3 days originally estimated.

The "frozen" meat samples were refrozen in a blast freezer at Iowa State University. Because of the cost involved in obtaining the meat, and because this type of temperature abuse could occur in routine commercial meat shipments, it was decided to continue with the trial.

No significant interactions were observed between treatments for percent cap, percent pump, and cook yield. Therefore, treatment means are shown in Table 29.

than British insides (Tables 23). Insides from the Brahman breeds in the present study tended to be heavier (data not shown), which may have contributed to the differences observed. The percent cap in the present trial is greater (34-39%) than the 26-32% obtained in earlier trials in this study (Section 3.6, 3.7, 3.9, 3.10). The insides from British breeds had higher percent pump, percent tumble, and cook yields than insides from Brahman breeds.

Storage condition affected muscle pH: meat stored frozen had a slightly higher pH than meat stored chilled (Table 29). Storage condition did not affect the percent cap, percent pump or cook yield. This result differs from that of an earlier trial (Section 3.6) in this study, where frozen storage gave a significant increase in cook yield of steer insides.

The purge and percent pump interactions observed come primarily from the Australian frozen insides (Table 30), which had significantly ($P<0.05$) higher purge than Australian chilled insides or U.S. frozen or chilled insides. However, the difference in purge between frozen and chilled U.S. insides approached significance. Some of the greater purge with Australian frozen insides may have been due to the temperature abuse they experienced during transit. Previous trials in this study also reported that freezing increased purge (Tables 10, 23).

Table 30
Interaction of storage condition and country for purge and tumble.

	Country	
	Australia	U.S.
Purge, %		
Chilled	1.9	1.8
Frozen	4.7	3.0
LSD (5%)	1.1	
Tumble, %		
Chilled	106.5	106.9
Frozen	107.9	106.0
LSD (5%)	1.5	

For Australian samples, frozen insides had a higher percent tumble than chilled insides. In contrast, frozen U.S. insides had a lower percent tumble than chilled U.S. insides. These observations contributed to the country - storage interaction for percent tumble. The higher percent tumble for insides from Australian Brahman cross and British breed cattle that had been stored frozen than for roasts processed from chilled meat had also been noted in an earlier trial in this study (Table 24).

Table 32
Effect of country, breed and storage condition on mean Warner Bratzler shear values of cooked beef insides.

	Peak shear force, kg	Energy to break, kg mm^{-1}	Energy to yield, kg mm^{-1}	Displacement at maximum load, mm
Country				
Australia	5.4	63.8	20.5	11.2
U.S.	4.5	59.6	17.6	9.9
LSD (5%)	0.7	5.3	3.2	0.8
Breed				
British	5.1	63.1	20.2	10.4
Brahman	4.8	60.4	18.0	10.7
LSD (5%)	0.6	4.9	3.0	0.8
Storage condition				
Chilled	5.1	62.2	20.8	10.8
Frozen	4.8	61.2	17.5	10.3
LSD (5%)	0.6	4.9	3.0	0.8

Roasts from Australian insides had a significantly ($P<0.05$) higher displacement at maximum load (Table 32). This variable may give information about the type of toughness in the sample. Møller (1980) suggested that the displacement measurement could be used to measure different factors contributing to toughness. He considered that the yield point of the sample within the first part of the curve (2.5 cm displacement) indicated the myofibrillar component of the sample, and the last part of the curve reflected the connective tissue component. Using this hypothesis, data from the present study indicate that beef roasts manufactured from Australian meat contained more connective tissue than roasts manufactured from U.S. meat. However, sensory data in the present study did not support this hypothesis (see next section).

Breed did not affect the Warner Bratzler shear values of beef roasts (Table 32), although other work has found that meat from Brahman breeds was less tender than meat from British breeds (Carpenter *et al.*, 1961; Norman, 1982). Carpenter *et al.* (1961) and Norman (1982) used broiled steaks, not roasts, which may explain some of the differences observed.

Beef roast samples made from chilled beef insides required more energy to get the first yield than did samples made from previously frozen meat (Table 32).

Table 33

Effect of country, breed and storage condition on the sensory characteristics of cubes of beef roasts made from insides. Samples were scored on a 6-point scale where 1 = a low (dislike) and 6 = a high (like very much) rating.

	Country		Breed		Storage condition		
	Australia	U.S.	British	Brahman	Chilled	Frozen	LSD (5%)
Juicy	3.7	3.5	3.8	3.5	3.5	3.7	0.11
Dry	2.8	2.9	2.7	3.0	2.9	2.8	0.14
Tender	3.9	3.9	4.0	3.8	3.9	3.9	0.12
Tough	2.7	2.6	2.6	2.7	2.6	2.6	0.13
Beef flavour intensity	4.0	3.8	3.8	3.8	3.7	4.0	0.10
Off-flavours	2.3	2.1	2.1	2.3	2.3	2.1	0.12
Buy	3.4	3.5	3.5	3.4	3.3	3.7	0.16
Overall quality	3.4	3.6	3.6	3.4	3.3	3.8	0.12

- The information obtained on manufacturing roast beef in the U.S. indicated that specifications for manufacturing roast beef varied. In general, most products contained no or only low levels of soy protein. The desired product yield is 120% of green-weight after cooking. If graded to USDA quality grade, most meat from Australia would be classified as Select (or No-Roll), which is most commonly used for food service. Product for the food service sector is typically cooked well-done. In contrast, retail and deli-served roast beef is usually manufactured from Choice grade sold medium-rare. There is a market for cheaper roast beef sold in the delicatessen, which must be sold medium-rare. Thus, it is important to understand colour stability in medium-rare roast beef. Most U.S. companies surveyed were very interested in importing Australian beef cuts that circumvent the import quota. Pre-injected or flavoured meat from Australia to circumvent the import quota would be used mainly for roast beef, corned beef or chunked and formed meat preparations.

4.2 Meat Functionality

- Patties made from thick flank and striploin from Friesian cows generally had better characteristics (lower cook yield and less shrinkage on cooking, more tender raw and cooked patties, and better WHC) than patties made from hindshank, chuck, brisket, silverside or rib trim cuts. However, striploin would generally be considered too expensive to be used for producing patties.

- Cuts with a higher salt soluble protein content generally lost less water and fat on cooking, giving a more cohesive (higher strain value) sausage than cuts with a lower salt soluble protein content.

- Sausages made from striploin, rib trim, hindshank, or chuck tended to have higher sensory scores (cohesiveness, chewiness and springiness) and higher shear strain at failure than sausages made from brisket, silverside or thick flank.

- Rib trim and chuck had higher pH values than the other cuts and produced significantly darker and redder sausages than the other cuts.

4.3 Roast Beef Manufacturing

- Roast beef manufacturers have to trim 25-30% from insides shipped with the cap muscle (gracilis) on. The manufacturers would prefer cap-off insides to avoid the trim losses, or they need find an economic use for the cap muscle.

- Raw colour of beef insides was affected more by the meat's ultimate pH and whether it had been stored frozen rather than chilled than by breed or country of origin. Meat stored chilled tended to be redder and more yellow than meat stored frozen. For raw meat, high pH meat was darker than normal pH meat, which consumers would find unacceptable. However, most of the other colour differences observed in the experiments would not be apparent to the general consumer.

- Insides were more red (higher *a* values) than flats and the red colour of insides was affected more by chilled storage than that of flats. Vacuum-packed flats and insides can be stored for up to 8 weeks at -1.5°C without changes in raw or cooked colour that are likely to be apparent to the general consumer.

- For cooked meat, high pH meat was redder, so this meat appears less done than normal pH meat cooked to the same internal temperature. Thus, high pH meat must be cooked to a higher internal temperature (or for a longer time) to achieve the same visual doneness as normal pH meat.

- As expected, the final internal temperature of steer insides had a dramatic effect on the cooked colour of the roast beef. The higher the end-point temperature, the browner the meat.

- Peak shear force data indicated that Brahman x insides were initially less tender than Brahman and British insides. However, all insides had similar shear force values after 20 weeks storage at -20°C.

- Sensory evaluations of roast beef using a U.S. consumer panel indicated that there were only slight sensory differences due to country of origin and breed. The most significant effect was due to whether meat had been stored frozen or chilled. In general, roast beef made from frozen meat was considered to have more beef flavour, less off-flavours and greater overall quality than roast beef made from meat stored chilled.

- Buyer action would be similar for roasts made from beef insides from Australia or the U.S. Buyers would prefer roast beef made from insides stored frozen.

- After starting this project and researching the factors that affect roast beef quality, information from the market place indicated that more technical information should be available on how factors such as using hot-boned rather than cold-boned meat, chilled or frozen storage time, meat pH, freezing rates (especially of boxed hot-boned meat) affect patty characteristics such as yield, bind, patty uniformity, and machinability. There is an increasing trend to market high-value table cuts (after suitable aging) from hot-boned carcasses (as this increases the return to the producer). This affects the "product mix" of boxed boneless meat. It is important to assess how this affects patty quality.

- Comprehensive bind information along the lines of the U.S. Saffle Bind Value should be collated for Australian manufacturing beef. Available values need to be updated to incorporate changes in modern slaughtering and processing techniques, and especially in freezing technology, which influence the functionality of frozen meat. This information could be used by sausage manufacturers. Roast beef manufacturers also want information on bind values of cuts used for restructured roasts.

- More information is needed on the characteristics of manufacturing beef that could be specifically used for sausages. This information would be useful for both exporters and the local market, which is a relatively large market sector for the beef kill.

6. Acknowledgements

This project was funded by the Meat Research Corporation. David List, David Sadler, Malcolm Reid, Warren Hall, Vivienne Mikkelsen, Stephen Frazerhurst and Anna Brooker of the Processed Meats Section, MIRINZ, participated in the technical and marketing work. The statistical analyses were carried out by John Waller of AgResearch, New Zealand Pastoral Agriculture Research Institute Ltd. The U.S. research work was done at Iowa State University Meat Laboratory, Ames, IA. Dr F.C. Parrish, Jr, Janis Brownlee and Becky Thiel contributed to this research.

David Beak (Managing Director, Beak & Johnston Pty Ltd) and Brian Todd (Australian Meat Marketing Pty Ltd) were involved in assembling the U.S. and Australian survey (and providing information for costings).

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Roast Beef Sensory Panel

Panelist number________

Today you will be participating in a consumer sensory panel. This is a little different than other you may have participated in. Please follow the directions and you should not have any problems.

On the scale below please indicate where you think the "ideal" roast beef would be rated. Mark your scorecard by placing a check (√) in the box to represent the degree to which the characteristic should be present in the ideal roast beef sample. There is no sample to evaluate, this is just what you think the ideal roast beef should be.

Ideal Roast Beef- your own ratings

	Not At All					Very Much So
Juicy	☐	☐	☐	☐	☐	☐
Dry	☐	☐	☐	☐	☐	☐
Tender	☐	☐	☐	☐	☐	☐
Tough	☐	☐	☐	☐	☐	☐
Beef Flavor Intensity	☐	☐	☐	☐	☐	☐
Off-Flavors	☐	☐	☐	☐	☐	☐

After completed, go on to next page.