Ein integriertes Aufbereitungsverfahren

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Um die Abkühlgeschwindigkeiten zu bestimmen, die für maximale Fleischqualität nötig sind, ist mit einer Studienserie begonnen worden. Semitendinosus Muskeln aus elektrisch stimulierten frischgeschlachteten Rindern wurden innerhalb einer Stunde nach der Schlachtung exzidiert und in 70 g Würfel geschnitten. Die Würfel wurden vakuumverpackt und anschließend bei 0^{o}, 5^{o}, 10^{o}, 15^{o}, 25^{o} und 35^{o} in Wasserbädern aufbewahrt. Lagerzeiten schwankten zwischen 3 Tagen bei 35^{o} und 28 Tagen bei 0^{o}. Proben wurden regelmäßig entfernt, um Einzelheiten über folgende Eigenschaften zu bekommen: pH, Tropfen, Farbe und Durchsichtigkeit. Textur, Kochverlust, Sarkomerlängen, myofibrilläre Fragmentation und Proteinveränderungen durch Elektrophorese. Bakterienwachstum unter diesen Bedingungen wurde mit identischen Proben verglichen, die mit einer Mischung von Pathogenen und zerfallsfordernden Organismen geimpft worden waren.

An integrated approach to conditioning

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A series of studies intended to define cooling rates for optimum beef quality has been started. Semitendinosus muscles from electrically stimulated beef carcasses were excised within one hour of slaughter, and cut into 70 g cubes. These were vacuum packed and held in water baths at 0^{o}, 5^{o}, 10^{o}, 15^{o}, 25^{o} and $35^{o}C$ for times ranging from 3 days at 35^{o} to 28 days at 0^{o}. Samples were removed periodically to obtain data on the following: pH, drip, colour and translucency, texture, cooking loss, sarcomere lengths, myofibril fragmentation and protein changes by electrophoresis. Bacterial growth under these conditions was monitored on identical samples which had been inoculated with a mixture of pathogens and spoilage organisms.

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Une approche intégrée au conditionnement

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Une série d'études visant à définir les taux de refroidissement nécessaires à la qualité optimum du boeuf a été commencée. Des muscles semitendinosus provenant des carcasses stimulées électriquement ont été enlevés dans l'heure qui a suivi l'abattage et découpés en cubes de 70 g. Ceux-ci ont été emballés sous vide et stockés dans des bains d'eau a 0^{o}, 5^{o}, 10^{o}, 15^{o}, 25^{o} et 30^{o}C pendant des périodes allant de 3 jours à 35^{o} jusqu'à 28 jours a 0^{o}. Des échantillons en ont été enlevés périodiquement pour obtenir des données concernant les suivants: pH, gouttes, couleur et translucidité, texture, perte à la cuisson, longueurs des sarcomères, fragmentation des myofibrilles et changements des protéines par électrophorèse. La croissance des bactéries dans ces conditions a été contrôlée sur des échantillons identiques auxquels on avait inoculé un mélange d'agents pathogènes et d'organismes de décomposition.

Комплексный подход к кондиционированию

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Мы начали ряд испытаний с целью уточнения скоростей охлаждения для достижения оптимального качества говядины. Полусухожильные мышцы вырезанные в течение первого часа после убоя из электростимулированных туш делились на кубические куски весом 70 г. Отдельные куски в вакуум-упаковках хранились в водяной бане при температурах 0, 5, 10, 15, 25 или 35°С в разные периоды, от 3 суток при 35°С до 28 суток при 0°С. Образцы брались периодически для определения pH, вытекания сока, цвета и просвечиваемости, консистенции, потери при варке, длины саркомеров, фрагментации миофибрилл и изменения белков электрофорезом. Контроль развития бактериальной флоры проводился на идентичных образцах зараженных смесью патогенных и вызывающих порчу микроорганизмов.

An Integrated Approach to Conditioning

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Introduction

The rapid removal of body heat from the meat carcass is desirable both to slow down bacterial growth as much as possible, and to minimise the weight loss due to the evaporation of water from the surface. Modern refrigeration technology provides the means for extremely fast cooling, but, while this allows a more economic process by reducing time from slaughter to despatch and optimising yield, it can cause grave losses in eating quality. Low temperature activated shortening results in toughness after cooking, but even when cold shortening has not taken place, meat will not achieve its maximum acceptability to the consumer unless it has been conditioned. Shortening can be overcome by electrical stimulation which accelerates the post-mortem biochemical changes to keep pace with more rapid cooling, but more investigation is required to define precisely the time and temperatures necessary to achieve a degree of conditioning adequate for the consumer at a cost acceptable to both trade and purchaser. The experimental work in this paper is confined to unfrozen meat, but the problem of conditioning meat intended for distribution in the frozen state differs little in scientific principle.

As the shortest possible conditioning time would be the most attractive, attempts have been made to accelerate ageing by holding meat at high temperatures with or without use of antibiotics or irradiation to inhibit microbial growth (Locker et al., 1975). These methods have proved largely impracticable and have not been taken up by industry. In most investigations, beef has been cooled in the carcass or side where temperature changes are slow, but present-day techniques of hot deboning can produce pieces of smaller dimensions where chilling rate need no longer be restricted by size, and the economic drawback of evaporative weight loss during prolonged storage can be overcome easily by vacuum packing.

Experimental

Material. Two Hereford x Friesian steers were slaughtered and, after removal of hide and guts, the carcasses were electrically stimulated by the method of Bendall et al., (1976) using 700 v, 25 Hz and 5.2A for 2 minutes with polarity reversed after each 0.5 min. At this time 50 min had elapsed from slaughter and pH had fallen from 6.9 to 6.5. Carcasses were then split and M. semitendinosus (St) removed from each side. Collagen contents of the St were 0.66 and 0.75 per cent.

Muscle Treatment. From each animal one St was cut into 70 g cubes to provide samples for quality assessment. Each cube was dipped in 100 ppm aureomycin (Lederle Chemicals Division) and blotted dry before vacuum packing in a Metathene X pouch (Metal Box Co. Ltd., London). The packed samples were then placed in water baths at a range of temperatures from 0^{o} to 35^{o}C for times up to 28 days.

The other St from each animal was used for microbiology. Circular slices 0.5 to 1 cm thick and 3 cm diameter were cut from the muscles and each slice was inoculated with a mixture of meat spoilage and food poisoning bacteria. This was done so that all samples would initially be of the same microbiological condition and also to give detectable levels of food poisoning bacteria. The inoculum consisted of two Pseudomonas spp., a Moraxella-like organism, a 'coryneform', a Lactobacillus sp., a naladixic acid-resistant Escherichia coli and one strain of each of the following: Brochothrix thermosphacta, Streptococcus faecalis and Clostriduum perfringens. The samples were then vacuum packed and placed in the appropriate water baths.

All samples were in water baths at 100 min from slaughter and temperatures had equilibrated within one hour.

Examination of samples

pH. pH was measured on homogenates of 1 g meat and 10 ml of a solution of 5 mM Sodium iodoacetate + 150 mM Potassium chloride.

Drip. Drip loss was calculated from the difference between the weight of meat samples before packing and their weight on removal for assessment. pH of the drip was also measured.

Colour and opacity. Hunter lightness ($L = 10Y^{\frac{1}{2}}$) (MacDougall & Taylor, 1975) was measured on the surface of each sample after removal from the pouch, and changes in opacity were estimated by impressing the tip of the MRI Fibre Optic Probe (FOP) (MacDougall & Jones, 1975) into the meat surface. Higher FOP values indicate increased opacity by light scattering.

Texture. From each 70 g sample a 40 g sub-sample of standard shape was repacked in a boilable plastic pouch which was heated in a water bath at 80^{o}C for 20 min and cooled in running tap water for 30 min. The sample was then cut into a minimum of two 1 x 1 x 2 cm blocks with fibres running longitudinally. Texture was measured on a Materials Testing Instrument (Instron) recording the force at first break (kg) during compression of the block (mean of 6-10 readings).

Cooking loss. Cooking loss was calculated from the difference in weight of sample before and after heat treatment.

Troponin T. Washed myofibrils, prepared from about 10 g of the sample, were subjected to electrophoresis on SDS polyacrylamide gel slabs. The slabs were then stained in Coomassie Blue and photographed. The negatives were scanned using a Joyce Loebl densitometer and traced on standard paper. The quantity of troponin T (M.W. = 37,000) was determined by weighing the peak (Penny and Ferguson-Pryce, 1978).

Histology. Samples were examined by light and electron microscopy for evidence of fracture of myofibrils at the Z-line and for indication of sarcomplasmic precipitation on myofibrils.

Sarcomere length. Sarcomere lengths were measured by optical diffraction (mean of 6 readings) (Voyle, 1971).

Microbiology. From each muscle, 4 samples were examined initially, and 2 subsequently at each time and temperature of storage. Bacterial counts were determined on homogenates prepared from each sample in 75 ml diluent (0.85% Sodium chloride, 0.1% peptone, pH 7.0), using a Colworth Stomacher (Seward & Co., London) for 1 min. The total viable count was determined as described by Taylor & Shaw (1977). The naladixic acid resistant E.coli was enumerated on MacConkey Agar without salt (Oxoid) and containing 200 ppm naladixic acid (Winthrop Laboratories, Newcastle-upon-Tyne) incubated for 24 hr at 37°C. Cl.perfringens was enumerated on egg yolk-free TSC medium (Hauschild & Hilsheimer, 1974) after incubation anaerobically at 44°C for 18 hr.

Results and Discussion

The results reported in this paper are the first in a study of the effects of pH, time and temperature on eating quality. In this experiment electrical stimulation produced a pre-conditioning pH of 6.35 and the results relate only to this. In further experiments other levels of pH will be used to determine the full relationship.

Rates of fall of post-slaughter pH are shown in Fig.1. During conditioning, rates were faster at higher temperatures; ultimate pH (5.6) was reached in 6 hours from slaughter in samples held at 25° and 35°C, but not until a day or more at 0° and 5°C. Subsequently, pH remained approximately constant except at 25° and 35°C where it may have been influenced by bacterial growth, final values being 5.2 and 5.9 respectively. The pH of the drip did not differ greatly from that of the meat.

Drip accumulation (Fig.2) increased with time and was much greater at 25° and 35°C. Approximately 5% drip was found after 1 day at the two higher temperatures, but not until 14 days at the lower temperatures. Much greater losses (approximately 5 times as much) occurred on cooking (Fig.3) and again increased with time and temperature. Cooking losses increased from about 20% to 28% over the period studied.

Samples held at the higher temperatures were slightly paler than the others and FOP measurements (Fig.4) showed this to be caused by increased light scattering. FOP values increased with time, the greatest increase being at the higher temperatures which suggests the possibility of protein denaturation at 35°C although histological examination showed no evidence of precipitation of sarcoplasmic proteins on the myofibrils.

Changes in texture with conditioning time and temperature are shown in Fig.5. The rate of tenderisation, determined at each temperature, was found to increase 6 fold from 0° to 10°C and 1.1 fold from 25° to 35°C. Toughness had decreased to half its initial value by 0.8 days at 25° and 35°C, 1.3 days at 15°C, 3.5 days at 10°C, 6 days at 5°C and about 22 days at 0°C. Improvement in tenderness was consistent with appearance of microscopic cracks and breaks in the myofibrils and was highly correlated with the decrease in extractable troponin T (Penny and Dransfield, 1978).

Final values for toughness were higher at the extremes of temperature, indicating that the pre-conditioning pH in this experiment was not low enough to avoid some shortening. This was confirmed by sarcomere lengths of 1.6 μm at 0° and 35°C and 1.9 μm at the intermediate temperatures.

Changes in total viable counts of bacteria are shown in Fig.6 for all temperatures except 35°C where counts were similar to those at 25°C. Further experiments with counts at other time intervals are necessary to make precise comparisons of rates of growth at the different temperatures. However, the results so far obtained indicate that bacterial numbers increase twice as fast with every 5°C rise in temperature between 0° and 15°C.

A more serious practical circumstance is the rapid growth of pathogenic bacteria which, on the evidence of this experiment (Table 1), would certainly preclude the use of 25° and 35°C for conditioning vacuum packed beef.

Table 1. Sampling times at which growth of E.coli and Cl.perfringens were first detected.

Storage temperature (°C)	E.coli	Cl.perfringens
35	6 hours	6 hours
25	6 hours	12 hours
15	2 days	4 days
10	5 days	No growth
5	No growth	No growth
0	No growth	No growth

Fig. 1

Effect of storage temperature on post-slaughter pH of beef St.

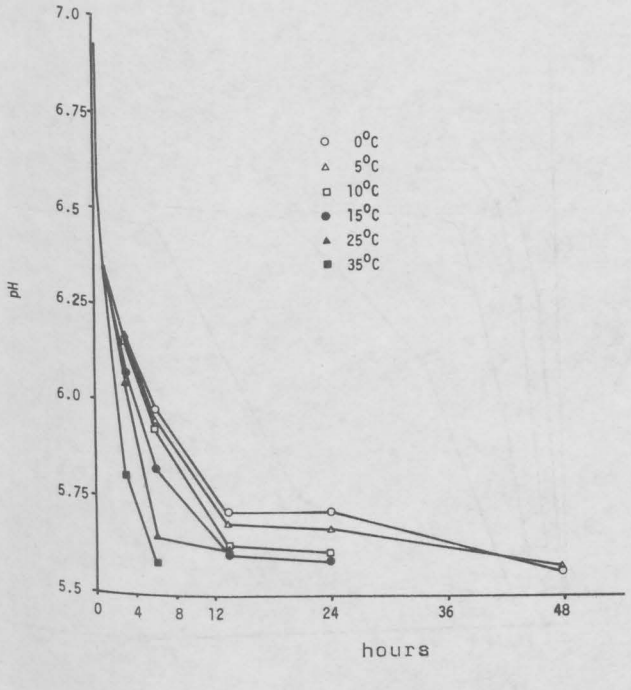


Fig. 2

Effect of storage temperature on loss of drip from beef St. held in vacuum pack.

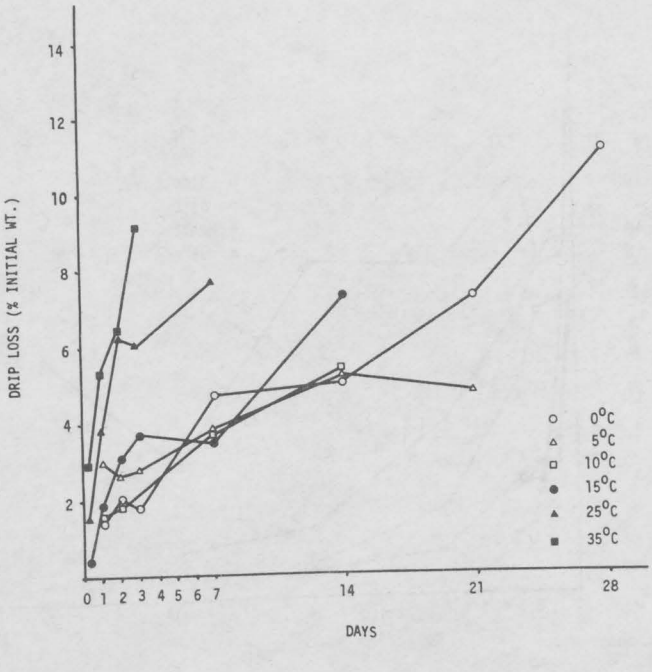


Fig. 3

Effect of storage temperature on loss of weight during cooking in beef St.

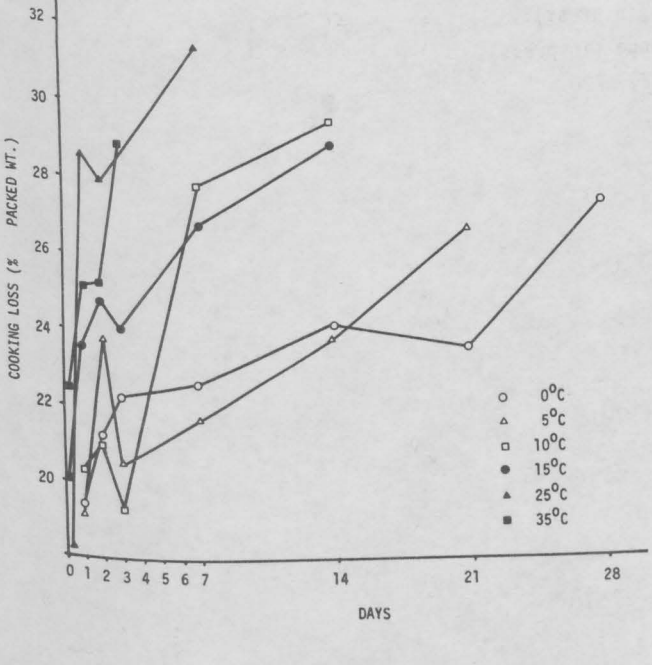


Fig. 4

Effect of temperature of storage on opacity of the lean of beef St. held in vacuum packs.

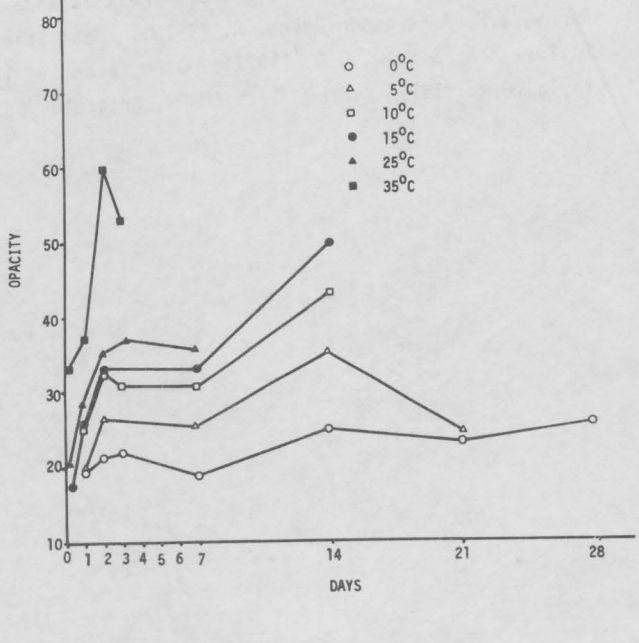


Fig. 5

Change in toughness of beef St. cooked after storage in vacuum pack, as measured by compression between blunt jaws.

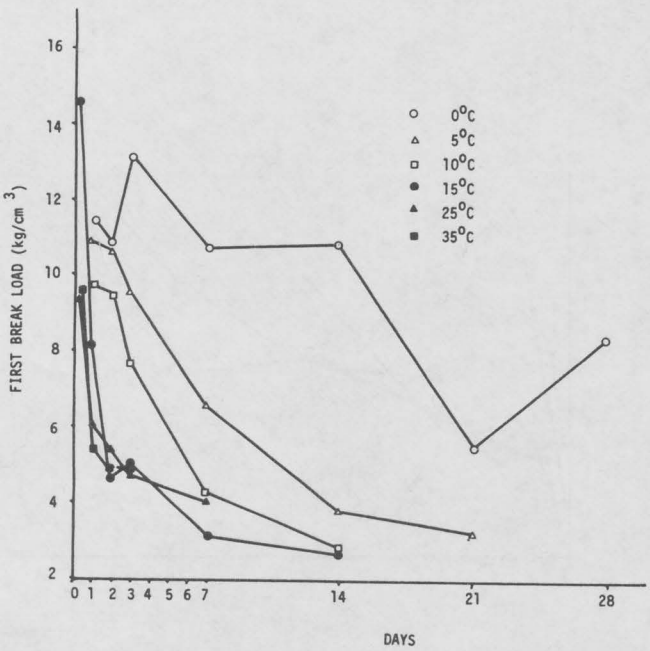
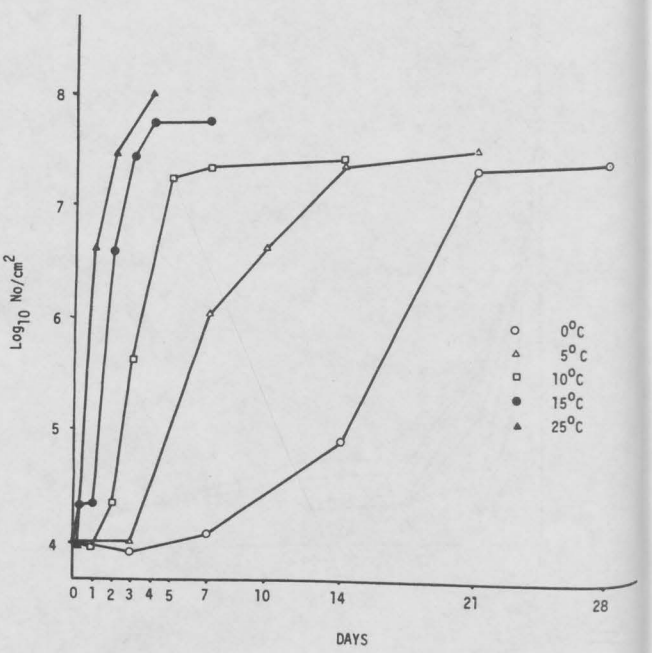


Fig. 6

Effect of temperature on the viable count on beef St. during storage in vacuum pack.



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