Preliminary investigations into the use of deepchill temperatures for prolonged storage of beef

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Abstract

The limited storage life of vacuum packaged beef is often the major factor affecting the distribution chain and can limit the versatility and market penetration of this product. Storage temperature is usually limited to a minimum of -1.5°C to prevent the meat from freezing, and previous legislation in Australia defined chilled meat as being stored between -1.5°C and 4°C. The current legislation has no such prescription. Deep chilling, super chilling or partial freezing are terms used to describe the process of cooling a product to one or two degrees below its freezing point. It has been utilised with some muscle foods, particularly seafood, to extend the storage life of products. This study describes preliminary investigations into the effect of storage of beef at -2.5°C or -5°C on physical, microbiological and sensory aspects, as compared with beef stored at 0°C or -20°C. Beef stored at -2.5°C or -5°C demonstrates characteristics of frozen meat in terms of microbiology and drip loss. In addition, unsightly small white spots form on the surface of the cuts. Neither temperature would appear to be suitable for a deep chilling process aimed at maintaining the attributes of fresh meat.

Introduction

The limited storage life of vacuum packaged beef and lamb is often the major factor affecting the distribution chain and can limit the versatility and market penetration of these products. Storage temperature is usually limited to a minimum of -1.5°C to prevent the meat from freezing. Chilling has been identified by industry groups as a priority area for improvement. Customer requirements and anecdotal evidence from the industry suggests that storage lives of greater than the current expectations can be achieved, but there is no scientific evidence available for processors to use in validating the process. Previous legislation defined chilled meat as being stored between -1.5°C and 4°C, but the current legislation has no such prescription (Anon 2006; 2007a; b).

Deep chilling, super chilling or partial freezing are terms used to describe the process of cooling a product to one or two degrees below its freezing point (Duun and Rustad 2007). It has been utilised with some muscle foods, particularly seafood, to extend the storage life of products (Chang *et al.* 1998, Sivertsvik *et al.* 2003; Olafsdottir *et al.* 2006; Rosnes *et al.* 2006; Duun & Rustad 2007). In some applications crust freezing occurs without any measurable effect on final product quality. In other cases a portion of the freezable water has been converted to ice.

Ideally, formation of ice should be prevented or avoided with a muscle food in order to retain its inherent properties. Slow freezing can result in formation of large intracellular ice crystals that cause more damage to the muscle structure resulting in higher loss of drip on thawing and poorer water holding capacity (Grujic *et al* 1993, Petrovic *et al* 1993). There is some evidence that the formation of ice crystals in meat at sub-freezing temperatures can be inhibited by the application of agents that prevent nucleation of crystals. Vacuum packaging alone may be sufficient to prevent freezing at slight sub-freezing temperatures (Eustace and Bill 1988).

This paper covers some preliminary investigations into the effect of storage of beef at temperatures just below 0°C (namely -2.5°C or -5°C) on physical, microbiological and sensory aspects, as compared with beef stored at 0°C or -20°C.

Materials and methods

Small cuts (ranging 1-3kg) of striploin (*m. longissimus dorsi*), outside (*m. semitendinosus* ST) and knuckle (*m. rectus femoris*) have been stored for 10 weeks under vacuum at temperatures of 0°C, -2.5°C, -5°C and -20°C. Packs were opened at weeks 6, 8 and 10 for assessment. Cuts from -20°C were given 48 hours tempering at 0°C, and cuts from -2.5°C and -5°C 24 hours tempering at 0°C prior to assessment. A sensory panel of five p articipants assessed the visual appearance of each pack before opening. Each pack was then opened and assessed by the panel for confinement odour. The cuts were allowed to bloom for 30 minutes and then reassessed by the panel for visual appearance. Panel assessments were based on a 9-point scale, 9 being excellent, 0 being extremely poor. The volume of drip remaining in the vacuum bag was measured.

Subsequently, two samples of tissue representing a surface area of 5cm² each were removed from each cut for microbiological analysis. Each cut was then sliced into 1.5cm thick steaks and packaged in overwrap trays. The resulting retail packs were assessed using MINOLTA colourimetry, and displayed in a retail cabinet at 3°C, under fluorescent light for three days. At the end of the three day display, the packs were again assessed by MINOLTA colourimetry, and by a 3-member panel for visual appearance. Samples were taken for physico-chemical analysis (lipid oxidation, expressible juice and soluble protein concentration) and the volume of drip present in the retail tray measured.

Samples for microbiological analysis were prepared and tested using standard Petrifilm® (3M, Australia) methods, for TVC, Enterobacteriaceae and Lactic Acid Bacteria. Samples for physico-chemical analysis were processed by standard methods for TBARs (Witte *et al*. 1970), water holding capacity (Bouton *et al*. 1971) and protein solubility (Gornall *et al.* 1949).

Results and discussion

There were no significant differences between the sensory panel scores assigned to packaged cuts, nor for post-bloom primals, nor post-retail display steaks, from different temperatures of storage. Scores of 'normal' (4) to 'excellent' (8) were assigned. However, white dots were observed on the meat surface of cuts stored at -2.5°C and -5°C. These were confined to the surface of the cut. The underside of the steak looked completely normal. In general, little confinement odour was evident from cuts stored at -20°C and -5°C. The odour associated with cuts stored at -2.5°C began to become apparent after 8-10 weeks of storage, whereas a 'normal' confinement odour (panel score 4) was evident in 0°C pack from week 6, and this odour became more marked, particularly in knuckle and outside in subsequent weeks.

In general, the cuts stored at 0°C produced more drip during the vacuum storage period than did those stored at sub-zero temperatures. This may be due to the drip being bound as ice crystals within the meat tissue of those stored at sub-zero temperatures or to increased proteolysis, resulting in a looser structure and increased amount of water in the extracellular space. Bacterial enzymes may also contribute to the degradation and thereby affect the ability to retain water. However, once in the retail packs, excessive drip was produced by meat previously stored at sub-zero temperatures, compared with 0-0.13% loss in meat previously stored at 0°C. There were no significant differences between the different storage temperatures in terms of water holding capacity, nor in terms of lipid oxidation as measured by TBARs. Neither were there consistent differences between the MINOLTA L, a, or b values for cuts stored at different temperatures.

In general, the TVC of cuts stored at 0°C was around 4 log10 cfu/cm² greater than that of cuts stored at -5°C or -20°C. The TVC of striploin stored at -2.5°C occupied an intermediate position, but that of outside (ST) and knuckle stored at -2.5°C was similar to those stored at -5 °C and -20°C. The TVC of cuts stored at 0°C was in the range of 6-7 log10 cfu/cm², while for frozen cuts, in the range of 2-3 log10 cfu/cm². In all cases, the TVC was predominantly made up of Lactic acid bacteria (LAB), which were again in the range of 6-7 log10 cfu/cm² in cuts held at 0°C and in the range of 1-4 log10 cfu/cm² in cuts held at -2.5°C, -5°C and -20°C (figures 26-28). The high result at week 8 in knuckle stored at -5°C is likely to be an artefact of the study, as only a single pack of each cut and temperature was evaluated on each sampling occasion. There were no significant differences between the populations of homofermentative and heterofermentative LAB in any sample.

Conclusions

Beef stored at -2.5°C or -5°C demonstrates characteristics of frozen meat in terms of microbiology and drip loss. In addition, unsightly small white spots form on the surface of the cuts. Neither temperature would appear to be suitable for a deep chilling process aimed at maintaining the attributes of fresh meat. It

would appear that both -2.5°C and -5°C deep chilling result in unacceptable drip loss and surface marking of the cuts, phenomena that were not evident until 6 weeks of storage or more.

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