THE EFFECT OF PRE-RIGOR TEMPERATURE ON THE AGEING POTENTIAL OF KANGAROO MEAT

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Background

Kangaroo is becoming an important meat source for the Australian domestic consumer and also as an export product into European and other markets. Field processors harvest kangaroos at night under spotlight, the bodies are eviscerated and the carcasses (skin-on) hung at ambient temperatures for up to 8 hours prior to chilling. Given the seasonal variation in ambient night temperatures (from below 0°C to 30°C), muscle temperatures during the early pre-rigor period can vary widely throughout the year. Hwang and Thompson (2001) have shown that the temperature of muscles at pH 6 (rigor) can influence the ageing potential of beef muscles, and that hotter or colder muscle temperatures than optimum (~27°C) can have deleterious effects upon meat quality. This paper reports work which forms part of a larger research program targeting those factors that influence the quality of field harvested kangaroo meat.

Objectives

The effects of delayed or rapid chilling upon the ageing potential of various commercially important muscles from the kangaroo carcass were investigated by subjecting carcasses to fast and slow chilling regimes representative of the normal range encountered in industry conditions and comparing shear force at 7 or 21 days in different muscles.

Methods

Eight kangaroo carcasses were obtained under typical industry conditions from NW New South Wales, Australia. Bodies (eviscerated with the skin on) were suspended by the tail, and either chilled as soon as possible post-harvest (chiller air temp ~2°C), or held in ambient temperature conditions (15-20°C, no air movement) for 12 hrs post mortem. Directly after harvest and at 1, 2, 3, 6 and 12 hours *post-mortem* (PM), samples of the *M. vastus lateralis* were excised and placed in liquid nitrogen for the subsequent determination of pH by homogenisation of muscle in iodoacetate-KCl buffer (pH 7.00) (Bendall, 1973). Temperature decline was measured using temperature loggers (Gemini Dataloggers (UK) Ltd.) with a thermocouple inserted in the *M. adductor*. Tail suspension allowed samples to be prepared from both left and right sides of the animal, which was necessary due to the small muscle size in some animals. Five females and three males were used, with 4 animals placed in each temperature environment (randomised for sex and carcass weight) as soon as practical post-harvest (within 2 hrs). The harvest was completed over two nights, with 4 animals sourced per night. Mean carcass dressed weights (±SD) were 20.4±3.4 and 23.3±3.5 kg for the female and male animals, respectively.

The *M. adductor* (topside), *M. vastus lateralis* (round or knuckle) and *M. sacrocaudalis dorsalis lateralis* (striploin) were excised from the carcasses at 12 hrs post mortem, and vacuum packed for storage at 1°C. The left side muscles were aged for 7 days and then frozen at -20°C, while muscles from the right side were aged for 21 days prior to freezing. Sarcomere length was determined from the 7 day aged frozen muscle samples as described by Perry *et al.,* (2001). Peak force at 7 and 21 days ageing was measured using the modified method of Bouton *et al.,* (1971), (as described by Perry *et al.,* 2001).

The rate of decline in both pH and temperature was modelled for each animal to produce a rate of pH (pHk) and temperature change (tempk), as described by Bruce *et al.,* (2001). Parameters from these functions were used to estimate the temperature at pH 6 for the individual animals.

The effect of rigor temperature on shear force and sarcomere length was analysed using PROC MIXED (SAS), in a model that contained fixed effects for muscle, sex, ageing treatment and collection night, covariates for estimated temperature at pH 6 (as both linear and curvilinear terms) and significant ($P<0.10$) first order interactions. Animal was included as a random effect.

Results and Discussion

A significant quadratic relationship was found between shear force and temperature at pH 6 ($p<0.01$). There was also an interaction between the quadratic effect of temperature at pH 6 with ageing time ($p=0.056$), so that the curve for 21 day aged meat was more pronounced than for 7 day aged meat (Fig. 1). This effect occurred across all three muscles sampled. Day of harvest and sex both significantly affected shear force ($p<0.01$). The harvest on day 1 yielded muscles with higher shear force than those of day 2, and the muscles from females had higher shear force values than those from males. However there was no interaction between these factors and pHk in their effect on shear force, so that all results are presented adjusted for these terms. Shear force also differed between muscles ($P<0.01$). The values for the *M. vastus lateralis* were higher than for the *M. adductor* and *M. sacrocaudalis dorsalis lateralis*, which were not significantly different from each other.

Previous studies into the effects of accelerated and delayed chilling regimes upon ageing potential of muscle have shown that hotter conditions at rigor can lead to reduced protease activity during the subsequent chilled storage (Pike *et al.,* 1993; Hwang and Thompson, 2001), possibly through the denaturation of proteolytic enzymes at the higher temperatures. Thus the ageing potential of the meat is compromised. Hwang and Thompson (2001) found the optimum temperature for minimum shear force to be around 27°C at pH 6, which is in agreement with the results from this study for kangaroo meat.

Sarcomere length of muscle aged for 7 days exhibited a significant curvilinear relationship with temperature at pH 6 ($p<0.05$, data not shown). This pattern was similar to that for shear force, with sarcomere length decreasing as temperature diverged higher or lower from 24°C at the standard pH of 6.0. Colder muscle temperatures at rigor can shorten sarcomeres to the extent to which proteases may not be able to gain access to the myofibres (Whipple *et al.,* 1990).

As shear force is correlated with the consumer perception of cooked meat tenderness (Perry *et al.,* 1998), these results suggest that consumers should find 21 day aged kangaroo meat, chilled under a regime which results in a muscle temperature of around 24°C at pH 6, to be more acceptable in terms of tenderness than meat aged for 7 or 21 days chilled under sub-optimal conditions. The relatively flat response of the 7 day ageing curve relative to temperature at pH 6 (Fig. 1) indicated that the chilling regimes of kangaroo carcasses had less impact on tenderness when the product was not destined to be aged more than 7 days. In addition to the ageing effect, the potential detrimental effects of heat shortening must be considered, with warmer temperatures than optimal at pH 6 leading to increased drip losses and decreased shelf life of product (Hwang *et al.*, 1999).

Kangaroos are generally harvested from early evening until near sunrise. The proximity of field chillers to harvesting sites does not always allow for carcasses to be placed quickly under refrigeration. Thus achieving a muscle temperature of 24°C at pH 6 is not easy under field conditions. In addition, the vast differences in ambient temperatures that occur between seasons, and even within a particular night's harvest, make the attainment of optimum muscle temperatures at rigor difficult.

Conclusions

Kangaroo meat shows potential for value adding through the extended chilled ageing of boned, vacuum packaged product. Significant decreases in peak shear force were found in 21 day aged product as compared with ageing for 7 days when muscle temperatures were at ~24°C upon commencement of rigor (pH 6). A curvilinear response of peak force with the temperature at pH 6 indicated that ageing potential was adversely affected when muscles entered rigor at temperatures higher or lower than the optimum of 24°C.

Pertinent Literature

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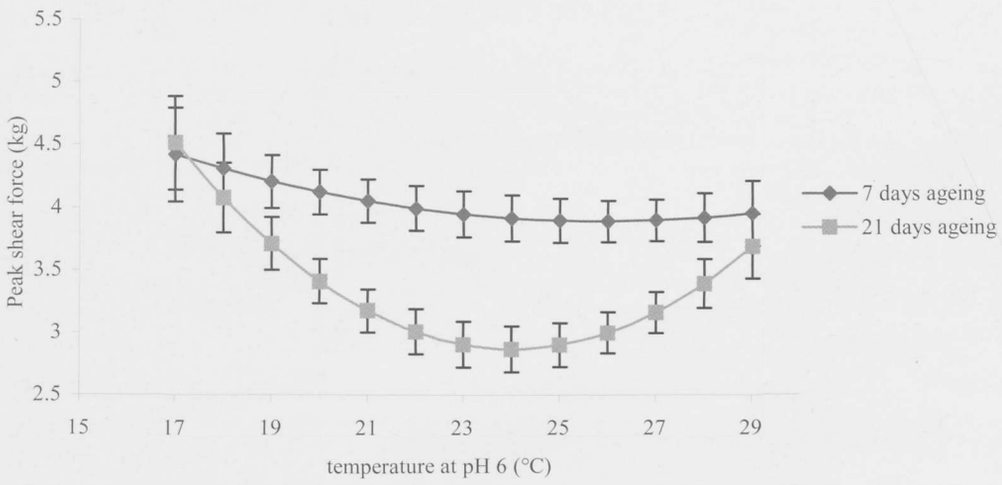

Fig 1. The effect of ageing and rate of chilling/glycolysis upon shear force after adjustment for muscle, day of harvest and sex (vertical bars are ± standard error).