Meat Science 84 (2010) 651–654

Contents lists available at ScienceDirect

Meat Science

journal homepage: www.elsevier.com/locate/meatsci

Mechanical tenderisation of beef muscles for use in re-formed joints made with a cold-set binder

A.M. Lennon, S.S. Moon, P. Ward, T. Kenny *

Teagasc, Ashtown Food Research Centre, Ashtown, Dublin 15, Ireland

ARTICLE INFO

Article history:
Received 19 May 2009
Received in revised form 21 October 2009
Accepted 26 October 2009

Keywords:
Mechanical tenderisation
Beef
Re-formed
Blade
Needle
Injection
Vacuum-pulsing

ABSTRACT

Three treatments, blade tenderisation (BT), needle tenderisation (NT) and enhancement by brine injection + vacuum-pulsing (VP), were applied to each of two muscles from beef forequarter, *M. pectoralis profundus* and *M. supraspinatus*, and two from the round of the hindquarter, *M. semimembranosus* and *M. vastus lateralis*. The tenderised muscles and non-treated controls were re-formed into joints using a cold-set bonding agent and tested as steaks cut from the joints. NT and VP gave a similar degree of tenderisation, as indicated by W–B shear force and taste panel, while BT had a lesser but still significant effect. Cook loss from steaks was increased by BT and NT treatments for the, tougher, forequarter but not the hindquarter muscles. The overall conclusion was that NT and VP treatments are more effective than BT but that the 3 methods are satisfactory for tenderisation of beef for production of re-formed steaks. Reduced redness and higher bacterial numbers arising from VP could render this treatment more suitable for re-formed steaks for catering than for retail sale. A supplementary trial showed that slices from roasted VP-treated re-formed joints(as distinct from grill-cooked steaks tested in the main trial) were better in sliceability and equal to or better in sensory quality than those from commercial whole-muscle round roasts purchased in a supermarket.

1. Introduction

Re-formed beef products provide a market outlet for low-value muscles. These contain high levels of connective tissue and therefore require tenderisation prior to re-forming (Rolan, Davis, Seideman, Wheeler, & Miller, 1988). Tenderness is the most important factor affecting US consumers' perception of taste in beef (Morgan et al., 1991). Glitsch (2000) found that for European consumers, tenderness and flavour were the most important factors in eating quality of beef.

Several studies on the effectiveness of mechanical tenderisation of meat have been reported (Jeremiah, Gibson, & Cunningham, 1999). The increase in tenderness by blade tenderisation is attributed to partial destruction of connective tissue and severance of muscles fibres which leads to reduced resistance to shear force, mastication and swallowing (Seideman, Smith, Carpenter, & Marshall, 1977). It has also been demonstrated that beef steaks and pork chops are more tender and juicy when injected with a phosphate + salt solution (Robbins et al., 2003). McGee, Henry, Brooks, Ray, and Morgan (2003) found that injected beef inside rounds were more tender than control products. Tumbling, or massaging treatment, is also used in the industry to increase tenderness.

This study was part of a project designed to increase the value of some muscles through tenderising and re-forming treatments. Tenderisation by both blade and needle methods and by injection + vacuum-pulsing was assessed in conjunction with preparation of re-formed beef joints using the cold-set binder Activa™ (Ajinomoto Ltd.). The active ingredient in Activa is transglutaminase cross-bonding enzyme which catalyses the polymerisation and cross-linking of proteins (Kolle & Savell, 2003).

2. Materials and methods

2.1. Muscle selection and tenderisation

Two muscles from the forequarter (*M. pectoralis profundus*, from the brisket, and *M. supraspinatus*, the chuck tender) and two from the hindquarter (*M. semimembranosus*, from the topside round, and *M. vastus* lateralis, from the knuckle) were tested. They were excised from grade R4L (E.C. Beef Carcass Classification Regulations, 1994) steer carcasses at 4 days post-slaughter. Muscles were trimmed PAD (prêt-a-decoupé, ready-to-slice)-style, i.e. all visible external fat and connective tissue were removed. The heavy central piece of connective tissue was removed from the *Supraspinatus* muscle and the *P. profundus* was used whole. Sufficient quantity of each muscle was pooled together to provide for 25 of 19 × 13 × 7.5 cm re-formed joints, each of c. 2000 g weight. This

* Corresponding author. Tel.: +353 18059500/353 863589437; fax: +353 18059550.
E-mail addresses: tony.kenny@teagasc.ie, tkenny14@gmail.com (T. Kenny).

0309-1740/$ - see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.meatsci.2009.10.026

allowed for 5 × replicate joints per muscle for each of 4 treatments, for cutting into steaks. The extra 5 × replicate joints were used for one of the treatments (VP, see below) and roasted whole for comparison with commercial roasted whole-muscle joint in a supplementary trial. The treatments were: (1) non-tenderised control (CO), (2) blade tenderised (BT), (3) needle tenderised (NT), and (4) injected + vacuum-pulsed (VP).

For BT treatment, muscles were passed once through a commercial roller-blade tenderiser in which blades from opposing rollers overlapped by 10 mm. NT muscles were passed through a commercial Tender Star Model TSE tenderiser, with stainless steel chisel-shaped needles. The muscles were cut into c. 200 g chunks following BT and NT treatment. Injected + vacuum-pulsed muscles (VP) were injected with brine, using a Dorit PSM-21 Inject-O-Mat brine injector, at 16% level, to give a concentration of 0.5% salt and 0.3% sodium tripolyphosphate (STPP) in the meat, chopped to give chunks of c. 200 g weight and vacuum-pulsed at 0–2 °C for 14 h in a Rühle vacuum tumbler-mixer (Model MKR 150–600, Rühle GmbH) using a "Tender beef" programme which alternated between 90% and 10% vacuum (100 and 900 hPa residual pressure).

2.2. Re-forming and packaging of treated muscles

Activa™ TG-RM (Ajinomoto Gmbh, transglutaminase preparation) at a level of 1% of raw meat weight was mixed with water at 4% of meat weight, using a hand-held whisk, to give a uniform suspension. The suspension was mixed with BT, NT, VP and CO (non-tenderised) meat chunks, ensuring that each chunk was fully coated. Meat chunks were then layered in a polythene-lined rectangular-shaped mould (1500–2000 g per mould), vacuum packed and held at 2 °C for 16 h to allow progress of the protein cross-linking reaction. The formed meat was then removed from the moulds and cut into steaks of 25 mm thickness (except for the extra VP joints for the supplementary trial which were vacuum packaged whole in Cryovac™ cooking bags and chilled overnight at 2 °C prior to cooking). Steaks were vacuum packaged on day of cutting (day 0) and held at 2 °C for periods indicated below, pending measurement of colour, texture and bacterial count, or at –20 °C pending taste testing.

2.3. Testing of steaks for colour, bacterial count, cook loss, shear force and sensory quality

Colour was measured on a HunterLab Ultrascan XE spectrophotometer with CIE ($L^*a^*b^*$) colour scale, D65 illuminant and 10° observer on the cut surface of PVC film-covered steaks after 1 h blooming in air at 2 °C on the same day that steaks were cut. Measurements were taken at 10 locations over 2 steaks per joint and averaged.

Total viable bacterial counts (TVCs) at 30 °C were determined on a cumulative representative 10 g sub-sample from steaks from one of the forequarter and one of the hindquarter muscles (*M. pectoralis p.* and *M. Semimembranosus*) on day 0 and after 7 days in MA-packs. The gas mixture used in the latter was 80% oxygen: 20% carbon dioxide, which is typical of the 70–80% oxygen and 20–30% carbon dioxide levels used commercially.

Cook loss was measured on day 1 on 2 steaks from each joint which were cooked in polythene bags in a water bath at 72 °C to an internal temperature of 70 °C and cooled to room temperature before re-weighing.

Shear force was measured on these steaks after they were chilled overnight at 2 °C. A total of 7 cores of 13 mm diameter were cut, parallel to the fibre direction insofar as possible, from each pair of steaks, and were sheared on an Instron Universal testing machine.

Sensory quality was assessed by a panel of 8 people drawn from a pool of staff members experienced in taste-testing of beef. The panellists had been screened for primary taste differentiation and trained in group instruction-cum-discussion tasting sessions on selected beef samples, adhering to some of the AMSA guidelines (AMSA,1995). Frozen steaks were thawed in-pack in cold running water to 2–4 °C and grill-cooked to a core temperature of 70 °C. Sub-sample strips were presented hot to the panellists who rated them on descriptive attribute six-point numerical scales (AMSA, 1995) where 1 = worst and 6 = best. The attributes rated were tenderness, chewiness, residual connective tissue, juiciness and overall acceptability.

2.4. Supplementary trial: Comparison of re-formed (VP) joints and commercial silverside joints for cook loss, sliceability and sensory quality

The 5 × VP joints packaged in cooking bags (see above) were cooked at 82° in a steam–air cooker (Jugema Ltd.) to a core temperature of 70 °C. Five beef silverside round roasts of c. 1000 g average weight were purchased in a supermarket and packaged and cooked with the VP joints. The purpose was to bench-mark one of the tenderisation treatments by comparing the product therefrom (at 5 days post-mortem) with a typically consumer – acceptable retail mid-price whole-muscle beef roasting joint.

Cook loss was measured by weighing the above joints after they were allowed to cool to ambient temperature, removed from the bags and wiped with a paper towel to remove adhering cook-out juice.

The cooked joints were then chilled to 2 °C and cut on a meat slicer into slices of 1 mm thickness.

Sliceability was measured as proportion of unbroken slices in 10 × 1 mm slice samples.

Kramer Shear Force (KSF) was measured on c. 30 g samples of the 1 mm-thick slices in a 10-blade Kramer shear cell attached to an Instron model 4464 texture metre. Measurements were recorded as Newtons force per g of sample.

For testing of sensory quality, slice samples were vacuum packed and stored frozen at −20 °C until required. They were then thawed and brought to ambient temperature for tasting by a panel of 8 trained tasters as described above for sensory testing of steaks, except that the attributes rated were colour acceptability, tenderness, binding/cohesion and overall acceptability (1 = worst and 6 = best).

2.5. Statistical analysis

The experiment was designed as a 4 (tenderisation treatments) × 4 (muscles) factorial, with five replicates (re-formed joints). All data were analysed using Genstat 5 Release 3.2 (Rothamstead experimental station) analysis of variance (ANOVA). Least significant differences ($P < 0.05$) were used to identify differences among treatment means. In the case of sliced roast beef, taste panel results showed no significant differences. The distribution was not ideal for the, parametric, ANOVA test, and transformation offered no advantage. Therefore, the non-parametric, Kruskal–Wallis test (Genstat 5) was used instead of ANOVA to check for differences. For total viable counts, the analysis used was a split plot in time design, with a 4(tenderisation treatments) × 2 (muscles) factorial arrangement on the main plot and time (days) on the sub-plot.

3. Results and discussion

3.1. Steaks

Shear force (WBSF) values and taste panel ratings showed that method of mechanical tenderisation significantly affected tender-