EATING QUALITY OF FROZEN AUSTRALIAN LAMB LEG MEAT

R.H. Jacob[1], K.L. Pearce,[2], A Gee[c] and D.W. Pethick[3]

[1] Department of Agriculture and Food Western Australia, Baron Hay Court, South Perth , WA, 6151

[2] Murdoch University, Division of Veterinary and Biomedical Science, South Street, Murdoch, WA, 6150.

[3] Cosign, Coffs Harbour.

[a] Corresponding author email: robin.jacob@agric.wa.gov.au

Abstract: *An experiment was conducted to benchmark the eating quality of Australian lamb meat frozen across a range of freezing times and methods used commercially. Legs were collected from 108 lamb carcases slaughtered at a commercial abattoir in Western Austarlia and allocated randomly to one of 6 treatments. The treatments were arranged in a 2X3 factorial design of freezer type (plate or blast) and freezing time (0.5, 1, or 3d from slaughter). Eating quality was assessed by an untrained consumer panel for meat roasted after thawing. Objective measurements of shear force, sarcomere length and drip loss were also made. Treatment affected shear force, tenderness, star rating, and sarcomere length but not overall liking, flavour, juiciness, liking of smell or drip loss. In particular freezing too soon after slaughter could reduce tenderness and star rating. There was no effect of freezing method or freezing time on drip loss. The conclusion was made that whilst some variation may occur due to processing method, the benchmark value for the eating quality of frozen Australian "easy carve leg" lamb meat is likely to have a satisfaction star rating of 3 out of 5 , that is "good everyday".*

Index Terms—*frozen lamb eating quality*

I. INTRODUCTION

In the past about 60% of lamb meat exported from Australia has been frozen. This amounted to 89,400 tonnes in 2006 (Mansfield and Cox 2007) although more recent figures suggest the proportion of lamb exported frozen has since declined. To date the Sheep Meat Eating Quality (Russell *et al.* 2005) program has focussed on the eating quality of chilled lamb hence a need exists to benchmark the eating quality of frozen product. The quality of frozen meat is known to be infuenced by several factors particularly the ageing period prior to freezing as well as the rate of freezing. Wicklund (2009) found that ageing for 4 weeks prior to freezing overcame any difference between chilled and frozen meat for tenderness with New Zealand lamb. Petrovic (1993) found that tenderness of beef increased with freezing rate.

However the practice of accelerated ageing and conditioning (Hagyard 1979) is not common in Australia and lamb meat frozen for export is often frozen 1 day post slaughter, after cold deboning. Furthermore within the scenario's that are common commercially, sufficient variation occurs in ageing period and freezing rate to affect eating quality. Freezing might commence as early as 12 hours post slaughter, in a double shift operation for meat that has been electrically stimulated post dressing then deboned warm. In a cold deboning scenario, meat from lambs slaughtered on Friday may not be deboned and frozen until Monday. In this case about 20% of an abattoirs production could be frozen at 3 days whilst the majority of 80% is frozen at 1 day post slaughter. Facilities used to freeze lamb meat varies between abattoirs from air blast chillers that freeze meat in 2 days (Eustace *et al.* 1997a) to plate freezers that freeze meat within 1 day (Eustace *et al.* 1997b).

Lamb meat frozen for export includes more of the lower value cuts that are likely to be cooked slowly. Rack and bone in loin made up 14% of chilled and less than 6% of frozen lamb meat exported from Australia in 2006 (Mansfield and Cox 2007). Cooking method is therefore an important consideration for evaluating the eating quality of frozen meat. This report describes an experiment done to benchmark the eating quality of Australian frozen lamb meat by sensory evaluation using a consumer taste panel. Treatments were designed to represent the range of freezing scenarios encountered under Australian commercial conditions, using lamb leg meat prepared with a roasting cook protocol.

II. MATERIALS AND METHODS

Experimental Design

The experimental design consisted of 2 freezer types and 3 periods of time *post mortem* before freezing commenced, arranged in a 2 x 3 factorial design. The two freezer types were plate and blast freezing and the 3 time periods were 0.5, 1, and 3 d post mortem. Eighteeen lambs were assigned to each treatment (n =18, N=108).

Lambs

The meat used in the experiment was selected from one single vendor consignment of crossbred lambs slaughtered at a commercial abattoir in Western Australia. Slaughter involved electrical head stunning followed by exsanguination. Each carcass received electrical stimulation from a post dressing medium voltage system. This system consisted of rubbing electrodes (shoulder to rump) that delivered a constant current (1A), pulse width 2.5mS, peak maximum voltage of 300V and frequency of 15Hz (Realcold Milmech, Brisbane, Australia).

There were no specific selection criteria for the consignment apart from the practical consideration that it was of sufficient size to supply all of the lambs required for the experiment. From this one consignment, 108 carcases in the hot carcase weight and fat ranges of 18-24kg and fat score 2-3 respectively were allocated randomly to one of the 6 treatment groups. Objective measurements were done using one hind leg and sensory evaluation done using the other hind leg with legs (left or right) being assigned randomly to each method.

Freezing facilities

Two separate commercial facilities were used for the freezing treatments, a blast freezer located on site at the abattoir and a plate freezer located off site some 260km from the abattoir. All samples were kept chilled in the range 0-2°C prior to freezing. Air temperature in the blast freezer was -25°C and air speed 1.5ms^{-1}. The refrigerant in the plate freezer was ammonia kept at -35°C and the plates were spaced at a distance of 170mm. The meat was packed in cartons made from B flute corrugated cardboard 7mm in thickness for both plate and blast freezers.

Objective Meat quality measurements

Shear force was measured on *m. semimembranosus* using a MIRNZ tenderometer (MIRNZ AgResearch, Hamilton New Zealand). Each meat sample was placed in a plastic bag and cooked in a water bath to an internal temperature of 75^{o}C. Once the meat reached this temperature it was removed and the plastic bag containing the meat placed in ice slurry to cool quickly. Once at 2^{o}C the meat sample was refrigerated in the plastic bag for 24 h. After 24 h the meat samples were cut parallel to the muscle fibre axis in a 10 x 10 mm cross-section across the grain (Bickerstaffe *et al.* 2001; Devine *et al.* 2002; Graafhuis *et al.* 1991) and placed into the tenderometer. MIRINZ tenderometer shear force values can be converted to, Warner-Bratzler values by multiplying the MIRINZ value by 0.65 (Graafhuis *et al.* 1991). Drip loss was measured on samples of *m. semimembranosus*. Approximately 40g of muscle was firstly weighed (A) then a 0.5 cm^2 commercial net material was tied around the sample and suspended in a plastic bag for 4 days at 4^{o}C. Samples were then reweighed (B) 4 days later. Drip loss percentage was calculated as: [(A-B)/A]*100. Sarcomere length was measured using a laser diffraction method. Meat temperature was measured using ibutton loggers (www.onsolution.com.au) placed between the *m. semimembranosus* and *m. semitendinosus* at a depth of 100mm approximately.

Consumer panel evaluation

The legs were vacuum packed after removal from a carcase then frozen at an appropriate time post slaughter depending on treatment, placed in foam boxes, packed with ice strips, sealed and shipped by frozen freight from Perth to Coffs Harbour. At Coffs Harbour the legs were thawed for 24h at 1-2°C, fashioned into "easy carve legs-Ausmeat cut 4821(Anonymous 2005), and then frozen again. The "easy carve" legs were thawed for 48h at 1-2°C then roasted and carved into consumer steaks for presentation to the taste panel according to the method described in Pethick *et al* (2006) . Consumers were asked to rate tenderness, juiciness, liking of flavour and overall liking from 0 to 100 (e.g. very tough =0, very tender = 100).

Statistical analyses

Genstat version 12 was used to conduct statistical analyses of the data. General analysis of variance (ANOVA) was used to test the effects of treatment with no blocking and no covariates.

III. RESULTS AND DISCUSSION

No difference was observed between treatments for hot carcass weight (HCW) and GR depth (P>0.1) (average HCW was 21.1 ± 0.4 kg and 12 ± 1 mm for GR depth). Legs in the blast freezer commenced freezing at -0.5°C and freezing was complete in about 40 h. Legs in the plate freezer commenced freezing at -7°C and freezing was complete in about 12h.

Table 1 The effect of treatment on objective measures of meat quality

	Blast			Plate			P values			*LSD
	0.5d	1d	3d	0.5d	1d	3d	Freezer type	Freezing time	Type x time	
Shear force (KgF)	45.0^{d}	35.8^{b}	36.2^{b}	46.6^{d}	41.3^{c}	31.0^{a}	0.48	<.01	<.01	2.73
Drip loss (%)	11.4	12.0	11.6	12.7	11.5	11.1	0.88	0.75	0.49	2.38
Sarcomere length (μ)	1.94	1.92	1.89	1.90	1.93	1.86	0.17	0.01	0.39	0.04

* LSD (P=0.05) is for interaction beteween time and type except for sarcomere length in which case it is for comparing different freezing times
Values with different superscripts (^{a,b,c}) within rows and freezer type (blast or plate) are different.
$^{\tau}$LSD (P=0.05) is for comparing means for freezing times

There was a significant (P<0.05) effect of freezing time on shear force (Table 1) that depended on (P>0.05) freezer type. Shear force for meat frozen 0.5d was higher than for meat frozen 1d and 3d post slaughter for plate and blast freezers. Shear force was lower for meat frozen on day 3 compared to day 1 for the plate but not the blast freezer, and shear force for meat frozen on day 1 was lower for blast than plate freezer. There was no effect (P>0.05) of treatment on drip loss. Sarcomere length was shorter for day 3 compared to day 0.5 and day 1 but not sufficiently short to increase shear force.

Table 2 The effect of treatment on consumer evaluation of eating quality

	Blast			Plate			P values			$^{\tau}$LSD
	0.5d	1d	3d	0.5d	1d	3d	Freezer type	Freezing time	Type x time	
Tenderness	58.4^{a}	65.3^{b}	60.9^{b}	53.5^{a}	59^{b}	62.2^{b}	0.01	0.02	0.26	4.8
Overall liking	57.6	61	60.4	55	58.7	59.1	0.23	0.16	0.96	NS
Flavour	57	60	59.9	56	59	59.5	0.61	0.18	0.98	NS
Juiciness	56.1	55.4	57	54.7	57	56.6	0.97	0.82	0.78	NS
Liking of smell	58.5	61	61.5	58.5	59.3	60.3	0.44	0.27	0.84	NS
Satisfaction star rating*	3.0^{a}	3.1^{a}	3.2^{ab}	2.9^{a}	3.2^{b}	3.2^{b}	0.69	0.04	0.88	0.18

*A star rating 5 indicates a premium product, 4 is better then everyday, 3 is good everyday, 2 is unsatisfactory and 1 is inedible .
Values with different superscripts (^{a,b,c}) within rows and freezer type (blast or plate) are different.
$^{\tau}$LSD (P=0.05) is for comparing means for freezing times

There were significant effects of treatment on tenderness and satisfaction star rating but no effects on overall liking, flavour, juiciness and liking of smell (Table 2). Tenderness was lower when freezing time was 0.5d compared to 1d and 3d. Satisfaction star rating was higher for meat frozen after 3d compared to after 0.5d. By comparison the overall likings scores for the meat in this experiment compared favorably to the mean value of 59.1 for easy carve legs in the study by Pethick *et al* (2006) using chilled lamb meat aged for 9 days. This result may have been influenced by the thawing procedure which effectively added another 2 days to the ageing period prior to consumer evaluation for all treatments.

IV. CONCLUSION

Frozen Australian lamb leg meat is likely to be rated by consumers as being of "good everyday" quality when roasted.

Variations in freezer types and times experienced under commercial conditions could contribute to variation in frozen lamb meat quality. In particular freezing at 0.5d is likely to reduce tenderness and satisfaction rating. However, meat slaughtered on a Friday then deboned and frozen on a Monday is likely to be little different for consumer rating to meat deboned and frozen the day after slaughter during the week.

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