BRIEF COMMUNICATION: Quality of chilled-never-frozen versus chilled-frozen-thawed lamb

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INTRODUCTION

Chilled lamb currently attracts a premium price over frozen accelerated conditioning and ageing (AC&A) lamb in New Zealand's traditional lamb markets. AC&A lamb is fully frozen within 48 h of slaughter (Hagyard, 1979). The price differential between chilled-never-frozen (CNF) and AC&A frozen lamb is due to CNF lamb having more reliable tenderness, less drip loss and longer colour display life than AC&A lamb. There is no clear evidence that the eating quality of CNF lamb is superior to frozen and thawed lamb, when the lamb has been correctly aged before freezing. This study was designed to test the hypothesis that there is no quality difference between CNF and chilled-frozen-thawed (CFT) lamb.

MATERIALS AND METHODS

Animals

Loins (*M. longissimus dorsi* of pH <5.8) from two groups of lambs (Group 1, n = 24; Group 2, n = 30) were included in the study. Lambs in Group 1 and Group 2 were slaughtered at approximately 4 and 7 months of age, respectively, and at two different abattoirs. Loins were deboned and vacuum packaged at one day post slaughter and chilled for four weeks at -1.5ºC and then randomly allocated to two treatments; chilled at -1.5ºC (CNF loins; n = 26) or frozen at -18 ºC (CFT loins; n = 27) for an additional five weeks, bringing the total storage time to nine weeks. At nine weeks the frozen samples were placed at -1.5°C for two days to thaw out completely. The following meat quality measurements were performed: purge, shear force, cook loss, total loss (purge + cook loss), colour during display up to seven days and sensory evaluation by 106 consumers (76 consumers tasted samples from Group 1 and 30 consumers samples from Group 2).

Purge loss, cook loss, total loss and shear force

Loins were removed from their packages, dabbed dry with a paper towel and then weighed. Purge loss was calculated as the difference in the weight of the loins before and after vacuum packaging and storage expressed as a percentage of the original weight of the loins. Samples were cooked to an internal temperature of 75°C as measured by thermocouples and then immediately placed in ice-water slurry. The weight of the meat was recorded before and after cooking. After cooking the meat samples were blotted dry and re-weighed. The cook loss was calculated as weight lost expressed as a percentage of the original sample weight. Total loss was calculated as: purge loss + cook loss. Shear force was measured using a MIRINZ Tenderometer. Once cooled, 10 x 10 mm cross section samples (n = 10 from each sample) were cut out from the cooked meat samples and sheared with the MIRINZ Tenderometer. The results were expressed as shear force (kgF).

TABLE 1: Quality of chilled-never-frozen (CNF) vs. chilled-frozen-thawed (CFT) lamb loins from two groups of animals slaughtered at four months of age (Group1) and seven months of age (Group 2). SED = Standard error of difference.

Treatment	Number of loins	pH	Purge (%)	Cooking loss (%)	Total loss (%)	Shearforce (kgF)
Group 1						
CNF	12	5.69	7.52	27.4	34.9	2.81
CFT	12	5.69	6.21	26.1	32.3	2.92
SED		0.00	0.63	1.0	1.2	0.17
P value		0.99	0.05	0.18	0.04	0.50
Group 2						
CNF	14	5.52	5.43	23.9	29.3	6.29
CFT	15	5.48	6.26	22.6	28.9	5.68
SED		0.04	0.66	1.1	1.3	0.79
P value		0.30	0.23	0.28	0.75	0.44

TABLE 2: Colour measurements of chilled-never-frozen (CNF) vs. chilled-frozen-thawed (CFT) lamb loins from two groups of animals slaughtered at four months of age (Group1) and seven months of age (Group 2). SED = Standard error of difference.

Display time	Treatment	Number of loins	Colour measurements			
			CIE L* (Lightness)	CIE a* (Redness)	CIE b* (Yellowness)	Hue angle (°)[1] (Brownness)
Group 1						
Day 0	CNF	12	42.8	20.8	9.0	23.3
	CFT	12	42.5	20.7	9.1	23.6
	SED		0.7	0.6	0.3	0.4
	P value		0.70	0.88	0.76	0.40
Day 1	CNF	12	43.0	18.2	8.2	24.4
	CFT	12	43.0	18.1	8.9	26.2
	SED		0.8	0.6	0.2	0.4
	P value		0.98	0.90	0.01	0.001
Day 3	CNF	12	41.9	14.5	7.9	28.7
	CFT	12	42.7	14.9	8.2	28.8
	SED		0.8	0.6	0.3	0.8
	P value		0.28	0.48	0.32	0.93
Day 7	CNF	12	42.8	10.2	7.8	37.7
	CFT	12	42.7	11.6	8.0	34.7
	SED		0.8	0.7	0.3	2.0
	P value		0.84	0.05	0.42	0.14
Group 2						
Day 0	CNF	14	43.9	20.7	8.9	23.3
	CFT	15	40.2	19.6	8.5	23.4
	SED		0.6	0.6	0.4	0.4
	P value		0.001	0.05	0.26	0.66
Day 1	CNF	14	42.8	20.3	8.9	23.7
	CFT	15	40.0	18.6	8.5	24.4
	SED		0.4	0.6	0.3	0.3
	P value		0.001	0.01	0.21	0.03
Day 3	CNF	14	42.3	18.6	8.5	24.7
	CFT	15	40.3	17.2	8.4	26.2
	SED		0.6	0.5	0.3	0.4
	P value		0.003	0.01	0.71	0.003
Day 7	CNF	14	42.6	14.6	7.6	27.5
	CFT	15	41.0	14.6	7.8	28.0
	SED		0.5	0.6	0.3	0.7
	P value		0.003	0.95	0.48	0.52

[1]Hue angle = arctan CIE b*/CIE a*

Colour measurements

A 2-cm thick steak was removed from each loin and placed on a white polystyrene tray, over wrapped with high clarity d-film and kept in the dark for 3 h at 1.5°C to bloom. Colour was measured on samples after 0, 1, 3 and 7 days of display using a Minolta Colorimeter (Minolta Camera Co., Ltd, Japan). CIE L* (lightness), CIE a* (redness) and CIE b* (yellowness) were measured through the film with a D65 illuminant at 10 degrees. Three measurements were taken from each sample. Hue angle (brownness) was calculated from the CIE a* and CIE b* values (arctan b*/a*).

Sensory evaluation

The loins were assessed by an in-house consumer panel at AgResearch Ruakura. Consumers were recruited through the campus by e-mail. The in-house panel evaluated the two treatments as they entered the cafeteria for morning and afternoon tea. "Each consumer was served a plate with two slices, one from each treatment, of warm lamb loins assigned with randomly selected three-digit numbers. In total, 106 panellists were involved. Panellists were asked to assess which of the two samples were most tender, most juicy and which they preferred overall. Panellists were also asked to

TABLE 3: Consumer preference of chilled-never-frozen (CNF) vs. chilled-frozen-thawed (CFT) lamb loins from two groups of animals slaughtered at four months of age (Group1) and seven months of age (Group 2).

Treatment	Total number of consumers	Number of consumer attribute preferences		
		Tenderness	Juiciness	Overall preference
Group 1				
CNF	76	41	48	43
CFT	76	35	28	37
Significance		NS	*	NS
Group 2				
CNF	30	9	17	12
CFT	30	20	13	17
Significance		*	NS	NS

record any other comments they had about the samples.

Statistical analysis

Due to the differences in animal origin and age, data was analysed as two separate experiments. The design was completely randomised. The statistical model included the effects of animal and treatment. Data was analysed by the ANOVA component of Genstat (Payne *et al*., 2007). For the consumer assessments, all data was analysed using Chi-square test.

RESULTS AND DISCUSSION

Treatment effect on moisture loss

Purge and total cook losses were lower ($P < 0.05$ and 0.04 respectively) in the CFT samples in the younger animals (Group 1) relative to CNF. The two treatments did not differ significantly in these quality attributes in the older animals (Group 2) (Table 1). We expected the CFT samples to lose more water as purge due to muscle structural damage caused by freezing of water (Anon & Calvalo, 1980) but the data in this study proved otherwise. The reason for the lower moisture loss in the CFT relative to CNF is not obvious from the data in this study, but could be related to muscle structural protein changes that resulted in improved water binding in the samples. Zang *et al*. (2006) demonstrated reduced moisture losses with low levels of structural protein breakdown in pork. The four weeks chilled storage for the CFT samples could have resulted in lower level disintegration of muscle structural proteins compared to CNF which were stored chilled for nine weeks. The improvement in moisture retention due to the structural changes could have neutralised any negative impact freezing might have had on moisture retention in the CFT samples.

Treatment effect on raw meat colour

CNF and CFT did not differ in CIE L* values in Group 1 but CNF samples were lighter than CFT in Group 2 throughout the storage periods. Redness (CIE a*) did not differ between treatments in Group 1 except on display day 7 when CFT samples were redder than CNF. The opposite was the case in Group 2 (Table 2) where CNF were redder on all display days except day 7. Hue angle, an indication of brownness, was lower in CNF compared to CFT in both groups of lambs on display day 1 and on day 3 in Group 2. CNF were lighter in the older animals (Group 2) probably due to a higher fat content and lipid oxidation in the meat from this group compared to Group 1. Farouk and Swan (1998) showed in a model study that the lightness of beef increased with increased fat content and lipid oxidation. The higher CIE a* values and the lower hue angle of CNF relative to CFT could be because of the higher metmyoglobin reducing activity in CNF compared to CFT (Bekhit & Faustman, 2005).

Treatment effect on cooked meat acceptability

The freezing treatment had no significant effect on the consumer preference for cooked meat tenderness and the overall liking of the meat from the younger group of lambs (Table 3). However, the freezing treatment significantly affected the juiciness of these samples, with CNF being juicier than CFT. Treatment only affected the preference for tenderness in the older lambs with CFT being more tender than CNF (Table 3). Overall, the consumers found lamb from the two treatments equally acceptable ($P > 0.05$). The higher moisture retention (Table 1) of the CFT lamb could be the reason this lamb was perceived to be less juicy by the sensory panel compared to CNF lamb. CFT lamb in Group 2 was perceived to be more tender probably due to structural damage caused by freezing.

CONCLUSION

In conclusion, the eating quality of CFT lamb loins was very similar to that of CNF loins. Therefore, it is suggested that properly processed and aged lamb can be frozen with no deleterious effect on its eating quality relative to equivalent lamb that has not been frozen. Because data in this study indicates the colour of CFT lamb tends to become brown faster on display relative to CNF, the CFT lamb will best be targeted to hotel and restaurant outlets as a medium priced meat intermediate between AC&A frozen meat and CNF. In hotels and restaurants the shorter display life of the CFT meat will not be an issue considering consumers do not get to see the meat in its raw state. The relationship between the age of lambs at slaughter and the treatments used in this study on the quality of lamb needs to be explored. The effect of the treatments on the quality of meat from different muscles and species of meat animals should also be studied.

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