EFFECT OF FREEZING METHOD ON MEAT QUALITY OF BEEF CATTLE

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I. INTRODUCTION

Freezing practices are widely used to prolong meat preservation as an effective safety method and efficient storage process across the meat supply chain. Moreover, it can ensure acceptable level of chemical quality and even increase some organoleptic traits of frozen/thawed meat. However, the positive freezing impact on meat tenderness and colour stability is still debated because of the crucial impact on muscle structure, the extent of physical cell damage and chemical change of proteins are related to the ageing period prior lowering the conservation temperature and the freezing rate to reach both the beginning (between −1 and −7 °C) and the complete frozen (approximately −18 °C) process [1]. The purpose of this study was to investigate the effects on histological, chemical and instrumental quality traits of beef loin of two freezing methods differing for the rate of the freezing process.

II. MATERIALS AND METHODS

At approximately 16 months of age, fifteen (n = 15) Limousine heifers were slaughter and then carcass (294 ± 16 kg of cold weight) were refrigerated at 4 (± 0.5) °C for 5 days *post mortem*. After this chilling ageing, boneless joint sample (m. *longissimus dorsi*) where excides (5th to 10th thoracic vertebra) from both the right and left side of carcasses and loin muscles samples (approximatively 500 g) were randomly assigned to three experimental storge methods (*n* = 10 per thesis): i. no frozen (NF); ii. frozen with no air blast (slow freezing, SF); iii. frozen with air blast (rapid freezing, RF). An experimental refrigerator was used in order to freeze beef samples by using air at −40 °C and the air flow was driven by a variable speed axial fan (air blast) that ensure an average air velocity up to 3 m/s for the RF thesis. Frozen samples were stored (at −28 °C) for 7 days and then thawed (4 °C) overnight. As fresh (NF, 5 + 2 d *post mortem*) or after the freezing-thawing process, the loin samples were analysed for drip loss, fat content, pH, colour (CIE-*L*a*b**), cooking losses and instrumental tenderness according to referenced methods [2]. Slices of 10 μm of thickness were removed parallel to the muscle fibre orientation and hematoxylin/eosin (H&E) stained for the evaluation of the structural aspects of muscle tissue. After assumption of normality and variance homogeneity, data were submitted to one-WAY ANOVA (PROC GLM of SAS) to test the fixed effect storage method. LSMeans were separated using the probability of difference option with a Bonferroni adjustment for multiple comparisons.

III. RESULTS AND DISCUSSION

The temperature decline rates of the centre of loin samples were almost different between the freezing methods since the −10 and −18 °C were recorded after an elapsed time of 448 and 552 min for the SF thesis, and 332 and 367 min for the RF one. Freezing process significantly increase the drip loss (steaks hung for 24 h) and pH when meat was exposed to air (1 h of blooming) as reported in Table 1. The storage method affected also the instrumental colour since frozen-thawed samples showed a significant ($P < 0.05$) lower value of lightness (*L**) and higher value of yellowness (*b**) likely due to a

large concentration of solutes (e.g., heme pigments) that contributed to a greater absorption of light, resulting in darker colour than unfrozen samples. The storage method significantly ($P < 0.05$) affected the instrumental tenderness, while cooking loss tended ($P < 0.10$) to differ among experimental theses. The tenderising effect of freezing/thawing is likely associated with loss of muscle structural integrity induced by ice crystal formation and fibre distortion and/or rupture but this positive effect on meat tenderness was not improved by the fast freezing process. As illustrated in Figure 1, indeed the freezing process induced a muscle myofibre contraction and more marked micro-breaks into the myofiber (white lines within the myofibers). The shrinkage of the myofibres led to an increase of the space from their perimysium (white spaces among myofibers) resulting in a significant reduction of the values of shear force likely due to this muscle filaments fragmentation and/or structural weakening.

Table 1 Effect of storage method (fresh vs frozen) on beef quality traits

Item	NF	SF	RF	SEM	P-value
Drip loss (%)	2.08^{b}	5.63^{a}	5.17^{a}	0.28	0.001
Intramuscular fat (%)	2.64	2.82	2.98	0.19	0.112
pH	5.53^{b}	5.65^{a}	5.62^{a}	0.03	0.002
*L**	38.2^{a}	36.1^{b}	36.6^{b}	0.58	0.045
*a**	18.8	19.6	19.8	0.42	0.091
*b**	7.68^{b}	9.73^{a}	9.31^{a}	0.39	0.002
Cooking loss (%)	31.2^{α}	28.8^{β}	29.9^{β}	0.72	0.062
Shear force (N)	46.3^{a}	40.9^{b}	38.9^{b}	2.10	0.017

NF, no-frozen (fresh sample); SF and RF, slow- and rapid-frozen (frozen-thawed samples). Treatments with different superscript letters within a row are different: $^{a\text{-}b}$: $P < 0.05$; $^{\alpha\text{-}\beta}$: $P < 0.10$.

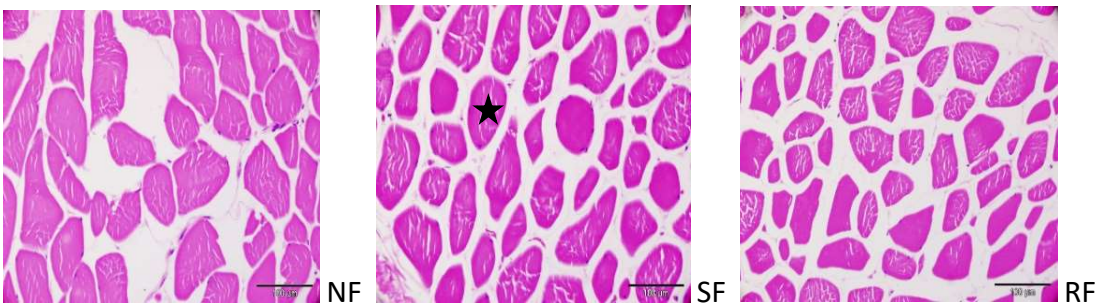

Figure 1. Histological hematoxylin/eosin staining of fresh (NF, no frozen) or frozen-thawed (SF, slow frozen; RF, rapid frozen) loin samples; scale bar refers to 10 μm, and the symbol * indicate a myofibre

IV. CONCLUSION

Freezing altered muscle structure making meat darker and tender. However, not noticeable differences were detected between the two freezing methods probably due to both the short ageing and limited frozen storage. These outcomes should be confirmed using similar freezing conditions in an operative scenario, which should be considered heavier muscle samples.

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