IMPACT OF PEF TREATMENT ON THE PROTEIN OXIDATIVE STABILITY OF WET AND DRY AGED VENISON

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I. INTRODUCTION

Application of Pulse Electric Field (PEF) treatment has shown in recent studies to improve mass transfer and drying kinetics leading to a reduction in processing time and enhanced control of weight loss in in dry aged venison [1]. PEF has also been shown to enhance meat quality attributes such as tenderness [1]. There is, however, limited knowledge on how PEF can impact oxidative stability of venison meat proteins. Recent research shows that PEF may trigger free radical generation via electrolysis of water leading to the release of highly reactive hydroxyl (OH^-), and H^+ ions which can form free radicals that can play a role in further electrochemical reactions [2]. The current study investigated the impact of applying PEF treatments (HPEF 10 kV, 50 Hz, 5 µs; and LPEF 2.5 kV, 50 Hz, 5 µs) on protein oxidative stability of wet and dry aged venison loins. To achieve these goals, total carbonyl content, Schiff bases (SB) and targeted analysis of protein oxidation biomarkers (γ-glutamic semialdehyde (GGS) and α-aminoadipic semi-aldehyde (AAS)) were used to establish the effect of PEF processing on the oxidative modification.

II. MATERIALS AND METHODS

Venison loins (*M. longissimus et lumborum*, LL) were obtained as reported by Mungure *et al*.[1] from 6 hinds raised on pasture with an average cold carcase weight of 98 ± 6.7 kg (processed at Lorneville Plant, Alliance Group, Invercargill, NZ). The left and right loins were excised at 24 h postmortem. Connective tissue and visible fat were removed from the loins that were then processed into blocks of 318 ± 11.6 g. The blocks were randomly allocated to wet-aged control (WAC), dry-aged control (DAC), wet-aged low PEF (WALPEF), dry-aged low PEF (DALPEF), wet-aged high PEF (WAHPEF) and dry-aged high PEF (DAHPEF). Total specific energy was approximately 1.93 kJ/kg for LPEF and 70.2 kJ/kg for HPEF. Samples were aged in a chiller at 4°C (air velocity 3 m/s and 80% RH) for 21 days.
Total carbonyl content was assessed following the 2, 4 dinitrophenylhydrazine (DNPH) coupling method as described by Lund *et al*. [3]. Synthesis and optimisation of AAS and GGS standard compounds, meat sample preparation and assessment of SB was as described by Utrera *et al*., [4]. Multi-way analysis of variance (MANOVA) was performed on collected data using R (Version 3.4.1; R Core Team, 2019) with the "lme4" package to determine the effect of PEF treatment and ageing method. Post hoc comparison of means was performed using Fisher's least significant differences (LSD) and Tukey's (HSD) test at the 5% significance level.

III. RESULTS AND DISCUSSION

No differences ($P > 0.05$) in total protein carbonyl content, AAS, GGS, and SB were found that resulted from PEF treatment (Table 1). The ageing method was found to have a significant effect across all

samples ($p < 0.05$), with higher total protein carbonyls, AAS, GGS and SB in the dry aged samples than the wet aged ones.

Table 1 Protein oxidation results for PEF treated wet and dry aged venison.

PEF	Ageing	Total carbonyl content (nmol/mg protein)	Schiff base structures (Fluorescence arbitrary unit/AU)	AAS (nmol/mg protein)	γ-glutamic semialdehyde (GGS) (nmol/mg protein)
Control	Wet (WAC)	1.51^{d}	419^{b}	0.33^{b}	0.14^{cd}
	Dry (DAC)	1.94^{ab}	655^{a}	0.42^{a}	0.20^{ab}
Low	Wet (WALPEF)	1.51^{d}	398^{b}	0.34^{b}	0.16^{cd}
	Dry (DALPEF)	2.03^{a}	722^{a}	0.45^{a}	0.24^{a}
High	Wet (WAHPEF)	1.66^{cd}	428^{b}	0.35^{b}	0.17^{c}
	Dry (DAHPEF)	1.97^{ab}	648^{a}	0.47^{a}	0.22^{ab}
	SEM	0.08	52.3	0.05	0.02
P values	PEF treatments	0.124	0.287	0.213	0.103
	Ageing method	0.000	0.000	0.001	0.001
	PEF*ageing method	0.042	0.093	0.014	0.045

PEF treatment interaction with ageing method increased accumulation of total carbonyl content and GGS ($p < 0.05$). PEF treatment in combination with dry ageing appears to have an increased rate of proteolysis and the resultant loss of meat structure may enhance mobility of iron from myoglobin and residual blood and facilitate the interaction between pro-oxidant and muscular proteins [5]. Increased cell rupture, changes in physiochemical properties due to HPEF and exposure to aerobic conditions most likely triggers formation of more protein acyl radicals leading to increased carbonyl products [5].

IV. CONCLUSION

PEF treatments (both LPEF and HPEF) do not directly influence oxidative modifications such as protein carbonylation, however, cell poration, particularly with the HPEF treatment, appears to increase the interactions of cellular contents with pro-oxidants encouraging more protein oxidation when coupled with dry ageing. The results are encouraging from an industrial application perspective, as the results obtained indicate that PEF treatments can be applied prior to both ageing methods to improve meat quality of venison. The amount of carbonylation generated with these ageing regimes is low compared to minimum acceptable thresholds in aged red meats.

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