# Effects of combining PEF treatment and drying conditions on conjugated linoleic acid and lipid oxidation of NZ venison

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## I. INTRODUCTION

Dry aging of red meat produces unique flavours and a high quality product [1]. Pulsed electric field (PEF) treatment can cause cell electroporation under specific conditions. Combining PEF and manipulation of relative humidity in a chilling space could potentially improve moisture diffusion and mass transfer, which can reduce the required dry aging time [2]. While these physical manipulations are desirable benefits, limited knowledge is available on their effects on the oxidative stability of lipids and bioactive conjugated linoleic acid (CLA). CLAs are a group of geometric and positional isomers of linoleic acid found in meat from ruminant animals, and have been reported to provide antidiabetic, anti-atherogenic and anticancerogenic effects [3]. This study investigated the oxidative changes in polyunsaturated fatty acids (PUFA), monounsaturated fatty acids (MUFA) in dry and wet aged venison. Nuclear magnetic resonance spectroscopy (NMR) was used to monitor the oxidative changes in the aliphatic to diallylmethylene proton ratios ($R_{ad}$), aliphatic to olefinic proton ratios ($R_{ao}$), and determine CLA concentrations (mg/g lipid).

## II. MATERIALS AND METHODS

Venison loins (*M. longissimus et lumborum*, LL) were obtained from 12 hinds of average cold carcase weight of 108 ± 9.8 kg over two slaughter days. The hinds were pasture raised and processed at Lorneville Plant (Alliance Group Invercargill, NZ). At 24 h post-mortem, the left and right loins were excised. Visible fat and connective tissue were removed; the loins were then processed into 318 ± 11.6 g blocks and treated as described by Khan et al. [4]. The loin blocks were randomly distributed 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 $kJ.kg^{-1}$ for LPEF (2.5kV, 50Hz and 20µs) and 70.2 $kJ.kg^{-1}$ for HPEF (7.5kV, 50Hz and 20µs). The first set of samples (n = 6) were dry aged in a chiller set at 65% RH and dry aged for 10 days before being vacuum packed and stored for a further 11 days. The set of samples (n = 6) was dry aged at 80% RH for 21 days at 4°C. Lipid extraction, NMR protocol for CLA ($mg.g^{-1}$ lipid) [4], aliphatic to olefinic, aliphatic to diallylmethylene proton ratios,], positional distribution and production of fatty acid methylesters were determined as described by Mungure et al [5]. The collected data was analyzed using one-way ANOVA and Tukey's honest significant difference among mean values determined at $P < 0.05$.

## III. RESULTS AND DISCUSSION

For both trials, DAHPEF treatments had significantly lower PUFA ($p < 0.05$) (Table 1). This is could potentially be due to the higher PEF treatment generating more free radicals, and coupled with the exposure to ambient flow during aging increasing lipid oxidation. This is supported by the significant increase in $R_{ad}$ ratio ($p < 0.05$) in both trials, showing decline in the methylenic protons in the α-position in relation to 2 or more double bonds of various acyl groups (i.e. the PUFAs). The MUFAs were not affected by PEF across 65% RH treatment ($p > 0.05$) compared to 80% RH. This could be attributed to the limited dry aging time for the 65% RH samples. Generally the PUFA/SFA, omega 3 fatty acids, and $R_{ad}$ ratios were affected by the ageing method ($p < 0.01$) but not with PEF treatment. CLAs were not affected by aging method, PEF and RH ($p>0.05$). CLAs are more

stable compared to other PUFAs. The results suggest that CLA does not follow the same oxidative pathway as other PUFAs

Table 1. The variations in fatty acids profile, unsaturation levels and CLA concentrations for wet vs dry aged venison at two different RH

| Treatment | | Fatty acids | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PEF | Ageing | SFA (%FA) | MUFA (%FA) | PUFA (%FA) | PUFA/SFA ratio | Omega-3 FA | Omega-6FA | n-6/n-3 ratio | Rao | Rad | CLA (mg/g lipid) |
| 80%RH | | | | | | | | | | | |
| Control | Wet | 46.78b | 27.82bc | 25.39ab | 0.54a | 11.54a | 13.86a | 1.20bc | 22.31a | 36.24b | 3.32 |
| | Dry | 48.61ab | 29.38ab | 22.01cd | 0.45bc | 9.12b | 12.89ab | 1.42abc | 24.39a | 52.92a | 3.75 |
| Low | Wet | 46.83b | 28.61abc | 24.52ab | 0.53a | 11.33a | 13.53ab | 1.20bc | 21.32a | 36.38b | 2.72 |
| | Dry | 47.68b | 30.19a | 22.15cd | 0.46bc | 9.49b | 12.66ab | 1.35abc | 26.05a | 56.58a | 3.20 |
| High | wet | 47.32b | 28.92abc | 23.74b | 0.50ab | 11.39a | 12.36ab | 1.09c | 22.45a | 35.98b | 3.13 |
| | dry | 49.75a | 29.43ab | *20.81d* | 0.42c | 8.30b | 12.17b | 1.47ab | 26.43a | 62.91a | 3.40 |
| | SEM | 0.43 | 0.39 | 0.38 | 0.01 | 0.30 | 0.35 | 0.07 | 1.20 | 2.45 | 0.26 |
| 65%RH | | | | | | | | | | | |
| Control | Wet | 51.29 | 34.23a | 14.47a | 0.28ab | 7.38ab | 7.08a | 0.96b | 22.81a | 39.12bc | 2.51 |
| | Dry | 52.89 | 34.99a | 12.11b | 0.23c | 5.69c | 6.21bc | 1.09ab | 24.99a | 47.25a | 2.93 |
| Low | Wet | 50.53 | 34.84a | 14.58a | 0.29a | 7.57a | 7.01ab | 0.93b | 22.72a | 34.62c | 2.74 |
| | Dry | 53.65 | 34.08a | 12.26b | 0.23c | 5.64c | 6.62abc | 1.17a | 25.25a | 45.38ab | 3.02 |
| High | wet | 51.59 | 35.42a | 12.99b | 0.25bc | 6.71b | 6.28abc | 0.94b | 23.49a | 36.28c | 2.82 |
| | dry | 54.81 | 34.45a | *10.74c* | 0.20d | 4.80d | 5.94c | 1.25a | 25.15a | 50.27a | 3.16 |
| | SEM | 0.57 | 0.55 | 0.30 | 0.01 | 0.18 | 0.19 | 0.04 | 1.27 | 1.75 | 0.34 |

[abc] Figures with different letter in a column are significant different (at $p < 0.05$)

## IV. CONCLUSION

The dry aging regime at 65% RH reduced the oxidative changes and reduced ageing time. Both RH treatment and ageing type did not have an effect on the stability of CLAs.

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