71st ICoMST
GIRONA - CATALONIA - SPAIN
3rd-8th August - 2025

TAILORING DRY-AGEING AND COOKING TO ENHANCE TECHNOLOGICAL QUALITY AND VOLATILE FINGERPRINTS IN BEEF STRIPLOIN

Renyu Zhang[1*], Santanu Deb-choudhury[1], Noby Jacob[1], Arvind K. Subbaraj[1], Charles Hefer[1], Marie-Pierre Ellies-Oury[1,2,4], Thierry Astruc[3], Carolina E. Realini[1]

[1]AgResearch Ltd, New Zealand; [2]INRAE, UMR Herbivores, Saint-Genès Champanelle, France; [3]INRAE, UR QuaPA, Saint-Genès-Champanelle, France; [4] Bordeaux Sciences Agro, Gradignan, France

*Corresponding author email: renyu.zhang@agresearch.co.nz

I. INTRODUCTION

Dry-aged beef is valued for its unique eating quality and flavour, but high processing costs and low yields limit industry adoption and consumer accessibility. Alternative strategies like in-bag dry-ageing (BD) and stepwise ageing (SA) were reported to offer similar meat quality with higher yields at lower costs [1]. While cooking significantly influences meat eating quality and flavour, it is unclear whether tailored cooking strategies can enhance the quality and flavour of unaged (U) or stepwise aged beef with shorter dry-ageing periods to resemble traditional long-term dry-aged beef. This study aims to investigate the synergistic effects of ageing and cooking strategies on the technological quality and volatile fingerprints of beef striploin.

II. MATERIALS AND METHODS

Eight striploins (*M. longissimus lumborum*) were collected at 24 h post-mortem from Angus crossbred heifers and steers (n=4 per sex). High-pH beef was excluded. Striploins were halved and randomly assigned to BD (Tublin10®) for 28 days or SA (wet-ageing for 14 days followed by BD for 14 days) at 2 °C and 75% RH. Meat section weights were recorded to calculate ageing losses. Subsamples were taken before (U) and after ageing (BD & SA) for lipid oxidation (TBARS assay), fatty acids (FA) profile and intramuscular fat (IMF) content via direct trans-methylation as described by Zhang [2]. Major FA groups were expressed as g/100 g meat and % of total FA.

Two steaks from U, BD, and SA were cooked using: (1) SV: *sous-vide* at 49 °C for 1 h followed by pan-fry at 200 °C, flipping every 30 s until reaching a 59 °C core temperature; (2) O: wrapped in cooking paper and oven precooked at 49 °C for 24 h, then pan-fry as above. Volatile fingerprints produced from cooking were captured using an SPME cartridge (IonSense® PDMS/DVB SPE-it, Sigma) at two points: (a) after precooking and opening the vacuum packaging or wrapping; (b) after the first pan-fry flip. The SPME tip was placed over the steak (no direct contact) for 15 s and then stored in an air-tight tube for Direct Analysis in Real Time – Mass Spectrometry (DART-MS) analysis [3]. Cooking losses were recorded, and cooked steaks were cooled down in ice slurry and stored at 4 °C for shear force testing the next day. Data was analysed using R software (version 4.4.1). Volatile fingerprints from DART-MS were assessed using PLS-DA models. ANOVA and Tukey's honest significant difference ($P<0.05$) were used to determine any effects and interactions between sex, ageing treatments, and cooking methods.

III. RESULTS AND DISCUSSION

No sex effects or interactions with ageing and cooking ($P>0.05$) were observed for technological quality. BD for 28 days resulted in higher ageing loss (22.7% vs. 17.2%) and lower moisture content (65.5% vs. 67.4%) than SA ($P<0.001$). BD and SA increased IMF and major FA content (g/100g meat) in beef ($P<0.05$, Table 1) compared to U, which may be partially driven by dehydration, as indicated by similar proportions of straight-chain saturated FA and monounsaturated FA (% of total FA) across samples. Aged beef, especially those from BD, showed lower polyunsaturated FA, n-3 and n-6 FA and higher branch-chained saturated FA compositions, likely due to lipid oxidation, as evidenced by elevated TBARS. Significant interactions between ageing and cooking methods ($P < 0.01$) were observed in the analysis of shear force and cook loss (Table 2). Both BD and SA improved tenderness to the same extent and reduced cook losses compared to U. Low-temperature oven precooking tenderised unaged steaks to the levels comparable to aged counterparts but increased cook losses across all beef steaks. BD exhibited the lowest cook loss which is likely due to its higher ageing losses.

DART-MS detected 1037 mass features (*m/z*), with 134 mass features (present in ≥6 samples) used for multivariate analysis (Figure 1). Interactions between sex, ageing, and cooking were observed. Volatile fingerprints differed between BD and SA for both cooking methods, likely due to variations in flavour precursors formed during ageing.

Cooking effects were evident in steaks from BD and U regardless of sex, but only in heifers for SA. Low-temperature oven precooking of U steaks produced volatile fingerprints close to BD, suggesting its potential to mimic dry-ageing flavour while improving yields (80.2% vs. 64.5%). This effect was absent for SA, though SA-SV produced volatile fingerprints similar to BD-O in heifers but not in steers.

Table 1. Fatty acids profile, intramuscular fat, and TBARS of raw beef striploin after different ageing treatments.

	U	BD	SA	P-Ageing	U	BD	SA	P-Ageing
	g/100 g meat				% of total FA			
Branched-chain Saturated FA	0.07^{b}	0.13^{a}	0.12^{a}	**	1.54^{b}	1.73^{a}	1.71^{a}	**
Straight-chain Saturated FA	2.13^{b}	3.62^{a}	3.48^{a}	**	47.25	48.60	48.34	ns
Monounsaturated FA	2.08^{b}	3.44^{a}	3.30^{a}	**	46.45	45.99	45.93	ns
Polyunsaturated FA	0.19^{b}	0.27^{a}	0.26^{a}	**	4.75^{a}	3.68^{b}	4.02^{ab}	*
n-3 FA	0.08^{b}	0.11^{a}	0.10^{a}	***	1.93^{a}	1.46^{b}	1.61^{ab}	*
n-6 FA	0.09^{b}	0.13^{a}	0.12^{a}	***	2.37^{a}	1.73^{b}	1.90^{b}	*
IMF (%)	4.91^{b}	8.18^{a}	7.84^{a}	*				
TBARS (mg MDA/kg dry matter)	1.22^{b}	1.47^{a}	1.48^{a}	**				

Levels of significance: * means <0.05; ** means <0.01; *** means <0.001. ns = not significant. No sex effect was observed. FA = fatty acids, IMF = intramuscular fat, U = unaged, BD = in-bag dry-ageing, SA = stepwise ageing.

Table 2. Shear force and cook loss of beef striploin after different ageing treatments and cooking methods.

	U		BD		SA		P-Ageing	P-Cooking	P-Ageing × Cooking
	SV	O	SV	O	SV	O			
Shear force (N)	34.98^{a}	25.70^{b}	24.03^{bc}	23.92^{bc}	22.04^{bc}	20.19^{c}	***	**	**
Cook loss (%)	14.46^{d}	25.08^{a}	7.83^{f}	15.81^{c}	9.95^{e}	18.81^{b}	***	***	**

Levels of significance: ** means <0.01; *** means <0.001. No sex effect was observed. U = unaged, BD = in-bag dry-ageing, SA = stepwise ageing; SV = *sous-vide* precooking + pan-fry, O = oven precooking + pan-fry.

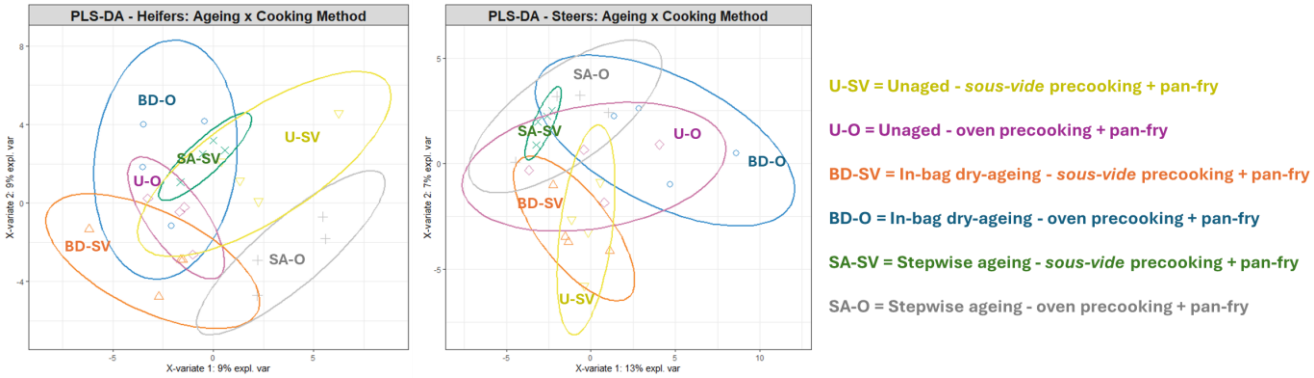


Figure 1. PLS-DA score plots of volatile fingerprints (DART-MS) in beef loin steaks (grouped by sex) after different ageing treatments and cooking methods.

IV. CONCLUSION

BD and SA had similar effects on beef tenderness, lipid composition, and lipid oxidation but differed in volatile fingerprints, with SA retaining lower ageing losses. Low-temperature oven precooking showed the potential to mimic the tenderness and flavour of dry-aged beef in unaged steaks while improving yields.

ACKNOWLEDGEMENTS

This research was part of the International Associated Laboratory - RUMQUAL project (Real time assessment and modelling of meat QUAlity from RUMinants) co-funded by INRAE and BSA in France and AgResearch in New Zealand (A28948).

REFERENCES

1. Zhang, R.; Yoo, M. J. Y.; Ross, A. B.; Farouk, M. M. (2022). Mechanisms and strategies to tailor dry-aged meat flavour. Trends in Food Science & Technology 119: 400-411.
2. Zhang, R.; Jacob, N.; Agnew, M.P.; Farouk, M.M.; Realini, C.E. (2025). Dry-ageing impacts on meat quality, oxidative stability, and release of free amino acids in striploins from dairy crossbred yearling and 2-year-old steers. Meat Science 219: 109674.
3. Subbaraj, A.K.; Deb-choudhury, S.; Pavan, E.; Realini, C.E. (2023). Volatile fingerprints of beef cooking methods using sol–gel-based solid-phase microextraction (SPME) and direct analysis in real-time mass spectrometry (DART-MS). Rapid Communications in Mass Spectrometry 38: e9655.