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IMPACTS OF DRY-AGING METHODS ON BISON MEAT QUALITY AND FLAVOR CHARACTERISTICS WITH METABOLOMICS PROFILING

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I. INTRODUCTION

Bison meat products have garnered consumer interest as healthier, leaner alternatives to traditional beef [1]. However, consumption remains limited due to inferior flavor and inconsistent tenderness, highlighting the need for post-harvest processing strategies to improve the quality and value of bison meat. Dry-aging has been considered a natural, value-adding process because of its ability to develop a unique flavor profile [2]. Nevertheless, little to no published information is available on the effects of different dry-aging methods on the quality and sensory characteristics of bison loins. Furthermore, no research has been conducted to determine underlying mechanism by which flavor-related chemical compounds are naturally liberated through different postmortem aging techniques in bison meat products. Therefore, the objective of this study was to evaluate the effects of different dry-aging methods on the quality attributes and flavor characteristics of bison loins through a metabolomic approach.

II. MATERIALS AND METHODS

At 7 days postmortem, pairs of bone-in loins (*M. Longissimus lumborum*) from 15 grass-fed bison carcasses were collected. Each pair of loins was split in half as four sections and each section was randomly assigned to one of four aging treatments: wet-aging (WA), dry-aging (DA), dry-aging with ultraviolet light exposure (UDA), and dry-aging using a moisture-permeable bag (Umai dry aging bags, Umai, USA, DWA). All treatments were aged for 28 days under controlled environmental conditions (1–2 °C, 65% relative humidity, and 0.8 m/s air flow). Upon aging, the sections were deboned, trimmed, and weighed to determine the final saleable yield. The samples were further fabricated and sliced into steaks for subsequent analyses: pH, Warner–Bratzler shear force (WBSF), myofibrillar fragmentation index (MFI), initial color (CIE *L*a*b**), microbial attributes (yeast, mold, total bacteria count, and lactic acid bacteria), and metabolomics analysis (UPLC-MS). Consumer (n=90) and trained panel (n=7) sensory evaluations were also performed. The experimental design followed a balanced randomized complete block design, and data were analyzed using the PROC GLIMMIX procedure in SAS 9.3, with significance of $P<0.05$. Sparse partial least squares discriminant analysis (sPLS-DA) was performed on metabolites (Metaboanalyst 6.0).

III. RESULTS AND DISCUSSION

Dry-aging significantly decreased saleable yields compared to WA due to its higher shrink/purge loss and trim loss. Among dry-aging treatments, however, DWA had a significantly lower shrink loss compared to DA and UDA. No significant differences in pH, WBSF, and MFI were observed between treatments. Bison loins from dry-aging treatments had significantly lower microbial loads, including yeast, mold, total bacteria count, and lactic acid bacteria, compared to the loins from wet-aged counterparts. WA steaks had slightly higher lightness (L*) and redness (a*) values compared the dry-aged counterparts ($P<0.05$). The consumer panel responded that DWA and UDA had significantly higher flavor liking compared to WA. There were no differences in tenderness, juiciness, and overall liking between treatments ($P>0.05$). The trained panel evaluated DWA and UDA significantly higher than beef in juiciness and lower in green, hay-like flavor, suggesting an enhancement in organoleptic quality. Notably, UDA showed significantly higher scores in brown-roasted flavor compared to WA, as well as higher umami scores compared to beef. A total of 3212 metabolites were detected through the UPLC-ESI-MS metabolomics analysis. The sPLS-DA analysis revealed distinct clustering of metabolites between dry-aged and wet-aged treatments, and among dry-aged samples, features from DWA were clearly separated from those of DA and UDA (Fig 1.). Although further identification of metabolite features is ongoing, dry-aged samples exhibited a higher relative abundance of compounds potentially related to flavor, including multiple glutamine containing dipeptides, inosine-5'-monophosphate, aspartate, and carnitine compared to WA ($P<0.05$).

Table 1. Consumer panel sensory evaluation of bison loins with various dry-aging methods.

Trait	WA	DA	DWA	UDA	SEM	P-value
Flavor	67.29[b]	74.44[ab]	74.88[a]	75.09[a]	2.08	0.021
Tenderness	78.94	82.47	81.54	82.09	1.76	0.489
Juiciness	73.11	77.39	77.68	78.08	1.84	0.194
Overall	72.00	77.34	77.80	77.64	1.94	0.103

[a,b]Means within same row with different superscript letters differ significantly ($P < 0.05$). SEM, standard error of mean. 100-point scale was used for all traits. WA, wet-aged; DA, dry-aged; UDA, dry-aged under UV light; DWA, dry-aged in a wet permeable bag.

Table 2. Trained panel sensory evaluation of the bison loins with various dry-aging methods.

Trait	Beef	WA	DA	DWA	UDA	SEM	P-value
Brown, roasted	8.89[ab]	8.47[b]	8.84[ab]	8.81[ab]	9.26[a]	0.437	0.017
Beef identity	8.76	8.60	8.85	8.82	8.84	0.451	0.700
Bloody	6.73	6.74	6.59	6.29	6.24	0.529	0.082
Umami	6.64[b]	6.75[ab]	7.17[ab]	7.20[ab]	7.45[a]	0.362	0.008
Green, Hay	3.46[a]	3.20[a]	3.07[a]	2.75[b]	2.54[b]	0.374	0.004
Tenderness	10.77[b]	11.57[a]	11.75[a]	11.69[a]	11.93[a]	0.363	<0.001
Juiciness	8.80[b]	9.53[a]	9.50[ab]	9.58[a]	9.51[a]	0.394	0.013

[a,b]Means within same row with different superscript letters differ significantly ($P < 0.05$). SEM, standard error of mean. 15-point scale was used to all traits. Beef, grass-fed beef; WA, wet-aged bison; DA, dry-aged bison; UDA, dry-aged bison under UV light; DWA, dry-aged bison in a wet permeable bag.

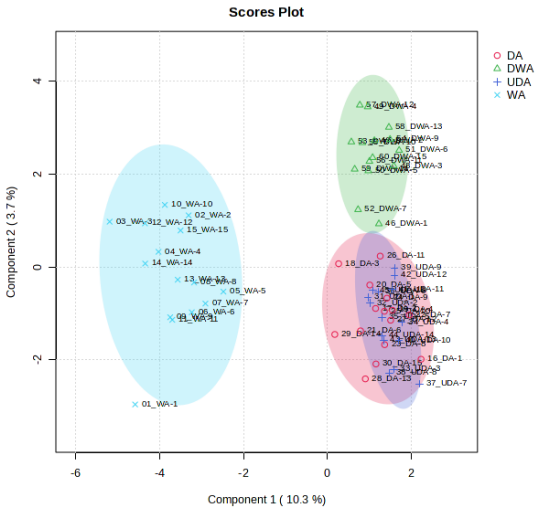


Figure 1. Sparse partial least squares discriminant analysis (sPLS-DA) of metabolites from bison loin with various dry-aging methods. WA, wet-aged; DA, dry-aged; UDA, dry-aged under UV light; DWA, dry-aged in a wet permeable bag.

IV. CONCLUSION

The results from the present study demonstrated that dry-aging, particularly DWA and UDA, improved the flavor attributes of bison loins compared to conventional wet-aging. Specifically, the trained panel found that DWA and UDA effectively reduced off-flavor attributes commonly associated with grass-fed bison loins, such as green-hay flavor, while enhancing brown-roasted and umami flavors. The discriminant analysis from multivariate analysis indicated distinct metabolite profiles associated with different aging methods, suggesting varied contributions to flavor development during dry-aging. Further research is ongoing to identify key metabolite features linked to dry-aged flavor and taste by correlating those metabolites, volatile chemical compounds, and sensory evaluation results.

ACKNOWLEDGEMENTS

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