IN-THE BAG DRY AGEING AS A STRATEGY TO PRODUCE VALUE-ADDED BEEF WITH ENHANCED FLAVOUR PROFILES

N. Prieto*, R. Singh, B. Schmidt, R. Thacker, I.L. Larsen and J.L. Aalhus

Lacombe Research and Development Centre, Agriculture Agri-Food Canada, Lacombe, AB, Canada T4L1W1

*Corresponding author e-mail: nuria.prietobenavides@agr.gc.ca

Abstract – This study evaluated the eating quality of in-the bag dry aged *longissimus lumborum* (LL) from cows and steers. Ten LL from cows and steers were cut in half and randomly wet and dry aged, using conventional and dry-age specifically manufactured plastic bags, respectively. The LL sections were vacuum-packed and aged at 2°C for 28 d. The LL segments were then removed from packaging, and weighed to determine purge losses. Six 2.5 cm steaks were removed from each segment for subsequent cooking loss, shear force, descriptive panel, flavour profile and flavour chemistry analyses. Purge loss, initial juiciness, livery aroma and sweet taste were affected by an animal×ageing interaction ($P<0.05$). Dry ageing decreased livery aroma ($P<0.0001$) in steers, and increased salty taste ($P<0.05$) and perception of amount of connective tissue ($P<0.05$) as well as decreased cooking loss ($P<0.0001$) in both steers and cows. Dry ageing increased the concentration of several volatile compounds ($P<0.05$) associated with positive aromatic descriptors in cows, although they were not reflected in significant differences in flavours detected by the panelists. Dry ageing might be a successful strategy to decrease the undesirable livery aroma in susceptible muscles from steers. Further studies are required with longer dry ageing periods for cows that might enhance those flavour compounds sufficiently to be detected by the panelists.

Key Words – beef, dry ageing, flavour, volatile compounds

I. INTRODUCTION

In the last years, beef prices in Canada have been at historically high levels, which have turned away some consumers. Indeed, per capita beef consumption dropped in Canada by 25 per cent from 2003 to 2015 [1]; the price of meat being the biggest deciding factor for people in grocery stores. The hefty prices for beef, especially for primal cuts such us striploin and tenderloin, have more and more consumers looking for sources of protein in other cuts of beef or meat from other less expensive species. However, at the same time, consumers increasingly want meat that is tasty and demand more value-added products with enhanced flavour profiles.

In a previous survey of Canadian cow quality, flavour was identified as a superior characteristic compared to youthful beef but cow meat is priced on average 25% lower for dressed weight carcasses. In other countries such as Spain, steaks from cull cows or oxen are considered exquisite and served at gourmet restaurants for a premium. Premiums are paid because carcasses have been aged in dry conditions, which enhance flavour profiles as well as improve tenderness and overall acceptance of beef. Dry ageing is a process used to produce uniquely flavoured, value added beef. Wet-aged beef has a sour and strong bloody/serumy flavour, whereas dry-aged beef has a beefy, brown roasted flavour that is considered desirable. Several studies indicate that many consumers are more familiar with wet- than dry-aged flavours, but when consumers recognized or preferred the dry-aged flavour profile, they were willing to pay more for this product. In Australia, for instance, there appears to be increased interest in dry ageing, especially for the high quality restaurant market where premium cuts from grain-fed cattle of the Angus and Wagyu breeds are often used.

Traditionally, dry ageing has been done without packaging, which places more emphasis on plant quality control practices to achieve a consistent product. This limits the number of processors that have the ability to produce dry-aged product. Packaging bags designated for dry ageing (Umai®), however, are approved by the Canadian Food Inspection Agency (CFIA) and have a very high water vapor transmission rate that may simulate traditional dry ageing. Therefore, the use of these dry ageing bags will allow the plants/meat packers to dry age meat in coolers at conventional temperature and humidity, without having to adapt the conditions of the plant. Overall, an in-the bag dry ageing system would require fewer controls and still result in decreased weight losses, which would provide a significant yield advantage. The aim of this study was to evaluate the eating quality of in-the bag dry aged *longissimus lumborum* (LL) from cows and steers.

II. MATERIALS AND METHODS

A. Sample collection and treatment

At 72 h post mortem, ten LL from cull cows and steers were cut in half and randomly wet and dry aged, using conventional (Winpak Vak 3.0 R) and dry-age specifically manufactured (Umai®) plastic bags, respectively. After vacuum packing, LL sections were placed in a 2 °C cooler with controlled wind speeds of 0.5 m/sec and humidity of 80%. At 28 d of ageing, the LL segments were removed from their respective packaging, and weighed to determine purge losses. Afterwards, six individual 2.5 cm steaks were removed from the pre-cut edge of the muscle: the first two steaks were assigned to flavour profile panel, the next two to descriptive panel, the fifth to flavour chemistry analysis and the sixth to Warner-Bratzler shear force. Steaks for sensory analyses and flavour chemistry were vacuum packaged in conventional bags and frozen at -35°C until analyses.

B. Meat quality

Prior to cooking, raw steak weights were recorded. Cooking was conducted on a grill preheated to 210 °C to a final endpoint temperature of 71 °C using the same procedure as described in Juárez et al. [2]. Immediately after cooking, steaks were placed into polyethylene bags, sealed and placed in an ice-water bath to prevent further cooking. Steaks were then placed in a 2 °C cooler for 24 h. Final steak weights were recorded and six 1.9 cm diameter cores were removed parallel to the fiber grain. Core peak shear force was determined perpendicular to the fiber grain (TA-XT Plus Texture Analyzer equipped with a Warner-Bratzler shear head at a crosshead speed of 200 mm. min^{-1} and a 30 kg load cell using Texture Exponent 32 Software; Texture Technologies Corp., Hamilton, MA). Shear force was calculated as the average peak force of all six cores. Raw and final steak weights were used to determine cooking loss.

C. Sensory analyses

Upon thawing at 4 °C for 24 h, steaks were cooked to a final temperature of 71 °C [2]. After cooling for 5 min, each steak was sub-sampled by cutting 1.3 × 1.3 × 1.3 cm cubes avoiding excessive fat or connective tissue. The temperature of the cubes was equilibrated by placing them in covered glass containers and then into a circulating water bath (68 °C). Samples were presented to an eight-member trained sensory panel in a balanced design, and attribute ratings were collected electronically using Compusense 5 Software, version 4.6 (Compusense Inc., Guelph, ON, Canada). For descriptive sensory analyses, 6 steaks were evaluated per session for initial and overall tenderness, initial and sustained juiciness, beef flavour and off-flavour intensity, and amount of connective tissue using nine-point descriptive scales, as follows: 9 = extremely tender, extremely juicy, extremely intense beef flavour, extremely bland off-flavour, and none connective tissue; 1 = extremely tough, extremely dry, extremely bland beef flavour, extremely intense off-flavour, and extremely abundant connective tissue. For flavour profile analysis, 3 steaks were evaluated per session using a 15 cm line scale with standard reference points for detected aromas, tastes and flavours, according to flavour lexicon described by American Meat Science Association [3]. Panelists conducted their evaluations in well-ventilated, partitioned booths, with 180 lux green lighting. A palate cleanser of distilled water and unsalted soda crackers was provided between samples to avoid residual flavour notes [4].

D. Flavour chemistry analyses

Upon thawing at 4 °C for 24 h, steaks were cooked to a final temperature of 71 °C [2]. Stir bar Sorptive Extraction (SBSE) coupled with thermal desorption-gas chromatography-mass spectrometry (TD-GC-MS) was used for identification and quantification of volatile flavour compounds in grilled beef samples as described in Ruan et al. [5].

E. Statistical analyses

The effect of animal and ageing method on meat quality and sensory characteristics as well as volatile flavour compounds was determined by two-way analysis of variance (ANOVA) using the MIXED procedure in the Statistical Analysis Software (SAS) system (Version 9.2, SAS Institute Inc., Cary, NC). Animal and ageing method were used as main effects, and trained panelist and replicate as random effects. A two-way interaction term was included in the model. Least square means differences were identified as significant at $P < 0.05$ using the PDIFF option in SAS [6].

III. RESULTS AND DISCUSSION

Purge loss was affected by an animal×ageing interaction ($P = 0.004$) (Table 1). Purge loss was not different between cows and steers for dry samples but was significantly lower for wet cow than wet steer. Cooking loss was only influenced by ageing method, with wet having more ($P < 0.0001$) cooking loss than dry.

Table 1 Effects of animal and ageing process on meat quality and sensory characteristics

	Cow		Steer			*P*-value		
	Dry	Wet	Dry	Wet	SEM	Animal	Ageing	Animal*Ageing
Meat quality								
Purge loss (%)	27.27^{a}	2.30^{c}	25.68^{a}	4.61^{b}	0.63	0.5737	<0.0001	0.0040
Cooking loss ($mg.g^{-1}$)	143.43	244.21	138.92	225.49	15.83	0.4679	<0.0001	0.6563
Shear force (kg)	5.59	5.89	4.53	4.09	0.29	<0.0001	0.8138	0.2085
Descriptive sensory panel								
Initial Tenderness	4.50	4.49	6.74	6.34	0.29	<0.0001	0.2372	0.0833
Initial Juiciness	4.83^{c}	5.13^{ab}	5.41^{a}	5.10^{bc}	0.24	0.0620	0.9403	0.0037
Beef Flavour Intensity	5.37	5.35	5.95	5.76	0.25	0.0609	0.4658	0.2471
Off-Flavour Intensity	6.73	6.81	7.06	7.58	0.43	0.0755	0.1079	0.1005
Amount of Connective Tissue	6.87	6.47	8.22	8.19	0.32	<0.0001	0.0452	0.0821
Overall Tenderness	5.08	4.89	6.79	6.59	0.28	0.0004	0.1511	0.9135
Sustainable Juiciness	5.04	5.06	5.39	5.21	0.23	0.0005	0.4194	0.1791
Flavour profile								
Aroma-Livery	2.50^{b}	2.50^{b}	1.10^{c}	3.00^{a}	0.37	<0.0001	<0.0001	<0.0001
Taste-Salty	3.00	2.66	3.29	2.91	0.20	0.1083	0.0258	0.8589
Taste-Sweet	2.17^{c}	2.34^{b}	2.58^{a}	2.16^{c}	0.14	0.4432	0.3774	0.0382
Taste-Umami	2.76	2.51	2.77	2.84	0.27	0.0354	0.3868	0.0513
Flavour-Beef	4.39	4.42	4.85	4.72	0.54	0.0272	0.6906	0.3088
Flavour-Brown-Roasted	3.53	3.18	4.10	3.63	0.48	0.0085	0.0942	0.6493

SEM: standard error of mean.

Shear force and descriptive sensory attributes such as initial and overall tenderness, and sustained juiciness were only influenced by animal, with steer having less shear force ($P < 0.001$) and higher scores for those sensory attributes ($P < 0.001$) than cows. Initial juiciness was affected by an animal×ageing interaction ($P = 0.0037$), with the greatest initial juiciness found in dry steers, lowest in dry cows, and intermediate for wet cows and steers. The amount of connective tissue perceived by the panelists was affected by both animal and ageing method, with steers having more than cows ($P < 0.001$) and dry having slightly more than wet ($P = 0.0452$).

During the flavour profile, 5 tastes and 19 aromas and flavours were evaluated by the panelists, but only those being statistically different due to main effects or interactions are shown in Table 1. The umami taste and beef and brown-roasted flavours were only affected by animal ($P < 0.05$), with steers having higher scores than cows; whereas salty taste was only affected by ageing, with dry being more salty than wet. Sweet taste was affected by an animal×ageing interaction ($P = 0.0382$), with the greatest sweet taste found in dry steer, lowest in wet steers and dry cows, and intermediate in wet cows. Livery aroma was also affected by an animal×ageing interaction (P < 0.0001), with the greatest livery aroma found in wet steer, lowest in dry steer, and intermediate in both dry and wet cows.

From flavour chemistry analyses, a total of 95 flavour compounds were identified, including hydrocarbons, aldehydes, alcohols, ketones, pyrazines, nitrogen- and sulfur-containing compounds (data not shown). Greater concentrations of 3-Nonanone (P < 0.01) and 5-Methyl-2-phenyl-2-hexenal (P < 0.05) were found in dry steers. These volatile compounds are associated with aroma descriptors such as cheese, green, fruity and chocolate [7], and could have contributed to the highest sweet taste found in the dry aged steers. As previously indicated, dry ageing decreased the livery aroma in steers; the Dihydro-5-pentyl-2(3H)-furanone volatile compound, associated with an herbaceous aroma descriptor [6], was highly correlated to the highest livery aroma found in the wet aged steers. Yancey et al. [8] found an intense livery flavour in different cuts of steers; therefore, dry ageing might be a successful strategy to decrease that undesirable flavour in steers. In cows, dry ageing significantly increased the concentrations of several volatile compounds (P < 0.05) that are associated with waxy, green, citrus, orange, mushroom, earthy, meaty, cheesy, banana, fruity, dairy and buttery aromas [7]. Nevertheless, the highest content of these volatile compounds in dry cows was not reflected in significant differences in flavours detected by the panelists, probably due to the relatively short period that cows were aged in this study.

IV. CONCLUSION

In-the bag dry ageing could be a strategy to produce value-added beef with enhanced flavour profiles. Further studies are required with longer dry ageing periods for cows that might enhance the volatile flavour compounds sufficiently to be detected by the panelists. Additionally, further investigation of dry ageing in low value cuts of steers to decrease their livery aroma and enhance their positive flavour profiles, may lead to increased economic value.

ACKNOWLEDGEMENTS

Dr. Singh thanks AAFC Science and Technology Branch A-base funding for her funding support.

REFERENCES

1. Canfax. (2015). Annual Reports. Retrieved from: http://www.canfax.ca/Main.aspx [Accessed: March. 09, 2017].
2. Juárez, M., Caine, W. R., Larsen, I. L., Robertson, W. M., Dugan, M. E. & Aalhus, J. L. (2009). Enhancing pork loin quality attributes through genotype, chilling method and ageing time. Meat Science 83: 447-453.
3. AMSA (2016). Research Guidelines for Cookery, Sensory Evaluation, and Instrumental Tenderness Measurements of Meat. Chicago, IL: American Meat Science Association.
4. Larmond, E. (1977). Laboratory methods for sensory evaluation of food. Ottawa: Agriculture Canada, Research Branch.
5. Ruan, E. D., Aalhus, J. L., Juarez, M. & Sabik, H. (2015). Analysis of volatile and flavor compounds in grilled lean beef by stir bar sorptive extraction and thermal desorption-gas chromatography Mass Spectrometry. Food Analytical Methods 8: 363-370.
6. SAS (2009). SAS user's guide: Statistics. SAS for windows. Release 9.2. Cary NC: SAS Institute Inc.
7. Sigma-Aldrich (2014). Flavours & Fragrances Catalog. SAFC Supply Solutions TM, Sigma-Aldrich Co. LLC.
8. Yancey, E. J., Dikeman, M. E., Hachmeister, K. A., Chambers IV, E., Milliken, G. A. & Dressler, E. (2003). Factors causing livery flavor in beef steaks from the chuck and loin. Cattlemen’s Day 2003.