Meat Science 111 (2016) 168–176

Contents lists available at ScienceDirect

Meat Science

journal homepage: www.elsevier.com/locate/meatsci

Effects of dry-aging on meat quality attributes and metabolite profiles of beef loins

Yuan H. Brad Kim [a,c], Robert Kemp [a], Linda M. Samuelsson [b,*]

[a] AgResearch Ltd., Ruakura Research Centre, Bisley Road, Private Bag 3123, Hamilton 3240, New Zealand
[b] AgResearch Ltd., Grasslands Research Centre, Tennent Drive, Private Bag 11008, Palmerston North 4412, New Zealand
[c] Meat Science and Muscle Biology Laboratory, Department of Animal Sciences, Purdue University, West Lafayette, IN 47907, USA

ARTICLE INFO

Article history:
Received 6 May 2015
Received in revised form 10 August 2015
Accepted 23 September 2015
Available online 26 September 2015

Keywords:
Beef
Dry-aging
Meat quality
Flavour
Metabolite
NMR

ABSTRACT

The objectives of this study were to evaluate different dry-aging regimes and their impacts on quality attributes and metabolite profiles of beef loins. Thirty loins (*M. longissimus lumborum*) from 15 beef carcasses at 2 days post-mortem were obtained. Each loin was cut in half yielding 60 sections, which were randomly assigned to six treatments including 4 dry-aging (2 temperatures (1 or 3 °C) × 2 air-velocities (0.2 or 0.5 m/s)) and 2 wet-aging regimes for 3 weeks; n = 10/treatment. The sensory panel found that dry-aged loins had better flavour and overall liking ($P < 0.05$), but there were no differences in tenderness and juiciness. No differences in drip/cook-loss and colour were observed. Metabolite analysis showed that 7 metabolites, including several flavour precursors, were more abundant in the dry-aged beef compared to the wet-aged beef, which may contribute to the enhanced flavours of the dry-aged beef. Overall, dry-aging loins at 3 °C with 0.2 m/s resulted in the greatest improvement in beef palatability.

1. Introduction

During post-mortem aging, substantial improvements in meat palatability attributes such as tenderness, flavour, and/or juiciness occur likely due to a structural breakdown of muscle by endogenous proteases (Huff-Lonergan & Lonergan, 2005; Kemp, Sensky, Bardsley, Buttery, & Parr, 2010; Kim, Warner, & Rosenvold, 2014; Kristensen & Purslow, 2001). In general, aging can be progressed through either dry-aging (where beef carcasses or primal/sub-primal cuts are stored in a refrigerated temperature without protective packaging materials), or wet-aging (mostly wholesale primal/sub-primal cuts under vacuum packaging). Dry-aging is typically the aging of premium meat under critically controlled ambient conditions of temperature, relative humidity and airflow. These parameters need to be carefully balanced and monitored to inhibit microbial growth and minimise weight loss, while producing excellent eating quality resulting from tenderisation and enhanced flavour (Savell, 2008). Warren and Kastner (1992) found more intensified flavour characteristics such as beefier and more brown/roasted flavour from dry-aged beef samples compared to wet-aged or unaged beef samples. However, several other studies found no significant dry-aging impacts on palatability components of beef (Dikeman, Obuz, Gök, Akkaya, & Stroda, 2013; Laster et al., 2008; Smith et al., 2008). These conflicting results between studies would likely be associated with uncontrolled and/or inconsistent processing environment conditions applied for dry-aging. In fact, although dry-aging has been practiced for decades, there is little information on the impacts of various combined dry-aging regimes on meat quality attributes.

Metabolomics is the study of biochemical processes involving metabolites (i.e. compounds with a molecular weight <1 kDa) and aims to measure (qualitatively or quantitatively) many metabolites in a given biological system at a certain time point and under certain conditions (Fang & Gonzalez, 2014). The 'metabolome' represents the collection of all metabolites in a system, e.g. a biological cell, tissue, organ or organism, which are the reactants, intermediates and end products of metabolism (Dunn, Broadhurst, Atherton, Goodacre, & Griffin, 2011). Metabolite abundances are directly related to external stimuli, the phenotype and physiology of the biological system and provide information about the biochemical processes involved. Metabolites are measured using several different analytical techniques, of which NMR, GC–MS and LC–MS are the most commonly used (Daykin & Wülfert, 2006; Fang & Gonzalez, 2014).

In meat science, metabolomics has been used to investigate beef tenderness (D'Alessandro et al., 2012; D'Alessandro & Zolla, 2013), effects of different packaging conditions on beef metabolites, (Ercolini et al., 2011; King, Matthews, Rule, & Field, 1995), metabolite changes in beef caused by aging time (Graham et al., 2012) and effects of diet on beef metabolites (Osorio et al., 2013; Osorio, Moloney, Brennan, & Monahan, 2012). However, metabolite analysis to identify dry-aged flavour related metabolites (flavour precursors) has not been studied. Therefore, the objectives of this

* Corresponding author.
E-mail address: linda.samuelsson@agresearch.co.nz (L.M. Samuelsson).

http://dx.doi.org/10.1016/j.meatsci.2015.09.008
0309-1740/

study were to determine the effects of various dry-aging regimes on meat quality and sensory attributes of beef loins and investigate the metabolite differences of dry-aged and wet-aged beef, with particular emphasis on flavour precursors.

2. Materials and methods

2.1. Meat quality attribute analyses

2.1.1. Raw materials and processing

A total of 30 beef short loins (*M. longissmus lumborum*; bone-in) from 15 beef carcasses (steers; around 2 years old) at 2 days post-mortem was obtained from a local meat processing plant. Each short loin was divided in half using a band saw yielding a total of 60 loin sections, to which 6 different dry/wet-aging regimes (Table 1) were randomly assigned based on the pre-allocated balanced incomplete block design ($n = 10$/per treatment). The six treatments included 4 dry-aging regimes (2 aging temperatures (1 or 3 °C) × 2 air-velocities (0.2 m/s or 0.5 m/s), and 2 wet-aging control groups (1 or 3 °C). The wet-aged control groups were only tested for the temperature effect, since beef loins in vacuum bags would not be affected by air-velocity, when placed in a dry-aging testing chamber (DTC; Fig. 1). A total of 4 DTCs was used to set the four different dry-aging regimes. Each DTC was monitored for the processing regimes including temperature, relative humidity (RH) and air-velocity during the whole aging process period. The given 2 × 2 (temperature × air-velocities) combinations resulted in various RH regimes, such as 76% (at 1 °C and 0.2 m/s), 73% (at 1 °C and 0.5 m/s), 49% (at 3 °C and 0.2 m/s), and 55% (at 3 °C and 0.5 m/s) as summarised in Table 1. Once initial pH and weight were measured, each loin section was placed in each assigned DTC and aged for 3 weeks. Each loin section was relocated within the individual testing chambers on a weekly basis to avoid any location effect on meat quality attributes. After 3 weeks of aging, the final pH and after storage weight were measured. The beef loin sections were removed from the assigned aging test chamber, and a certified butcher performed further processing (trimming and boning-out) simulating actual retail butchery practice (Fig. 1). Surface trimming loss and time taken for trimming were recorded. From each loin section, steak samples were cut for meat quality analyses including shear force, drip loss, initial colour, and sensory evaluation. Samples for metabolomics analysis were selected based on the sensory evaluation data. The steaks for shear force were cooked on the same day for the measurement. The steaks for consumer sensory evaluation (two steaks per treatment) were vacuum packaged and stored at −20 °C for less than a month.

2.1.2. pH

The pH of the loin sections before and after aging was measured in duplicate by inserting a calibrated pH probe (Hanna 99,163 pH meter with a FC232D combined temperature and pH insertion probe, Rhode Island, USA) directly into the meat.

2.1.3. Saleable yield, purge (or weight), drip and cooking loss

The processing weight loss for the loin sections after aging was calculated by obtaining the initial weight prior to each sample being placed either in the DTC (for dry-aging) or vacuum-packaged (purge loss for wet-aging). After aging, the samples were reweighed for the post-storage weight (wet-aged beef loins were removed from the vacuum bags, patted dry on paper towels and reweighed). The percentage storage weight loss was calculated as the difference between initial weight and final weight divided by the initial weight. The loin sections were then further processed by boning out and trimming dried surfaces and non-edible fat, and reweighed to calculate the final saleable yield (%) after aging and trimming.

Drip loss was measured following the procedure of Honikel, Roncalés, and Hamm (1983) with a minor modification. A sample (about 50 g) of meat with any visible fat and connective tissue removed was weighed and then placed in plastic 'onion bag' netting and suspended by a hook within a closed container. After storing the container for 48 h at 4 °C, the sample was blotted dry and reweighed. The drip loss was calculated as weight lost expressed as a percentage of the original sample weight.

Cooking loss was measured using the steaks cooked for shear force measurement. The steaks (6 cm thick) were cooked in a water bath controlled at 99 °C to an internal temperature of 75 °C. After cooking, the samples were transferred to ice-water slurry for at least 10 min. Each sample was weighted before and after cooking. The percentage cook loss was calculated using the difference between the pre-cooked weight and final cooked weight divided by the initial weight.

2.1.4. Shear force

The cooked samples were used for the shear force measurement, which was obtained by determining the force required to shear through a 10 mm × 10 mm cross section sample at right angles to the fibre axis using the MIRINZ tenderometer (Chrystall & Devine, 1991; MacFarlane & Marer, 1966). Ten replicates were measured for each cooked sample. The results were expressed as shear force (kgF).

2.1.5. Colour

The initial meat surface colour of the steaks after the retail processing was measured by using a Minolta Colour Meter (CR-300; Konica Minolta Photo Imaging Inc., Mahwah, NJ, USA) that had been calibrated using a standard white tile. This was done by allowing at least 30 min of blooming under simulated retail display light at 4 °C. CIE L* (lightness), a* (redness) and b* (yellowness) values were measured (Illuminant D65, 1 cm diameter aperture, 10° standard observer) through overwrap-polyvinyl chloride film at three random locations on each sample.

2.1.6. Consumer sensory evaluation

The steaks (2.54 cm thick; two steaks per treatment) for consumer sensory evaluation were vacuum packaged and stored at −20 °C until required for sensory evaluation. The frozen steaks were thawed at 3 °C overnight and cooked on an MV16 electric hotplate (Henry Berry Ltd., New Zealand). The internal cooking temperature of steaks was monitored using a Digi-Sense scanning temperature logger (Eutech Instruments Pte. Ltd., Singapore) to reach the targeted centre temperature at 71 °C. Immediately after cooking, the steaks were wrapped with aluminium foil and placed in a BOV550 Toast & Roast mini oven (Breville, Australia) set at 120 °C (less than 10 min) to maintain warm temperature before being served for the sensory analysis. Each steak was cut into 1.27 × 1.27 × 2.54 cm pieces (cut across the grain avoiding fat and any visible connective tissues) and placed in a plastic cup closed with a lid. Randomly identified three-digit-codes for each aging treatment were labeled on the side of the cup and served to consumer

Table 1
Different aging types (dry or wet) and processing regimes (temperatures, air-velocity, and relative humidity (RH)) for the trial. DTC: dry-aging testing chamber.

	Temperature (°C)	Air velocity (m/s)	RH (%)	Type of aging (treatment ID)	
DTC 1	1	0.2	76	Dry (Dry1a2)	Wet (Wet1)
DTC 2	1	0.5	73	Dry (Dry1a5)	
DTC 3	3	0.2	49	Dry (Dry3a2)	Wet (Wet3)
DTC 4	3	0.5	55	Dry (Dry3a5)	