Meat Science 123 (2017) 57–63

Contents lists available at ScienceDirect

Meat Science

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

Effects of stepwise dry/wet-aging and freezing on meat quality of beef loins

Yuan H. Brad Kim [a,*], Brandon Meyers [a], Hyun-Wook Kim [a], Andrea M. Liceaga [b], Ronald P. Lemenager [a]

[a] Meat Science & Muscle Biology Lab, Department of Animal Sciences, Purdue University, West Lafayette, IN 47907, USA
[b] Sensory Evaluation Lab., Department of Food Science, Purdue University, West Lafayette, IN 47907, USA

ARTICLE INFO

Article history:
Received 26 March 2016
Received in revised form 16 August 2016
Accepted 6 September 2016
Available online 07 September 2016

Keywords:
Beef
Wet-aging
Carcass dry-aging
Cryogenic freezing
Water-holding capacity
Sensory attributes

ABSTRACT

The objective of this study was to evaluate the effects of stepwise dry/wet-aging and freezing method on quality attributes of beef loins. Paired loins (*M. Longissimus lumborum*) from eight carcasses were assigned to either stepwise dry/wet-aging (carcass dry-aging for 10 days then further wet-aging for 7 days in vacuum bags) or carcass dry-aging only for 17 days. Then, each loin was divided into three sections for freezing (never-frozen, blast or cryogenic freezing). Stepwise dry/wet-aged loin had lower purge/drip loss and shear force than conventionally dry-aged loin ($P < 0.05$), but similar color and sensory characteristics ($P > 0.05$). The cryogenic freezing resulted in a significant decrease in shear force values and a significant improvement in water-holding capacity (WHC). These findings indicate that the stepwise dry/wet-aging coupled with cryogenic freezing could provide beneficial impacts to the local meat industry by providing equivalent quality attributes as conventional dry-aging and improving WHC of frozen/thawed meat, while reducing the time needed for dry-aging.

1. Introduction

Dry-aging is a traditional process to store whole carcasses or unpackaged primals or sub-primals under a controlled environment (e.g. temperature, humidity, and air flow) for a certain period of time (Kim, Kemp, & Samuelsson, 2016; Savell, 2008). Due to its known positive impacts on palatability attributes (particularly flavor), dry-aging has been typically practiced in local meat processors or small meat purveyors for upscale butcher shops and/or gourmet restaurants (Savell, 2008; Warren & Kastner, 1992). Although most dry-aging involves beef sub-primals (particularly middle portion), conventional carcass dry-aging (by hanging whole carcass sides in a cooler for 10 to 35 days) still has been practiced in many local meat processors as a value adding process to attract local customers (Jeremiah & Gibson, 2003; Richardson, Nute, & Wood, 2008).

However, outcomes of several studies have provided conflicting results showing no detectable dry-aging impacts on palatability components of beef (Dikeman, Obuz, Gök, Akkaya, & Stroda, 2013; Laster et al., 2008; Smith et al., 2008) despite considerable costs associated with yield loss due to excessive surface drying and additional trimming. Given the fact that dry-aging is an extremely costly and time-consuming process (Savell, 2008), these conflicting results indicate that there remains a need to reassess the efficacy of dry-aging beef carcasses for an extended period of time. Furthermore, many studies found that wet-aging, whereby storing vacuum-packaged primals or sub-primals in a sealed barrier package at refrigeration temperature, could result in equivalent eating quality attributes of beef muscles compared to the dry-aged counterparts (Dikeman et al., 2013; Laster et al., 2008; Parrish, Boles, Rust, & Olson, 1991; Smith et al., 2008).

While there have been inconsistent results regarding the effects of dry- and wet-aging on meat quality, it would be reasonable to postulate that combining these two aging methods as stepwise dry/wet-aging, by conducting carcass dry-aging first and then continued wet-aging beef loins for additional times, could provide equivalent meat quality attributes to beef loins from the conventional carcass dry-aged only counterpart for the same aging period.

In addition to carcass dry-aging, "freezer beef" is one of the most common ways for local processers to merchandise their beef products for regional consumers, as freezing is one of the most effective and efficient methods for food preservation. However, considerable quality deteriorations caused by increased purge/drip loss and/or reduced meat eating attributes have been often associated with the previously frozen meat (Leygonie, Britz, & Hoffman, 2012; Mateo-Oyague & Perez-Chabela, 2004). A recent study from Kim, Liesse, Kemp, and Balan (2015) suggested that the quality attributes of frozen/thawed beef loin could be improved by rapid cryogenic freezing, which could decrease the purge/drip release upon thawing by minimizing structural damage to meat from large extracellular ice-crystal formation. Furthermore, Grayson, King, Shackelford, Koohmaraie, and Wheeler (2014) suggested that freezing/thawing and/or aging could improve the

* Corresponding author.
E-mail address: bradkim@purdue.edu (Y.H.B. Kim).

http://dx.doi.org/10.1016/j.meatsci.2016.09.002
0309-1740/

tenderness of beef steaks compared to fresh steaks within the same aging period.

Taken together, we hypothesized that the application of rapid cryogenic freezing to stepwise dry/wet-aged beef could substantially improve meat quality attributes of freezer beef by minimizing the freezing-related tissue damage. This would subsequently add more value to locally processed aged/frozen meat products by improving the appearance through less drip (and thus minimizing the loss of soluble nutrients), reducing weight loss, or minimizing adverse freezing/thawing impacts on meat texture, juiciness, and/or flavor. Therefore, the objective of this study was to evaluate the effects of the stepwise dry/wet-aging coupled with rapid cryogenic freezing on the meat quality of frozen/thawed beef loins. Findings from this study may provide potential implications for local meat processors to develop post-harvest aging/freezing strategies that could accelerate processing throughput, while not compromising palatability attributes of aged and/or frozen/thawed beef.

2. Materials and methods

2.1. Raw materials and aging process

A total of eight steers (approximately 16 months of age; *Bos taurus* crossbred beef steers; A-maturity; average quality grade of low Choice (USDA, 1997)) was slaughtered at the Purdue University Meat Laboratory over four different slaughter days (2 steers/day). By random, one side of each carcass was conventionally dry-aged in a 1 °C cooler (average relative humidity 78%; air flow, 1.5 m/s) for 17 days by being suspended on the rail as dry-aged only control. The other side of each carcass was assigned for stepwise dry/wet-aging, where each short loin (*M. longissimus lumborum*) was separated from dry-aged carcasses at 10 days postmortem. Immediately after, the loins were vacuum-packaged and stored for an additional 7 days as wet-aging in the same cooler. On day 17 of total aging time after slaughter, the remaining intact loins were removed from the dry-aged carcasses, and the stepwise dry/wet-aged loins were removed from their vacuum packages. Each loin was cut into three equal sections and randomly assigned to three freezing treatments: blast freezing (BF), cryogenic freezing (CF) and a never-frozen (NF) control, as shown in Fig. 1. Initial pH and weight of all subsamples were measured prior to the freezing treatments. The NF control samples were further processed for quality analyses such as pH, display color, water-holding capacity (purge/thaw, drip and cook loss), shear force, and sensory analyses.

2.2. Freezing process

The loin sections assigned to freezing were vacuum-packaged and immediately subjected to the allocated freezing treatments. The loins assigned to BF were placed into a commercial −20 °C blast freezer. CF was conducted by placing the vacuum-packaged loin sections in a liquid nitrogen freezing cabinet (CF Cabinet Freezer, RS Cryo Equipment, Inc., Manteno, USA) set at −75 °C as an operating temperature. Once the internal target temperature of −20 °C was reached, the samples were then removed from the CF cabinet freezer and placed in the −20 °C blast freezer with the BF samples. The internal temperatures of beef samples as well as freezing ambient temperature were being recorded for both freezing treatments with the use of type T thermocouples (Omega Engineering, Stamford, CT) connected to an OCTEMP2000 data logger (OctTemp2000, MadgeTech, Inc., Warner, NH). All frozen samples were then stored in the same freezer for 1 month until being thawed. The frozen samples were thawed in a 2 °C cooler for approximately 48 h to be used for the further quality analyses.

2.3. pH

The pH was measured in triplicate by inserting the pH probe (HI 99163, Hanna Instruments Inc., Hoonsocket, USA) directly into the beef loin sections at three random locations.

2.4. Display color

Four steaks (2.5 cm thickness) along with a meat cube (for drip loss) were cut from each loin section. Each steak from the middle portion was used for display color evaluation and the others were used for other quality analyses as described next sections. The steak was placed on a food grade polystyrene tray, wrapped with oxygen-permeable polyvinylchloride film, and placed under simulated display lighting conditions (approximately 1450 lx, Color temperature = 3500 K) for 7 days at 2.5 °C. On day 1, 4 and 7 of display, the surface color characteristics were measured in three random locations on each steak using a Hunter MiniScan EZ colorimeter (Hunter, Reston, VA, USA) calibrated using a standard white and black tile. The setting for the illuminant was D65 source and the observer was standard 10°. The CIE L*, a*, and b* values were used to calculate chroma and hue angle (AMSA, 2012).

2.5. Water-holding capacity (purge, drip, and cook loss)

Purge/thaw loss (%) of beef loins sections was determined by measuring weight differences between an initial weight prior to freezing

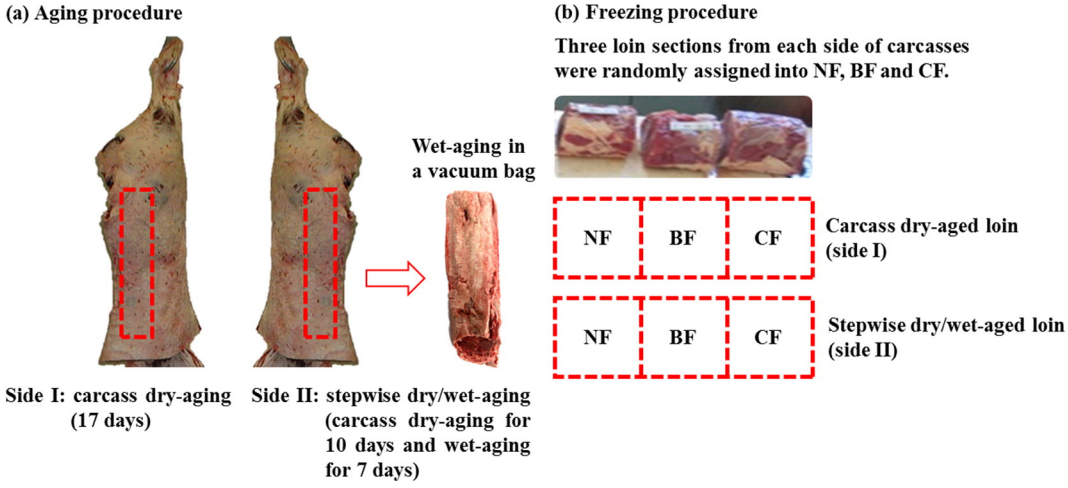

Fig. 1. Schematic figures illustrating carcass dry-aging verse stepwise dry/wet-aging (a) and the treatment random allocation (NF, never-frozen control; BF, blast-frozen; CF, cryogenic frozen) (b).