Meat Science 88 (2011) 128–138

Contents lists available at ScienceDirect

Meat Science

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

Evaluation of the storage life of vacuum packaged Australian beef

A. Rodas-González *, C. Narváez-Bravo, M.M. Brashears, H.B. Rogers, J.L. Tedford, G.O. Clark, J.C. Brooks, B.J. Johnson, R.J. Rathmann, M.F. Miller

Department of Animal and Food Science, Texas Tech University, Lubbock 79409, United States

ARTICLE INFO

Article history:
Received 26 December 2009
Received in revised form 25 June 2010
Accepted 2 December 2010
Available online 10 December 2010

Keywords:
Shelf-life
Vacuum packaging
Spoilage bacteria
TBARS
CIELab

ABSTRACT

To establish the shelf-life of vacuum packaged Australian beef, 15 Strip-loins and 15 Cube-rolls for each Processor (A, B, and C) were evaluated at two week intervals (since wk 10 to 20). Steaks on the trays were placed in retail cabinets at 3 °C. Shelf-life evaluation was based on off-odor (only at week 10), microbial analysis, lipid oxidation, and color assessment by trained panelist and Hunter colorimeter. Panelists detected "slightly off-odor" in both primal cuts for Processors B and C ($P<0.05$). Processor A primal cut steaks displayed better color scores as well as CIE L*, a*, b*, Chroma and Hue values during storage and display period than steaks from the other processors. Also, primal cuts from Processor A showed lower microbial counts and TBARS values with respect to other processors during the trial. Processor A cuts showed improved shelf life attributes initially which helps to explain its slow shelf-life deterioration.

1. Introduction

In 2008, the United States imported 2538 million pounds of beef and veal, representing U.S. $3028.8 m in value (NCBA, 2009); meanly imports from Australia, Canada, New Zealand, Uruguay and Brazil lean boneless beef trim to meet demands for ground beef production (USDA, 2009).

According to the Meat & Livestock Australia Ltd. (MLA, 2008), the United States has the second position among the leading markets for Australian beef and veal products in 2006 and 2007, with annual exports of 296 metric tons. Additionally, it is expected that beef and veal production exported to the United States will increase to 3% in 2008.

Therefore, Australian processors need to know the shelf-life of their products once it reaches the USA. Thus, it is important to generate data that could be useful to the Australian industry to validate or change their current practices of processing to increase the exports to the United States. At the same time, U.S. processors and retailers need to verify the incoming Australian beef cuts to ensure that they are acceptable and establish material purchase specifications to the supplier (i.e. spoilage microbial and TBARS profile).

Despite the development of new packaging technology, the Australian beef industry has continued using the vacuum-packaging as a mechanism for increasing shelf-life during extended periods of shipment and storage (i.e. intercontinental transport). Thus, it is well-known that multiple factors can affect the storage life of vacuum-packaged beef cuts (Seideman & Durland, 1983; Bell & Garout, 1994) that processors control, although specific differences among processors which use this technology have to be determined. The present research explored the differences in shelf-life that may exist as a result of these differences that occur among processors.

The objective of this study was to determine the shelf-life of Australian beef vacuum packaged beef exported under refrigeration to the USA, through analysis of: sensory evaluation of color and odor, instrumental color evaluation, microbiological analysis and lipid oxidation determination.

2. Materials and methods

2.1. Procurement of samples

Vacuum packaged wholesale Strip-loins (AUS-MEAT No. 2140/NAMP 180) and cube rolls (AUS-MEAT No. 2240/NAMP 112A) were received at the "Gordon W. Davis" Meat Science Laboratory, Texas Tech University from three Australian processing companies at 9 weeks of having been harvested and packaged. The sub-primal cuts (AUS-MEAT, 2006; NAMP, 2007) (15 Strip-loins and 15 cube rolls from each processor) were stored under refrigeration (3 °C) and the experiment began on week 10 after packaging and subsequently at two week intervals (weeks 12, 14, 16, 18, and 20). The total number of samples from three processors evaluated by week and cut is shown in Table 1. The number of samples decreased in some weeks due to either sub-primal cut ran out or the package lost of the vacuum conditions.

The first time the vacuum packages were opened (week 10), they were assessed for off-odor. On each designated sampling occasion, tables and knives were disinfected among sub-primal cut package to

* Corresponding author. Tel.: +1 806 8314885.
E-mail address: argenisrodas@yahoo.es (A. Rodas-González).

0309-1740/$ – see front matter © 2010 The American Meat Science Association. Published by Elsevier Ltd. All rights reserved.
doi:10.1016/j.meatsci.2010.12.013

Table 1
Total number of samples from three processors evaluated by week and cut.

Week	Processor					
	A		B		C	
	Strip-loins	Cube-rolls	Strip-loins	Cube-rolls	Strip-loins	Cube-rolls
10	15	15	15	15	15	15
12	14	15	15	15	15	15
14	14	15	15	15	15	15
16	10	14	15	15	8	15
18	–	14	–	13	–	15
20	–	13	–	7	–	15
Total	53	86	60	80	53	90

maintain aseptic conditions. Before opening, an area for sampling (avg. 302 cm^2) was measured out on each pack. This area would be swabbed (micro analysis) and sliced to obtain steaks for TBARS and color evaluation; thus, the primal cut was not exposed in its totality, rather only the packaging was peeled off this area of the package in order to not contaminate the rest of the primal surface. Once samples were taken (swabbed and sliced), the remnant portion of the sub-primal was immediately repackaged (Barrier bag BH620T, Sealed Air Inc.—Cryovac division, Duncan, SC) under vacuum condition for storage until next evaluation (every two weeks), avoiding to oxygenate the surface. Thus, the remnant portion in each sampling occasion was taken a new area of 302 cm^2 (avg); in the Cube-roll was taken in caudal–cranial direction; while in the Strip-loin was taken in cranial–caudal direction.

Due to a limited amount of sub-primal cuts per processor, it established a repeated exposure and repackaging of the remnant portion, trying to maintain in the package a very low oxygen tension. According to Brooks (1935) very low oxygen tension maintains myoglobins in a deoxygenated state. On the other hand, residual oxygen remaining in the vacuum-packaged is depleted mainly by respiration of the fresh muscle (cytochrome enzymes) and generates carbon dioxide; so aerobic or facultative bacterial microflora could utilize very little of this residual oxygen on its growth, when such organisms are initially present in relatively low numbers (Gill, 1986; Jackson, Marshall, Acuff, & Dickson, 2001).

After having swabbed the exposed surface of sub-primal, three steaks were sliced from exposed area, one 0.5 cm-thick steak for TBARS analysis of and two 1.5 cm-thick steaks for color evaluation. The steaks for TBARS analysis were flushed with nitrogen and frozen immediately (−20 °C), for subsequent analysis. Steaks assigned to color evaluation (by panelist and colorimeter) were overwrapped with polyvinyl chloride film (MAPAC L, oxygen transmission rate [OTR] = 21,700 cc of oxygen per m^2 per 24 h; Borden Packaging and Industrial Products, North Andover, MA.) in white foam trays (expanded polystyrene), taking care that the fresh cut surface (face up on the tray) was not touched by hands. The trays were placed in multi-deck (Model M3, Hussmann Corp., Bridgeton, MO) and coffin-style (Model M1, Hussmann) retail cabinets at 3 °C, under fluorescent light for three days (2515 lx for multi-deck style; 2140 lx for coffin style) using high-output bulbs with a color temperature rating of 3500 K and a color rendering index of 70.

Once the trays were prepared for retail display, and the steaks bloomed, color evaluation was carried out by trained panelist and Hunter colorimeter. The color evaluation was repeated every 24 h for 3 days. At the end of the display period, the steaks were removed of retail cabinets flushed with nitrogen packaged and frozen at −20 °C for subsequent TBARS analysis.

2.2. Microbiology analysis

The samples were taking on the surface each primal, using a sponge moistened with 10 ml of buffer peptone water (BPW). After taking the sample an additional 10 ml of BPW was added to give a final volume of 20 ml. The samples were then stomached for 2 min to obtain a homogenate sample.

From each sample serial dilution was prepared by using dilution blanks with 9 ml of sterile phosphate buffer and 1 ml aliquots. Each sample was diluted serially to 10^{-7}. The numbers of dilutions used on the spiral plate for plating were chosen based of the previous bacterial counts for each sample. Each sample was plated in duplicate.

Culture media used were APC (mesophiles) and psychrotrophic counts: aerobic plate count agar (Difco), and LAB: MRS agar (Difco) (Man, Rogosa and Sharp).

For aerobic plate count (APC), psychrotrophic count and lactic acid bacteria (LAB) counts, by the spiral plate method as described in the USFDA CFSAN Bacteriological Analytical Manual (USFDA/CFSAN, 2001). In this method, a mechanical platter inoculates a rotating agar plate with liquid sample. The sample volume dispensed decreases as the dispensing stylus moves from the center to the edge of the rotating plate. The microbial concentration was determined by counting the colonies on a part of the Petri dish where they were easily countable and dividing this count by the appropriate volume.

After inoculation of the Petri dishes, they were placed in incubators at appropriate times and temperatures as follows: Aerobic plate count (Mesophiles): 48 h at 37 °C; Aerobic Plate count for psychrotrophic organisms: 7 days at 5 °C; LAB (MRS agar): 48 h at 37 °C. After the incubation time, the plates for each sample were counted with the Q-counter.

2.3. Instrumental color

Instrumental color was determined using a Hunter Lab Miniscan XE Plus (Hunter laboratories Model MSXP'4500C, Reston, VA) using illuminant D65 and the 10 standard observer angles and 2.54 cm aperture (CIE, 1978). Meat color was measured at three different locations across the surface of steaks at 1 h post-bloom and every 24 h for 3 days. CIE L* (lightness), a* (redness) and b* (yellowness) values were measured and hue angle and chroma were calculated.

2.4. Sensory assessment of odor and color

The sensory panel (for odor and color evaluation) was composed of 6 trained panelists from Animal and Food Science department at Texas Tech University.

Off-odor evaluation was conducted the first time that packages were opened (at 10 weeks). Scores for "off-odor" referred to the intensity of off-odors associated with meat deterioration: 1 = none, 2 = slight, 3 = small, 4 = moderate and 5 = extreme; also it was characterized the off-odor if present (1 = no off-odor; 2 = rancid; 3 = sweet; 4 = sour; 5 = acidic; 6 = putrid and 7 = none of the above).

The color evaluation was conducted at 1 h post-bloom and every 24 h for 3 days. The trained panelists ($n = 6$) scored the samples through descriptive scale for color from 1 to 9 (1 = very bright red or pinkish red; 2 = bright red or pinkish red; 3 = dull red or pinkish red; 4 = slightly dark red or pinkish red; 5 = moderately dark red or pinkish red; 6 = dark red or dark reddish tan; 7 = dark pinkish red or dark pinkish tan; 8 = tannish red or tannish pink; 9 = tan to brown) and for surface discoloration a scale from 1 to 7 (1 = no discoloration, 0%; 2 = Slight discoloration, 1–19%; 3 = small discoloration, 20–39%; 4 = modest discoloration, 40–59%; 5 = moderate discoloration, 60–79%; 6 = extensive discoloration, 80–99%; 7 = total discoloration, 100%).

2.5. Lipid oxidation analysis

Oxidative rancidity was evaluated in the samples by measuring TBARS at 10 and 16 weeks of storage for Strip-loins, and 10 and 20 weeks for Cube-rolls using the modified extraction method described by Buege and Aust (1978).