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Effect of hot water treatment of beef trimmings on processing characteristics and eating quality of ground beef

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ABSTRACT

The effect of hot water treatment of beef trimmings on the processing characteristics, shelf-life and consumer acceptability of ground beef was evaluated. Hot water treatment (85 °C for 40 s) substantially enhanced the microbial quality of trimmings during refrigerated storage and this was independent of the fat level of the trimmings. Treatment had no effect on the oxidative stability of trimmings stored up to 7 days, ground beef displayed in a retail cabinet for up to 3 days, and had minimal effect on textural properties. Instrumental results demonstrate that ground beef from hot water treated trimmings was slightly lighter and tended to have less red color compared to non-treated beef. These color differences did not impact the consumer acceptance of raw patties, and in addition, hot water treatment did not significantly affect the consumer acceptability of cooked patty attributes.

1. Introduction

Public health experts estimate that 4 million cases of domestically acquired foodborne illness occur every year in Canada (CFIA, 2013). Enteric infections associated with the consumption of undercooked beef are a cause of public health concern. Because of concerns about the microbiological safety of undercooked beef, the industry has been testing numerous interventions to reduce/eliminate pathogens in beef (Koohmaraie et al., 2005).

Hot water treatment has already been determined to be an effective intervention for beef carcasses (Barkata, Acuff, Lucia, & Hale, 1993; Dorsa, 1997; Dorsa, Cutter, Siragusa, & Koohmaraie, 1996). Due to the possibility of product microbial contamination through processing before the production of ground beef, an additional decontamination step before grinding would act as an additional measure to reduce microbial numbers on beef trimmings. The only way to address these microorganisms is to develop a treatment that will adequately target areas (deep crevices, space between muscle fibers, etc.) within trimmings that are difficult for other interventions to be effective in lowering microbial counts.

Various single or multiple antimicrobial interventions on beef trimmings have been widely researched including the use of organic acids, chlorine dioxide, cetylpyridinium chloride, acidified sodium chlorite, ozone, trisodium phosphate and chemicals (Ellebracht, Castillo, Lucia, Miller, & Acuff, 1999; Mohan & Pohlman, 2016; Pohlman, Stivarius, McElyea, Johnson, & Johnson, 2002; Quilo et al., 2010; Ransom et al., 2003; Stivarius, Pohlman, McElyea, & Waldroup, 2002; Stivarius, Pohlman, McElyea, & Apple, 2002a, 2002b). Although the efficacy of these antimicrobial interventions has been shown to reduce bacteria in ground beef, the presence of these compounds might be perceived by some consumers as undesirable. Therefore, hot water pasteurization, which utilizes hot water only, may be more advantageous from a consumer understanding perspective relative to other food safety interventions which may utilize less familiar substances.

Previous research demonstrated that pasteurizing manufactured beef with water of 85 °C could be a practical treatment for enhancing the microbiological safety of ground beef (Gill & Badoni, 1997, 2002; Gill, Bryant, & Badoni, 2001). However, the impact of the hot water treatment on processing and eating qualities of beef has not been fully explored. The suitability of hot water treatment of beef trimmings would be commercially acceptable only if the ground products produced from treated meat retained the processing and sensory characteristics of the ground beef prepared from untreated product. Therefore, the objective of this study was to determine the effects of hot water treatment of beef trimmings on processing characteristics, shelf-life stability and consumer acceptability of ground beef.

2. Materials and methods

2.1. Collection and treatment of beef trimmings

Fresh beef trimmings with two target fat levels (85% lean:15% fat and 65% lean:35% fat, representing round trimmings and beef plates)

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were collected at Cargill Foods (High River, AB). Trimmings were boxed fresh and delivered under refrigeration to the Food Processing Development Centre (FPDC) at three separate times, each within four days of fabrication. Upon arrival, boxes were immediately transferred to 2 °C coolers at the FPDC until required for processing.

In preparation for processing, the trimmings from each fat level were randomly assigned and divided into two groups: control and hot water treatment (HWT) batches. To determine the effect of HWT on processing yield, the beef designated for HWT was further divided into approximately 10 kg lots that were immediately subjected to hot water treatment at 85 °C for 40 s. Hot water treatment was performed using a trim pasteurizer — an industrial hot water continuous pasteurizing system under ambient pressure (Stanfos Inc.; Edmonton, AB). A conveyor belt moved (1.5 m/min) the product through a trim pasteurizer tank (450 l). During this process, hot water from the tank was circulated to the system of nozzles located at the top of the pasteurizer and sprayed on the trimmings moving through the pasteurizer. Water levels within the trim pasteurizer were adjusted to ensure that samples did not float. To maintain constant level of water in the pasteurizer and to compensate for water loss due to evaporation, the tank was continuously supplied with hot water at the rate of 30 l/h. The total hot water treatment time was recorded from the time the product entered the water spray section until the product exited the trim pasteurizer.

The treatment time was selected based on results from preliminary trials in which beef trimmings at two target fat levels (lean, regular) were subjected to three pasteurization treatments comprising of application of 85 °C water for periods of 20, 40 or 60 s. The results showed that the 40 s pasteurization at 85 °C was sufficient to decrease aerobic plate counts by up to 2 log CFU/g without an adverse effect on processing characteristics of beef trimmings. Hot water treatment for 20 s reduced the total numbers of bacteria by less than one order of magnitude while the treatment for 60 s had detrimental effect on color and processing yield (data not shown).

Each lot was weighed before being treated using scales readable to 10 g. After the hot water treatment, each lot of meat was collected into a tarred, plastic bin with the meat pieces in one or two layers. The bins were placed on metal wire racks and allowed to drain and cool for 10 min before being weighed to determine weight change of trimmings due to HWT. After weighing, the beef was mixed by hand with dry ice and placed in a cooler for about 1 h. All trimming groups were then pooled and packaged into boxes lined with plastic bags. Each cardboard box held 27 kg of meat. The boxes were randomly allocated to four storage interval subgroups (1, 7, 10, 14 days). The trimmings were stored in aerobic conditions and refrigerated at 2 °C until further processing and evaluation.

2.2. Evaluation of beef trimmings and ground beef

Following the designated storage intervals and prior to processing, the trimmings were removed from boxes and approximately 1 kg of intact trimming (whole muscle) samples was taken for odor evaluation using a trained sensory panel. The remainder of the meat was ground separately through a plate with 4 mm orifices (K & G Wetter, Model AW114, Mississauga, ON, Canada). Samples were taken from each batch of ground meat for odor evaluation, microbiological analyses and proximate composition determined using a Foss FoodScan Analyzer (FoodScan Lab, Type 78800, FOSS, Hillerod, Denmark).

2.2.1. Odor evaluation

Odor evaluation was obtained to provide additional information towards determining the shelf life of these products both prior to and following grinding. It was hypothesized that storage of meat trimmings over an extended shelf life would lead to the production of off-aromas due to microbiological or processing factors. In order to assist with determining the optimal shelf life of trimmings, a trained sensory panel was used to describe and rate the intensity of aromas elicited by both intact, whole muscle trimmings and ground samples. Over the course of ten 1 h sessions, 8 panelists were trained using Quantitative Descriptive Analysis® to identify, describe and rate the intensities of 7 aroma descriptors (bloody/serumy, metallic, sour, sour/sweet, warmed over, spoilage, fat-like) (Table 1). A 15 cm visual analog scale was used to collect the intensity ratings of all 7 descriptors and 'other' — a term used to capture additional odors that may have been perceived. The scale contained indented points at 1 and 14 cm representing 'low' and 'high' intensities, respectively. After training, sensory data collection for each processing replicate (n = 3) was performed in triplicate and analyzed for the effects of HWT vs control, lean (15%) vs regular (35%) fat level, and ground vs whole muscle trim. For the first processing replication, odor evaluations occurred at storage days 1, 3, 7 and 14. Due to extensive spoilage at day 14, a day 10 evaluation was included at processing reps 2 and 3.

Sample preparation involved weighing and placing meat into 8 oz paper Dixie cups. Each cup was lidded and then placed at room temperature for 30 min prior to panel commencement. Using a fully randomized block design (Lawless & Heymann, 2010), samples were delivered to panelists monadically. Panelists received each sample and were instructed to remove the lid and take three short sniffs. Following the three short sniffs, they replaced the lid and continued to rate each sample for all attributes. A three minute mandatory rest period and sniffing of room temperature filtered water was enforced in order to prevent carryover and sensory fatigue.

2.2.2. Microbial evaluation

The samples for microbial evaluations for each treatment were collected immediately after grinding from the batch of approximately 25 kg trimmings. For each processing replication, three sets of twenty samples, each of 10 g, were selected at random from each batch of ground meat. Within each set, the samples were combined in a sterile sample bag (Whirl-Pak®, Nasco, Fort Atkinson, WI) to give a 200-g composite sample and shipped in a chilled state to the Agri-Food Laboratories Branch of Alberta Agriculture and Rural Development for evaluation. Microbiological testing was conducted on the day following hot water treatment and at 7, 10 and 14 days post-processing. Samples of ground beef were analyzed for Aerobic Colony Count (MFHPB-18), *Enterobacteriaceae* (MFLP-09), Coliforms (MFHPB-34) following procedures in the Compendium of Analytical Methods (Health Canada, 2012). Lactic acid bacteria were analyzed using a conventional pour technique.

Briefly, an initial dilution of each sample was prepared by weighing >11 g of ground beef and adding enough 0.1% peptone water to obtain a 1 in 10 (*w*/*w*) dilution. Each sample was then serially diluted by transferring 1 mL to 9 mL of 0.1% peptone water. All samples were plated in duplicate by transferring 1 mL of the dilution to the appropriate plates.

Table 1
Lexicon[1] of beef odor attributes for ground and whole trimmings[2] samples with corresponding reference standard compositions and end point labels for 15 cm visual analog scale.

Orosensory descriptor	Reference composition	End point labels on 15 cm (1 cm, 14 cm)
Sour	Buttermilk, Dairyland® 3.25% (90 mL)	Low, high
Sour/Sweet	Plain yogurt, Bles-wold (90 mL)	Low, high
Metallic	Ferrous Sulfate in aqueous solution (0.85 g/L) (20 mL)	Low, high
Bloody/serumy	Cross rib steak, raw, 1 in. cubes (90 g)	Low, high
Warmed over	Suet, 1 in. cubes, microwave for 30 s on high	Low, high
Spoilage	Dimethyl disulfide in propylene glycol (10,000 ppm)	Low, high
Fat-like	Lean ground beef, cooked through, cooled, reheated in microwave until warm	Low, high

[1] Sourced from Adhikari et al., 2011.
[2] Ground = trimmings ground through a plate with 4 mm orifices, Whole = intact not ground trimmings.