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Research note

Consumer acceptability of high hydrostatic pressure (HHP)-treated ground beef patties

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ABSTRACT

High hydrostatic pressure (HHP) is a non-thermal process that can effectively reduce pathogenic *Escherichia coli* in ground beef. This commercially-available process uses water under extreme pressure to denature proteins by breaking covalent bonds, eventually resulting in microbial death. While HHP has been successfully applied to plant based foods with limited flavor changes, little is known about the influence of HHP on the sensory properties and resultant consumer acceptability of HHP-treated beef. Accordingly, we performed blind sensory tests with 70 regular consumers of ground beef, using commercially-processed ground beef patties. Although HHP-treated patties were still acceptable (i.e. rated above neutral on a 9 point hedonic scale), they received significantly lower ratings for overall liking, texture, flavor and juiciness when compared to control patties. Also, Just-About-Right (JAR) scales indicate the HHP patties were more dry and less flavorful than the control patties. Collectively, these data suggest consumers may find HHP-treated ground beef to be less acceptable than untreated ground beef on the basis of their sensory properties. Since these data were collected blind, additional work is warranted to determine the degree to which consumers are willing to balance a loss of sensory quality against their nascent food safety concerns.

1. Introduction

High hydrostatic pressure (HHP) is a commercially available, non-thermal process that utilizes water under pressure to reduce pathogens, while also extending the shelf life of the product (Hugas, Garriga, & Monfort, 2002; Morales, Calzada, Avila, & Nunez, 2008). The mode of action of HHP against microbes is protein denaturation (breaking of covalent bonds), ultimately resulting in cellular death (Morales et al., 2008). Researchers have documented the effectiveness of HHP on reducing pathogens in a variety of muscle foods. For example, HHP was found to be an effective intervention against *Escherichia coli* O157:H7 in ground beef (Morales et al., 2008). However, very little information has addressed the effect of HHP on other Shiga-toxin producing *E. coli* (STEC), including *E. coli* O145, O26, O45, O103, O111, and O121, or the "big 6" STEC. Therefore, treatment of fresh ground beef with HHP to eliminate these STEC, which are considered adulterants in ground beef (as of June 2012), could provide a means to protect consumers against foodborne illness and prevent recalls for the beef industry.

In a recent study, 80:20 or 93:7 (lean:fat) irradiated ground beef was experimentally inoculated with ~6 $\log_{10}$ CFU/g of various STEC (O145, O26, O45, O103, O111, O121 and O157:H7), formed into patties, crust-frozen with liquid nitrogen, vacuum packaged, stored at 4 °C, and subjected to 4 HHP cycles (one cycle = 400 MPa for 1 min @ 17 °C) (Cutter, Depasquale, Hayes, Raines, & Seniviranthe, 2012). Under experimental conditions, this HHP treatment resulted in a 3 to 4 $\log_{10}$ CFU/gram (99.99%) reduction of the STEC in the ground beef patties (Cutter et al., 2012). Unfortunately, HHP-treated ground beef patties in unopened vacuum packages exhibited excessive purge and appeared gray in color prior to cooking. Given these observations, subsequent sensory experiments were warranted. Therefore, the goal of the present experiment was to compare the consumer acceptability of cooked ground beef

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hamburger patties that had been HHP-treated, compared to untreated (control) patties.

2. Materials and methods

2.1. Overview

A central location test with 70 consumers was conducted at the Penn State Sensory Evaluation Center to assess acceptability of HHP-treated ground beef patties. Participants were recruited from the Penn State University community and were eligible if they had eaten ground beef patties at least once in the last two weeks.

2.2. Materials and HHP treatment

Patties were formed in a patty maker (Hollymatic; Countryside, IL) from the same batch of ground beef (80% lean; 20% fat) at the Penn State University Meat Lab (University Park, PA) to dimensions of 4 $^{3}/_{4}$″ (12.07 cm) diameter and 3/8″ (.95 cm) thick. Two stacks of 8 patties with food-grade wax paper in between each patty were vacuum-packaged (Smith CM 117; Evanston, IL) in poly-nylon pouches (10 × 15, 3 mil, Vac bag; PCS, Penns Grove, NJ) and stored for 24 h under refrigerated conditions. Vacuum-packaged patties were transported under refrigerated conditions to the HHP facility. Half of the patties were subjected to four HPP cycles (one cycle = 400 MPa for 1 min at 4 °C) using a Hiperbaric 420 HPP machine (Burgos, Spain) located at Millard Refrigerated Services (Allentown, PA). The remaining patties (control) were not treated, but were otherwise handled and stored under the same conditions. All patties were transported and stored under refrigeration for 18–24 h at the Department of Food Science, Penn State University (University Park, PA) until the consumer test was executed.

2.3. Sample handling and preparation

Patties were received at the Penn State Sensory Evaluation Center the morning of the test, fresh, in sealed plastic bags at 40 °F (~4 °C). The patties were removed from the bags and placed on trays lined with butcher paper. Each tray held 6 treated patties and 6 untreated patties. The trays were then covered with plastic wrap, placed back into the refrigerator and held at 40 °F (~4 °C) until needed. When needed, a tray containing both treated and untreated samples was removed from the refrigerator and cooked. Griddles were preheated to 380 °F (~193 °C) to compensate for the initial temperature drop when samples were added. Three patties of each condition were cooked on two griddles (6 patties per griddle). Three untreated patties were placed along the front of the griddle and three treated patties were placed along the back of the griddle. Position of untreated and treated patties on the griddle (front or back) was alternated for every tray. Patties were cooked for 3.5 min at 350 °F (~177 °C) and then flipped and cooked for an additional 3.5 min. Patties were cooked to ensure a temperature of medium well (internal temperature 158 °F + 3 °F; ~70 °C) and then transferred from the griddle to a 225 °F (~107 °C) oven to equilibrate for 5 min. The patties were removed from the oven, quartered and placed into sample cups with three-digit blinding codes for serving. Cooking was staged in 15-min intervals throughout the two test sessions. The first session lasted 45 min and the second session lasted 75 min (11:00–11:45am; 12:00–1:15pm). Seven trays of product (84 patties) were processed in total.

2.4. Sample presentation and evaluation

Participants rated the patties for overall liking, texture, flavor, and juiciness on a standard 9 point hedonic scale (Lawless & Heymann, 2010). Data were also collected using 5 point categorical Just-About-Right (JAR) scales (Rothman & Parker, 2009). Obvious color differences were not observed in the cooked patties, so color was not assessed on the ballot or obscured via monochromatic lighting. Each participant was served four, blind coded samples, as well as a cracker and room temperature water for rinsing. Each participant received two treated and two untreated samples in a complete block design. Serving order among the four samples was fully balanced and resulted in 24 possible serving orders. Participants were presented samples in a sequential monadic fashion and asked to taste and evaluate each sample in the order presented. Evaluations by each participant were performed independently in isolated sensory evaluation booths under white light. All responses were collected and analyzed using Compusense *five* (release 5.2, Compusense Inc., Guelph, ON, Canada).

2.5. Statistical analysis

Data were analyzed using SAS 9.2 (Cary, NC) and significant criterion was set at alpha = .05. Liking scores were tested via 2-way (replicate by treatment) repeated-measures analysis of variance (ANOVA) using *proc mixed*. Treatment and processing replicates were handled as fixed effects, with participants as a random effect, assuming compound symmetry for the covariance structure. Post-hoc comparisons were made via the Tukey–Kramer method. Within a treatment (control versus HHP), the correlation between overall liking and individual attribute liking scores (texture, flavor, juiciness) were assessed via Pearson's *r* using *proc corr*; scores were collapsed across replicates within a treatment. Just-About-Right (JAR) scores were analyzed via *proc freq* using the Cochran-Mantel-Haenszel (CMH) option. The CMH models were used to test two distinct null hypotheses: first, that the distribution of scores did not differ across samples, and second, that the mean JAR scores did not differ across samples. When significant differences were found across the four samples, additional pairwise models were run to determine where the significant difference lay, as recommended by Fritz (2009).

3. Results and discussion

3.1. Participant demographics and consumption habits

All 70 participants (57 women; 13 men) had consumed a hamburger in the last two weeks (per the inclusion criteria). Participant ages ranged from 22 to 60+; most (78.6%; 55 of 70) were between 30 and 59. Most individuals (92.8%; 65 of 70) reported eating burgers at home 1–3 times a week, with modal at home consumption of once per week (51.4%; 36 of 70). Typical consumption of burgers outside the home (restaurants and fast food establishments) was slightly lower: 18.6% (13 of 70) endorsed zero times per week, and most individuals (77.1%; 54 of 70) reported eating burgers outside the home once or twice a week. Modal household size was 2 (31.3%), and most had a household size between 2 and 4 (74.3%; 52 of 70). Modal household income was $59,001–79,000 (34.3%), and 35.7% had a household income over $79,001. Most individuals (60%; 42 of 70) preferred their burgers 'medium' or 'medium well'; 21 (30%) preferred them 'well done' and 7 (10%) preferred them 'medium rare'. No one endorsed preferring 'rare' hamburgers.

3.2. Acceptability of the samples

All samples were generally well liked; individual sample means across treatment and replicates were above 5 (neutral) on a 9 point hedonic scale (not shown). However, as shown in Fig. 1, there was a