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EFFECTS OF REPETITIVE HIGH ENERGY PULSED POWER (RHEPP) IRRADIATION ON SENSORY ATTRIBUTES, COLOR, AND SHELF LIFE OF GROUND BEEF

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Summary

We investigated the effects of packaging atmosphere and three levels of irradiation dose (Repetitive High Energy Pulsed Power, -RHEPP) on microbial populations, vitamin retention, and display color attributes of ground beef patties stored either chilled or frozen. Beef knuckles and beef fat were coarsely ground, sampled and analyzed to achieve 20% fat, mixed, ground through a 1/8 in. plate, and processed into 1/4-lb patties, which were sealed either aerobically or nitrogen-flushed. Patties were not irradiated or irradiated to 1.5 or 3.0 kGy, chilled, and displayed at 37 ± 4EF for 6 days under 150 foot-candles of Deluxe Warm White fluorescent lighting in an open-top display case defrosted at 12 hour intervals. Hunterlab Instrumental color was measured daily. The experiment was replicated three times. Aerobically packaged patties were lighter, more yellow, more discolored, and less red (all P<.05) than nitrogen-flushed patties over the 6-day display. Nitrogen-flushing for irradiated patties resulted in higher (P<.05) retention of thiamin, but riboflavin was not affected (P>.05). At $ 1.5 kGy, aerobic and lactic acid bacteria were reduced (P<.05), and no *E. coli* and coliforms survived. Nitrogen-flushing combined with irradiation resulted in more stable, intensely red colored patties, which retained more thiamin. The effect of irradiation on various flavor notes was minimal and generally diminished in nitrogen-flushed compared to aerobic packages.

(Key Words: Irradiation, Ground Beef, Color, Vitamin Retention.)

Introduction

An estimated 45% of the total beef produced in the United States is consumed as ground beef, which is utilized widely in households and institutional establishments such as school lunch programs, fast food chains, and hospitals.

The effectiveness of irradiation in controlling microorganisms in meat is well documented. A dose of 2.5 kGy theoretically should kill 4.10 $\log_{10}$ *Listeria monocytogenes* and 5.12 $\log_{10}$ *Staphylococcus aureus* per gram of ground beef. A 3 log kill means 99.9% kill. A dose of 2.5 kGy would be sufficient to kill 8.1 $\log_{10}$ *Escherichia coli* O157:H7, 3.1 $\log_{10}$ *Salmonella*, and 10.6 $\log_{10}$ *Campylobacter jejuni*, thus, resulting in a high probability of complete inactivation of microbial pathogen populations likely to be present in ground beef patties.

Other researchers have shown that in ground beef with an initial total plate count (TPC) of 7.0 log CFU/g, an irradiation dose of .80 kGy reduced TPC by 1.5 log and 2.0 kGy reduced TPC by 3 log. These researchers concluded that meat samples with higher microbial loads such as ground meat required a higher dose of irradiation to effectively extend shelf life.

Quality concerns such as sensory and color changes have been studied less extensively. Some researchers have reported that irradiation causes detrimental changes to flavor and aroma, whereas others have reported minimal effects. Some of these differences may have been due to different levels of oxygen in the packages.

Because meat quality affects consumer acceptance, our objective was to determine sensory attributes, thiamin and riboflavin retention, color, and shelf life of ground beef patties in two packaging systems (aerobic or nitrogen atmosphere) and two holding temperatures (30EF or 0EF) exposed to two irradiation dose levels (1.5 or 3.0 kGy of RHEPP) or not irradiated (control).

Experimental Procedures

Beef knuckles from a commercial source and beef fat trim from Kansas State University (KSU) Meat Laboratory were coarsely ground separately through a 3/8 in. plate, mixed to obtain a fat level of 20%, then ground twice through a 1/8 in. plate. Quarter pound patties were crust frozen (!40EF for 15-20 minutes) and either aerobically packaged in oxygen-permeable polyethylene bags or nitrogen packaged in high oxygen barrier packages.

Products were transported to Sandia National Laboratories, Albuquerque, NM for irradiation. Frozen cooler packs were used to control the temperature of the product during transportation, and product temperature was monitored by a temperature logger.

Dosimeters were used to verify radiation doses. Patties were arranged on an aluminum base plate and irradiated using RHEPP. One pass of the beam provided 1.5 kGy of irradiation and two passes provided 3.0 kGy. Control samples were treated in a similar fashion without the beam turned on. Base plate temperature and air temperature were monitored at 1-minute intervals. A maximum to minimum dose ratio of <1.7 was our target.

Descriptive flavor, aroma, and texture analyses were conducted 48 to 60 hours (chilled ground beef patties) and 6 to 8 days (frozen ground beef patties) after irradiation, using a professional panel at The Sensory Analysis Center (Kansas State University, Manhattan, KS). No more than six samples of ground beef patties were presented in a simple 1.5-hour test session. Products were evaluated independently for various flavor and texture attributes by five panelists. Each panelist had 120 hours of training in flavor and texture analysis, over 2,000 hours of sensory testing experience, and extensive experience in testing meat products. Before product testing, panelists were oriented to flavor, texture, and aroma attributes of this beef and were given irradiated beef samples to identify the aroma, texture, and flavor attributes to be evaluated.

Descriptive testing was performed in an environmentally controlled room. Thirteen flavor/texture attributes were assessed using a 15-point scale with .5 increments (0=none to 15=very intense) for each descriptor.

Aromatic attributes were determined prior to cooking, during cooking, and immediately following removal from the oven. Immediately prior to broiling, in-package raw aromas were determined by panelist(s) placing their noses about 2 in. from the sample and sniffing the released aroma. Cooked aroma was determined immediately upon removal of patties from the oven. Five raw patties per treatment per replication were broiled (3 in. from the heating element) to 165EF internally (about 4 minutes per side).

Each flavor panelist received one patty that had been cut into six wedges. After the patties cooled to approximately 155EF internally, panelists evaluated them for texture and flavor attributes.

Chilled patties were displayed at 38+2EF for 6 days under 150 foot-candles of Deluxe Warm White fluorescent lighting in an open-top display case defrosted at 12-hour intervals. Instrumental color data were collected during the 6-day display. Thiamin and riboflavin were determined by AOAC procedures.

Chilled and frozen studies were each replicated three times. Ground beef data were analyzed as a strip-strip-split-plot design using the maximum likelihood, mixed model analysis of the Statistical Analysis System. The whole plot was package type × dose with the split plot being panelist. Random effects were included to account for

variability in the batch of meat, patty, and panelist. Least square means were used to separate means at P<.05. Color data were analyzed using SAS Proc Univariate and Proc Mixed.

Results and Discussion

In chilled patties, no differences (P<.05) were noted in any of the aromatic attributes before, during, or after cooking, irrespective of irradiation dose or packaging. Nitrogen-flushing reduced (P<.05) oxidized flavor and other off-notes associated with irradiation. Irradiation had minimal effects on tenderness, beef identification, and browned/ roasted flavor for all treatments.

In frozen patties packed in nitrogen, there were no differences (P>.05) in animal hair aroma, irrespective of irradiation level. Animal aroma during cooking was less (P<.05) in nitrogen-flushed patties than in those packaged aerobically. Juiciness, tenderness, beef identification, and browned/roasted flavor were not affected (P>.05) by irradiation. Barrier packaging and flushing with nitrogen reduced (P<.05) off-notes associated with irradiation. Furthermore, ground beef, juiciness, and tenderness were not affected adversely by RHEPP irradiation.

Aerobically packaged patties had a lighter, yellower (P<.05), more discolored instrumental color, whereas nitrogen-packaged patties had more redness (P<.05) compared to aerobically packaged patties over the 6-day display. Patties irradiated at 3.0 kGy were redder (P<.05) than control patties. The redness values of nitrogen-packaged patties irradiated at 0.0 and 1.5 kGy were not different (P>.05) at any display day. For all display days, instrumental discolorations for nitrogen-packaged patties irradiated at 3.0 kGy were similar (P>.05). Irradiation combined with nitrogen-flushing resulted in more stable, intensely red colored patties.

Irradiated patties had a longer (P<.05) display life compared to the nonirradiated samples. Nitrogen flushing for irradiated patties resulted in greater (P<.05) retention of thiamin than aerobic packaging. Riboflavin was not affected (P>.05) by any treatments.