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Thiamin and riboflavin retention in ground beef patties pasteurized by electron beam

Abstract

This research focused on the effects of an electron beam irradiation treatment with the Repetitive High Energy Pulsed Power (PHEPP) accelerator at Sandia National Laboratories. Test variables included irradiation/storage temperatures (30 or 0°F), packaging environments (aerobic or nitrogen-flushed), and irradiation dose (0, 1.5, or 3.0 kGy). Ground beef patties formulated to a target fat level of 20% were packaged in barrier film under nitrogen (ca = 400 ppm residual oxygen) or sealed in aerobic packages (no vacuum), stored, and irradiated chilled or frozen. Thiamin and riboflavin levels were not affected (P>.05) by irradiation dose. Thiamin content of irradiated patties was greater for frozen vs. chilled and for nitrogenpackaged vs. aerobically packaged product. Riboflavin content was greater in frozen patties that were nitrogen packaged. Electron beam pasteurization by this method did not affect thiamin or riboflavin concentration of treated ground beef patties.

Keywords

Cattlemen's Day, 2000; Kansas Agricultural Experiment Station contribution; no. 00-287-S; Report of progress (Kansas State University. Agricultural Experiment Station and Cooperative Extension Service); 850; Beef; Ground beef; Electron beam; Thiamin; Riboflavin

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THIAMIN AND RIBOFLAVIN RETENTION IN GROUND BEEF PATTIES PASTEURIZED BY ELECTRON BEAM

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Summary

This research focused on the effects of an electron beam irradiation treatment with the Repetitive High Energy Pulsed Power (PHEPP) accelerator at Sandia National Laboratories. Test variables included irradiation/storage temperatures (30 or 0°F), packaging environments (aerobic or nitrogen-flushed), and irradiation dose (0, 1.5, or 3.0 kGy). Ground beef patties formulated to a target fat level of 20% were packaged in barrier film under nitrogen (ca = 400 ppm residual oxygen) or sealed in aerobic packages (no vacuum), stored, and irradiated chilled or frozen. Thiamin and riboflavin levels were not affected (P>.05) by irradiation dose. Thiamin content of irradiated patties was greater for frozen vs. chilled and for nitrogen-packaged vs. aerobically packaged product. Riboflavin content was greater in frozen patties that were nitrogen packaged. Electron beam pasteurization by this method did not affect thiamin or riboflavin concentration of treated ground beef patties.

(Key Words: Ground Beef, Electron Beam, Thiamin, Riboflavin.)

Introduction

Ground beef is popular, economical, and widely used. Publicity from foodborne disease outbreaks involving meat products has increased consumer awareness of food contamination with pathogens, especially *Escherichia coli* O157:H7, *Salmonella*, and *Listeria*. Irradiation is a promising method to ensure meat safety; however, concerns have been raised about its possible effect on nutrients, especially thiamin and riboflavin.

Experimental Procedures

Beef knuckles (IMPS 167) obtained from a commercial processor within 5 days of carcass fabrication were trimmed of external and seam fat. Beef subcutaneous fat trim was obtained from the Kansas State University Meat Laboratory. Lean and fat sources were coarsely ground separately through a 3/8 in. plate. A sample of each source was ground using a 1/8 in. plate, mixed and analyzed for fat and moisture (CEM Corp., Matthews, NC). Lean and fat sources were mixed to obtain a targeted fat level of 20%, then mixed and ground twice through a 1/8 in. plate.

Twelve square, ground beef patties (1/4 lb, 4×4×1/2 in.) were made per replication per treatment. Patties were placed in a single layer on metal trays and crust frozen at –40°F for 20 min to facilitate handling. Half of the patties were packaged in barrier bags (3-6 cc $O_2/m^2/24$ hour at 40°F and 0% RH, Viskase Corp., Chicago, IL). The other half were sealed (not evacuated) in oxygen-permeable bags (Polyethylene; 3550 cc $O_2/m^2/24$ hour at 72°F and 50% RH).

Integrity of the nitrogen-flushed packaging was confirmed by using a gas analyzer to analyze residual gas in one nitrogen-flushed irradiated patty per treatment per replication. The probe was inserted into the package through a sticky rubber patch. The detection limit of the gas analyzer was 400 ppm O_2.

Patties were stored at 34±5°F (chilled) or !4±5°F (frozen) temperature. Packaged patties were packed into insulated ice chests and transported by air to Sandia National

Laboratories, Albuquerque, NM, for irradiation. Frozen cooler packs were used to control the temperature during transportation. Internal temperature was monitored using temperature loggers. Temperatures increased about 12°F in frozen product and 9°F in chilled product during shipment. After arrival, product temperature was stabilized overnight to !4 or 34°F. Control samples receiving no irradiation treatment were shipped and treated the same as product to be irradiated.

To measure actual irradiation, 48 calibrated dosimeters were placed on 1×1× 3/8 in. acrylic blocks on four corners of the patties. A total of 96 dosimeters was used to collect absorbed dose data. Minimum and maximum doses for each dose level and replication were determined. Because the ground beef patties were only 1/2 in. thick, a maximum to minimum ratio of <1.7 was our target.

Patties were placed on a 1/4 in.-thick aluminum base plate (18×53 in.). A refrigeration unit beneath the base plate maintained the required temperature. Each patty was irradiated with 1.5 or 3.0 kGy of non-radioactive electron beam, Repetitive High Energy Pulsed Power (RHEPP-II) at an energy level of 2 Mev, a power level of 200 kW, and an approximate dose rate of 10^{10} to 10^{11} kGy/sec at a conveyor speed of 1 in./sec. Patties irradiated at 1.5 kGy were exposed under the beam once, and patties irradiated to 3.0 kGy were exposed twice in one run. After each run, all patties and dosimeters were inverted and irradiated again in the same manner. Control (0 kGy) patties were placed on the conveyor and run through the unit with the electron beam turned off. Immediately after irradiation, patties were placed in ice chests (cooled with dry ice) and returned to two separate refrigeration units maintained at !4°F for frozen patties and 30°F for chilled patties.

After irradiation, samples for vitamin analysis were packed in Styrofoam boxes lined with dry ice and sent to Midwest Laboratories, Inc., Omaha, NE. During shipping, temperature was maintained at !13°F. Thiamin and riboflavin were measured using AOAC methods. The detection limit of each method was .02 mg/100 g. Duplicate values were averaged, and a statistical analysis was performed.

Results and Discussion

Maximum:minimum ratios for dose levels of irradiation ranged from 1.46 for 3.0 kGy frozen patties to 1.48 for 1.5 kGy chilled patties. Therefore, our target ratio of <1.70 was achieved.

Thiamin contents for control and after irradiation at 1.5, and 3.0 kGy were .077, .079, and .078 mg/100 g meat, respectively (Table 1). Corresponding riboflavin levels were .172, .174, and .172 mg/100 g. Thiamin was higher (P#.05) in nitrogen-flushed patties (.083 mg/100 g) than in aerobically packaged patties (.072 mg/100 g). Riboflavin was higher (P<.05) in nitrogen-flushed frozen (!4°F) patties than in nitrogen-flushed chilled (34°F) patties (.167 vs. .179 mg/100 g) (Table 2). Riboflavin in aerobically packaged ground beef patties at both chilled and frozen temperature was .172 mg/100 g.

Under our conditions, irradiating ground beef with electron beams generated from RHEPP-II resulted in no loss of either thiamin or riboflavin compared to nonirradiated controls. This encouraging observation could be due to low dose, packaging atmosphere, temperature, irradiation system, or a combination of those factors.

Table 1. Thiamin Content (mg/100 g) in Ground Beef Patties as Affected by Dose Level, Temperature, and Packaging Atmosphere

	Dose (kGy)				Temperature °F			Packaging		
Vitamin	0	1.5	3.0	SE	34	–4	SE	N_2	Air	SE
Thiamin	.077	.079	.078	.001	.074[a]	.82[b]	.001	.83[b]	.072[a]	.001

Detection limit: Thiamin .02 mg/100 g.

SE = Standard error.

[a,b]Means with the same or no superscript in the same row within a treatment parameter are not different (P>.05).

Table 2. Riboflavin Content (mg/100 g) in Ground Beef Patties as Affected by Temperature by Packaging Atmosphere (Standard Error = .005)

	Temperature °F	
Packaging	34	–4
Nitrogen	.167[a]	.179[b]
Aerobic	.172[a]	.172[a]

Detection limit: Riboflavin .02 mg/100 g.

[a,b]Means with the same superscript are not different (P>.05).