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Effects of soy hull pectin and insoluble fiber on physicochemical and oxidative characteristics of fresh and frozen/thawed beef patties

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ABSTRACT

The objective of this study was to determine the effects of pectin and insoluble fiber isolated from soy hulls on water-holding capacity (WHC), texture, color, and lipid oxidation of fresh and frozen/thawed beef patties. Beef patties were formulated with no dietary fiber (control), 1% soy hull pectin, insoluble fiber, or their mixture (1:1), respectively. The addition of soy hull pectin significantly decreased display weight loss and increased cook yield of both fresh and frozen/thawed beef patties. In addition, no significant difference in hardness between fresh and frozen/thawed beef patties was observed for all dietary fiber treatments. However, incorporation of insoluble soy hull fiber decreased color and lipid oxidation stabilities of both fresh and frozen/thawed beef patties. Our results indicate that the incorporation of soy hull pectin could be an effective non-meat ingredient to minimize water loss and hardness defects of frozen beef patties.

1. Introduction

Freezing has extensively been practiced in the meat industry as well as in households, since it is one of the most effective ways to preserve meat and meat products. According to the consumer survey conducted through the NCBA (2011), 44% of beef patties were sold fresh, whereas the remaining 56% were sold frozen. Moreover, the survey found that 47% of the beef patties that consumers purchased fresh from retail stores actually ended up being stored in household freezers. This survey result implies that a majority of the beef patties undergo the freezing/thawing process in the food supply chain from manufacturers to consumers.

Despite the positive impact of freezing on the extension of shelf life, however, the quality deterioration related to freezing/thawing, such as a decrease in water-holding capacity (WHC), discoloration, texture, and/or lipid oxidation has been reported. In particular, the decline of WHC due to the damage of muscle structure by ice crystal formation causes the excessive moisture loss during thawing/cooking and the decrease of tenderness of frozen/thawed beef patties (Bhattacharya, Hanna, & Mandigo, 1988; Berry & Leddy, 1989; Georgantelis, Blekas, Katikou, Ambrosiadis, & Fletouris, 2007; Hanenian, Mittal, & Usborne, 1989).

Dietary fiber obtained from several plants has been substantially used as a functional non-meat ingredient, and their physiological and technological benefits largely differ from its solubility in water (Talukder, 2015). Considering positive effects of dietary fiber on WHC, freeze/thaw stability, and texture of processed meat products, in general, it could be expected that dietary fiber incorporation can minimize the quality changes of frozen meat products due to freezing/thawing process. In this regard, some fiber-rich sources, such as oat's soluble fiber (Piñero et al., 2008), wakame (López-López et al., 2010), and walnut (Jiménez-Colmenero et al., 2003) have been applied. However, there has been little information on the comparison on insoluble and soluble fibers as a functional non-meat ingredient in frozen beef patties.

Pectin, which is one of water-soluble hydrocolloids, has been previously utilized as an effective fat replacer, texture modifier in meat products (Cardoso, Henry, Almeida, Ferreira, & Ladeira, 2013; Thakur, Singh, Handa, & Rao, 1997), and a cryo-protectant in fish surimi (Sych, Lacroix, Adambounou, & Castaigne, 1990). Recently, pectin and insoluble fiber (residues after pectin extraction) from soy hulls, which are the seed coats of soybeans, have been evaluated for their potential efficacy for the meat application. Kim, Lee, and Kim (2015b) found that the addition of both soy hull pectin and insoluble fiber improved WHC and textural properties of meat emulsions. Furthermore, Kumar, Biswas, Chatli, and Sahoo (2011) and Kumar, Biswas, Sahoo, Chatli, and Sivakumar (2013) reported that soy hull flour could delay the lipid oxidation of chicken nuggets.

Given the observed functional characteristics of dietary fiber from soy hulls, it could be postulated that the incorporation of soluble pectin and insoluble fiber from soy hulls can improve some quality attributes

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of frozen/thawed beef patties. Therefore, the aim of this study was to determine the effects of pectin and insoluble fiber isolated from soy hulls on WHC, texture, color, and lipid oxidation of fresh and frozen/thawed beef patties.

2. Materials and methods

2.1. Preparation of soy hull pectin and insoluble fiber suspension

The isolation of pectin (by acid extraction and alcohol-precipitation) and insoluble fiber (by alkali hydrolysis after pectin extraction) from soy hulls was conducted with the method described by Kim et al. (2015b). Dietary fiber suspensions of the pectin, insoluble fiber, and their mixture (1:1), were prepared by mixing with 5 volumes of deionized distilled water (1:5, v/w), respectively, and stirred at room temperature for 1 h.

2.2. Beef patty manufacture

Beef rounds (*Musculus semimembranosus*) and beef back fat from same beef carcasses were obtained at the Purdue University Meat Laboratory at 7 days postmortem, vacuum-packaged, and stored at −40 °C until use. The frozen beef muscle and fat were thawed in a 2 °C cooler for 24 h. After the removal of visible connective tissue and excess fat from the beef muscle, the beef muscle and fat were ground through a 3/8 in. plate using a meat grinder (M-12-FS, Torrey, Monterrey, NL, Mexico). Beef patties were formulated with 80.75% beef lean, 14.25% beef fat, and 5% cold water as a control, whereas dietary fiber treatments were prepared with 79.75% beef lean portion, 14.25% beef fat, and each 6% dietary fiber suspension was prepared (1% dietary fiber and 5% cold water based on total weight), respectively. All ingredients were manually mixed by hand for 5 min, and then, re-ground through a 1/4 in. plate to be mixed uniformly. A total of eighteen patties (approximately 100 g each) per treatment were manufactured using a round shape patty maker (10 cm × 3 cm). Nine patties were analyzed as a fresh treatment on the manufacture day, whereas the other nine patties as a frozen treatment were weighed, placed on a wax paper, vacuum-packaged, and stored at −40 °C for 1 month. All frozen patties were thawed in a 2 °C cooler for 24 h and re-weighed after blotting with a blot paper to calculate a thaw loss. To assess display weight loss and lipid oxidation, two patties from each fresh and frozen/thawed treatment were placed on a Styrofoam tray, over-wrapped with PVC film, and displayed in a 2 °C cooler for 5 days under continuous fluorescent natural white light (3500 K).

2.3. Physicochemical and textural analyses

The pH value of raw beef patties was determined in duplicate from two patties using an electronic pH meter (Sartorius Basic Meter PB-11, Sartorius AG, Germany).

Surface color of raw beef patties was determined using a Hunter MiniScan EZ colorimeter (Hunter, Reston, VA, USA). CIE L* (lightness), a* (redness), and b* (yellowness) values were recorded at 1, 3, and 5 day retail display from five random spots from three patties (15 readings per treatment). Hue angle was calculated using the following expression; hue angle $= \tan^{-1}(b^* / a^*)$ (AMSA, 2012).

Thaw loss from all frozen patties was calculated as the weight difference between initial and frozen/thawed samples, which was expressed as a percentage loss. Cook yield was determined in quadruplicate by the weight differences between raw and cooked patties. Four beef patties per treatment were cooked in a pre-heated electric grill (135 °C) until the targeted core temperature reached 71 °C monitored by using a digital thermometer equipped with a data logger. Display weight loss was calculated in duplicate as the weight difference of displayed beef patties between 0 and 5 days.

Texture profile analysis was performed in quadruplicate from four patties according to the method of Bourne (1978) described by Claus and Sørheim (2006) using a TA-XT Plus Texture Analyzer (Stable Micro Systems Ltd., Surrey, UK).

On 0 and 5 days of display, lipid oxidation of fresh and frozen/thawed beef patties was assessed in duplicate by 2-thiobarbituric reactive substances (TBARS) assay described by Buege and Aust (1978).

2.4. Statistical analysis

Experimental design was a completely randomized design with a total of three independent batches. The dietary fiber, freezing/thawing, and display time (for TBARS and color stability) were considered as the main effects. All data were analyzed using the PROC MIXED procedure of SAS 9.4 software (SAS Institute Inc.). If there was no significant interaction between the main effects ($P > 0.05$), pooled data were used to compare the main effect means (display weight loss and TBARS). Least squares means for all traits were separated (F test, $P < 0.05$) by using least significant differences.

Table 1
Effects of soy hull pectin and insoluble fiber on pH, WHC, and texture of fresh and frozen/thawed beef patties.

Treatments[A]	pH	WHC (%)			Texture profile analysis				
		Thaw loss	Cook yield	Display weight loss[B]	Hardness (*N*)	Springiness	Cohesiveness	Gumminess (*N*)	Chewiness (*N*)
Fresh beef patties									
Control	5.60b	–	64.74c	2.79a	4.32b	0.75	0.67	2.07	1.55
Insoluble fiber	5.61b	–	68.98b	2.15b	4.24b	0.73	0.67	2.08	1.54
Pectin	5.47c	–	69.02a	2.03b	3.65c	0.73	0.67	1.75	1.26
Mixture (1:1)	5.54c	–	68.35ab	2.22b	3.61c	0.71	0.66	1.71	1.24
Frozen/thawed beef patties									
Control	5.76ab	3.76	61.72d	–	5.99a	0.68	0.59	2.54	1.87
Insoluble fiber	5.82ab	2.75	66.49bc	–	5.23b	0.69	0.62	2.20	1.62
Pectin	5.84a	2.62	70.09a	–	4.03c	0.67	0.61	1.67	1.17
Mixture (1:1)	5.83a	2.97	67.65b	–	4.59c	0.68	0.61	1.91	1.37
SEM[C]	0.044	0.537	0.805	0.132	0.356	0.036	0.014	0.089	0.652
Significance of P value									
Dietary fiber	0.3062	0.2460	0.0002	0.0018	<0.0001	0.4944	0.5173	0.0737	0.0815
Freezing/thawing	0.0559	–	0.1480	<0.0001	0.0854	0.3982	0.0224	0.4635	0.6076
Interaction	0.0042	–	0.0466	0.0832	0.0189	0.4370	0.2944	0.0918	0.1079

a–d least squares means within a column lacking a common superscript letter indicate significant differences ($P < 0.05$).
[A] Treatments: control, without dietary fiber; insoluble fiber, replacement of 1% beef lean with 1% insoluble soy hull fiber; pectin, replacement of 1% beef lean with 1% soy hull pectin; mixture, replacement of 1% beef lean with the mixture of 0.5% soy hull pectin and 0.5% insoluble soy hull fiber.
[B] Pooled data from both fresh and frozen/thawed beef patties.
[C] SED: standard errors of means.