LWT - Food Science and Technology 84 (2017) 183–188

Contents lists available at ScienceDirect

LWT - Food Science and Technology

journal homepage: www.elsevier.com/locate/lwt

Control of microbial growth and lipid oxidation on beef product using an apple peel-based edible coating treatment

So-Hyang Shin [a], Yoonjee Chang [b], Monique Lacroix [c], Jaejoon Han [d, *]

[a] Department of Food Science and Biotechnology, Sungkyunkwan University, Suwon 16419, South Korea
[b] Institute of Control Agents for Microorganisms, Korea University, Seoul 02841, South Korea
[c] Research Laboratory of Sciences Applied to Food, INRS-Institut Armand Frappier, Canadian Irradiation Centre, 531 Boulevard des Prairies, Laval, Quebec H7V 1B7, Canada
[d] Department of Food Bioscience and Technology, College of Life Sciences and Biotechnology, Korea University, Seoul 02841, South Korea

ARTICLE INFO

Article history:
Received 17 November 2016
Received in revised form
19 May 2017
Accepted 23 May 2017
Available online 26 May 2017

Keywords:
Edible coating
Apple peel
Carboxymethylcellulose
Microfluidization
Ground beef

ABSTRACT

Edible coating solutions, containing antioxidant and antimicrobial agents, were developed from mixture of apple peel powder and carboxymethylcellulose (CMC). Microfluidization, a high pressure homogenization technique, was used to reduce the particle size for the development of a highly dispersed apple peel powder solution. Tartaric acid was incorporated into apple peel powder/CMC solution, as an antimicrobial for active coating solution. The developed coating solution was applied to fresh beef patties, which were analyzed for antioxidant effects against lipid oxidation and antimicrobial activity against mesophilic aerobic bacteria, molds and yeasts, and *Salmonella enterica*. The sensory attributes were evaluated by 40 panelists. Results showed that active coating treatment completely inhibited lipid oxidation, and efficiently suppressed the growth of microbial on raw beef patties. The active coating formulation did not affect the sensory characteristics of raw and cooked beef patties. Therefore, apple peel-based edible coating treatment could be applied to meat products to protect the quality and prevent deterioration.

1. Introduction

Edible coating formulations include biopolymers or biomass and various additives, such as plasticizers, antioxidants, and antimicrobial agents (Takala, Salmieri, Vu, & Lacroix, 2011). They enhance the quality of food products by extending shelf-life and preventing physical, chemical, and biological deterioration (Pranoto, Rakshit, & Salokhe, 2005). To maintain and extend the shelf-life of food products, natural compounds have been used to replace chemical preservatives that can potentially lead to problems with toxicity. Typical natural antioxidant and antimicrobial compounds include phenolic compounds and organic acids (Nychas, 1995).

Apples are one of the most widely cultivated fruits in the world (FAOSTAT, 2010). Large amounts of apple peel are generated as manufacturing by-products (Wolfe, Wu, & Liu, 2003) and it is estimated that approximately 9000 tons of apple peel are generated each year by the apple processing industry (Henríquez et al., 2010). Various phenolic and flavonoid compounds exist in apple peel which are responsible for the high antioxidant capacity (Veberic et al., 2005). Consequently, new methods of utilizing apple peel as biomass have been sought after, including in edible coating formulations. However, preliminary studies have shown that a film-layer made from apple peel powder alone exhibits uneven and brittle surface characteristics (Shin, Kim, Lee, Park, & Han, 2014), which restrict its industrial applications. Hence, it is necessary to find suitable ways to strengthen the film-forming ability of an apple peel powder, a blend of apple peel powder and plant-derived biopolymer materials (starch, cellulose, other polysaccharides, and proteins) as the thickening agents, for examples.

Carboxymethylcellulose (CMC) is one of the biopolymeric cellulose derivatives which is well-known for its good film-forming property (Minami, Kim, Miyashita, Kazaoui, & Nalini, 2006). Moreover, as CMC has biodegradability, flexibility, and non-toxicity, it has been used in edible film formulation (Toğrul & Arslan, 2004). It also provides a good barrier against oxygen, oil, moisture, and it shows amphiphilic characteristics. Therefore, it would be a good

* Corresponding author. Department of Food Bioscience and Technology, College of Life Sciences and Biotechnology, Korea University, Seoul 136-701, South Korea.
E-mail address: jjhan@korea.ac.kr (J. Han).

http://dx.doi.org/10.1016/j.lwt.2017.05.054
0023-6438/

additive for edible coating.

Another method to facilitate film-forming ability is to reduce the particle size of biomass particles in coating formulations. Microfluidization, which is a high-pressure homogenization technique, can be beneficially applied to apple peel powder disaggregate using a combination of pressure and shear force (Khan et al., 2014). When a high-pressure homogenization is applied to a biomass coating solution, it can reduce biomass particle size, thus, the materials become miscible, and the coating solution is homogenized (Shin et al., 2014). The physical and barrier properties, as well as the appearance of the resulting blended coating formulations, may therefore be different following a high-pressure homogenization treatment.

Edible coating can be endowed with antimicrobial functionality through formulations with antimicrobial agents. Organic acids are generally recognized as safe (GRAS), and they are either naturally present in fruits and vegetables or synthesized by microorganisms via fermentation (Beuchat, 1998). In addition, they are low-cost and easy to manipulate without inducing sensory changes in products, such as meat and poultry. Therefore, organic acids are excellent antimicrobials against bacteria (Eswaranandam, Hettiarachchy, & Johnson, 2004). Tartaric acid is a dicarboxylic organic acid found naturally in various fruit-bearing plants and berries and it has been approved for direct addition to food products (Eswaranandam et al., 2004; Mani-López, García, & López-Malo, 2012). In our preliminary study (Lee, Han, & Han, 2016), antimicrobial activities of five different organic acids were tested, and tartaric acid showed the most effectiveness in antimicrobial and antioxidant properties with the least acidic aroma. Moreover, tartaric acid was previously reported as an antimicrobial agent which could control *Salmonella* in meat and poultry products (Mani-López et al., 2012). *Salmonella* is one of the most widely distributed pathogens, responsible for serious illness and death worldwide. Ground beef can become contaminated during processing if pathogens on the carcass surfaces survive intervention procedures (Brichta-Harhay et al., 2008). This has led to numerous ground beef recalls in the last five years due to *Salmonella* contamination (CDC, 2012; FSIS-USDA, 2012). Therefore, it is important to manage and storage in a safe way. Thus, we selected tartaric acid as an organic acid for antimicrobial coating formulation.

The aims of the present study were (1) to develop an apple peel-based edible coating formulation, (2) to determine the inhibition ability of lipid oxidation and microbial killing effect, and (3) to evaluate the sensory effects of the coating treatments when applied to fresh or cooked ground beef patties during refrigerated storage. This is the first report to develop apple peel-based edible coating for both lipid oxidation prevention and microbial growth inhibition to enhance food safety.

2. Materials and methods

2.1. Apple-peel powder preparation

Fresh Fuji apples (*Malus domestica* Borkh.) were obtained from a local farm in Yungjoo, Korea. After washing and peeling, the apple peels (with an average thickness of 0.36 ± 0.10 mm) were dried in an oven (VS-1202D2, Vision Scientific Co., Daejeon, Korea) at 45 °C for 24 h. The dried peels were then finely pulverized using an electric grinder (Daesung Artron Co., Seoul, Korea), and particles smaller than 149 μm were separated by passing through a standard sieve (U.S. No. 100). The collected apple peel powder was used to make edible coating solutions.

2.2. Preparation of the coating solutions

To prepare the CMC coating solution, glycerol (0.5 g) used as a plasticizer, and 1.5 g of CMC (Sigma-Aldrich Co., Ltd., St. Louis, MO, USA) were dissolved in 50 mL of distilled water (final concentration; 3% w/v) for 24 h. For the active coating solution with antioxidant and antimicrobial functionality, 1.5 g of apple peel powder was dispersed in 50 mL distilled water (final concentration; 3% w/v) including glycerol (0.5 g), and the solution was then treated using a high-pressure homogenizer (M-110S, Microfluidics 137 International Co., Newton, MA, USA) to reduce the apple peel powder particle size. The high-pressure homogenizer, which had a H10Z (100 μm) interaction 138 chamber, was run at 150 MPa for three passes. Then, 0.75% (w/v) L (+)-tartaric acid (2,3-dihydroxybutanedioic acid) (Junsei Chemical Co., Tokyo, Japan) was added to the prepared mixture. The resulting solutions (CMC coating solution and active coating solution) were homogenized using a homogenizer (Model SR30, Mtop-Korea, Seoul, Korea) at 18,000 rpm for 1 min and degassed, using an aspirator, to remove air bubbles.

2.3. Preparation of sample ground beef patties

Fresh raw beef was purchased from a local butcher shop (Seoul, Korea) and prepared using separable lean from top round roasts. On the day of purchase, the roasts were trimmed of all separable fat and connective tissue, and then ground twice through a 1.27 cm plate, followed by a 0.32 cm plate. Beef patties were formulated with beef of similar fat content using a lean cut (low in fat) and were combined in the proportions necessary to achieve approximately 20% (w/w) fat content. Then, each beef patty (10 g) was formed on plates (35 mm diameter, 10 mm thickness).

Fat content of the meat sample was analyzed according to the method of Folch, Lees, and Sloane-Staneley (1957). A 5 g portion of meat sample was homogenized with 75 mL of chloroform:methanol (2:1, v/v) using a stirrer for 3 min. After filtering, the meat residue was re-homogenized for 3 min with 5 mL of chloroform:methanol (2:1), and then re-filtered. The collected filtrate was transferred to a separatory funnel, and then 25 mL of distilled water was added and the phases were allowed to separate. The lower phase in the funnel (organic phase) was drained and brought to a volume of 100 mL with pure chloroform. The solvent was removed under reduced pressure at below 40 °C using a rotary evaporator, and the samples were dried at 100 °C for 1 h. The mean fat content was determined by averaging the triplicates.

2.4. Preparation of packed ground beef patties for evaluating lipid oxidation

The ground beef patties were prepared as follows: control (ground beef patties without coating solution), ground beef patties coated with CMC coating solution, and ground beef patties coated with active coating solution. The ground beef patties were picked up using sterilized tongs and completely immersed into one of the two different (CMC or active) coating solutions for 5 s. After immersion, the beef patties were dried on petri dishes at room temperature for 10 min, and the process was repeated twice. Both the coated beef patties (with CMC- and active coating solutions) and the uncoated beef patties (control) were packed in polypropylene (PP) containers (400 μm thickness, 135 mm width, 135 mm depth and 40 mm height; O_2 permeability = 79.40 × 10^3 cc·μm/m^2·day·atm; SR Technopack, Cheonan, Korea), and all PP containers were covered with low density polyethylene (LDPE) films