Effects of *Salicornia herbacea* Powder on Quality Traits of Sun-Dried Hanwoo Beef Jerky during Storage

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Abstract

The objective of this study was to evaluate the quality characteristics of sun-dried Hanwoo beef jerky added with *Salicornia herbacea* (SH). Sliced Hanwoo beef shank were marinated and sun-dried at 28-30°C, relative humidity (RH) 30-35% for 3.5 h. The physicochemical and microbiological traits of the Hanwoo beef jerky were analyzed during the aerobically packaged storage at 25°C. The water activities of beef jerky with 0.5% and 1.0% SH were lower than those of the control at 0 d (p<0.05). The pH values of beef jerky with SH were significantly higher than those of the control (p<0.05). The beef jerky with SH and ascorbic acid showed significantly lower TBARS values than the control (p<0.05). The beef jerky with SH showed a significantly lower redness (a*) than the control (p<0.05). Total plate count (TPC) of beef jerky with 1.0% SH was significantly lower than that of the control during the storage of 20 d (p<0.05). Yeast/mold was detected in the control and beef jerky with SH after storage periods of 10 and 20 d, but was not detected in jerky with ascorbic acid. With regard to the sensory properties, beef jerky with SH showed significantly greater flavor scores than the others (p<0.05). The result shows that SH powder can be used to increase the sensory quality and microbial safety of beef jerky.

Key words: beef jerky, sun-dried, *Salicornia herbacea*, quality, microbial safety

Introduction

Jerky is a food that has been prepared by humans at least since ancient Egyptian times. It derived from the Spanish word “charqui” and is classified by the U.S. Department of Agriculture (USDA) as a heat-treated and shelf-stable ready-to-eat meat product (USDA-FSIS, 2011). As a meat product, beef jerky is nutritious and shelf-stable due to its low water content, resulting in its high demand as a snack food (Calicioglu et al., 2003). Although the moisture content of beef jerky is low, there are still microbial safety problems during marketing and distribution in Korea, as well as worldwide (Park et al., 2009). Therefore, the efficacy of pretreatment on the inactivation of foodborne pathogens in the beef jerky-making process should be investigated. Jerky is preserved by curing and drying to reduce water activity and control microbial survival and growth (Choi et al., 2008).

Drying is the world’s oldest and most common method of food preservation in production of meat and meat products. By drying, the meat products such as jerky reach $a_w$ of 0.6-0.9 equivalent to a RH of 60-90% at ambient temperature and the growth of microorganisms can be efficiently inhibited by a low $a_w$ system (Chang et al., 1996). There are several types of drying methods in the process of making jerky. For example, natural drying, hot and cold air-drying, vacuum drying, freeze-drying and so on can be used (Kim, 1990; Labelle and Moyer, 1966). Two types of natural drying are used mainly, which is sun and shade drying as traditional system. Traditional sun-drying process could be very time-consuming in drying and hard to control moisture contents (Lee et al., 2004). Hot air-drying from an artificial heat source is commonly used in the meat processing plants and done by placing food in either a warm oven or a food dehydrator (USDA-FSIS, 2011). This drying method is useful to inhibit the growth of microorganisms by lowering moisture contents during the hot air-drying process and prompt-dried evenly (Kim, 1990; Labelle and Moyer,
1966). However, it has some disadvantages of not only surface hardening by this rapid drying and deterioration in meat quality such as flavor and texture due to maillard reaction (Labelle and Moyer, 1966), but also it is more susceptible to lipid oxidation and meat color with increasing drying time and temperature (Kim, 1990). So far, there have been few attempts to assess the quality and microbiological aspects of Hanwoo beef jerky produced under different drying conditions.

Lipid oxidation can have negative effects on the meat quality causing changes in sensory attributes (color, texture, odor, and flavor) and nutritional quality. Synthetic antioxidants such as butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) have been widely used in meat to suppress or retard the lipid oxidation (Chastain et al., 1982). However, the use of synthetic antioxidants has come under more scrutiny due to their potential toxicological effects (Rababah et al., 2004). Consumer preferences for natural products have resulted in increased interest in the use of natural antioxidants. Recently, there is a growing interest in searching for natural antioxidants due to their lower toxicities than synthetic antioxidants (Kim et al., 2012). *Salicornia herbacea* (SH) has been known as glasswort and distributed in salt marshes and muddy seashores along the Western coast of Korea (Chung et al., 2005). This plant, which is called ‘hamcho’ and ‘tungtungmadi’ in Korean, is consumed in a variety of ways such as a seasoned vegetable, salad, and fermented food in coastal areas of Korea (Kim et al., 2010). The whole plant is greedily devoured by cattle for its salty taste. It has been used as a traditional medicine for disorders such as constipation, obesity, diabetes, and cancer (Bang et al., 2002). SH (also known as glasswort) is annual succulent herb of Chenopodiaceae family and one of the most salt tolerant plants (Kim et al., 2012). It contains large amounts of salts and minerals such as magnesium, calcium, potassium, and iron (Cho et al., 2008). It also contains large amounts of betaine and choline. The beneficial effects of consuming SH may be in part due to betaine or choline absorption (Shin et al., 2002).

Recently, the consumption of the plants has been extended into the functional food and medicinal plant due to its beneficial effects (Cho et al., 2008). A number of investigators have reported anti-oxidative, immunomodulatory, anti-hyperglycemic, and anticancer activities of SH (Lee et al., 2006), although there are a few references that may explain scientific base for its claimed therapeutic use. SH powders have recently been shown to reduce serum cholesterol and lipid contents in rats when fed with drinking water (Jo et al., 2002).

However, studies on the physiochemical traits of sun-dried beef jerky added with natural antioxidant plant such as SH have rarely been reported. Therefore, the aim of the study was to investigate the effects of SH powder on the physicochemical quality and microbiological safety in sun-dried Hanwoo (Korean native cattle) beef jerky during storage.

### Materials and Methods

#### Preparation of beef jerky

Four fresh Hanwoo beef shank muscles were purchased from local retail shops (Goheung, Korea) to make 4-replication and were frozen at -45°C. After thawed until the internal temperature reached to -1°C in the refrigerator prior to 1 d, beef samples were sliced to 0.5 cm-thick pieces with a meat slicer (HFS 350G, Hankook Fugee, Korea). The sliced jerky samples were cut parallel in direction to muscle fibers and all subcutaneous and intermuscular fat and visible connective tissue were removed from the muscles. The formulation for the production of Hanwoo beef jerky is presented in Table 1.

Four different beef jerky formula including 0% (control), 0.5% SH powder, 1.0% SH powder, and 0.5% ascorbic acid were prepared. Ascorbic acid was used to compare the anti-oxidative activities of SH in beef jerky. The SH powder was prepared by drying at 50°C for 48 h and passed through 100 mesh sieve. The sliced beef samples were submerged for 24 h in a curing liquid. The cured samples were then mixed using a mixer (SK5S5, KitchenAid, USA) for 1 min and aged for 24 h in refrigerated temperature. All cured muscles samples put on netted tray were sun-dried in the open sunny spot with air breezes at 28-30°C, finally containing around relative humidity (RH) 30-35% for 3.5 h until a_w reached below 0.75. All dried samples were then stored in a desiccator at room temperature until used for further analysis. The jerky samples were loosely packed in oxygen impermeable plastic bags and displayed at room temperature for up to 20 d.

#### Moisture contents and water activity

Moisture content was obtained with a slightly modified method of AOAC methods (AOAC, 2000). The total moisture content of 3 g of finely chopped samples placed in aluminum moisture dishes were determined from their pre-dry and dry weights (dried in an air oven at 104°C for 24 h) and expressed as the percentage of pre-dry weight and gram water per gram dry weight. The moisture con-