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Effect of Tenderizer on Physical Quality and Microbial Safety during Korean Beef Jerky Production

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한국형 우육포의 제조공정 중 연화제가 육포품질 및 미생물학적 안전성에 미치는 영향

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Abstract

The physical quality and microbial safety of Korean beef jerky was evaluated at various steps during its preparation. Microbial counts in raw beef demonstrated mesophillic bacteria at 4.20 Log CFU/g, psychrotrophic bacteria at 3.85 Log CFU/g, anaerobic bacteria at 4.90 Log CFU/g, and yeast and molds at 1.92 Log CFU/g. Spore-forming bacteria and coliforms were not detected in raw beef samples. Spices and spiced meats showed similar trends in microbial counts, demonstrating minimal microbial contamination during these stages of preparation. The final beef jerky product exhibited counts of mesophillic bacteria at 1.15-1.66 Log CFU/g, psychrotrophic bacteria at 1.15-1.66 Log CFU/g, and anaerobic bacteria at 0.81-1.72 Log CFU/g. Spore-forming bacteria, yeast and molds, and coliforms were not detected in beef jerky. Significant differences from added ingredients occurred for instron textural profile analysis traits for hardness. In general, Korean beef jerky with humectant and tenderizer had lower hardness than control (without humectant and tenderizer). Also, the sample added with 0.01% protease from *Streptomyces griseus* had lower hardness than all samples. All samples had 0.71 to 0.72 water activities, and the color and pH were not shown in significant changes of all samples.

Key words : Korean beef jerky, physical quality, microbial safety, protease

Introduction

Food-borne illness poses a significant public health threat throughout the world. Chemical and microbial contaminants pose a significant health risk for the consumers, marketers, and producers of agricultural products. Current estimates suggest that microbial food-borne illnesses will affect between 6.5 and 33 million people in the United States each year, and will account for as many as 9,000 deaths (Smith, 2000).

Jerky is a food that has been prepared by humans at least since ancient Egyptian times. This product is a nutrient-dense meat that has been made lightweight by drying. A pound of meat or poultry weights about four ounces after being made into jerky. Because most of the moisture is removed, it is shelf stable and can be stored without refrigeration, making it a handy food for backpackers and others who don't have access to refrigeration (FSIS, 2006).

Intermediate moisture (IM) meat products are processed almost everywhere in the world and each product has its own characteristics. Since there has been an increase in refrigeration costs, increasing interest in IM meat products has developed (Garcia *et al.*, 2001). After drying, the IM meat product reaches an a_w of 0.6-0.9 equivalent to a relative humidity (RH) of 60-90% at ambient temperature (Ledward, 1981; Chang *et al.*, 1996). The application of a processing method that involves hurdle technology results in charqui meat (Leistner, 1987). As recently described, salt, sodium nitrite, dehydration, and packaging are hurdles sequentially applied to inhibit spoilage microorganisms (Torres *et al.*, 1994; Shimokomaki *et al.*, 1998) .

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Humectants are hygroscopic, "water-pulling" substances that are incorporated into food in order to promote retention of moisture. These substances include moisture-retention agents and anti-dusting agents. Since hygroscopic substances, such as glycerin, absorb water from the air, the addition of humectants can keep foods moist.

Texture is an important characteristics of meat products that influences consumer preference. Meat toughness can be subdivided into actomyosin toughness, which is attributable to changes in myofibrillar proteins, and background toughness, which is attributable to connective tissues (Chen *et al.*, 2006). Because most of the moisture in jerky is removed, it has a stable shelf-life, is microbiologically safe (a_w<0.70), is easy to prepare, light-weight, has a rich nutrient content, and can be stored without refrigeration (FSIS, 2006).

The objective of this study was to assess the physicochemical quality and microbiological safety of Korean jerky meats during its preparation.

Materials and Methods

Preparation of Korean beef jerky

A ready-to-eat type of jerky was prepared from beef. Fig. 1 summarizes the processing of the jerky product and indicates the points in this process at which samples were collected for analysis.

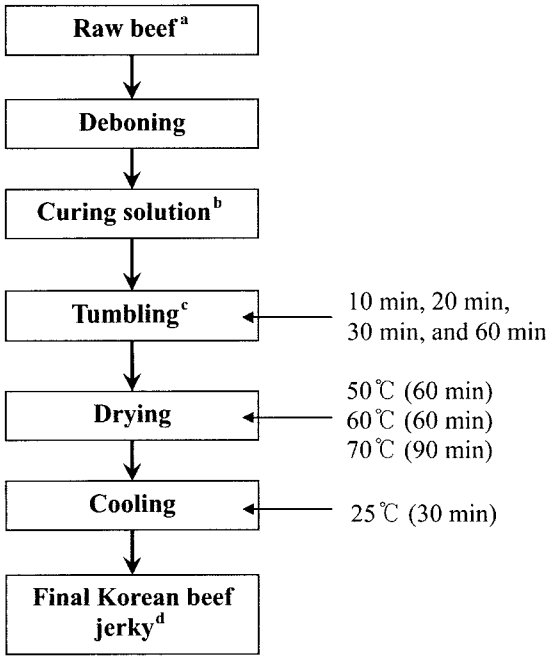

Fig. 1. Flow chart of Korean beef jerky process showing the actual location of samples collection for microbial analysis. The samples were collected in the points listed below: a, raw beef; b, jerky spice; c, after wet tumbling; d, finished manufactured product.

The composition (w/w) of jerky spice was water (10%), soy sauce (9%), starch syrup (5%), sugar (2%), D-sorbitol (6%), pepper (0.5%), ginger powder (0.1%), garlic powder (0.2%), onion powder (0.2%), sodium nitrate (0.007%), sodium citrate (0.01%), potassium sorbate (0.1%), sodium erythrobate (0.036%), and soup stock powder (0.1%). The spice mixture also contains a humectant and tenderizer to improve the moisture and texture of the jerky. The humectant was prepared for 1.0 kg of raw beef as added konjack 0.05%. The tenderizer was comprised of proteases derived from *Streptomyces griseus* (add protease from *S. griseus* into tenderizer, TS1; 0.01%, TS5; 0.005%) and *Bacillus polyfermenticus* SCD (add protease from *B. polyfermenticus* SCD into tenderizer, TB1; 0.01%, TB5; 0.005%).

Treated raw beef was phase dried in dehydrators at 50°C for 60 min, 60°C for 60 min, and 70°C for 90 min. The dehydrators were rectangular in shape and consisted of a base unit and three drying trays. The dehydrator base unit generated hot air, which ventilated upward through the sides and a hole in the middle of the trays. The target temperature was based on the air temperature measurements taken from the middle hole of the dehydrator. The empty trays were then replaced with trays loaded with meat slices. After drying, the jerky strips were held in the dehydrators overnight to allow the moisture level in the jerky slices to equilibrate. The jerky was subsequently placed into sterile plastic bags.

Physicochemical analysis

The texture of the meat slab was measured as piercing force by inserting a plunger of 5 mm diameter into a meat block using a Rheometer (model Compac-100, Sun Scientific Co., Japan). The texture of stored meat slices was quantified as cutting force by inserting a blade of 0.26 mm diameter using the Rheometer into a cylindrical slice, using a 10 kg load and a plunger speed of 60 mm/min.

The surface color of the meat was measured using a Hunter color system (L, a, and b values) using a Color Difference Meter (model JC 801, Color Techno System Corp., Tokyo, Japan). The pH of the product was measured for the brine solution using an Orion model 520A pH Meter (Orion Research Inc., Boston, USA). Water activity was determined, in duplicate, using a Rotronic Hygroskop DT (Rotronic Instrument Corp., Huntington, USA) at 25°C according to manufacturer's instruction.

Microbiological analysis

Microbiological analysis was performed on raw beef, jerky spice mixtures, spiced meats, and processed jerky products. In order to assess the microbial contamination of

the stored jerky product, duplicate packs from each treatment were taken and 50 g samples of the meat were aseptically transferred into a sterile lateral filter bag (Interscience, St Nom, France). Fifty mL of sterile 0.1% peptone water (Difco Laboratories, Detroit, MI, USA) were added to each bag, and the samples were macerated for 2 min. These samples were then subjected to serial dilution in 0.1% peptone water.

The presence of mesophilic microorganisms was determined using Plate Count agar (PCA, Difco) at 35°C for 48 hr and psychrotrophic microorganisms were incubated at 21°C for 72 hr using PCA. Anaerobic microorganisms were determined by spread-plating on PCA using a BBL anaerobic jar (Difco) at 35°C for 48 hr. Spore-forming bacteria were formed through heat treatment at 80°C for 10 min and plated on PCA at 35°C for 48 hr. The yeast and molds were counted after incubation at 25°C for 5 to 7 d on Potato Dextrose agar (PDA, Difco), which was adjusted to pH 3.5 with tartaric acid. Coliforms were determined using Violet Red Vile agar with MUG (Difco) at 35°C for 48 hr.

Results and Discussion

Physicochemical analysis

The pH values of jerky generally ranged from 5.60 to 5.70 (Table 3). Based on the experimental results, Korean beef jerky prepared with humectant and tenderizer did not affect its pH. Jose *et al.* (1994) reported that the average pH for IM-meat products was in the broad range of 4.72-6.73. Also, Lee *et al.* (2004) reported that the pH value of gamma-irradiated semi-dried beef jerky was between 5.81 and 5.85, and Choi *et al.* (2008) reported that the average pH for semi-dried jerky prepared with various pork/beef levels and casings was between 5.73 and 5.76, values that were similar to our results here.

When manufacturing IM-food, it is important to control the water content because water activity is closely related to water content (Leistner, 1987). In this study, the water activity of semi-dried jerky was within the range of 0.71-0.72 (Table 3). Water activity is useful in describing the thermodynamic equilibrium state of jerky (Labuza, 1980; Rockland and Nishi, 1980), and foods such as jerky must have a stable water activity to avoid changes in quality during storage (Yamaguchi *et al.*, 1986). Thus, the manufacturing process has an important effect on the water activity and, hence, the quality of the product during the storage.

Texture is an important factor in the preparation of meat products and in consumer preference (Szczesniak and Kleyn, 1963; Guerrero *et al.*, 1999). In this study, the texture (hardness) of Korean beef jerky was within the range of 4.52-4.83 (Table 3), and Korean beef jerky with humectant and tenderizer had lower hardness than control (without humectant and tenderizer). Also, TS1 had lower hardness than all beef jerky. Kim *et al.* (2008) reported that tenderness of jerky with crude protease was greater than the control on sensory evaluation and these results are consistent with those reported in instrument texture analysis. Lee and Kang (2003) indicated that the texture of jerky-type snack foods is one of the most important sensory attributes, determining the uniqueness and market attractiveness of the products. Konieczny *et al.* (2007) indicated that the high chewiness of home style beef jerky is a desirable attribute for the consumer.

Table 1 shows the color values (L, a, b) of pork jerky prepared with humectant and tenderizer. The L (lightness), a (redness), and b (yellowness) values were not significantly different regardless of the kind of humectant and tenderizer. While Han (2006) reported that the addition of humectants had an only slight effect on the color of pork jerky, Kim *et al.* (2008) reported protease was found to have a greater effect on the CIE-L value of beef jerky, however jerky held

Table 1. Physical analysis of beef jerky

Parameters	Control	Humectant[1)]	Tenderizer[2)]			
			TS1	TS2	TB1	TB2
Water activity	0.71±0.43	0.71±0.57	0.71±0.52	0.71±0.47	0.72±0.44	0.71±0.51
Color						
L	41.95±0.64	41.27±0.85	41.24±0.96	40.66±0.69	40.51±0.57	40.39±0.54
a	4.83±0.83	4.06±0.85	3.35±0.74	6.49±0.71	6.80±0.48	7.15±0.52
b	1.11±0.28	0.92±0.29	0.78±0.59	0.65±0.44	0.56±0.27	0.46±0.34
Hardness (kg)	4.83±0.60	4.69±0.42	4.46±0.57	4.74±1.04	4.52±0.55	4.67±0.50
pH	5.70±0.09	5.67±0.09	5.63±0.07	5.62±0.05	5.60±0.07	5.60±0.04

[1)] Humectant: prepared for 1.0 kg of raw meat as add konjack 0.05%

[3)] Tenderizer: comprised of proteases derived from *Streptomyces griseus* and *Bacillus polyfermenticus*. TS1: added protease from *S. griseus* at 0.01%, TS5: added protease from *S. griseus* at 0.005%, TB1: added protease from *B. polyfermenticus* at 0.01%, TB5: added protease from *B. polyfermenticus* at 0.005%.

for 24 hr after marination showed no significant difference in CIE-L value, and the CIE-a and b values were not significantly different regardless of the type of crude protease and holding time.

Microbiological analysis

Microbial contamination may be increased or reduced at different stages of processing of Korean beef jerky. The results for microbial contamination in raw meat and jerky spice are summarized in Table 1. Raw beef contained mesophillic bacteria at 4.20 Log CFU/g, psychrotrophic bacteria at at 3.85 Log CFU/g, anaerobic bacteria at 4.90 Log CFU/g, and yeast and molds at 1.92 Log CFU/g. Jerky spice contained mesophillic bacteria at 1.41-2.96 Log CFU/g, psychrotrophic bacteria at 1.04-1.60 Log CFU/g, anaerobic bacteria at 1.20-1.76 Log CFU/g, and yeast and molds were not detected. Spore-forming bacteria and coliform were not detected in raw beef and spice samples.

The incidence of microbial count in jerky is summarized in Table 2. Spiced meat contained mesophillic bacteria at 3.18-5.04 Log CFU/g, psychrotrophic bacteria at 3.23-5.04 Log CFU/g, anaerobic bacteria at 3.15-5.04 Log CFU/g, and yeast and molds at 1.62-4.85 Log CFU/g. Spore-forming bacteria and coliform were not detected. Beef jerky had mesophillic bacteria at 1.15-1.66 Log CFU/g, psychrotrophic bacteria at 0.81-1.72 Log CFU/g, and anaerobic bacte-

Table 2. Distribution of microbial groups in raw beef and spice (Unit: Log CFU/g)

		Mesophilic bacteria	Psychrotrophic bacteria	Anaerobic bacteria	Yeast & Molds	Spore-forming bacteria	Coilform
Raw beef		4.20	3.85	4.90	1.92	ND[1)]	ND
Spice	Control	2.15	1.04	1.20	ND	ND	ND
	Humectant[2)]	2.18	1.58	1.53	ND	ND	ND
	Tenderizer[3)]						
	TS1	2.96	1.60	1.76	ND	ND	ND
	TS2	1.41	1.32	1.57	ND	ND	ND
	TB1	1.54	1.53	1.49	ND	ND	ND
	TB2	1.48	1.48	1.43	ND	ND	ND

[1)] ND: Not detected.

[2)] Humectant: prepared for 1.0 kg of raw meat as add konjack 0.05%.

[3)] Tenderizer: comprised of proteases derived from *Streptomyces griseus* and *Bacillus polyfermenticus*. TS1: added protease from *S. griseus* at 0.01%, TS5: added protease from *S. griseus* at 0.005%, TB1: added protease from *B. polyfermenticus* at 0.01%, TB5: added protease from *B. polyfermenticus* at 0.005 %.

Table 3. Distribution of microbial groups in spicy meat and jerky product (Unit: Log CFU/g)

		Mesophilic bacteria	Psychrotrophic bacteria	Anaerobic bacteria	Yeast & Molds	Spore-forming bacteria	Coilform
Spiced meat	Control	3.18	3.23	3.15	2.04	ND[1)]	ND
	Humectant[2)]	3.26	3.30	3.20	2.30	ND	ND
	Tenderizer[3)]						
	TS1	4.91	4.89	4.66	1.79	ND	ND
	TS2	5.04	4.93	4.80	1.62	ND	ND
	TB1	4.67	5.04	4.81	1.98	ND	ND
	TB2	4.76	4.94	5.04	4.85	ND	ND
Jerky product	Control	1.59	1.72	1.69	ND	ND	ND
	Humectant	1.66	1.65	1.51	ND	ND	ND
	Tenderizer						
	TS1	1.36	1.34	1.41	ND	ND	ND
	TS2	1.23	1.26	1.26	ND	ND	ND
	TB1	1.15	1.04	1.30	ND	ND	ND
	TB2	1.32	0.81	0.54	ND	ND	ND

[1)] ND: Not detected.

[2)] Humectant: prepared for 1.0 kg of raw meat as add konjack 0.05%.

[3)] Tenderizer: comprised of proteases derived from *Streptomyces griseus* and *Bacillus polyfermenticus*. TS1: added protease from *S. griseus* at 0.01%, TS5: added protease from *S. griseus* at 0.005%, TB1: added protease from *B. polyfermenticus* at 0.01%, TB5: added protease from *B. polyfermenticus* at 0.005%.

ria at 0.54-1.51 Log CFU/g. Spore-forming bacteria, yeast and molds and coliforms were not detected in beef jerky.

The microbial counts of raw beef used for jerky were consistent with previous studies (FSIS, 1994; FSIS, 1996a; FSIS, 1996b; Kim *et al.*, 2005) and are within the microbiological standards for fresh meat (ICMSF, 1980). On average, the raw beef emulsion contained 5.0×10^2 CFU enterobacteriaceae/g, a mesophoilic count of 1.6×10^5 CFU/g, and lactic acid bacteria counts of 1.0×10^4 CFU/g (Borch, 1988). The significant increase in yeast and molds and coliforms in the present study may be ascribed to other ingredients, such as starch and spices. However, this increase in microbial counts does not have much relevance from the point of microbial safety, because the subsequent cooking process would largely eliminate these contaminants.

Our results indicate that heating for 60 min at 50°C, 60 min at 60°C, and 90 min at 70°C effectively reduced the microbial counts. This study suggests that measures such as maintaining low initial microbial counts, hygienic precautions during preparation of jerky, heating for 60 min at 50°C, 60 min at 60°C, and 90 min at 70°C was sufficient to curb microbial growth and thus ensure the wholesomeness and safety of the jerky.

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