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# Marination Technique Influences Whole Muscle Beef Jerky Salt Content and Flavor Intensity

*G.R. Skaar and E.A.E. Boyle*

## Introduction

Beef jerky is a popular meat snack that is simple to recognize and define. The USDA Food Standards and Labeling Policy Book (FSLPB) allows labeling use of the title “jerky” to a product that has been dried to a moisture-to-protein ratio (MPR) of 0.75:1.0 or less, and states the species or kind (such as beef, pork, or venison) in the name. As long as the product is dried to the required MPR and the species of origin is noted, all additional ingredients used, spice applications, and processing procedures are open for interpretation and application. The USDA FSLPB goes on to state that the product may be cured or uncured, dried, and may be smoked or unsmoked as well as air dried or oven dried.

With such a short list of requested, jerky has a great deal of optimization potential for small- and large-scale production. Marination of sliced meat is one stage in the jerky-making process that is open to variation. Our study compared two common beef jerky marination techniques: 1) traditional marination via extended soaking in a tub, and 2) short-time vacuum tumbling. Additionally, a liquid smoke-based anti-mold spray provided by Kerry Ingredients & Flavors (Monterey, TN) was applied after drying to evaluate the final product for taste differences.

## Experimental Procedures

### *Jerky Production*

Beef inside rounds were obtained from the Kansas State University Meat Laboratory. Three rounds were used, one on each of three days, resulting in three replicated jerky production batches. On the initial day of production a round was trimmed practically free of fat and heavy connective tissue, weighed as an intact muscle, and then sliced into 0.25- to 0.125-in.-thick pieces. The round slices were weighed and separated into two equal weight portions; half were designated for a traditional, long-time soaking marination and half for short-time vacuum tumbling. Those slices designated for tumbling were re-packaged in a vacuum bag and stored in a cooler to be tumble-marinated the following day. The slices for traditional long-time soaking marination were placed in a large tub with 42.7% marinade (Table 1), according to meat weight. Alternating layers of sliced beef and marinade were added until all designated beef and marinade were utilized. A single piece of plastic wrap was placed over the marinating beef to serve as a temporary seal to prevent drying of those pieces on the top layer. Beef slices soaked for 24 hours in cooler storage.

The following day, soaked pieces were removed from the tub and weighed to find the amount of marinade picked up by the meat. This ratio (% pickup) was used to determine the amount of marinade to be added during vacuum tumbling. The remaining half of the sliced round was then placed in a vacuum tumbler (Model VTS-42, Biro Manufacturing, Marblehead, OH) with the correlating amount of marinade from above. Twenty-in. mercury (Hg) vacuum was applied and the beef slices were tumble-

marinated for 20 minutes. After tumbling, both marination treatments were randomly placed on a single smoke truck to be cooked and dried. The product was cooked for 90 minutes at 140°F and dried for 2.5 hours at 145°F. Upon completion, a final dried weight for the product was recorded and each marination group was split in half by weight. Lastly, a liquid smoke-based anti-mold spray (Kerry Ingredients & Flavors, Monterey, TN) was applied to one half from each marination technique. Final production treatments were as follows: (1) soaked, not sprayed (S); (2) soaked, sprayed (SS); (3) tumbled, not sprayed (T); and (4) tumbled, sprayed (TS). Product was allowed to cool to at least 40°F for packaging and then stored for subsequent analysis.

### ***Jerky Evaluation***

Color was evaluated with readings taken with a HunterLab MSEZ-4500L spectrophotometer (Hunter Associates Laboratories, Reston, VA). Individual jerky pieces were placed on top of another jerky piece prior to taking each set of readings. Values were recorded for L\* (lightness), a\* (redness), and b\* (yellowness).

Water activity readings were taken with an AquaLab 4 Water Activity Meter (Decagon Devices, Pullman, WA). Readings were taken in duplicate for each treatment on the day of production.

Warner-Bratzler shear force values were evaluated using an Instron Universal Testing Machine (Instron Worldwide, Norwood, MA). Six 1.2-in.-wide strips were cut and sheared from each treatment/production day, taking care to avoid areas where the product may have folded over and dried together or areas where the product appeared uncharacteristically thin. A flat blade was used to cut each strip six times with readings taken to assess total force required to shear each strip.

Salt (NaCl) content was analyzed with Quantab chloride strips (Hach Company, Loveland, CO). Samples were frozen with liquid nitrogen, pulverized in a blender, and mixed with boiling water. After cooling to room temperature, samples were filtered and evaluated with an individual test strip, according to the manufacturer's printed instructions, for Quantab number and correlating NaCl concentration.

Moisture and protein composition were evaluated by the Kansas State University Analytical Laboratory for use in determining the MPR.

A sensory panel composed of faculty and students from the Kansas State University Department of Animal Sciences and Industry was assembled and trained over three orientation sessions on the assessments to be taken for the beef jerky samples. Panelists were asked to score jerky samples on a scale of 1 to 8 for initial bite (1 = extremely soft, 8 = extremely firm), chewiness (1 = no chews, 8 = 19 to 21 chews), moisture (1 = extremely dry, 8 = extremely moist), saltiness (1 = not at all salty, 8 = extremely salty), flavor intensity (1 = extremely bland, 8 = extremely intense), smoke flavor (1 = none, 8 = abundant), and off-flavor intensity (1 = abundant, 8 = none). Jerky from each of the four treatments made on each of the three production days resulted in 12 total "products," each of which were evaluated by the panel twice. Six panel sessions were held with each of the four treatments represented in all panels. The production day used for each panel was randomly selected from each treatment independently.

## Results and Discussion

During production, marinade pickup percentage was approximately 3% higher for soaked product compared with tumbled product. Soaked product was placed in a marinade amount equal to 42.7% of the meat weight, whereas tumbled product was placed in a marinade amount equal to the percentage pickup of the soaked product for that production day, equaling 23.5%, 20.8%, and 24.3% for productions 1, 2, and 3, respectively. Ideally, the final pickup percentages of each treatment would have been equal. Notably, vacuum tumbling does not result in 100% marinade pickup and more marinade should be added than is intended to be absorbed by the product when utilizing this form of production.

The required MPR for jerky products is 0.75:1 or less. Although final MPR for all treatments were lower than 0.75:1, the final MPR ( $P>0.05$ ) was similar for all treatments, regardless of whether jerky had been produced by soaking or tumbling (Table 2). Therefore, any quality differences due to over- or under-drying a single product were avoided. The compared techniques of soaking marination and vacuum tumbling showed minimal differences for composition of the final product (Table 2). Although a lower ( $P<0.05$ ) water activity was noted for S compared with all other treatments, this difference is not at a level that would affect final product quality. Color values for lightness, redness, and yellowness were similar ( $P>0.05$ ) for all treatments (data not shown). Of greater interest is the approximately 2% higher salt content ( $P<0.05$ ) for soaked product compared with tumbled treatments. This difference could be due to the similar increase in marinade pickup for the soaked product. The salt level of some marinade ingredients, such as soy sauce, is unable to be accounted for; therefore, we cannot say with any certainty that marination technique is responsible for the resulting salt difference.

The increased salt level of product soaked for 24 hours was also identified in the sensory panel evaluation (Table 3), with the saltiness of both soaked treatments scoring higher than tumbled treatments ( $P<0.01$ ). Additionally, soaked treatments were evaluated as having a more intense flavor ( $P<0.05$ ) than tumbled treatments. A higher salt content potentially intensifies beef jerky flavor. We hypothesized that an additional smoke flavor might present itself as a result of the liquid smoke-based anti-mold spray application; however, the sensory panel did not find any differences ( $P>0.05$ ) in smoke flavor or off-flavor among all treatments, suggesting that the application of this specific spray would not alter the flavor profile of beef jerky.

## Implications

Using vacuum tumbling as a form of marination saves time compared with soaking beef slices for 24 hours and could alter final product attributes, but if an equal level of marinade pickup is expected compared with soaking then additional marinade above the desired absorption level needs to be included in the tumbler.

**Table 1. Beef jerky marinade ingredients**

Soy sauce
Worcestershire sauce
Water
Purasil P Optiform 4
Seasoned salt
Monosodium glutamate
Seasonings

**Table 2. Composition of beef jerky marinated by 24-hour soaking or 20-minute vacuum tumbling, with and without a liquid smoke-based anti-mold spray**

Treatment*	Water activity	Salt, %	Moisture, %	Protein, %	MPR <sup>†</sup>
S	0.542 <sup>a</sup>	7.27 <sup>a</sup>	16.7 <sup>a</sup>	55.9 <sup>a</sup>	0.30 <sup>a</sup>
SS	0.591 <sup>b</sup>	6.58 <sup>a</sup>	17.3 <sup>a</sup>	56.0 <sup>a</sup>	0.31 <sup>a</sup>
T	0.594 <sup>b</sup>	5.01 <sup>b</sup>	17.8 <sup>a</sup>	59.9 <sup>b</sup>	0.30 <sup>a</sup>
TS	0.619 <sup>b</sup>	4.66 <sup>b</sup>	18.0 <sup>a</sup>	58.1 <sup>b</sup>	0.31 <sup>a</sup>

<sup>a</sup> Means within a column followed by different superscripts differ (P<0.05).

\* Treatments: S – 24-hour soak marinated, SS – 24-hour soak marinated, anti-mold spray, T – 20-minute vacuum tumble marinated, TS – 20-minute vacuum tumble marinated, anti-mold spray.

<sup>†</sup> MPR: moisture-to-protein ratio.

**Table 3. Trained panel sensory evaluation<sup>†</sup> of beef jerky marinated by 24-hour soaking or 20-minute vacuum tumbling, with and without a liquid smoke-based anti-mold spray**

Treatment*	Initial bite	Chewiness	Moisture	Saltiness	Flavor intensity	Smoke flavor	Off-flavor intensity
S	7.0 <sup>a</sup>	7.0 <sup>a</sup>	2.3 <sup>a</sup>	6.0 <sup>a</sup>	6.4 <sup>a</sup>	3.4 <sup>a</sup>	7.5 <sup>a</sup>
SS	6.9 <sup>a</sup>	6.9 <sup>a</sup>	2.6 <sup>a</sup>	6.1 <sup>a</sup>	6.4 <sup>a</sup>	3.4 <sup>a</sup>	7.6 <sup>a</sup>
T	6.9 <sup>a</sup>	6.7 <sup>a</sup>	2.4 <sup>a</sup>	5.5 <sup>b</sup>	5.9 <sup>b</sup>	3.3 <sup>a</sup>	7.8 <sup>a</sup>
TS	6.8 <sup>a</sup>	6.6 <sup>a</sup>	2.6 <sup>a</sup>	5.4 <sup>b</sup>	5.9 <sup>b</sup>	3.3 <sup>a</sup>	7.7 <sup>a</sup>

<sup>ab</sup> Means within a column followed by different superscripts differ (P<0.05).

\* Treatments: S – 24-hour soak marinated, SS – 24-hour soak marinated, anti-mold spray, T – 20-minute vacuum tumble marinated, TS – 20-minute vacuum tumble marinated, anti-mold spray.

<sup>†</sup> A scale of 1 to 8 is used for all descriptors. A score of 8 for all traits would describe jerky as extremely firm, chewy, moist, and salty with an intense flavor, abundant smoke flavor, and no off-flavor.