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# The effect of bacon pump retention levels following thermal processing on bacon slice composition and sensory characteristics☆

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ABSTRACT

The objective was to evaluate the effect of belly pump uptake and cook yield during processing on bacon slice composition and sensory attributes. A total of forty-four bellies were commercially sourced and randomly assigned to two experiments. Each experiment consisted of one smokehouse cooking cycle. Within each experiment, bellies were separated at the medial point and one belly half was assigned to a high pump uptake treatment (HIGH; target of 30% uptake) and the remaining belly half was assigned to a normal pump uptake treatment (NORM; target of 15% uptake). In experiment-1, cook yields were 107.79% for the HIGH bellies and 101.52% for the NORM bellies. In experiment-2, cook yields were 97.41% for the HIGH bellies and 94.74% for the NORM bellies. Overall, bacon slice composition and sensory attributes of bacon from bellies with greater pump retention were largely unaffected, accordingly it was concluded that cook yields ranging in level of pump retention does not affect most attributes of bacon.

## 1. Introduction

The amount of curing solution permitted to be retained in bellies during bacon production varies from country to country (Knipe & Beld, 2014). The regulation for a product to be labeled as "bacon" in the United States according to CFR 319.107 is "The weight of cured pork bellies ready for slicing and labeling as "Bacon" shall not exceed the weight of the fresh uncured pork bellies" (US GOP 9 CFR 319.107 - bacon;, 2010). Therefore, legislation requires bellies to return to original green (starting) weight following thermal processing (cooking and smoking) and immediately before slicing of the belly and labeling product as "bacon" (USDA-FSIS;, 2013). However, some countries do not have a restriction on the amount of curing solution allowed to be retained in bellies during thermal processing (Knipe & Beld, 2014). For example, the standard of identity for bacon in Canada is grouped into a broad spectrum with little limitations; according to the Canadian Food Inspection Agency (CFIA), "side bacon, Wiltshire bacon, salt beef, and pork jowls are exempted from the minimum protein standard and the percent (%) meat protein label declaration." At the same time, the standard of identity for bacon in the United States according to the Food Safety and Inspection Service (FSIS) 319.107 is "the weight of cured pork bellies ready for slicing and labeling as 'bacon' shall not exceed the weight of the fresh uncured pork bellies". With that said, bellies in the United States are typically pumped to 11 to 12% uptake of the original green weight with intentions to return as closely as possible to green weight after cooking (Knipe & Beld, 2014; Kyle, Bohrer, Schroeder, Matulis, & Boler, 2014; Soladoye, Shand, Aalhus, Gariépy, & Juárez, 2015). While there are limited reports on pump uptake and retention levels in countries without restrictions; processor profitability would be increased if pump retention following thermal processing slightly exceeded 100% of green weight. It can be speculated that increased pump retention following thermal processing (beyond 100% of green weight) may alter bacon slice composition and bacon sensory attributes. Thus, the purpose of this study was to evaluate the effect of belly pump uptake and cook yield during processing on bacon slice composition and sensory attributes. Two experiments were used to address different cooking techniques used by bacon processors – bacon in experiment 1 was cooked to an internal meat temperature of approximately 55 °C, and bacon in experiment 2 was cooked to an internal meat temperature of approximately 62 °C. It was hypothesized that increasing pump retention following thermal processing would affect bacon slice composition by increasing moisture content and inherently decreasing lipid and protein content. Furthermore, it was hypothesized that bacon with greater pump retention levels following thermal processing would have altered texture when sensory attributes were evaluated.

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## 2. Materials and methods

### 2.1. Fresh belly analysis

Forty-four fresh pork rind-on bellies (NAMI #408 Pork Belly) were sourced and obtained from a commercial pork processor (North American Meat Institute, 2014). Each belly was measured for length, width, thickness, and flop distance. Length and width measurements were taken at the center of each belly. The thickness of each belly was measured four individual times along the dorsal edge of the belly; as well as, four individual times along the ventral edge of the belly according to the protocol of a previous study (Kyle et al., 2014). This allowed for a total of eight thickness measurements which were then averaged to give a final thickness of each belly. The flop distance of each belly was obtained by measuring the distance between the two ends of each belly (skin-to-skin) after being draped vertically over a hanging bar using similar techniques as those described in a previous study (Tavárez et al., 2014). Flop distance measurements were taken following a one-minute interval which allowed the bellies to settle over the bar.

### 2.2. Processing procedures and experimental design

Each belly was skinned and cut into two halves at the medial point of the belly, with the two pieces representing the blade and flank end (Fig. 1). Slices were collected from the center portion of the belly to obtain an uncured proximate composition. Each belly half was weighed individually and treatments were assigned to the blade or flank end of each belly so that each belly could be represented in each treatment group, which limited belly to belly variation. Twenty-two paired belly halves were randomly assigned to experiment 1 and the remaining twenty-two paired belly halves were assigned to experiment 2. Belly halves were assigned to treatment so that an equal number of anterior halves (blade ends) and posterior halves (flank ends) would be represented in each treatment.

Each belly half was injected with a commercially available curing solution containing water, salt, corn syrup solids, sodium phosphate, sodium erythorbate, sodium nitrate, sodium bicarbonate, and glycerin (Herman Laue Spice Company Inc.; Uxbridge, Ontario, Canada). Cure ingredients were formulated in accordance with manufacturer instructions (15% pump target = 313 g cure/ 1 kg water; 30% pump target = 156 g cure/1 kg water). Belly halves targeted at a pump uptake of 15% were assigned to the normal pump uptake treatment (NORM) and belly halves targeted at a pump uptake of 30% were assigned to the high pump uptake treatment (HIGH). Bellies were pumped using a needle injector (Inject Star Pökelmaschinen Gesellschaft m.b.H; Hagenbrunn, Austria). Each belly was weighed immediately after injection to determine initial pump uptake (this weight measurement was recorded as pump weight), and reweighed 30 min after injection to determine rested pump uptake (this weight measurement was recorded as equilibrium weight). Bellies were thermally processed in a smokehouse (Enviro-pak CVU-490; Clackamas, OR, USA) with liquid smoke application (Table 1).

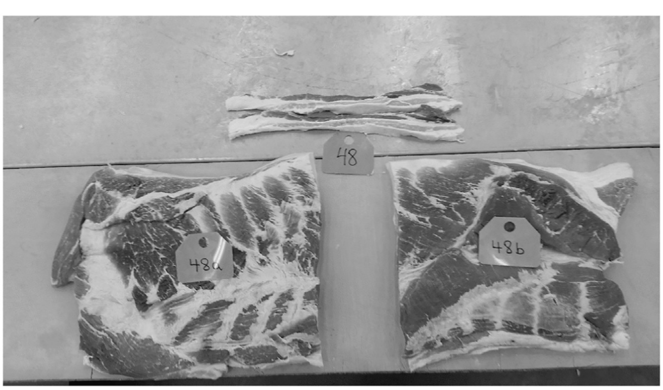


**Fig. 1.** An example of treatment design within each individual belly. Each belly was skinned and cut into two halves at the medial point of the belly, with the two pieces representing the blade and flank end. Slices were collected from the center portion of the belly to obtain an uncured proximate composition. Each belly half was weighed individually and treatments assigned to the blade or flank end of each belly so that each belly could be represented in each treatment group, which limited belly to belly variation. Belly halves represented the experimental units for all analyses in this study.

**Table 1**
– Belly/bacon smokehouse cook cycle[a].

| Stage | Time (min) | Humidity (%) | Liquid smoke application | Temperature (°C) |
|---|---|---|---|---|
| 1 | 30 | 0 | No | 54.4 |
| 2 | 60 | 25 | Yes | 57.2 |
| 3 | 60 | 40 | Yes | 62.8 |
| 4 | 60 | 45 | Yes | 68.3 |
| 5 | 60 | 45 | Yes | 73.9 |
| 6 | 180 | 45 | Yes | 79.4 |

[a] Belly halves were thermally processed in a smokehouse (Enviro-pak CVU-490; Clackamas, OR, USA) and were removed once desired internal temperature was achieved (i.e. stage 6 was not completed once desired internal temperature was reached).

Two cycle loads were used to evaluate extremes in bacon processing techniques. Bellies in cycle 1 (experiment 1) were cooked to an internal meat temperature of approximately 55 °C. Bellies in cycle 2 (experiment 2) were cooked to an internal meat temperature of approximately 62 °C. For each experiment, only one smokehouse cycle/run was required. An equal number of NORM bellies and HIGH bellies were represented in each of the cycle loads (experiments), as the 22 paired belly halves were represented in each experiment. Cooked weight was determined by weighing cured and smoked bellies after the bellies were allowed to cool for a period of 12 h following cooking. Cooked yield was calculated using the formula: (cooked weight/ green weight) × 100. Each belly half was sliced using a deli slicer set at 2.8 mm thickness. Before slicing of samples occurred, each belly half was faced to provide even slices and to prevent collection of samples with greater amounts of liquid smoke present. Bacon slice samples from the center location of each belly (posterior end of blade halves and anterior end of flank halves) were collected for further analysis of bacon slice proximate composition, bacon slice cooking loss, and bacon slice sensory characteristics. Samples for bacon slice proximate composition were placed in a Whirl-Pak bag (Nasco; USA) and stored at −20 °C. Samples for bacon slice cooking loss and sensory analysis were vacuum packaged and stored at −20 °C.

### 2.3. Proximate composition

Moisture, lipid, and protein concentrations were determined with methods previously described by Bohrer, Kyle, Little, Zerby, and Boler (2013). In short, samples were prepared by homogenizing bacon slices in a food processor (KitchenAid model KHB23511CU; St. Joseph, MO, USA). Duplicate 5-g samples of the homogenate were weighed into an aluminum weighing dish and covered with filter paper. The sample was oven dried in duplicate at 110 °C for approximately 24 h to determine percent moisture. The dried sample was washed multiple times over an 8 to 10 h period in warm petroleum ether using a modified procedure of the soxhlet method (Association of Official Analytical Chemists, 2006; method 991.36) to determine lipid content. Protein concentrations were measured by determining nitrogen content using the combustion method (Association of Official Analytical Chemists, 2000; model TruMac, method 990.03, LECO Corp., St. Joseph, MI), using EDTA as a standard. A multiplication factor of 6.25 was used to calculate crude protein.