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Effects of Smokehouse Humidities on Quality Characteristics of Canadian Bacon

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Abstract

The effect of four different humidities during smokehouse processing on cured color development, color intensity, pH, residual nitrite, phenol deposition, TBA value and product yield of Canadian bacon was determined. High humidity resulted in high pigment conversion and lower pH. As the humidity was lowered, more residual nitrite remained. The highest humidity had the highest phenol deposition and TBA value. The lowest humidity had the highest yield.

Key words: smokehouse humidity, quality, Canadian bacon

Introduction

Modern smokehouses and systems for cooking with hot air are equipped with instruments for programming of air temperature and for control of humidity and air velocity, thus offering potential for optimization of heat processing schedules. Optimization requires the application of fundamental heating principles during processing and the identification of their effect on product characteristics.

Some advantages of using smoke in the past were that objectionable flavors and odors were overcome. In addition, a preservative action was obtained by the deposition of organic acids and other compounds from the smoke. These deposited compounds had a bacteriostatic and antioxidative effect upon the meat[1]. One other important advantage was the enhancement of flavor[2]. Finally, smoking provides typical color[2].

In general, high humidity and high temperature have been shown to have adverse effects on emulsion stability, texture and color development. High humidity also encourages fat rendering in the product[4,5]. These processing conditions, however, may also result in decreased shrink, enhanced peelability, reduced cooking time and increased permeability of casings to smoke[6,7]. Effects of smokehouse relative humidity have not been thoroughly explored though some researches have been done in this area.

The present study was conducted to determine the effects of smokehouse humidity differences on quality characteristics of Canadian bacon.

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Materials and Methods

Experimental design

Four different smokehouse humidities were utilized to study the effect on quality characteristics of Canadian bacon. Canadian bacon is produced from the large muscle of pork loins, the longissimus dorsi. The predominant feature of Canadian bacon is leanness and little intermuscular fat is encountered.

Table 1 shows the four smokehouse schedules used in the present study which are based on four different levels of relative humidity. The relative humidities for Canadian bacons were 98%, 75%, 50% and 35%.

The samples were examined at 0, 1, 7 and 14 days after processing for nitroso pigment, total pigment, residual nitrite, pH, photovolt color reflectance. TBA value and phenol deposition were observed at 1, 7, 14 and 21 days. Yields were measured just after smoking and the 0 day measure-

Table 1. Smokehouse schedule for Canadian bacon

Time	Program	Service temp.	Moist I a)					Core temp.
			98%	75%	50%	34%	MI b)	
3 hours	Reddening	50°C	49.5°C	45°C	39°C	34°C	85	—
1 hour	Hot smoke	60°C	59.5°C	55°C	47°C	42°C	85	—
2 hours	Reddening	70°C	69.5°C	64°C	56°C	45°C	85	—
—	Hot air finish	75°C	74.5°C	69°C	60°C	48°C	85	68°C

a) Wet bulb temperature.
b) Moisture impulse.

Table 2. Brines for Canadian bacon

Ingredients	Amounts
Brine for Canadian bacon (10% pump)	
Salt	5.01 kg
Sugar	1.2 kg
Sodium phosphate	0.6 kg
Sodium erythorbate	0.165 kg
Sodium nitrite	0.06 kg
Water	30 kg

ment used to indicate the day that products were made. Each product was separated into inside and outside portions; the outside was obtained removing the outside (about 1-2mm thick) of the products. Nitroso pigment, total pigment, residual nitrite, pH and photovolt color reflectance were done on both the inside and outside portions of the products. TBA value was done on whole samples and phenol deposition was measured only on the outside portion. All measurements had three replications except TBA value, phenol deposition and photovolt color reflectance which were replicated twice.

Sample preparation

Frozen pork loins were thawed in a 4°C cold room for a period of 36-48 hours. After thawing, the pork loins were trimmed of all external fat and assigned to one of the four treatment groups.

Each loin was stitch pumped with a curing solution (Table 2) to 110% of its initial weight. The loins were then placed in plastic tubs, and stored at 4°C for a period of 24 hours to allow equilibration and curing.

After curing and equilibration, the loins were hand stuffed into stockinettes. These loins were then divided into four groups, hung on a smokehouse rack and subjected to the appropriate smokehouse cycles.

After smoking, these products were chilled, packaged and stored during the rest of the experimental period.

Physical measurement

Canadian bacon was weighed before and after heat processing and yield was calculated by the following formula:

$$\frac{\text{Finished weight}}{\text{Raw weight}} \times 100 = \%\ \text{product yield.}$$

Objective color measurements of samples were made on a Photovolt Photoelectric Reflection Meter (Model 610). The chromaticity coordinates were calculated as described by Jude[8]:

$$x = \frac{X}{X+Y+Z};\ y = \frac{Y}{X+Y+Z};\ z = \frac{Z}{X+Y+Z}$$

Chemical analysis

The pH of the slurry was determined using a Corning pH meter (Model 125) fitted with a combination electrode after ten gram samples and 90 ml of deionized, distilled water were blended in a Waring blender for 60 seconds.

The thiobarbituric acid (TBA) test for rancidity was run the day following processing and every week for three weeks[9].

Nitrite concentrations of the samples were determined spectrophotometrically by using the method described by the Association of Offical Analytical Chemists[10]. Quantitation of nitroso pigment was performed by an acetone water extraction according to techniques described by Hornsey[11]. Pigment conversion was the percentage of total heme pigments converted to nitric oxide hemochrome.

Phenol compounds were extracted using the methods described by Tucker and Bratzler et al.[12,13].

Statistical analysis

The data were analyzed using analysis of variance and Duncan's Multiple Range Test to determine the significance of variability of means for all tests measured[14].

Results and Discussion

Effects of smokehouse humidity and length of storage on cured color

There were no significant differences in nitric oxide heme pigment, but the total pigment and cured color (pigment conversion) of the outside of the Canadian bacon was significantly different ($p<0.05$) between the treatments. The 75% and 98% humidity levels showed quite similar and better color development than the other two humidity levels (Table 3). The outside of Canadian bacon shows significant differences ($p<0.05$) betwen the treatments. The 35% relative humidity showed increased color devělopment at 1 day significantly and decreased during the rest of the storage time. The other of the humidity levels were increased slightly 1 day and constant during the storage time (Figure 1).

Effects of smokehouse humidity on objective color measurement

Canadian bacon showed significant differences ($p<0.05$) on the outside for X tristimulus value,

Table 3. Effect of smokehouse humidity levels on color of Canadian bacon [a),b)]

Levels of humidity	Nitric oxide heme pigment (ppm)		Total pigment (ppm)		Pigment conversion (%)	
	Inside	Outside	Inside	Outside	Inside	Outside
98%	25.69a	20.72a	47.52a	45.28b	55.39a	53.06a
75%	22.21a	22.83a	44.99a	41.68b	48.61a	54.29a
50%	26.43a	19.79a	52.64a	98.71a	48.95a	20.76b
35%	24.34a	18.69a	45.99a	92.59a	51.58a	24.96b
SE	±1.72	±1.35	±2.68	±7.52	±4.34	±6.66

a) All means in a column with the same superscripts are not significantly different (p 0.05).
b) n -12.

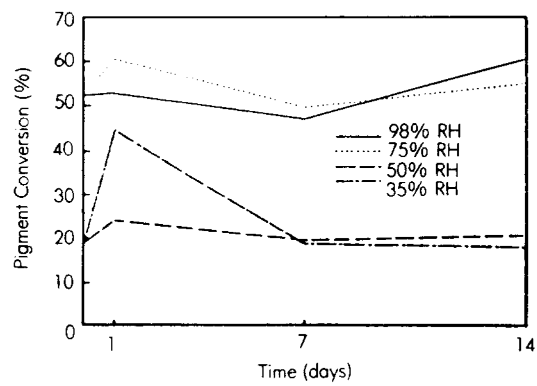

Fig. 1. The effect of smokehouse humidity levels and storage period on pigment conversion of outside of Canadian bacon

but the other values were not different. The chromatocity coordinates did not show evident variations between the treatments except the Z value which shows a significant difference ($p<0.05$) for the inside of Canadian bacon. The 35% relative humidity gave significantly higher ($p<0.05$) value for the chromaticity coordinates Z value on the inside of Canadian bacon. Even though high humidity gave high tristimulus values and chromaticity coordinates, no obvious trends were observed (Table 4).

Effects of smokehouse humidity and length of storage on pH

Table 4. Effect of smokehouse humidity levels on tristimulus values and chromaticity coordinates for the color shades of Canadian bacon[a),b)]

Levels of humidity	Tristimulus values						Chromaticity coordinates					
	X		Y		Z		x		y		z	
	Inside	Outside	Inside	Outside	Inside	Outside	Inside	Outside	Inside	Outside	Inside	Outside
98%	39.91a	10.67b	38.04	9.6a	35.41a	6.69a	0.352a	0.393a	0.335a	0.359a	0.313b	0.248a
75%	43.09a	9.95b	39.15a	9.1a	38.04a	5.99a	0.358a	0.381a	0.326a	0.371a	0.316a,b	0.249a
50%	39.40a	12.40a,b	37.81a	10.67a	34.89a	5.58a	0.352a	0.440a	0.338a	0.367a	0.310b	0.192a
35%	40.88a	15.68a	38.59a	12.74a	37.68a	6.91a	0.349a	0.448a	0.329a	0.360a	0.322a	0.192a
SE	±1.22	±1.06	±0.75	±1.14	±0.87	±0.89	±0.002	±0.015	±0.003	±0.004	±0.0023	±0.014

a) All means in a column with the same superscripts are not significantly different (p 0.05).
b) n = 8.

Table 5. Effect of smokehouse humidity levels on pH and residual nitrite of Canadian bacon[a),b)]

Levels of humidity	pH		Residual nitrite	
	Inside	Outside	Inside	Outside
98%	5.84b	5.69b	15.15b	10.30b
75%	5.84b	5.68b	15.81b	7.80b
50%	6.01a	5.83a,b	32.79a	18.83a
35%	5.99a,b	5.89a	28.61a	20.92a
SE	±0.06	±0.09	±5.49	±3.67

a) All means in a column with the same superscripts are not significantly different (p 0.05).
b) n = 12.

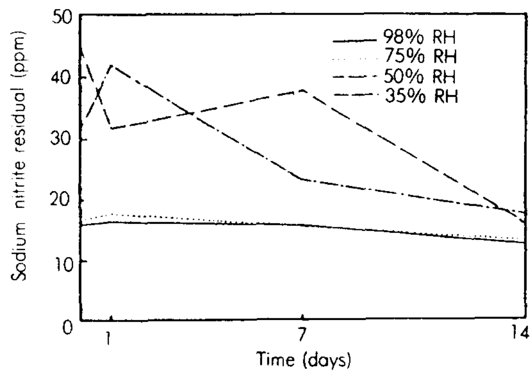

Fig. 2. The effect of smokehouse humidity levels and storage period on residual nitrite of inside of Canadian bacon.

Table 5 shows the pH values for Canadian bacon. There was a significant difference ($p < 0.05$) between inside and outside locations. High humidities (98% and 75% relative humidity) gave a lower pH value then that of low humidities (50% and 30% relative humidity). The outside of the Canadian bacon shows a constant pH value during the storage time while the inside of Canadian bacon decreases slightly.

Sink and Hsu found that frankfurter pH was significantly affected by smoke treatment[(15)]. These franks made with a liquid smoke dip were the most acidic and smoke deposition (phenol content) was highly related to the pH value. Their data showed that as the phenol deposition increases, the pH values decreased.

In this present investigation, even though pH values are product specific, the high humidity generally gave a lower pH value. These results agreed with Sink and Hsu's result because, as it will be presented later, high humidity also gave higher phenol deposition.

Effect of smokehouse humidity levels and length of storage time on residual nitrate

There was a significant difference in residual nitrite ($p < 0.05$) between high and low humidities (Table 5). In this case, as the humidity was lowered, more residual nitrite remained. Comparing the inside and outside of Canadian bacon showed that the inside had a significantly higher ($p < 0.05$) amount of residual nitrite. The effect of humidity level and storage time on residual nitrite are demonstrated in Fig. 2 and 3. The low humidity treatments (50% and 35% relative humidity)

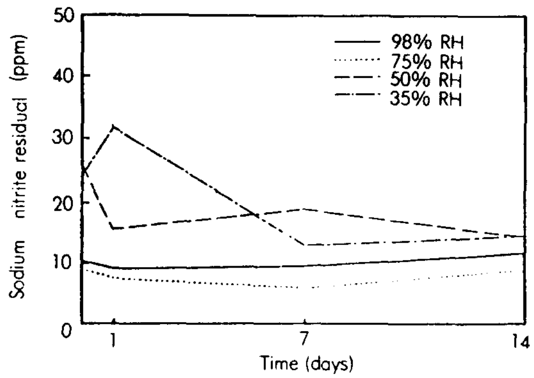

Fig. 3. The effect of smokehouse humidity levels on residual nitrite of outside of Canadian bacon.

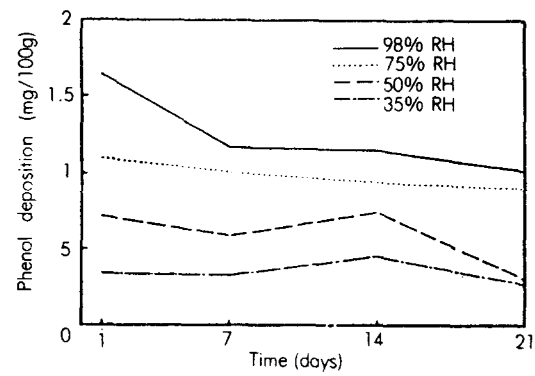

Fig. 4. The effect of smokehouse humidity levels and storage period on phenol deposition on Canadian bacon.

Table 6. Effect of smokehouse humidity levels on phenol deposition[a)] and rancidity development[b)] of Canadian bacon[c) d)]

Levels of humidity	Phenol deposition	TBA No.
98%	1.24a	0.45a
75%	0.98a	0.32a,b
50%	0.59b	0.35a,b
35%	0.35b	0.26b
SE	±0.16	±0.04

a) Mg per 100g of meat.
b) Mg Malonaldehyde per 1000g of meat.
c) All means in a column with the same superscripts are not significantly different (p 0.05).
d) n = 8.

showed a greater change than high humidity (98% and 75% relative humidity) during storage (both inside and outside). Depletion of nitrite was again observed during storage, with the high humidity treatments (98% and 75% relative humidity) showing a constant nitrite value whereas the low humidity treatments (50% and 35% relative humidity) decreased in nitrite concentration during storage.

Phenol deposition

The highest humidity (98% relative humidity) had the highest phenol deposition and there were significant differences ($p < 0.05$) between high humidity treatments and low humidity treatments. The deposition of phenolic compounds was depndent on humidity and as the humidity levels decreased, the phenolic compounds also decreased (Table 6). Figure 4 shows the interaction of humidity levels and storage time on phenol concentration in Canadian bacon. The 98% relative humidity treatment was depleted greatly at 7 days and continued to slowly lose phenol concentrations during storage. The 75% relative humidity showed more or less constant levels of phenols while the 50% and 35% relative humidity showed an increase at 14 days but a decrease at 21 days.

TBA value

Table 6 shows that the mean for TBA values for Canadian bacon at 98% relative humidity was higher than that of other humidity levels. The 98%

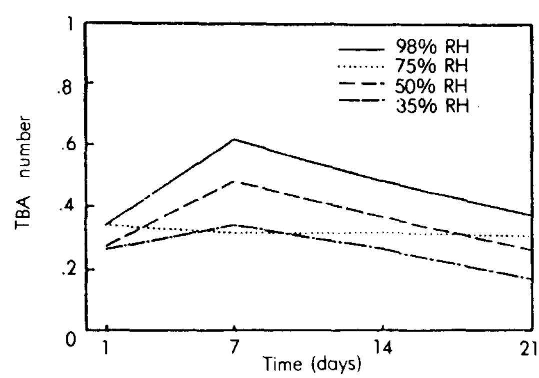

Fig. 5. The effect of smokehouse humidity levels and storage period on TBA value of Canadian bacon.

Table 7. Effect of smokehouse humidity levels on yield [a] of Canadian bacon [b),c)]

products	Levels of humidity				
	98%	75%	50%	35%	SE
Canadian bacon	82.40^{b}	$86.20^{a,b}$	88.27^{a}	88.64^{a}	±1.19

a) Percent.
b) All means in a row with the same superscripts are not significantly different (p 0.05).
c) n = 3.

relative humidity treatment was significantly different ($p<0.05$) from the lowest humidity (35% relative humidity). There were no significant differences ($p<0.05$) between the 75% and the 50% relative humidity treatments. Fig. 5 shows that TBA numbers increased at 7 days and then decreased in all the treatments except for the 75% relative humidity which shows constant TBA number during storage.

Lea found that smoking gave substantial protection against rancidity development on the surface of bacon, and made observation that smoke components are found largely at the surface of a product[16]. Kurko found that the phenols were effective antioxidants[17].

In this study, Canadian bacon had a higher phenol deposition when submitted to high relative humidity and these products also had high TBA numbers. This result does not agree with the above researchers' conclusions but Melton explained that there was adverse effect of nitrite on TBA value and low humidity levels had high residual nitrite[18].

Product yield

The lowest humidity (35% relative humidity) had the highest yield and the highest humidity had the lowest yield (Table 7).

Andross found that the higher yields associated with lower relative humidities may be attributed to a surface drying effect which results in the formation of a moisture barrier curtailing the evaporation of moisture from the interior of the product[19]. This may have occurred in the case of Canadian bacon.

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훈연상대습도가 Canadian Bacon 품질특성에 미치는 영향

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훈연처리 중 4가지 습도(98%, 75%, 50%, 35%)가 Canadian bacon 품질에 미치는 영향을 알아보기 위해서 염지육색, pH, 잔유 아질산량, 페놀 축적, TBA 치 그리고 수율을 측정하였다. 높은 습도에서 생산된 제품은 높은 발색율과 낮은 pH 치를 나타내었으며, 낮은 습도일수록 잔유 아질산량이 높았다. 또한 높은 습도에서는 페놀 축적량과 TBA 치가 높았으며 가장 낮은 습도에서는 수율이 가장 높았다.