Acceptability of Bacon Stored Six Weeks at 4 or -23°C

ABSTRACT

Bacon was obtained from production lines of two local processing plants, H and M. The slices from 8 bellies from each plant were sequentially rearranged to form composite portions representative of each belly; these were analyzed for moisture-phase NaCl and for acceptability by a panel of judges using a 9-point hedonic scale. Samples were tasted shortly after processing and again after 6 weeks of storage at 4 or -23°C. The moisture-phase NaCl content ranged from 4.62 to 7.80% (c.v. = 18.2%) for bacon from plant H; the range for bacon from plant M was 3.25 to 10.05% (c.v. = 37.7%). The belly from plant M with the highest moisture-phase NaCl content also gave the lowest hedonic score of the bacon samples tasted before storage. The average hedonic scores for bacon from the two plants were different ($p<0.05$). There were no significant differences due to storage condition for bacon from plant M, but bacon stored at 4°C from plant H had lower ($p<0.05$) average scores than the bacon sampled shortly after processing or that kept 6 weeks at -23°. Storage at 4°C caused a significant ($p<0.01$) reduction in hedonic score in one belly from each plant.

In a previous study (*3*), we reported that bacon stored 6 weeks at 2°C showed no loss in flavor scores even when it was prepared without nitrite. There were considerable variations in flavor scores between bellies as well as in the ability of *Clostridium botulinum* spores to outgrow and produce toxin; toxin production appeared to be inversely correlated with the moisture-phase salt content of the bacon. Bacon is commonly stored at refrigeration temperatures for periods up to 6 weeks (its normal shelf life) before being consumed; such temperatures should prevent growth of most strains of food pathogens although spoilage organisms could grow, especially if NaCl levels are low. Because of large variations in pumping efficiency of the bellies, the actual levels of NaCl (and residual nitrite) may vary considerably among bellies pumped at the same plant under similar conditions (*6*); some may therefore be susceptible to growth of undesirable microorganisms. Frozen storage of bacon would be an effective deterrent to growth of such organisms. Our study was designed to compare the acceptability of unstored bacon and bacon stored 6 weeks at normal refrigeration or freezer temperatures. Pumping variability was also determined by analyzing the NaCl content of individual bellies.

[1]*Agricultural Research Service, U.S. Department of Agriculture.*

MATERIALS AND METHODS

Bacon processing

Bacon was processed at two local plants, H and M, which were selected because they used different levels of NaCl in the curing brine. The plants' normal processing schedules and brine ingredients were used; both used a combination of liquid and natural smoke and both had equal target levels of nitrite (120 ppm), sodium erythorbate (550 ppm), and sodium tripolyphosphate (0.3%). Plant M had a target NaCl content of 1.50% while plant H had a target level of 1.85%. The pump rate of the brine was approximately 15% with a processed weight of 105% above green weight. Bacon slices from 8 bellies from each plant were obtained from the production lines after approximately 2 h of operation.

Preparation of bacon portions

The slices from each belly were sequentially rearranged (*3*) to give 0.4 kg portions representing equal amounts of each original package from each belly. The portions of rearranged slices were heat sealed under vacuum in plastic pouches. One pouch from each belly was placed at -23°C (frozen) and another at 4°C (refrigerated); these were stored for 6 weeks; one portion was used for NaCl and H_2O analysis using methods of the AOAC (*1*).

Sensory evaluation

For tasting, bacon slices were fried under controlled oven conditions (*3*), and were cut into 2 to 4-cm pieces which were mixed and kept warm. Four samples were tasted by an untrained panel of 19-25 judges at each sitting. The unstored bacon was submitted to the panel in daily sessions, four bellies per session. The bacon from one plant was tasted the first 2 d; the bacon from the second plant, which had been collected 2 d later, was tasted during the next 2 d. The judges were asked to rate the samples for acceptability on a 9-point hedonic scale with 1 being the lowest score. The score sheets also had a space for "comments" but no specific instructions were given as to the type of comments to be entered.

Statistical treatment

Statistical significance was determined by analysis-of-variance for main and interaction effects and by Chi square for differences in discrete variables (atypical flavors). Differences between means were determined by a modified least significant difference method (*4*). In some instances, the Student "t" test was used to determine the significance of differences in hedonic scores of individual bellies before and after storage.

RESULTS AND DISCUSSION

The hedonic scores for the bacon are shown in Table 1. The averages for plant H showed that the score for the refrigerated bacon was lower ($p<0.05$) than the scores for the unstored bacon or that kept frozen for 6 weeks. The lower score for the refrigerated bacon could be attributed to the significantly lower scores of belly #6 ($p<0.01$) and belly #8 ($p<0.05$). The average score for the bellies kept frozen was about the same as the average for the unstored bacon, although two of the frozen bellies had lower scores ($p<0.05$) than the other six.

The overall average hedonic score for the bacon from plant M was lower ($p<0.05$) than the score for bacon from plant H. One of the unstored bellies from this plant (#7) had significantly lower score ($p<0.01$) than the other bellies. This was probably due to its high salt content (Table 3) since the low score for this belly was evident in the stored bacon as well. There were no statistically significant differences in the average scores for bacon from plant M although, as with the bacon from plant H, the frozen bacon scores were higher and the refrigerated bacon had the lowest score.

One of the refrigerated bellies from plant M (#8) and one from plant H (#6) had significantly lower ($p<0.01$) hedonic scores than the other bellies. The data in Table 2 show that these bellies elicited significantly more ($p<0.05$) atypical flavor comments than the other bellies. These atypical flavors were likely due to growth of undesirable microorganisms since the unstored and frozen portions of these bellies produced only a few atypical flavor comments. The moisture-phase NaCl contents of these

TABLE 1. *Effect of 6 weeks of storage on hedonic scores[a] of bacon.*

Belly No.	Plant H			Plant M			Total for plant	
	NS[b]	R	FR	NS	R	FR	H	M
1	6.55[a]	7.00[a]	6.88[a]	6.70[a]	6.35[a]	7.05[a]	6.81	6.48
2	6.95[a]	7.11[a]	7.38[a]	7.00[a]	6.60[a]	6.80[a]	7.15	6.58
3	6.35[a]	6.45[a]	6.04[c]	6.05[b]	6.30[a]	6.43[a]	6.28	6.23
4	6.50[a]	6.63[a]	7.00[a]	6.20[b]	6.57[a]	6.24[b]	6.71	6.30
5	6.65[a]	6.91[a]	7.08[a]	6.75[a]	6.70[a]	6.60[a]	6.88	6.70
6	6.40[a]	4.04[b]	6.16[c]	5.70[b]	6.28[a]	6.40[a]	5.53	6.14
7	6.55[a]	6.66[a]	7.38[a]	4.65[c]	4.65[c]	5.05[c]	6.86	4.77
8	7.10[a]	6.19[c]	6.80[a]	6.65[a]	4.50[c]	6.85[a]	6.70	5.99
Average	6.63[α]	6.37[αβ]	6.84[α]	6.21[β]	5.99[β]	6.43[β]	6.62	6.15
							Different ($p<0.05$)	

Statistical differences ($p<0.05$) denoted by unlike superscripts within each plant. Averages for both plants were used for determining differences (bottom row).

[a]Mean scores of 19-25 judges. Best score on hedonic scale is 9, bacon with a score of 5 or better is acceptable.

[b]NS = not stored; R = stored at 4°C; FR = stored at -23°C.

TABLE 2. *Atypical flavor comments by judges[a] of bacon stored 6 weeks.*

Belly No.	Plant H				Plant M			
	NS[b]	R	FR	Total	NS	R	FR	Total
1	0[a]	0[a]	0[a]	0[a]	1[a]	3[a]	0[a]	4[a]
2	1[a]	0[a]	0[a]	1[a]	0[a]	0[a]	0[a]	0[a]
3	0[a]	3[a]	4[a]	7[a]	0[a]	0[a]	0[a]	0[a]
4	0[a]	3[a]	1[a]	4[a]	3[a]	2[a]	1[a]	6[a]
5	1[a]	1[a]	0[a]	2[a]	2[a]	1[a]	2[a]	5[a]
6	1[a]	15[b]	0[a]	16[b]	2[a]	0[a]	2[a]	4[a]
7	1[a]	2[a]	1[a]	4[a]	0[a]	0[a]	0[a]	0[a]
8	0[a]	5[a]	1[a]	6[a]	2[a]	13[b]	3[a]	18[b]
Total	4[a]	29[b]	7[a]	40	10[a]	19[ab]	8[a]	37

Unlike superscripts within columns and bottom row denote differences ($p<0.05$).

[a]Total from 19-25 judges. Typical comments were "off-flavor," "little flavor," "rancid," "spoiled," "sour," "burnt."

[b]NS = not stored, R = stored at 4°C, FR = stored at -23°C.

two bellies were 4.88 and 5.32% for the two plants, H and M (Table 3). The a_w value of these bellies, calculated from the formula a_w = moles H_2O/moles H_2O + moles solute, was 0.99, which is insufficient for inhibiting nearly all microorganisms.

TABLE 3. *Sodium chloride content (%) of bacon.*

	Plant			
	H		M	
Belly No.	Total	Moisture phase	Total	Moisture phase
1	2.34[a]	7.80[b]	1.18	4.09
2	2.04	6.45	2.19	5.78
3	1.57	4.62	1.47	4.23
4	1.96	5.78	1.82	5.36
5	1.89	6.94	0.95	3.25
6	1.74	7.06	2.02	5.32
7	1.87	5.52	2.60	10.05
8	1.67	4.88	1.68	5.44
Average	1.88	6.13	1.74	5.44
Range	0.77	3.18	1.65	6.80
C.V.	12.7	18.2	31.0	37.7

[a]NaCl content of whole bacon.
[b]NaCl content in moisture phase $\left(\frac{\%NaCl \times 100}{\%NaCl + \%H_2O}\right)$.

Clostridium botulinum, the organism of main concern in vacuum packaged meat products of relatively high pH (6.0 - 6.4) such as bacon, also is not inhibited by these NaCl levels unless at least 100 μg of nitrite/g is present (*5*). In underpumped bacon, nitrite levels also would be reduced from target levels at 120 μg/g. The risk of human intoxication from growth of this microorganism in bacon is slight (*2*), mainly because of the low incidence of the organism in meat. However, spoilage organisms could grow, as indicated by our studies; their growth could be effectively prevented by storing bacon under frozen conditions which, as we have indicated, does not detract from its acceptability.

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