BACON, AN INHOMOGENOUS PRODUCT

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INTRODUCTION

BACON is not a well-defined product, moreover, bacon processing varies in different countries. In the U.S.A. mainly bellies are processed, in the U.K. back bacon. The traditional Wiltshire cure consists of brine injection followed by tank curing and draining/maturation (7, 9). A range of bacon cures have been developed in the U.S.A. varying from a dry salt box cure to a short cure for bellies (1, 15). Smoking and drying may be applied; smoke has antimicrobial as well as antioxidant properties (13). Sometimes the product is heated to internal temperatures of 49 °C (8), 53 °C (11) or 55 °C (15), which reduces considerably the microbial load on the surface.

U.S.A.-publications mostly deal with the sensory aspects of belly bacon, the lean: fat ratio being a very important parameter (12). U.K.-publications generally contain information on the microbial aspects of sliced vacuum packed bacon (2, 5, 10), in which form bacon is generally packed and distributed.

The safety and microbiological stability of sliced vacuum packed bacon depend on the wateractivity (a_w), the pH, the nitrite content, the bacterial contamination and the storage temperature (4, 6, 16). In the past probably the high salt content of the old-fashioned bacon, resulting in a fairly low wateractivity, was the most important preservative for bacon. For Wiltshire bacon salt contents of 2.5 to 5 % (on the whole bacon), that is about 8 - 14 % NaCl-on-water and salt (brine percentage) were considered normal (7); American bacon was considered mild when the salt content was lower than 3 %, that is lower than 12 % NaCl brine (8). Brine percentages of 8, 10 and 14 % correspond with a_w-values of resp. about 0.94, 0.92 and 0.88, at which a_w-values virtually no growth of pathogenic micro-organisms can occur, especially under anaerobic conditions.

However, a strong trend to lower salt contents exists in the present time. From figures in American publications brine percentages can be calculated of 6 - 7 (3) and 3 - 5 (11). U.K.-publications mention brine percentages of 6.6 (14), 4.5 - 6.5 (17), sometimes referred to as medium salted bacon (16), but also brine percentages of 3 - 5 (5), sometimes referred to as mildly salted bacon (16), or even as low as 2 - 4 (sweet cure) (5).

In the past differences in salt content between sides and between parts of each side were probably of minor importance as a result of the high average salt contents. However, the safety and keeping quality of bacon with fairly or extremely low average salt contents might be affected to a large extent by the varying salt concentration in different sides or different parts of each side.

Information on differences in salt content between sides or cuts and/or packs is scarce, but a rough estimation of the standard deviation of the salt-on-water content (brine %)of different sides in the above-mentioned publications, gives standard deviation of 0.5 to 1 % (6).

Experiments were carried out in the Netherlands to obtain information on the variability of salt contents, the results of which experiments are reported in this paper.

MATERIALS AND METHODS

FOR the experiments in Factory A a Belam type 140 multi-needle injecting apparatus was used. Ten short middles of about 10 kg, bone-in, were injected with a brine containing 23.6 % ($^m/_m$) NaCl, 1408 mg/l $NaNO_2$ and 2908 mg/l KNO_3 to about 115 % of their green weight. The average weight increase however was 13.9 % (12.0 - 16.0 %). For the experiments in Factory B a PI440 (5) multi-needle injecting apparatus was used. Five short middles of about 10 kg, bone-in, were injected with a brine containing 16.0 % ($^m/_m$)NaCl, 640 mg/l $NaNO_2$ and 640 mg/l KNO_3, to about 115 % of their green weight. The average weight increase was 15.6 % (13.0 - 17.5 %).

Deboning was carried out just after injection. After making a cut along the middle, back and belly were pressed on each other. Both were then divided into 19 equal parts of about 250 g, back and belly were separated and alternating portions of both back and belly, starting with the collar and ending at the ham, were coded from 1 to 10, packed separatedly in polyethylene bags and frozen at - 40 °C.

After thawing the contents of each bag were analysed for fat, moisture and NaCl, according to ISO-standard or comparable methods.

RESULTS AND DISCUSSION

THE AVERAGE brine percentages calculated of each back and belly injected in the factories A and B with standard deviations and coefficients of variation are recorded in Table 1. The coefficients of variation of backs and bellies of factory A were comparable, as well as those of factory B. The variation in factory A seemed to be somewhat smaller than the variation in factory B. Brine percentages of backs were generally smaller than those of bellies. These differences are not caused by differences in fat content as is shown in Figures

1 and 2; no relation can be seen between fat contents of backs (Figure 1) or bellies (Figure 2) and their respective brine percentage.

The average brine percentage of all slices 1, 2 etc. of the 10 backs and bellies of factory A and of the 5 backs and bellies of factory B have been graphically recorded in resp. Figures 3 and 4. The average brine percentages of the slices of backs and bellies of factory A follow roughly the same pattern (Figure 3), though the brine percentages of the bellies are greater than those of the backs. The patterns of the brine percentages of backs and bellies of factory B are quite different; especially at the ham end of the bellies the brine percentages are much greater than the corresponding parts of the backs.

No explanation can be given for the generally higher salt contents of the bellies and for the different patterns in both injection apparatus. Two factors might be responsable: the complex system of the middle itself (bone, fat, lean meat) and the relative simple injection system.

Wiltshire cured bacon receives after injection a tank curing and maturation treatment. Other bacons are only drained for some period after injection. There is, however, no indication that tank curing and/or draining significantly reduces the variation of the salt content in the different parts of a middle. Thus, a more homogeneous distribution of the salt in the bacon, especially desirable in the modern mildly cured bacon, might only be obtained with more appropriate multi-needle injection systems. A promising method to compare different injection apparatus appears to be dye-injection method.

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Table 1 Average brine percentages with corresponding standard deviations (s.d.) and coefficients of variation of backs and bellies injected in two factories and analysed after injection

Bacon type	no	Factory A mean brine percentage	s.d.	coeff. of variation %	Factory B mean brine percentage	s.d.	coeff. of variation %
back	1	4.57	0.78	17	3.01	0.61	20
	2	4.45	0.44	10	3.20	0.69	21
	3	4.23	0.79	18	3.17	0.51	16
	4	4.90	0.98	20	2.92	0.72	24
	5	4.61	0.71	15	2.91	0.54	18
	6	4.96	0.74	15			
	7	5.03	0.80	16			
	8	4.54	0.83	18			
	9	5.20	0.60	11			
	10	5.47	0.64	11			
belly	1	5.62	0.96	17	4.36	1.20	27
	2	5.36	0.96	18	4.45	1.15	26
	3	5.06	0.57	11	4.15	1.18	28
	4	5.52	0.92	16	3.87	0.92	23
	5	4.48	0.88	19	3.75	0.68	18
	6	5.98	0.94	15			
	7	5.39	0.81	15			
	8	5.17	0.96	18			
	9	5.28	0.36	7			
	10	6.48	1.20	18			

Figure 1 Relation between brine and fat percentages in 10 slices of bacon from 5 different back bacon (Factory B)

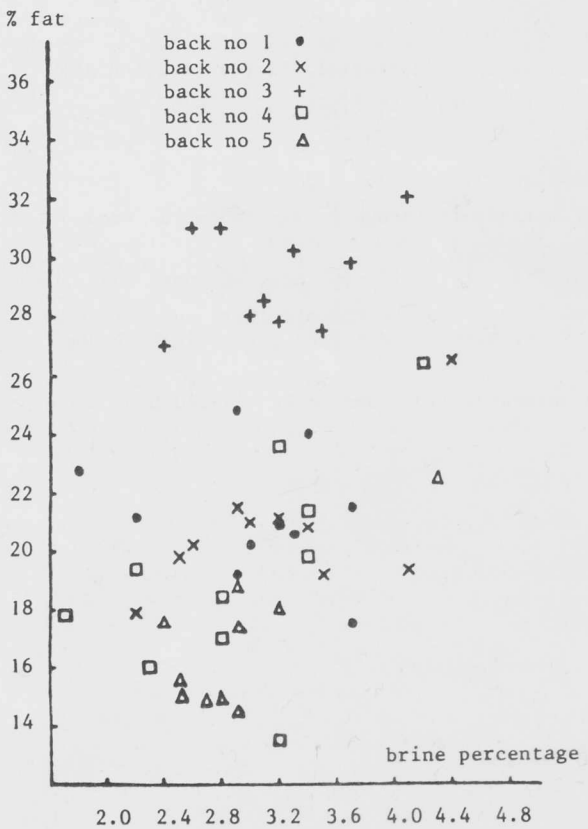

Figure 2 Relation between brine and fat percentages in 10 slices of bacon from 5 different belly bacon (Factory B)