The effect on the bacterial flora of bacon of feeding sugar to pigs before slaughter.

by

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Introduction and Methods.

The experiment was intended to show the effect on the keeping quality of bacon of feeding a diet containing sugar to bacon pigs.

There were 4 experimental treatments, viz:-

1 - starved of both ordinary food and sugar;

A - starved of ordinary food, but fed sugar;

B - fed ordinary food, but not fed sugar;

AB - fed ordinary food and sugar.

The animals in treatment group 1 were starved for 24 hours before slaughter, whereas those in group B were fed ordinary food on the farm 12 hours before slaughter. The sugar feeding in groups A and AB was done 4 hours before slaughter, the ration being on average 2 lb. (c. 1 kg.) white sugar per animal. Each treatment was given to 6 animals, thus there were 48 sides of bacon in all.

Bacteriological samples were taken from 3 places on each side, two from muscle surfaces (adductor and longissimus dorsi) and one from the skin (axilla). Samples from each site on the 6 left sides and the 6 right sides in each treatment group were bulked together. Thus each treatment group yielded 6 bulked samples representing the 3 sites on the left and right sides. Modified drop-plate counts were done on 4 different culture media viz:- (i) tryptic digest agar (TDA) + 3% NaCl, (ii) TDA + 10% NaCl, (iii) a medium containing 2 p.p.m. crystal violet (CVA), and (iv) a tomato juice-dextrose agar (TJDA). These media were considered to give information respectively on the total count, the salt-tolerant bacteria (largely Gram +ve cocci), the Gram -ve bacteria, and Streptococcus plus Lactobacillus species.

Samples were taken after 2, 8, 14 and 21 days post-mortem. These times corresponded with (1) immersion in pickle (2) removal from pickle (3) 6 days of maturation, and (4) 13 days of maturation.

Analysis of data

Only data from the last three times of sampling covering the maturation period were subjected to statistical analysis, since the first samples were from pork not bacon. Because samples were bulked in the way outlined above it was not possible to estimate the variation between animals given the same treatment: thus treatment effects have been confounded with pig effects. In the variance tables which follow, each term is a combination of the effect under consideration and an inestimable error. Such results as are presented, therefore, can only be considered to be indicative.

In the analysis, the 4 experimental treatments were considered in relation to the following:-

a) the counts on the 4 different media, for which purpose the numbers of bacteria present on each of the three occasions of sampling after pickling were added together to give one figure for each of the media.

b) the rate of increase in the numbers of bacteria on the various media. In this case, the number taken was the difference between the first count and the final count.

c) the grand total of bacteria counted on all but the control medium (i.e. TDA + 3% NaCl) for which the figures for the three appropriate counts used in (a) above were summed.

d) the rate of increase in the grand total of bacteria counted on all media except TDA + 3% NaCl.

Results

Considering first the analyses based on the sums of the figures for the separate bacterial counts (excluding the total count figures i.e. (c) and (d) above) which give a general picture of the effect of the various treatments, Table 1 shows that sugar feeding has a significant effect on both the numbers of bacteria (1% level) and their rate of increase (2% level). Those pigs fed sugar before slaughter produced bacon on which the numbers of bacteria and their rate of increase were less than those on bacon from pigs not so fed (see figure 1). It is interesting to note the absence of any similar effect of ordinary food (treatment B in Table 1).

In the analyses based on the counts on 4 different media (see (a) above) only two media showed significant treatment effects. The TJD counts

(Streps. + Lactobacilli) and those on TDA + 3% NaCl gave F values for the main effect of sugar feeding which were significant at the 2% and 5% level respectively. No other comparisons were significant.

In another analysis (see (b) above), however, other significant contrasts were observed. The increase in numbers of bacteria, as observed on TDA + 3% NaCl, reflected an interaction between sugar-feeding and the actual muscle samples (1% level), but no other contrasts were significant. The increase in the Gram -ve bacteria showed several significant contrasts including the main effect of sugar feeding (1% level), but since the contrast between left and right sides was also significant (2% level) when, in fact, sides should be strictly comparable, this particular part of the analysis cannot be given much weight. None of the contrasts in the figures from TDA + 10% NaCl or from TJD were significant.

Despite the anomalies just mentioned it will be clear that the general picture of the effect of sugar feeding given by the various analyses is of a significant decrease both in the rate of increase in the number of bacteria on sides of bacon during maturation and in their total numbers.

Discussion and conclusions

Although the feeding of sugar resulted in bacon carrying a smaller load of bacteria, our data suggest that the difference, though statistically significant, would be of little practical importance since it would extend the storage life by only 3 or 4 days, i.e. by about 25%.

It is important, of course, to consider the means by which sugar feeding exerts an influence on the microflora of bacon. The obvious possibility from earlier work (Callow, Ingram & Hawthorne, 1939) is that the treatment increases the acidity of muscle. In fact, an analysis of data representing single pH determinations made on 3 muscles (the psoas, adductor, and longissimus dorsi) from each animal used in this experiment showed that sugar feeding lowered significantly (1% level) the pH of each of these muscles (see Table 2). The mean value for muscles from sugar-fed pigs was pH 5.804 as compared with 6.035 for muscles from pigs not fed sugar. Ordinary food was again without effect.

Although the pH difference caused by sugar-feeding is small, it seems

that it may be sufficient to account for the effect observed. From a consideration of the rates of growth of more than 40 bacon spoilage bacteria in liquid media adjusted to a range of pH values, it appears that micrococci are more adversely affected by changes in the range pH 6.0-5.8 than are Gram -ve and Gram +ve rods (Table 3). Micrococci, of course, constitute an important element of the flora developing on bacon.

Nevertheless, assuming such a change in the pH to account for the reduced number of bacteria on muscle tissue of bacon, it is difficult to see why the numbers on the skin surfaces are similarly reduced. The fact that no significant differences were detected between the counts from skin and muscle in our analysis may result from its inherent defect arising from the bulking of samples. We intend to reinvestigate this point.

Table 1. Analysis of Variance - Bacteriological Data.

Based on:-	Source of variation	D.f.	SS.	M.S.	F.	P.
1) Total number of bacteria	Sides	1	3.13	3.13	4.53	N.S.
	Treatment A	1	37.064	37.06	53.72	< 0.01
	" B	1	0.307	0.31	0.45	N.S
	" A X B	1	0.674	0.67	0.97	N.S.
	Trt. error	3	2.08	0.69		
	Places	2	0.22	0.11	0.26	N.S.
	Places X trts.	6	6.75	1.13	2.69	N.S.
	Places error	8	3.33	0.42		
	Total	23	53.56			
2) Rate of increase of bacteria	Sides	1	1.84	1.84	3.54	N.S.
	Treatment A	1	11.696	11.70	22.49	< 0.02
	" B	1	0.884	0.88	1.69	N.S.
	" A X B	1	1.130	1.23	2.37	N.S.
	Trt. error	3	1.55	0.52		
	Places	2	3.97	1.99	3.01	N.S.
	Places X trts.	6	4.04	0.67	1.02	N.s.
	Places error	8	5.28	0.66		
	Total	23	30.49			

Table 2. Mean values for the pH of three muscles from the animals in each experimental treatment.

Treatment	Group	Mean pH value	S.E. of difference
Starved	1	6.048	
" + sugar	A	5.786	± 0.061
Ordinary food	B	6.023	
" + sugar	AB	5.823	
Fed sugar	A + AB	5.804	± 0.043
Not fed sugar	1 + B	6.035	

Table 3. The growth rates of four groups of bacon spoilage bacteria at pH 5.8 expressed as a percentage of the growth rate at pH 6.0

Bacterial type	Number tested	% growth rate
Micrococcus	11	58
Achromobacter & Pseudomonas	8	72
Alkaligenes	5	78
Bacillus	5	85