The filtration of bacon brine

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INTRODUCTION

In 1961 a system of converting pork slices to bacon by a process of immersion into brine containing salt and nitrite was outlined by Barrett, Galbraith, Holmes, Davies and Herschdoerfer at the 7th European Meeting of Meat Research Workers at Warsaw. (1). The slice cure process used by my Company for bacon production employs a relatively weak brine (approximately 2/3 saturated) and organisms that can eventually spoil bacon will survive, if not actually multiply, in it. As more and more pork rashers are passed through the tank, contamination of the brine with these organisms increases. If counts on 6 % salt agar are made on slice cure brine, the values steadily rise as production proceeds so that counts of about 100,000 per ml are often reached by the end of a day. Lactobacilli and various Gram positive cocci associated with bacon spoilage account for most of the colonies found in such tests. For this reason the brine used for the slice cure process was discarded at the end of a days production.

The total cost of materials for making slice cure bacon brine in two factories was about £ 15,000 per annum. The object was to salvage this brine in as cheap a manner as possible.

Possible Methods of Brine Salvage

The problem was to destroy or remove spoilage bacteria and leave the soluble materials unaltered. The cost of this operation should be significantly less than the cost of a new brine. A number of methods were considered.

(a) *Heat*

Heating the brine to temperatures of 60° C or over would certainly destroy the spoilage organisms, but would present several difficulties. The brine would have to be cooled again to its operating temperature and the heat would cause precipitation of the soluble protein which would have to be removed in some way.

(b) *Ultra Violet Radiation*

Schoevers (2) used ultra violet light to clean a recirculating ham brine, but found that filtering or centrifuging to remove debris was required as a pre-treatment and that the presence of protein and blood absorbed the radiation, thereby reducing the sterilising power.

(c) *Use of Centrifuge*

Experiments were made with an Alfa Laval centrifuge working at 1450 r.p.m. Although the flow rate was varied between 44 and 160 gallons per hour (200—727 litres per hour), the best reduction in bacterial numbers was only 50 %. The efficiency of such a process would depend on the density differences between the bacteria and the brine.

(d) *Filtration*

It was learnt that a small portable bacteriological filter supplied by Carlson Ford was in use in Ulster (3) for the express purpose of salvaging traditional brines that were spoiling due to abnormal dilution or temperature fluctuation. Experiments were carried out with a small pilot scale Carlson filter which led to the installation of factory scale equipment.

Carlson Filter

The Carlson filter is basically a series of stainless steel mesh plates fitted with inlet and outlet pipes so that the couplings are in parallel. Between the plates can be fixed cellulose- asbestos filter sheets. It is also possible, with the use of special plates, for filter sheets of different porosity to be used in series, each series being coupled in parallel. The whole assembly has a suitable mono pump, adjustable inlet and outlet valves, sight glasses, etc. and can be mounted on wheels.

The flow of liquid through the filter depends on the surface area available for filtration. Thus, by experimentation with a 4-sheet 20 × 20 cm pilot plant (1600 sq.cm.s) it was possible to predict the likely throughput through the 39 sheet 60 × 60 cm. equipment eventually installed.

Pilot Plant Tests

Pilot plant testing was made on samples of brine taken from a curing tank while in use. In Table 1 are given the results of seven tests:

Table 1. *Counts and Flow Rates of Brine through Pilot Filter*

Test	Grade of Sheet (Carlson-Ford Number)	Plate Counts per ml. Before filter	Plate Counts per ml. After filter	Time to filter 36 litres
1	No. 7	21,000	400	14½ mins.
2	No. 7	12,400	5,900	15½ »
3	No. 3	28,000	3,040	4 »
4	No. 3	14,000	1,600	3½ »
5	3 followed by 8	17,280	60	12 »
6	No. 8	5,040	210	16 »
7	3 followed by 8	72,000	19	16 »

The lower the number of the filter sheet the coarser the garde.

The results obtained were of the order expected. The most effective filtration was when two sheets, coarse and fine, were used in series. However, about a 90 % reduction in numbers could be obtained with a single coarse sheet and the rate of flow was four times as fast as the two sheet system.

Experiments were made to test the bacterial contribution of the assembly itself. This was slight in comparison to the infection of the incoming brine, but the plant could be effectively sanitized by pumping through it a warm solution of benzalkonium chloride (active strength 600 p.p.m. quaternary ammonium compound).

When in use the rate of flow of brine through the filter remained almost constant, then fell rapidly as the pores clogged. In practice, it was found that as soon as the flow rate had dropped to about 50 % of the initial value, there was little point in proceeding further.

As a result of the experiments with the pilot plant equipment, a full scale equipment was obtained and connected to a production tank.

Possible Modes of Operation

There were two possible modes of operating the factory plant:

(a) (I) Pump the spent brine through the filter into a holding vessel, (II) clean the production tank, (III) pump the filtered brine back into the tank.

or (b) (I) Pump the spent brine from one end of the tank, through the filter, (II) allow the filtered brine to run straight back into the tank preferably at the opposite end.

The first method would give the most efficient bacterial reduction, but would require an extra vessel to hold 8000 litres. This method would mean, as a general rule, that filtration would have to be done at nights when the

tank was not required for production. The second method could be carried out at any time, even when pork was passing through the tank. Because of limitations of space for a holding tank, the second method was chosen.

Experiences with the Factory Filter

The most serious practical difficulty with the full size production filter involved pieces of meat debris present in the brine. Not only did these rapidly block up the filter sheets, but they also accumulated in the meshes of the plates. The latter point was doubly serious because not only did the debris present a bacterial hazard if it was not removed, but it spoilt the evenness of the flow and had an abrasive action, so that in some instances holes were produced in the filter sheets. Various expedients were tried, the one that was completely successful was the fitting of an extra 'sieving tank' between the main tank and the filter. This tank 75 cm × 75 cm × 40 cm contained two sets of slots in which sieves could be fitted. The inlet and outlet pipes to the tank were near the bottom, on the broad faces of the tank. The sieve plates were of stainless steel, perforated with holes 0.17 cm diameter, 15 per sq. cm. The outlet pipe also was fitted with a cylindrical sieve of the same material.

Carlson Ford recommended that we should not operate the plant after the differential pressure between the inlet and outlet sides of the filter reached 20 lbs p.s.i. (1.41 Kg per sq. cm.) because of the danger of buckling the plates. In practice, it was found that when this value had been reached the flow rate was so low that filtration was virtually ineffectual. Table 2 shows the flow rates and pressure differentials during a typical run. All the experiments with the factory plant involve the No. 3 (coarse) filter sheets.

Table 2. *Flow Rates of Brine through Factory Filter*

Time (hrs)	*Flow Rate (litres/hour)*	*Pressure (lbs.p.s.i.)*
0	3850	0
$^1/_4$	4450	0
$1^1/_4$	4250	3
2	3700	5
$2^1/_4$	3700	8
$3^1/_4$	slow, filter stopped	17

It can be seen from Table 2 that a tank load of brine would take about 2 hrs. to be turned over.

Bacteriological Effect

Results of one typical run with the filter are given in Table 3. In this test the filter was stopped after 2 ½ hours. Bacon was being produced while the filter was operating.

Table 3. *Bacterial Reductions in Brine passing through Factory Filter*

Time (hrs)	*Plate Count per ml*		
	Before filter	*After filter*	*% Reduction*
0	11,000	1,660	85
$1\frac{1}{4}$	6,000	1,040	84
2	5,400	640	88
$2\frac{3}{4}$	4,000	500	88

As would be expected, the counts both before and after filtering fell steadily during the run in spite of the contamination being washed off the pork being processed.

In another experiment a tank of brine was used for three days and nights without being destroyed, the filter being used on four occasions during this period. (Table 4) In this and all subsequent work, no adverse effect on the quality of the bacon was observed.

Table 4. *Brine Tank used for 3 days and 3 nights*

Day	*Time*	*Filter Run*	*Plate Count per ml*		
			Before filter	*After filter*	*% Reduction*
1	0700 hrs		No filtration, no tests		
2	0830 »	1	380,000	3,500	99
	1000 »	1	20,400	130	99
			New sheets immediately fitted		
	1025 »	2	10,400	2,400	88
	1255 »	2	1,080	15	98
3	0715 »	3	12,500		
	0920 »	3	—	70	
	1400 »	4	2,200	100	95

These results illustrate a number of points:

(a) When an untreated brine is used for more than a days production,

the total count on brine becomes high. (380,000 per ml at beginning of Day 2).

(b) When a well used brine is first filtered, the filter clogs rapidly (1 ½ hrs for first run on Day 2, compared with 2 ½ hrs for second run).

(c) The % reduction appears to be variable, being as high as 99 %. This apparent variation may well be due in part to the inherent inaccuracies of the 'Plate Count'. However, in none of the numerous tests carried out has the apparent reduction been less than 84 %, and in the majority of tests it has been 90 % or over.

During the period covered by Table 4, particular attention was given to the bacteriological condition of the bacon produced. This, of course, was not only influenced by the condition of the brine, but by the condition of the original pork and by the subsequent operations after brining. The results obtained are given in Table 5.

Table 5. *Total Counts on Bacon treated in the tank incorporating filter*

Day	*Time*	*Plate Count per g.*
1	0700 hrs.	New brine
1	2300 »	L.T. 1,000
2	0530 »	17,000
2	0830 »	20,000
2	2130 »	5,000
3	0130 »	12,000
3	0530 »	9,000
3	1700 »	24,000
		33,000
		23,000

The results were in the normal range of Plate Counts and were satisfactory.

Routine Operation

Carlson filters of the same type are in operation in two factories producing Slice Cure Bacon. The filters are capable of holding 100 plates, but it has never been found necessary to increase the capacities beyond the 39 plates fitted. All the filtering operations are carried out during daytime shifts by operators who have time also for other duties. Although there seems no obvious reason why regularly filtered brines should not be used indefinitely the tanks and ancilliary equipment must occasionally be cleaned and this can only be done when they are empty. In the absence of spare brine holding

vessels a brine has to be discarded when a tank is emptied. Periodically the brines in use must be checked for their chemical composition and additions of strong solutions of the components are made as necessary.

In our experiments with the small pilot filter we had some limited success in backflushing used sheets so that they could be reused. The increased volume of brine that could be filtered as a result of backflushing was about 25 %. With the factory equipment we were not so successful in backflushing, even though we tried various solutions of detergents and brine as well as water. In view of the very limited advantage that was to be gained by this extra operation we have not backflushed as a routine practice. The net saving in materials per annum by use of the two filters is about £ 10,000. The cost and installation of the two filters was about £ 6,200. The earliest installation has been in use since the autumn of 1966 and so far there have been no major breakdowns or other problems.

The operation of the filter is comparatively simple, but some care must be taken in fitting the sheets. As mentioned before, damage may be caused during operation if the differential pressure exceeds 20 lbs. p.s.i. A safety device can be fitted.

REFERENCES

(1) Barrett, J., Galbraith, C., Holmes, A. W., Davies, J. M., Herschdoerfer, S. M. Slice Curing of Bacon. 7th Meeting European Meat Res. W.

(2) Schoevers, J. F. A. Private communication.

(3) Wilson, D. C. Private communication.