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Further research into the possibility of salmonella-free fattening and slaughter of pigs

By J. OOSTEROM and S. NOTERMANS

Laboratory for Zoonoses and Food Microbiology, National Institute of Public Health, P.O. Box 1, 3720 *BA Bilthoven, The Netherlands*

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SUMMARY

At a pig-fattening farm in the south-western Veluwe which was infected with salmonellas it was sought to achieve salmonella-free fattening in a specially adapted piggery. The test piggery was thoroughly cleaned and disinfected and measures were taken to exclude birds, insects and rodents. An attempt was also made to obtain salmonella-free piglets. Clean clothing, special footwear and disinfectants were used when entering the piggery.

During the experiment an infection was detected in the test piggery caused by the same salmonella serotypes as had only been found immediately before the test at the breeding farm. Other salmonella serotypes occurring at the fattening farm did not find their way into the test piggery, and therefore it can be concluded that after the pigs had been brought in all the hygienic barriers functioned adequately. The test showed that the hygienic measures taken had a beneficial effect on growth performance, even though salmonellas were not entirely excluded.

After fattening the pigs were slaughtered in two groups. The first group was slaughtered in the usual way, but with the second group extra care was taken with the individual singeing of the carcasses and the careful removal of the intestines. Tests on the carcasses showed that 46% of the pigs in the first group were contaminated with salmonellas as against only 7% in the second. From this it can be concluded that slaughter need not lead to further contamination by salmonellas present in the intestines; indeed, carefully carrying out the slaughter process can even reduce the contamination of the surface of pig carcasses by salmonellas.

INTRODUCTION

In order to reduce the large number of salmonella infections which are found every year in human beings in The Netherlands it is essential to produce salmonella-free foodstuffs. Meat, and particularly pork, is frequently contaminated with salmonellas and is thus one of the main sources of infection for man. Research was therefore directed in the first place towards the question what conditions were needed for salmonella-free pig-fattening.

The authors of this paper are rapporteurs for a working party on salmonella-free pigs, comprising representatives of the industry, the National Institute of Public Health, the National Animal Health Committee and the Veterinary Chief Inspectorate of the Ministry of Welfare, Health and Culture.

Earlier research (Edel *et al.* 1974) has shown that salmonella-free pigs can be produced under experimental conditions in specially equipped test piggeries. The requirements which then have to be met are: the piglets brought in must be salmonella-free; the all-in all-out system must be adopted; decontaminated feed must be used; strict hygiene must be enforced, attention must be paid to the exclusion of insects, birds and rodents; the house itself and the tools used must be properly cleansed and disinfected; and special clothing and footwear must be worn when entering the piggery (Edel *et al.* 1967; Edel, Van Schothorst & Kampelmacher, 1976; Edel *et al.* 1978).

However, when pigs were kept under normal working conditions on a farm, again taking all the measures listed above, salmonella-free animals were produced in only one of the four tests carried out on the former island of Walcheren (Oosterom, Van Erne & Van Schothorst, 1982). The conclusion from these four tests was that in working conditions it is virtually impossible to meet all the hygienic requirements. It was also found that pigs could be contaminated with salmonellas while being transported to and kept at the slaughterhouse, even though the lorry and the slaughter-house itself had been cleansed and disinfected.

The fifth test, which is described in this paper, was carried out at a pig-fattening farm in another part of the country; in it was investigated whether the conclusion from the earlier tests was generally valid. Once again tests for salmonella were made both while the pigs were being fattened and during their transport to the abattoir and during slaughter. All the measures listed for the prevention of salmonella contamination were again enforced as far as possible.

MATERIALS AND METHODS

The test farm

The experiment was carried out at a pig-fattening farm in the south-western Veluwe. Initial fact-finding tests had shown that this farm was infected with salmonellas (see Table 1); this was one of the reasons why the farm was chosen, since the impact of hygienic measures can be studied only in a contaminated environment.

The enterprise comprised three piggeries, housing a total of some 800 pigs; one of these piggeries was used for the test. The test piggery consisted of two parts, separated by a wooden wall and doors; each part could house some 100 pigs. The piggery was entered through two doors, one in the front wall and one half-way along the side wall. There was no entrance lobby. The test piggery was some distance (about 100 m) from the remaining houses.

The interior of the piggery had the usual layout: the feeding troughs were positioned along the central passage, and at the back of the pens there was a slatted floor covering a slurry pit. Along the slatted passage the pens were separated by small gates.

The farm used a wet-feeding system. After feeding, pellets were placed in the troughs and mixed with water for the next feeding time. The pigs had no access to water except at feeding time. The pellets were obtained from a nearby animal-feed factory.

A number of measures were taken in and around the test piggery in preparation for the experiment. These included placing fly-proof netting over all the air inlets

in the side walls and the outlet ventilators in the roof ridge. Fly-proof doors were placed inside each access door.

Since there was no entrance lobby a stone calf shed, situated about three metres from the entrance to the test piggery, was used for changing footwear and clothing. After the shed had been cleansed and disinfected a footbath filled with a 1% Halamid^R solution was placed in it, together with several clean pairs of boots and clean jackets. To minimize the risk of contamination in walking from the calf shed to the piggery entrance a paved pathway was laid between the two buildings, at a slightly higher level than the surrounding grass. A second footbath containing a Halamid^R solution was placed inside the piggery entrance so that persons entering the piggery could disinfect their boots a second time.

After the piggery had as far as possible been made rodent-proof by blocking all holes in the walls and floor the interior was cleaned with a high-pressure spray and disinfected using a Lyorthol^R solution (10%) and formalin vapour. After disinfection the piggery was entered as little as possible. The bedding for the pens, consisting of sawdust, was disinfected along with the interior on the first occasion. Care was also taken that all the other articles needed during the fattening period – brooms, feed, trolley, feed scoops, injection syringes etc. – were also in the piggery when it was disinfected. When new bedding was needed during the fattening period the plastic bags in which the sawdust was packed were wetted on the outside with a Lyorthol^R solution before being brought into the house and opened.

The test animals

The pigs used in the test all came from the same breeding farm. Initial research at this farm indicated for a long period that it was salmonella-free, until *Salmonella london* and *S. panama* were isolated shortly before the start of the experiment. Since they were the only two serotypes found and since the salmonella present on the fattening unit was mainly of another type it was decided nonetheless to go ahead with the test.

The pigs were brought in in two groups: at first 110 animals were brought into the test piggery and a further 80 six days later. Their average weight was 23 kg. They were transported in a livestock lorry which was cleansed and disinfected for the occasion (Stafilex^R, one tablet in 10 l of water). When they were loaded the short distance from the weaner house to the lorry was covered with agricultural plastic to prevent contamination of the animals; disinfected footwear was worn.

The fattening period

In the test piggery the animals were fed starter pellets with 50 mg/kg of Carbadox^R for the first few weeks; thereafter normal fattening pellets (containing 10 mg/kg of Tylan^R) were given. During fattening a record was kept of the pigs' feed consumption so that an accurate assessment of their growth performance could be made at the end of the period. During the fattening period three pigs were treated by injection for lameness or thick joints; in each case the treatment lasted 3 days. None of the 190 test animals died during the test. The pigs were dispatched in two groups: 105 were transported to the slaughterhouse in the first group, the remaining 85 following 2 weeks later.

Slaughter procedures

Since the research on the test pigs extended to their transport and slaughter it was agreed that they would be the first group to be dispatched and slaughtered in the morning. It was also agreed that the livestock lorry would be thoroughly cleansed and disinfected and that in addition to the usual hygienic measures at the slaughterhouse extra care would be taken over the work of cleansing and disinfection.

The first group of pigs were slaughtered in the usual way. In the case of the second group extra care was taken with the individual singeing of the carcasses and the careful removal of the intestines.

Sampling

At the breeding farm the sows' faeces were sampled once a week, except in the period immediately before the dispatch of the young pigs, when faeces samples were taken from the young pigs themselves. At the fattening farm faeces from pigs in the test piggery were sampled once a week; faeces samples were also taken every week from pigs housed in the farm's other piggeries.

All faeces samples, on both the breeding farm and the fattening farm, were taken using a plastic bag over the hand, collecting together into a single sample several separate lumps of excrement from each pen. The work of collecting samples on both farms was begun several months before the start of the experiment, because full information was needed on any salmonella contamination in either enterprises.

After the test piggery had been cleansed and disinfected thirteen samples were taken, consisting of swabs from the floors and walls, to check that the cleansing and disinfection work had been carried out effectively.

When the weaners were transported swabs were taken from the interior of the livestock lorry before the animals were loaded. Immediately before dispatch the last samples were taken of the pigs' faeces, and after the first group had been transported a few lumps of excrement were taken from the lorry for testing.

Food samples were taken by collecting a quantity of pellets in a plastic bag in a sterile manner. In the same way a sample of sawdust was taken from one of the other piggeries on the fattening farm. The mice caught were also packed in a plastic bag.

When the fatteners were sent for slaughter, swabs were taken from the interior of the livestock lorry before the animals were loaded. On arrival at the slaughterhouse a few faeces samples from the lorry were collected in plastic bags.

After cleansing and disinfection of the slaughterhouse, swabs were taken from surfaces and equipment and water samples were collected in sterile glass jars. Finally, after slaughter, swabs were collected in the cold store from a large number of the test animals. All samples were tested for the presence of salmonellas. The swabs taken to check on the effectiveness of cleansing and disinfection were also tested for the presence of other members of the *Enterobacteriaceae*.

Testing for salmonella and Enterobacteriaceae

25 g of each sample of faeces, feed and bedding was placed in 225 ml of buffered peptone water (BPW). Also 25 ml of the water samples was put in 225 ml BPW.

The swabs were placed in 100 ml of BPW immediately after they were taken from the surfaces being tested. The mice taken for examination were cut open under sterile conditions in the laboratory; a section of the intestine, weighing about 1 g, was then cut into pieces and added to 10 ml of BPW.

In the laboratory the BPW was incubated at a temperature of 37 °C for 16–20 h. Thereafter 10 ml of this pre-enrichment broth was transferred into 100 ml of tetrathionate broth (Muller-Kauffmann formula), which was incubated at 43 °C. After 24 h and again after 48 h one loopful (diameter 3 mm) was streaked onto brilliant green-phenol red-agar plates with a diameter of 15 cm, which were incubated at 37 °C for 24 h. Suspected colonies were tested biochemically using triple-sugar-iron/urea-agar and lysine decarboxylase medium (ISO Report, 1981).

From each plate one culture, with biochemical reactions coinciding with those of salmonella, was sent for further identification (serotype and phage type) to the National Salmonella Centre (Drs P. A. M. Guinée and W. J. van Leeuwen).

Tests for the presence of *Enterobacteriaceae* were made by transferring 10 ml of the BPW after incubating it as described above into 100 ml of selective medium (EE broth) and incubating the latter at 37 °C for 24 h. One loop (diameter 3 mm) from the EE broth was then streaked on violet red bile glucose agar (VRBG), which was checked after 24 h at 37 °C for the presence of violet-red colonies with a violet-red halo (ISO Report, 1979).

RESULTS

The results of the tests made at the breeding and fattening farms and in the lorries used to transport the pigs are set out in Table 1. A few weeks before the experiment began an infection, principally by *S. london* and *S. panama*, was detected at the breeding unit. In the preliminary tests in the test piggery, salmonellas were isolated only once (*S. panama* OS), in a faeces sample taken 3 months before the start of the experiment. Over the same period *S. typhimurium* phage types I 656 and I 655, was found to be present in the other piggeries of the fattening unit; shortly before the test began *S. london* was found in a group of newly delivered pigs. *S. typhimurium*, phage type I 656, was isolated in sawdust stored in one of the other piggeries.

After the test piggery had been cleansed and disinfected no salmonellas were found on the 13 swabs taken from the interior; however, 11 of the 13 were found to contain *Enterobacteriaceae*. Salmonella was not detected in a mouse caught in the test piggery.

When the pigs were brought to the test piggery it was found that they were infected with salmonella: in the first group *S. london* was detected three times and in the second group *S. panama* once. No salmonella was found in the livestock lorry, but 15 of the 30 swabs examined were found to contain *Enterobacteriaceae*.

During the experiment salmonellas were repeatedly cultured from the samples taken from both the test piggery and the other piggeries of the fattening farm: 68 % of the samples from the test piggery, and 81 % of those from the other houses, were found to be positive. The results from the fattening period are grouped on a weekly basis in Table 2, which also shows the results for the same period from the breeding farm. In the test piggery and the breeding unit *S. london* and *S.*

Table 1. *Tests for salmonella at the breeding and fattening farms before and during the experiment and in the livestock lorries*

Origin of samples	Number	Number positive	Serotypes and phage types
(1) Preparatory stage			
Breeding farm before dispatch of pigs	110	13	5 × *S. london* 4 × *S. panama* G 1 × *S. panama* OS 2 × *S. london*/*S. panama* G 1 × Salm E_1-group
Test piggery before start of experiment	131	1	1 × *S. panama* OS
Other piggeries before start of experiment	124	16	13 × *S tm* I 656 1 × *S tm* I 655 2 × *S. london*
Sawdust	1	1	1 × *S tm* I 656
Test piggery after cleansing and disinfection	13	0	
Mouse	1	0	
(2) Transport of pigs to fattening farm			
First group of pigs before dispatch	18	3	3 × *S. london*
Lorry before transport of first group	9	0	
First group of pigs after delivery	9	0	
Second group of pigs before dispatch	12	1	1 × *S. panama* OS
Lorry before transport of second group	5	0	
(3) During experiment			
Pigs in test piggery during experiment	170	116	*See Table 2*
Feed in test piggery	34	0	
Mice in test piggery	2	1	1 × *S. london*
Pigs in other piggeries during experiment	170	137	*See Table 2*
(4) Transport of pigs to slaughter			
Lorry before dispatch of first group	8	0	
Lorry on arrival at slaughterhouse	3	2	2 × *S. london*
Lorry before dispatch of second group	8	0	
Lorry on arrival at slaughterhouse	4	4	2 × *S. panama* OS 1 × *S. panama* G 1 × *S. london*

panama were virtually the only types found, while in the other piggeries of the fattening farm *S. typhimurium*, phage type I 656, was predominant. Towards the end of the fattening period *S. panama* and *S. london* were also isolated there.

Table 1 also shows that no salmonellas were cultured from 34 feed samples taken in the test piggery and that one mouse, caught in the test piggery towards the end of the experiment, was found to be infected with *S. london*.

Table 1 shows finally that no salmonellas were isolated from the livestock lorries used for transporting the pigs to slaughter; however, *Enterobacteriaceae* were cultured from all 16 swabs. After the pigs had been transported the dung left in the lorry was found to be contaminated with *S. london* and *S. panama*.

The results of the tests at the slaughterhouse are given in Tables 3 and 4. On both the days when the test pigs were slaughtered salmonellas were found in the slaughterhouse: in the first test seven of the 29 samples were positive and in the second five of the 28. Seven different types of salmonella were found. After the

Table 2. *Tests for salmonella at the breeding and fattening farms during the experiment*

Date	*	Test piggery	*	Other piggeries	*	Breeding unit
18/12	1	1 × *S. london*	7	6 × *S. tm* I 656 1 × Salm of B-group	8	7 × *S. panama* G 1 × *S. london*/ *S. panama* G
29/12	0	—	10	10 × *S. tm* I 656	6	6 × *S. panama* G
07/01	1	1 × *S. london*	4	4 × *S. tm* I 656	3	3 × *S. panama* G
13/01	2	2 × *S. london*	10	10 × *S. tm* I 656	4	4 × *S. panama* G
19/01	5	4 × *S. london* 1 × *S. panama* G	10	10 × *S. tm* I 656	5	2 × *S. london* 3 × *S. panama* G
29/01	5	5 × *S. london*	6	6 × *S. tm* I 656	4	2 × *S. london* 2 × *S. panama* G
04/02	9	4 × *S. london* 4 × *S. panama* G 1 × *S. london*/ *S. panama* OS	6	6 × *S. tm* I 656	2	2 × *S. panama* G
09/02	9	4 × *S. london* 5 × *S. panama* G	10	10 × *S. tm* I 656	1	1 × *S. panama* G
19/02	10	2 × *S. london* 4 × *S. panama* G 2 × *S. london*/ *S. panama* G	9	4 × *S. tm* I 656 3 × *S. tm* I 656/ *Salm* B-group 2 × Salm of B-group	2	1 × *S. london* 1 × *S. panama* G
23/02	10	6 × *S. london* 4 × *S. panama* G	10	4 × *S. tm* I 656 6 × *S. panama* G	2	1 × *S. london* 1 × *S. panama* G
05/03	10	5 × *S. london* 1 × *S. panama* G 1 × Salm of D-group 2 × *S. london*/ *S. panama* G 1 × *S. london*/ *S. panama* OS	10	3 × *S. tm* I 656 5 × *S. panama* G 1 × *S. panama* G/ *S. panama* OS 1 × *S. panama* G/ Salm of D-group	2	2 × *S. panama* G
11/03	10	6 × *S. london* 2 × *S. panama* G 1 × *S. panama* OS 1 × *S. panama* G/ *S. panama* OS	9	8 × *S. tm* I 656 1 × *S. tm* V 510	0	—
17/03	10	5 × *S. london* 4 × *S. panama* G 1 × *S. london*/ *S. panama* G	7	1 × *S. tm* I 656 5 × *S. panama* G 1 × *S. london*/ *S. panama* G	0	—
25/03	8	3 × *S. london* 5 × *S. panama* G	8	8 × *S. tm* I 656	0	—
01/04	8	3 × *S. london* 4 × *S. panama* G 1 × *S. panama* G/ Salm of D-group	7	3 × *S. panama* G 2 × *S. panama* OS 1 × *S. panama* ORS 1 × *S. tm* I 60/ *S. tm* I 656	0	—
07/04	8	4 × *S. london* 1 × *S. panama* G 2 × *S. panama* OS 1 × biochem. Salm	6	3 × *S. tm* I 655 1 × *S. london* 2 × *S. tm* I 655/ *S. london*	0	—
13/04	10	2 × *S. london* 8 × *S. panama* G	7	5 × *S. tm* I 656 1 × *S. panama* G 1 × Salm of B-group	0	—

* Number of samples in each group found positive. Ten samples were taken on each visit.

Table 3. *Tests for salmonella at the slaughterhouse: slaughter of the first group of pigs under normal working conditions*

Sampling point	Number of samples	Number positive	Serotypes and phage types
Floor of unloading bay	1	0	
Pen walls and floors	7	1	1 × *S. tm* I 260
Race to restrainer	2	1	1 × *S. tm* OS
Restrainer	2	2	1 × Salm of B-group
			1 × *S. tm* II 505 var Cop
Sticking area	1	0	
Water in scalding tank	2	0	
Dehairing machine	3	3	3 × *S. bareilly*
Water from brusher unit	6	0	
Tray line	1	0	
Apron	1	0	
Walls	2	0	
Chopping machine	1	0	
Pig carcasses in cold store	35	16	2 × *S. london*
			5 × *S. panama* OS
			7 × *S. ohio*
			1 × *S. tm* I 655
			1 × *S. panama* G

Table 4. *Tests for salmonella at the slaughterhouse: slaughter of the second group of pigs taking extra care over singeing and evisceration*

Sampling point	Number of samples	Number positive	Serotypes and phage types
Floor of unloading bay	1	0	
Pen walls and floors	6	0	
Race to restrainer	2	0	
Restrainer	2	0	
Sticking area	1	0	
Water in scalding tank	2	2	1 × *S. bareilly*
			1 × *S. livingstone*
Dehairing machine	3	3	1 × *S. mbandaka*
			2 × *S. bareilly*
Water from brusher unit	6	0	
Tray line	1	0	
Apron	1	0	
Walls	2	0	
Chopping machine	1	0	
Pig carcasses in cold store	30	2	2 × *S. ohio*

first group of pigs had been slaughtered salmonellas were isolated from 46 % of the carcasses, while in the second group the proportion was reduced to 7 %. In all nine *S. ohio*, six *S. panama*, two *S. london* and one *S. typhimurium*, phage type I 655, were isolated.

DISCUSSION

A few weeks before the experiment began infection by *S. london* and *S. panama* was found at the breeding farm. An examination of the pigs used in the experiment clearly demonstrated that this infection was brought into the test piggery along with the pigs.

By the time the experiment in the test piggery began the preparatory testing had provided clear information on the salmonella infection at the fattening farm. In the three months prior to the experiment salmonellas were found in the test piggery only once. Tests thereafter showed that cleansing and disinfection of the test piggery had not been completely thorough, since *Enterobacteriaceae* could still be isolated from the majority of the samples taken. Salmonellas were again found to be absent.

Despite these facts we can most probably conclude that the *S. panama* isolated from the test piggery on one occasion some three months before the start of the experiment had no connection with the later infection of the test pigs with *S. panama*, in view of the fact that this type was not detected in the pigs in the intervening period.

The other piggeries of the fattening farm were found to be contaminated principally with *S. typhimurium*, phage type I 656. Just before the experiment *S. london* was introduced along with a group of pigs into these other houses, but thereafter this salmonella type was not detected there again for more than 13 weeks (Tables 1 and 2).

The tests on the livestock lorry used to transport the weaners to the fattening house showed that the vehicle was probably not contaminated with salmonella. A visual inspection indicated that cleansing and disinfection had been carried out satisfactorily, but tests revealed *Enterobacteriaceae* in half of the samples taken.

S. london and *S. panama* were isolated only on the odd occasion during the first few weeks of the fattening period (see Table 2). This low infection rate may have been partly due to the presence of antibiotics in the feed given at this time. Thereafter a more generalized infection of the test pigs set in, and from then until slaughter the majority of the faeces samples examined were found to be positive. It should be noted, however, that the pigs showed no symptoms of disease at any time in the fattening period, including when the increase in salmonella infection took place.

The course of events in the other piggeries of the fattening farm was quite different (see Table 2). Here too there was an increase in salmonella infection, mainly involving *S. typhimurium*, phage type I 656, but in this case symptoms such as diarrhoea, listlessness and reduced appetite were observed. Laboratory tests carried out by the Animal Health Service in Gelderland showed that in any event infections involving TGE (transmissible gastro-enteritis) and Aujeszky's disease played a part. Both infections occurred in the neighbourhood during the period of the test, one nearby breeder losing some 200 piglets through TGE. The 'all-in all-out' system was not used in the other piggeries of the fattening farm.

During the last part of the test period *S. london* and *S. panama* were also found in the other piggeries of the fattening farm. This infection is unlikely to have come from the test piggery; more probably it was brought in with new pigs from the breeding farm. Table 2 shows that the breeding farm had for some time been infected with these two types of salmonella and that this infection slowly died down until no more salmonellas could be isolated. From this it may be concluded that pigs infected with *S. london* and *S. panama* must indeed have been delivered to the fattening unit over a period of time.

No salmonellas were cultured from any of the feed samples taken from the test piggery. However, a visit to the factory supplying animal feed revealed that the

pelleting process was being carried out at a rather low temperature (52 °C). Pelleting in these conditions does not guarantee the absence of salmonella from the feed, but it is nonetheless unlikely that any salmonella infection was brought into the test piggery along with the feed.

Certain of the requirements set in advance could not therefore be met: in the first place it proved impossible to obtain salmonella-free piglets; in the second the feed was not pelleted in the proper manner; and in the third mice were found in the isolated piggery. Nonetheless it is clear that the hygienic measures taken reduced the infection rate, since the salmonella type encountered in the other piggeries did not find its way into the test house. The test animals were also unaffected by other diseases – TGE and Aujeszky's disease – found elsewhere on the farm. This is reflected in the pig's growth performance: the mean food-conversion ratio calculated for the pigs in the other piggeries was 3·35, while the figure for the test pigs was 3·00. This means that the strict observance of hygiene in pig-fattening brings immediately demonstrable benefits, even if the aim we set ourselves – the elimination of salmonella infections – was not achieved.

The results of the tests made at the slaughterhouse showed that the disinfection of surfaces and equipment succeeded on neither occasion in eliminating salmonella entirely. Various salmonella types were isolated. When carcasses were tested after slaughter salmonellas of various types were again cultured. The types which had not already been identified in the test piggery probably got onto the carcasses at the slaughterhouse, even though they were not found there (Tables 3 and 4). In view of the fact that towards the end of the experiment mostly eight out of 10 faeces samples from the test piggery were found to be positive, the proportion of infected carcasses (46 %) can even be considered low. This may have been due to the fact that the pigs were slaughtered with a relatively empty stomach: on the day before slaughter they had been fed only once, at around midday. (The less full the intestines are, the less likely they are to be punctured during evisceration, thus reducing the contamination of the carcasses.)

When the second group of pigs were slaughtered extra care was taken with the individual singeing of the carcasses and the careful removal of the intestines. We found that it was possible to eliminate the principal causes of carcass contamination – the contaminated skin and the contents of the intestines – and thus to produce a relatively bacteria-free product. The salmonella types found in the pigs themselves (*S. panama* and *S. london*) were not detected on the carcasses.

Our general conclusion is that under normal working conditions there are major obstacles in the way of salmonella-free pig-fattening in The Netherlands: firstly the pig-fatteners would clearly have difficulty in meeting the necessary requirements (relating both to the buildings and to stock management), and secondly they could have no guarantee whatsoever of an adequate and uninterrupted supply of salmonella-free pigs for fattening. In addition a number of changes will be needed in most livestock-feed factories before they can be sure of supplying salmonella-free pig feed with any degree of reliability. We were repeatedly faced by all these problems in carrying out our practical tests.

From all our work it is clear that only an integrated approach – involving breeders, fatteners, feed producers and livestock transporters – will produce results. We would recommend that a start be made using such an approach on a small scale in order to identify the organizational problems involved.

A World Health Organization report (WHO Report, 1980) indicate three lines of defence against salmonella infections in food, namely (*a*) the production of salmonella-free animals, (*b*) the enforcement of hygiene in the slaughter-house, and (*c*) public education on food preparation and storage. The results of our research show that if the first line of defence does not offer adequate protection against salmonellas, a number of measures can nonetheless be taken in the slaughterhouse to counter the contamination. Our data and the results obtained by others (Snijders & Gerats, 1976; Childers, Keahey & Kotula, 1977) point to the conclusion that slaughter need not necessarily lead to further contamination by salmonellas present in the intestines; indeed, carefully carrying out the slaughter process can even reduce the contamination on the surface of pig carcasses by salmonellas. An investigation will need to be made of the extent to which this can be achieved under normal working conditions. Only when slaughterhouse operations are carried out under optimal hygienic conditions – which will entail among other things changes in the equipment used – will it be possible to judge whether an additional decontamination of meat (for instance by irradiation or by the application of low-chain food acids) is necessary to ensure that it meets the requirements regarding salmonella contamination set for other foodstuffs.

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