Estimated effect of the *Salmonella* Surveillance-and-Control Programme “SALCONMEAT” on food safety related to pork produced within the programme

Alban L* (1), Barfod K (2), Pedersen JV (1), Dahl J (1), Ajufo JC (3), Sando G (1), Krog HH (4)

(1) The Danish Agriculture & Food Council, Axeltorv, DK-1609 Copenhagen, Denmark
(2) The Zoonosis Centre, Mørkhøj Bygade 17, DK-2860 Søborg, Denmark
(3) The Danish Veterinary and Food Administration, Mørkhøj Bygade 19, DK-2860 Søborg, Denmark
(4) Danish Crown, Bragesvej 18, DK-4100 Ringsted, Denmark

*corresponding author: lila@danishmeat.dk*

Abstract

There are basically two different ways of addressing *Salmonella* control; either pre-harvest or post-harvest. For a small to medium slaughterhouse, pre-harvest initiatives might prove effective whereas this is less likely for a large slaughterhouse. We present a pre-harvest programme by which we are able to produce pork with a very low prevalence of *Salmonella*.

Introduction

By Article 8 of Regulation 853/2004 fresh meat of bovine and porcine animals intended for Finland and Sweden must be tested for *Salmonella*. However, according to subparagraph (d) of Article 8, these microbiological tests need not be carried out for fresh meat from an establishment subject to a control programme recognized, by the EU in accordance with the procedure laid down in Article 12, as equivalent to that approved for Finland and Sweden. On the island of Bornholm in Denmark, the prevalence of *Salmonella* in finishers and in fresh pig meat is lower than in the rest of Denmark. The question is, therefore, whether a surveillance and control programme covering fresh pig meat from the slaughterhouse on Bornholm will enable the plant to be exempted from carrying out these microbiological tests. This would seem reasonable if the *Salmonella* prevalence in fresh pig meat produced on Bornholm does not represent a higher risk than what is found in fresh pig meat in Finland and Sweden. Therefore, a surveillance-and-control programme called SALCONMEAT was designed on top of the Danish *Salmonella* surveillance-and-control programme that already applies in Denmark.

To qualify for the SALCONMEAT programme, extra requirements must be met by the producers, including the feed suppliers. Moreover, nucleus and multiplier herds are monitored with an increased intensity both by use of serology and bacteriology. For finisher herds, nucleus and multiplier herds, a maximum of one positive serological reactor is allowed while all bacteriological tests must be negative. Sow herds are monitored indirectly through the finisher herds they supply with stock. Regarding finisher herds, serological monitoring is conducted. Samples are dispatched daily, and results are available 2 days later and before the next delivery of finishers from the herd. Qualifying herds are allowed to deliver animals in the following week. A sow herd and a finisher herd are most often contractually connected. If *Salmonella* is found in a sow pen-faecal sample, both the sow herd and the finisher herd are excluded from the programme. If a positive sample is found in a finisher herd, the sow herd supplying piglets is inspected through trace-back and trace-forward. By January 2009, three herds out of 203 did not fulfil the serological criterion, and six herds were under observation. The most common herd size of production is 1,000-2,000 finishers per year.

The aim of the present study was to assess the effect of the SALCONMEAT programme. The programme is not yet in operation. However, the effect of the programme can be estimated by examining the data from the herds which would have qualified for the programme. First, we inspected the number of herds that fulfilled the requirements of the programme as well as the number of herds that did not meet the criteria during the time period from 2006 to 2008. Next, we studied the effect on food safety defined as the proportion of *Salmonella*-positive carcasses among the pigs originating from herds that qualified for the
programme. Moreover, we estimated the number of human cases related to the pork produced within the programme in two realistic scenarios.

Materials and methods

The data used covered 3 years; from 2006 to 2008. We obtained data from the serological surveillance programme and by use of these we grouped the herds according to whether or not they fulfilled the requirements for the SALCONMEAT programme or not. This is a dynamic assignment because it changes every month. Moreover, we obtained data were from the slaughterhouse monitoring programme. This programme consists of daily swabbing of 300cm² of each of five carcasses daily. These swab samples are analysed as one pooled sample. A conversion factor of three is subsequently used to calculate the individual prevalence of *Salmonella* in a swab sample. The herd of origin of each of the five carcass swab samples is registered. The data were grouped according to the origin of each of the five samples in each pooled sample into three groups: 1) All five samples originated from herds that all qualified for the SALCONMEAT programme. 2) Lack of serological samples from at least one herd, hence its status with regards to the SALCONMEAT programme was unknown. 3) At least one out of five samples originated from a herd that did not qualify for the SALCONMEAT programme

![Graph showing the number of finisher herds and total number of meat-juice samples positive for antibodies against *Salmonella* grouped according to whether the herd would have qualified for the SALCONMEAT programme for *Salmonella* during 2006-2008, Bornholm](image)

Fig. 1. Number of finisher herds and total number of meat-juice samples positive for antibodies against *Salmonella* grouped according to whether the herd would have qualified for the SALCONMEAT programme for *Salmonella* during 2006-2008, Bornholm

A simulation model developed by Barfod et al. (2008) was used to estimate the number of human cases of salmonellosis due to the pork (fresh pig meat) produced within the SALCONMEAT programme. In a year, the Danish population consisting of around five million inhabitants consumes a little more than two million carcasses. Serving size is 200g. A reduction factor dealing with the effect of preparing food including heat-treatment is used. This factor is analogous to the so-called a-factor in the Danish *Salmonella*-attribution model (Hald et al., 2004). The reporting rate was set to around 5% implying that about 5% of the true *Salmonella* cases are reported. It is presumably the mildest cases that are not reported. The model simulates whether a serving is contaminated with *Salmonella* or not based on the input data from year 2006 from five Danish abattoirs. Here, carcass swab samples were obtained from around 2,000 pig carcasses and showed a *Salmonella* prevalence of 1.8% (Aabo et al., in prep.). Next, for positive servings, the quantitative number of *Salmonella* was simulated based on data on faecal carcass contamination and concentration data (*Salmonella* in faeces) from the same study by Aabo et al. (in prep.).
Subsequently, it was assessed whether a given quantitative number of *Salmonella* bacteria in a serving would result in disease. This was done by use of a beta-poission dose-response model, as recommended by FAO/WHO (Equation 1). This implies that with a dose of *Salmonella* of around $10^4$, around 50% of exposures would lead to sickness. For very low doses of *Salmonella* (<10) the probability of becoming ill is very low.

Probability of illness ($P_{ill}$) = $1 - (1 + \text{Dose}/\beta)\alpha$ where $\alpha, \beta = 0.1324, 51.45$ (Equation 1)

**Results**

The number of herds that would have qualified or not are depicted in Fig. 1. The variation in number of herds qualifying for the programme or not is also reflected in the total number of positive meat-juice samples found in herds that qualified/did not qualify for the programme (Fig. 1). In all 3 years, the total number of positive meat-juice samples in the herds within the programme was much lower than the number of positive samples in the herds outside the programme – despite the fact that the number of herds within the programme was much higher than the number of those outside the programme.

Table 1

<table>
<thead>
<tr>
<th>Prevalence of <em>Salmonella</em> in given year</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pools of 5</td>
<td>Carcass[^a]</td>
<td>Pools of 5</td>
</tr>
<tr>
<td>Within programme or lack of samples taken</td>
<td>Pos/total</td>
<td>(%)</td>
<td>Pos/total</td>
</tr>
<tr>
<td>Within programme</td>
<td>3/110</td>
<td>0.91</td>
<td>0/108</td>
</tr>
<tr>
<td>Outside programme</td>
<td>2/132</td>
<td>0.51</td>
<td>6/124</td>
</tr>
</tbody>
</table>

[^a]: A conversion factor of 3 was used to convert the prevalence of *Salmonella* measured in a pool to the prevalence on carcasses.

Table 1 shows that the prevalence of *Salmonella*-positive carcasses varied slightly during 2006-2008. In 2006, among qualifying herds, a carcass prevalence of 0.91% was obtained, whereas none of the 108 pools tested in 2007 was positive. Finally, in 2008 a prevalence of 0.45% was obtained. When the data for the 3 years are combined, a carcass prevalence of 0.46% is obtained for the herds within the programme and 0.97% for the herds outside the programme ($p=0.19$). If only data from 2007 and 2008 are used, then a prevalence of 0.26% is obtained.

Table 2

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Origin of pork</th>
<th>Assumed prevalence[^b] in pork</th>
<th>Mean No. of human cases of <em>Salmonella</em> (90% C.I.) Assuming all pork in Denmark are of specific origin</th>
<th>Adjusting production capacity in area of origin for</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Five Danish slaughterhouses[^c]</td>
<td>1.8%</td>
<td>107 (0-366)</td>
<td>107 (0-366)</td>
</tr>
<tr>
<td>2a</td>
<td>SALCONMEAT</td>
<td>0.5%</td>
<td>28 (0-123)</td>
<td>5 (xx-xx)</td>
</tr>
<tr>
<td>2b</td>
<td>SALCONMEAT</td>
<td>0.2%</td>
<td>11 (0-54)</td>
<td>2 (xx-xx)</td>
</tr>
</tbody>
</table>

[^a]: Includes testing of 2,000 finishers described in Aabo et al., (in prep.) and used in simulation model developed by Barfod et al. (2008).[^b]: Prevalence calculated as proportion of positive carcasses.

The prevalence of *Salmonella* in individual Danish carcasses found in the study by Aabo et al. (in prep.) was used as a baseline to compare with fresh pork from Bornholm. According to the simulation model,
107 human cases attributable to pork were estimated in Denmark in 2006, based on a 1.8% carcass prevalence originating from 2,000 finishers (Table 2). Then we assume that all pork consumed in Denmark originate from SALCONMEAT. Here a prevalence of 0.5 (scenario a) or 0.2% (scenario b) can be assumed based on the collected data. Again, the prevalence of Salmonella is measured as the proportion of positive carcass swab samples (the individual carcass prevalence). According to the model 28 or 11 human cases can be expected, respectively. A prevalence of 0.5% corresponds to the prevalence of 0.46% which was seen on average during 2006-2008, whereas a prevalence of 0.2% more or less corresponds to the prevalence observed during 2007-2008.

The initial results presented in scenario 2a and 2b in Table 2 assume that all pork consumed in Denmark originates from SALCONMEAT. The expected number of human cases due to Salmonella ascribed to pork from SALCONMEAT should be adjusted to the real production of pork within the programme. On Bornholm, 406,000 finishers are slaughtered annually, and 13,000 of these are expected to be excluded from the future programme because of presence of Salmonella. Therefore, 393,000 carcasses are expected to be produced within the SALCONMEAT programme. In Denmark, around 2.2 million carcasses are consumed annually. Hence, the production within the SALCONMEAT programme is 393,000/2,170,800=18% of the national consumption – if all pork from Bornholm were consumed in Denmark. The right column in Table 2 presents the estimated number of human cases of salmonellosis related to the production of pork within the SALCONMEAT programme. It is noted that the number is five or two – depending upon which scenario was assumed.

As a model control we used the national carcass prevalence of Salmonella in 2006 which was 1.0% - and in that year 101 human cases were ascribed to Danish pork. Hence, if a prevalence of 0.5% is assumed for pork from SALCONMEAT and the production at maximum constitutes 18% of what is consumed in Denmark, then around 101x(0.005/0.01)x0.18= 10 human cases can be expected. Similarly, when a carcass prevalence of 0.2% is assumed, the number of human cases is expected to be around four.

Discussion

For a given programme to be successful it needs to be able to correctly allocate herds into those which qualify and those which do not qualify for the programme. And this does not only apply at the beginning of the programme. Herds that at some stage no longer qualify for the programme should be removed from the programme immediately. Hereafter, the herds can receive advice on risk-mitigating action with respect to Salmonella. Once the action taken results in observable results which qualify the herds, then they can re-enter the programme. Our results show that the SALCONMEAT programme works this way in an effective manner. One of the main points of difference between the SALCONMEAT programme and the Danish Surveillance-and-Control programme for Salmonella in finisher herds is that Salmonella-positive herds are removed from the SALCONMEAT programme whereas the strategy in the national programme is a reduction strategy.

Once the programme is in operation, pigs from herds outside the programme will be slaughtered separately from pigs from herds within the programme. This will reduce cross-contamination between carcasses harbouring Salmonella and carcasses not harbouring Salmonella. In general, logistic slaughter has a limited effect among herds with lower levels of Salmonella. However, recent results show that if the number of seropositive pigs slaughtered in a day can be kept below 50, then a halving of the prevalence can be expected (Dahl, 2009). Reducing the number of seropositive pigs to below 50 per day is feasible in the SALCONMEAT programme because the slaughterhouse only slaughters between 1,700 and 2,100 pigs a day. Moreover, the herds in the programme are only allowed to have a maximum of one positive sample within the previous 6 months. This implies that there are very few Salmonella-positive pigs slaughtered on days where the programme is in action. The impact will be that the prevalence of Salmonella will be lower than seen today; and most likely less than 0.2% measured as the individual carcass prevalence. The estimated number of human cases related to the pork produced within the SALCONMEAT programme is very low: ≤10. This is a result of 1) low prevalence of Salmonella on the carcasses and 2) limited amount of pork produced within the programme. It is questionable whether such a small number will show up in a national statistics of the importing country.
Conclusion

For a medium-size slaughterhouse it is possible to keep the prevalence of *Salmonella* in pork very low by setting strict pre-harvest requirements based among others on a serological testing programme.