# COST – EFFECTIVENESS ANALYSIS OF THE DANISH *SALMONELLA* CONTROL STRATEGY

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**Abstract** The mandatory national Danish *Salmonella* Control Program in swine has been in place since 1995. The over all goal for the current program is to reduce the *salmonella* prevalence in pork from 1.7% in 2001 to a maximum of 1.2% in 2006. In order to achieve this, the Danish swine industry decided to conduct a cost-effectiveness study in order to achieve the optimal *salmonella* reduction at the lowest possible costs.

The study showed that further pre-harvest initiatives using the currently known measures can not reduce the *salmonella* prevalence in Danish pork sufficiently. At the present stage of the Danish *Salmonella* Control Program only intensified focus on slaughterhouse measures, like decontamination and intensified hygiene, can reduce the prevalence of Salmonella in Danish pork sufficiently to attain the goal of 1.2%.



**Introduction** The mandatory national Danish *Salmonella* Control Program in swine has been in place since 1995, and operates at all stages of the production chain (Mousing *et al*. 1997, Nielsen *et al*. 2001).

During the first 5 years of the program the strategy was mainly focused on *salmonella* control in the primary production, and to a less degree on slaughterhouse related factors. Since 2001 an increasing focus has been placed on evaluating the importance of each step in the *salmonella* control program in order to achieve a reduced level of *Salmonella* in Danish pork, and consequently in the number of pork related human salmonellosis cases. The *Salmonella* control program for swine has reduced the pork related number of human salmonellosis cases from 22/100,000 inhabitants in 1993 to 3/100,000 in 2003 (Anon 2004). The annual costs of the program were 4.5 million Euro in 2003. In total, the costs of the *salmonella* program have been close to 95 million Euro since its initiation in 1995.

Assuming that the number of human cases had remained at the pre-control level if the *salmonella*-program had not been implemented, the program has reduced the occurrence of human salmonellosis in Denmark by approximately 1,000 registered cases in 2002 (Nielsen et Korsgaard 2003).

The overall goal for the current Danish *salmonella* control program is to reduce the *salmonella* prevalence in pork from 1.7% in 2001 to a maximum of 1.2% in 2006. In order to achieve this, a new strategy needed to be developed an implemented. The Danish swine industry covers the majority of the expenses of the control program, and the industry consequently decided to conduct a cost-effectiveness study in order to achieve the optimal salmonella reduction at the lowest possible costs.

**Materials and Methods** *Salmonella*-reducing measures along the entire production chain were evaluated based on the following criteria: practical experience, literature, *salmonella*-reducing effect, costs, how easy or difficult the measure is to implement under practical conditions, and finally estimated consumer perception. After a first phase evaluation of possible *salmonella* reducing measures, 9 measures/ initiatives were selected for the final cost-effectiveness analyses. Each measure was scored with respect to: effect, easiness to implement, expenses over 15 years, 1-year costs, and ability to attain the goal of 1.2% *salmonella* in pork by 2006.

Results of approximately 16000 pooled swab samples from the Danish *Salmonella* surveillance of carcasses were used for the calculations. At each slaughterhouse, five randomly selected carcasses per slaughter day are swabbed at three defined areas (the hind leg near the tail, the sternum, and the jowl. The three areas are swabbed with the same gauze pad, and the pads from the five carcasses sampled on the same day are analyzed as one pooled sample (Sørensen *et al*. 2001). The samples originated from 22 slaughterhouses associated with the Danish Bacon and Meat Council. The samples covered the period from January 1 2001 to June 1 2004.

For each sample all 5 carcasses were identified by the herd register number. For these herds, serological samples from the Danish serological surveillance were obtained from the Danish

Zoonosis Register. Based on the previous 3 months samples, the *Salmonella*-index (Alban *et al*. 2002) of each herd was calculated. Seven different herd strata were defined, based on the index. The lowest level was defined as herds with 0 positive samples. The rest of the herds were stratified with an interval of 10 index-points up to 40, from 40-69 was defined as level 2, and from 70-100 as level 3, according to the Danish classification. The carcass with the highest level then classified each pool.

Based on these results a spreadsheet model for each scenario was constructed. The model was used to calculate the carcass prevalence after initiating the scenario. An important part of this was to calculate the number of pigs/herds that had to be affected by the implemented changes, in order to obtain the necessary reduction to 1.2 % in pork. These figures were then used for the cost-effectiveness analyses.

For the feed-interventions in the primary production, we estimated the effect by using data sets from epidemiological studies. The distribution of herds in the different levels after changing into home-mixed feed was assumed to be identical to the distribution of herds already using home-mixed feed. For organic acids we assumed the effect to be similar to the effect of home-mixed feed.

The cost calculations were split into two. First, the net present value of the total costs of each scenario was calculated for a 15-year period (reflecting the estimated life span of home-mixing equipment). Next, the first year costs were calculated including both investment costs and first-year variable costs. This was done to illustrate the differences between scenarios, as some involve high investment costs and low annual costs and others the opposite.

**Results** The overall results of the cost-effectiveness analyses are shown in table 1. None of the measures in primary production are separately able to give a sufficient reduction in pork. Additionally, it is considered to be difficult or very difficult to force farmers to implement the measures due to the associated high costs. From a legal point of view it is also unlikely to be a part of a future Danish legislation. The currently known *salmonella*-reducing measures used in the Danish swine herds are able to bring herds from a high infection level to a moderate-low level, the measures are not able to eliminate the *salmonella* infection.

Increased hygienic focus on slaughterhouses and use of decontamination appears to be

| Scenario | Easiness to Implement | Effect | Present value of costs (15 yrs) | 1-yr costs | Goal reached in time? |
|---|---|---|---|---|---|
| Increased *salmonella* reduction in all severely infected herds | Difficult | Little | ÷155 | n.c | No |
| All herds use home mixed feed | Very difficult | Little | ÷357 | 366 | No |
| Organic acids in feed to all finishers | Very difficult | Little | ÷92 | 8.6 | No |
| Separate transport & slaugther of level 0 swine | Difficult | Moderate | ÷50 | 5.2 | No |
| Increased hygienic focus on slaughter-houses with salmonella above the average | Possible | Moderate-good | n.c. | n.c. | Yes |
| Hot water decontamination of herds mod-erate or severely infected with salmonella | Difficult | Good | ÷22 | 3.4 | Yes |
| Hot water decontamination of all swine at selected slaughterhouses | Possible | Good | ÷7.5 - ÷11 | 2.4-3.2 | Yes |
| Steam decontamination of all carcasses at selected slaughterhouses | Possible | Moderate - Good | ÷13 - ÷22 | 1.6-2.7 | Yes |
| Hot water decontamination of all finishers | Difficult | Good | ÷23 | 12 | Yes |

Table 1. Results of the cost-effectiveness analyses of 9 different scenarios to reach a goal of max. 1.2% *Salmonella* in Danish pork. All costs are given in million Euro. n.c. = Not calculated.

more promising methods to reach the goal. None of the measures are easy to implement but possible or even difficult to implement under practical Danish slaughterhouse conditions. Increased hygienic focus on slaughterhouses, where all single steps on the slaugther line are evaluated and optimized from a hygienic point of view, should give a moderate to good result depending on the equipment and management of the slaughterhouse.

Decontamination of carcasses by hot water appears to be the single most effective measure, but in case decontamination by hot water should be applied to millions of Danish finishers, it would cause a tremendous use of high quality water.

Steam decontamination of selected critical areas of swine carcasses appears to be an attractive measure from a cost-effectiveness point of view; even though the efficacy of steaming is less than that of hot water decontamination. Investments, energy and water use is more attractive for steaming compared to hot water decontamination.

**Discussion** During the last 10 years, the Danish *Salmonella* Control Program for swine has included the entire production chain. The *salmonella* prevalence in finisher herds has been reduced from 23% in 1993 to 11% in 1999 (Anon. 1998) and the prevalence in pork has declined from calculated 7% in 1993 to 1.6% in the beginning of 2004. This is achieved by the currently known and used measures. However, over the last couple of years no further reduction in the number of seropositive finishers has been achieved. Apparently, it has become increasingly more difficult to reduce the seroprevalence further with the known *salmonella* reducing methods. Obviously, new solutions for further salmonella reduction needed to be identified.

In order to meet the goal of a maximum of 1.2% *Salmonella* in Danish pork in 2006 it has been important for the swine industry, which covers the majority of the cost of the *salmonella* control plan, to establish a solid decision platform before new initiatives are decided and become implemented. The present cost-effectiveness analysis is a decision tool assisting the industry in where to put the future focus in the *salmonella* control program. The calculation of the costs of the different scenarios is highly dependent on the quality of the available data. All data used have a certain degree of uncertainty and the calculated costs should therefore be interpreted with some care.To achieve a significant impact from further reduction in the primary production requires that herds not only have to reduce the level from highly infected level 2 and 3 to level 1, but that a large part of the herds can reach a "near to" zero level. This is due to the fact that more than 80% of the *Salmonella* in the Danish primary production can be found in level 1. So far the only known intervention to reach this level is depop-repop, but this would require depop-repop of the majority of Danish herds at a very high cost.

**Conclusions** The cost-effectiveness study showed that further pre-harvest initiatives using the currently known measures can not reduce the *salmonella* prevalence in Danish pork sufficiently. At the present stage of the Danish *Salmonella* Control Program only intensified focus on slaughterhouse measures, like decontamination and intensified hygiene, can reduce the prevalence of *Salmonella* in Danish pork. The Danish Bacon and Meat Council have subsequently decided to intensify the focus on slaughterhouses and not to initiate more pressure on herds.

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