Effect of Ante-Mortem Feeding Regimes on Bacterial Numbers in the Stomach and Caecum of Pigs and the Caecal Carriage of *Salmonella* spp.

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Background

Pre-slaughter management of pigs not only affects the ultimate carcass and muscle quality but it also affects the normal alimentary flora. Starvation of slaughter animals for 24 h has been shown to result in a marked decrease in the number of lactic acid bacteria (LAB) and a large increase in the number of *Escherichia coli* found in the gut (Morishita and Ogata, 1970). Although there is a decrease in carcass yield when feed is withheld, packers prefer to withdraw feed overnight prior to slaughter because the incidence of PSE pork is slightly reduced and gut fill is reduced, thus reducing the risk of carcass contamination from accidental spilling of gut contents during carcass dressing. When the normal flora of the gut is changed there can be a shift from inocuous intestinal bacteria to potentially pathogenic organisms (Kotula, 1987). Starvation of animals has an impact on the normal flora of the gut so that pre-slaughter starvation of pigs may increase the risk of introducing pathogens into the packing plant (Morgan *et al.*, 1987). Although processing is designed to minimize the spread of these organisms through the plant, it is not 100% effective and animal husbandry practices which encourage the colonization of meat animals with pathogens should be identified and avoided. *Salmonella* is the organism of particular concern because, although it is not often detected on carcasses, as the food moves through the distribution chain there is an increase in the number of samples found to be contaminated with *Salmonella* (Kerschner, 1980 as reported in Teufel, 1987). In their 1995 review of foodborne disease in the USA, the Food Safety Inspection Service and Animal and Plant Health Inspection Service of the USDA ranked salmonellosis as the most important disease linked to red meat and poultry products. Insufficient information regarding the epidemiology of foodborne agents in animal production systems is available and should be a priority research area (Davies *et al.*, 1997). Many but not all pigs are infected with *Salmonella* and enrichment and plating methods do not detect all positive samples so that detection of *Salmonella* from faeces is inconsistent (see Huis in 't Veld *et al.*, 1994). *E. coli*, on the other hand, is easily enumerated and can normally be recovered from the gut. It is often used as an indicator organism for the potential presence of pathogens.

Objectives

The objectives were 1) to examine the changes in stomach and caecal flora of LAB, coliforms, *E. coli* and *Salmonella* (caecum only) in pigs which were subjected to different regimes of feed restriction prior to and after transport to the abattoir and 2) To compare treatments to determine whether there were changes in "normal flora" or an increased risk of introduction of pathogenic bacteria into the packing plants as a result of ante-mortem treatment .

Methods

Pigs of similar age and weight were assigned to three feed withdrawal and transport treatments (Table 1). Thirty pigs, on each of five days, were slaughtered, three from each treatment at each of three kill times, 0, 2 and 4 h after the start of the kill day. Immediately post-mortem samples were aseptically removed from the stomach and the caecum and LAB (mesophilic and psychrotrophic), coliforms and *E. coli* biotype 1 were enumerated using standard methods. pH of the stomach and caecum contents was measured. The presence of *Salmonella* spp. was determined by a 6 h preenrichment, concentration with Dynabeads® anti-Salmonella (Dynal A.S., Oslo, Norway), 18 h enrichment in Rappaport Vassiliadis broth (Oxoid Inc., Nepean, Ont., Canada) at 42°C and plating on Bismuth Sulphite and XLBG agars (Difco Laboratories, Detroit, MI, USA).

Results and Discussion

The pH of the stomach contents dropped from 4.4 to 3 (Trt. I) and from 4.3 to 2.5 (Trt. III) in animals slaughtered 0, 2 and 4 h after transport (Table 2). Pigs that had been transported 18 h prior to slaughter and held in lairage with no food (Trt. II) had a stomach pH that was stable at 3.7. Caecal pH was much more stable than stomach pH as was the proportion of the population comprised of *E. coli* (Table 2). In both the stomach and the caecum the log CFU/g coliforms and *E. coli* differed by <1 so that only *E. coli* results are shown in further discussion. Since *E. coli* is quite resistant to acidic conditions an increase in the proportion of the population of the stomach comprised of *E. coli* as the stomach pH decreased is not unexpected, however the numbers of *E. coli* also dropped apparently in response to pH changes with the most pronounced changes in pigs subjected to feed withdrawal prior to transport (Trt. II, Fig.1A). LAB numbers dropped in all treatments and the numbers responded to both the feed withdrawal treatment and pH of the stomach (Fig.1A). When first pigs of the day were slaughtered the largest effect of feed withdrawal on bacterial loads in the caecum was observed (Fig. 1B, 3, 18, 18 h of feed withdrawal for Trt. I, II and III respectively). Pigs in Trt. I had *E. coli* levels in their caeca 1.2 log CFU/g less than those in Trt. III. *E. coli* numbers were 0.7 log CFU /g less in Trt. II than in Trt. III although the feed withdrawal time was the same. Numbers of *E. coli* in the caeca of all pigs increased during the kill day (Fig. 1B). LAB for all treatments remained stable between log9 and log10 CFU/g of caecal contents (Fig. 1B). LAB would be expected to be resistant to acidic conditions but their numbers per g of stomach contents decreased as the stomach pH decreased but did not increase in pigs subjected to 24.5 h of feed withdrawal despite an increase in stomach pH. Their numbers in pigs subjected to feed withdrawal were lower than in fed pigs. This probably is indicative of the transient nature of many LAB in the stomach and their introduction through the oral route from feed or grazing. On the contrary their numbers in the caecum were very stable regardless of treatment. They did not change significantly as a result of mixing, transport or even in pigs subjected to feed withdrawal of 24.5 h. The numbers of aciduric LAB for each treatment (data not shown) also remained stable indicating that there was no apparent shift in the types of LAB in the population. Psychrotrophic LAB were at levels below the detectable limit of 2.00 log CFU/g for all treatments. These results suggest that the treatments imposed did not upset the natural flora of the gut even though other indications are that the animals had undergone considerable physiological pressures. Coliforms and *E. coli* numbers in the caecum were affected by handling of the animals and increased in response to feed withdrawal and whether it was before or after transport. The effect of feed withdrawal was more pronounced if animals were mixed and transported after feed withdrawal than if feed was withdrawn while animals were in lairage at the abattoir. Numbers also increased in response to time of slaughter. The carriage rate of *Salmonella* spp. in the caecum was 24% overall. The rate of carriage increased during the study from 7% (Trial 2, July 1997) to 52% (Trial 6, September 1997). Trt. I pigs (no feed withdrawal) had higher rates of carriage of *Salmonella* spp. (38% Trt. I, 12% Trt. II, 22% Trt. III). The types of *Salmonella* spp. and their probable sources are under study.

Conclusions

Caecal numbers of coliforms and *E. coli* increase as a result of feed withdrawal and the impact is accentuated if feed withdrawal precedes mixing and transport. Although gut fill and spillage are reduced when feed is withdrawn, these observations should be considered when planning transportation and slaughter schedules.

Pertinent Literature

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Table 1. Description of the feed withdrawal treatments.

Trt.	Description of Treatment	Total hours of feed withdrawal at slaughter
I	Pigs had access to feed until transported[1] to the abattoir	3[2], 5, 7, 24.5
II	Pigs were transported to the abattoir and were held in lairage overnight with no access to feed	18, 20, 22
III	Feed was withdrawn 15 h before transport to the abattoir	18, 20, 22

[1] All animals were in transit for 3 h

[2] Animals were slaughtered at timed intervals of 0, 2 and 4 h during the day and on day 2 for 24.5 h treatment.

Table 2. pH and % of coliforms that were *E. coli*.

Trt.	Total hours of feed withdrawal at slaughter	pH Stomach	pH Caecum	% *E. coli* Stomach	% *E. coli* Caecum
I	3	4.4	6.0	53	50
	5	3.4	6.5	83	65
	7	3.0	6.7	89	68
	24.5	4.4	7.6	93	72
II	18	3.7	7.2	66	72
	20	3.7	7.1	93	65
	22	3.7	7.4	100	62
III	18	4.3	7.1	59	76
	20	3.1	7.4	89	60
	22	2.5	7.5	93	76

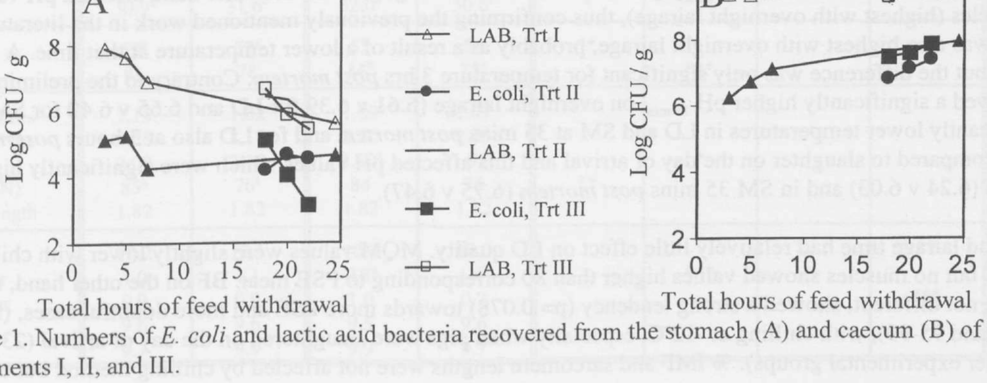

Figure 1. Numbers of *E coli* and lactic acid bacteria recovered from the stomach (A) and caecum (B) of pigs for Treatments I, II, and III.