Control of E. coli and Salmonella in growing-finishing pigs through the use of potassium diformate (KDF) – European case studies

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Abstract

Control of pathogenic bacteria has a high priority in European pork production. They can be a significant cause of zoonotic diseases and cause major economic losses in the pork production chain, through reduced productivity, increased veterinary and hygiene control costs. Preventing the spread of E. coli and Salmonella to the consumer requires special control measures during slaughter and processing. The extra cost of these controls is increasingly being transferred back to the producer in the form of financial penalties or the loss of the market for contaminated pigs. Improving gut health has been shown to be effective against intestinal pathogens, a strategy that has only really been made possible through the removal of antibiotic growth promoters in feed. Creating and maintaining a healthy intestinal environment has become essential to productivity and food safety programmes alike.
While biosecurity and hygiene in the feed mill and on farm are essential, the acidification of feed ingredients or finished feeds with organic acids also offers considerable benefits in E. coli and Salmonella control. Feed acidification is not only effective within the feed; possibly its biggest benefit occurs within the pig itself. Research trials in the UK, Denmark, France and Ireland with 0.6% dietary potassium diformate (KDF) have shown significantly reduced Salmonella count in the feed as well as in the gut of pigs. Further studies have proved that KDF exerts significant effects against E. coli at dosages between 0.6% and 1.2% in the duodenum, jejunum, colon and rectum of growing-finishing pigs. The authors concluded that a reduction in the number of coliforms will result in a better health status of pigs.

Introduction

Salmonella ranks among the world's biggest threats to health. In the United States alone, it is thought to be responsible for around 378 deaths and an estimated 19,336 hospitalisations each year. And these are just the reported cases. Salmonella ranks second on the food poisoning leader-board in the US where it's the premier bacterial food-borne disease. It's certainly serious enough to merit significant attention from the WHO and the US-based Center for Disease Control. Developing and implementing effective Salmonella monitoring, reporting and control systems has been prioritised in many countries. Salmonella is often associated with poultry products – chicken and eggs, but it would be a mistake to assume that these are the only food sources that can transmit the disease. Birds are a major source, true; strains can also be transmitted through pork and processed pork products, but it's also been spread through salad vegetables and peanuts. If we can eat it, there's a good chance that the bacteria can live on it, or at least survive long enough to be carried into an animal (or person)'s digestive tract. Since its discovery in the late 19th Century, more than 2,500 different types (serovars) have been discovered. All of these can cause disease in humans, which is most commonly associated with acute gastroenteritis – fever, abdominal pain, diarrhoea and nausea, sometimes with vomiting. More often than not, this clears up within a week of infection without treatment. However, if the pathogen enters the bloodstream or the disease leads to dehydration, effective antibiotic treatment can be a lifesaver. Children and the elderly are particularly vulnerable, as are people with weakened immune systems. The health statistics also make for some sobering economic facts. In the US, for instance, the Centers for Disease Control recently estimated a total annual cost of US$3 billion associated with Salmonella. Similar calculations from Denmark in 2001 took this further, suggesting that spending the equivalent of US$14.1 million implementing a salmonella control programme actually resulted in a net saving of US$25.5 million to the national economy. Like other foodborne bugs, Salmonella is developing resistance to the drugs we use to treat it. Much of the blame has fallen with animal production. Preventing or treating diarrhoeal diseases in livestock has played a major part in the development of multi-drug resistant strains. The two most commonly seen serovars in human salmonellosis epidemics, Salmonella enteritidis and S. typhimurium have emerged over the past 30 years in parallel with intensive animal husbandry. Now, we find bacteria, including these two, with worryingly high levels of resistance against the antibiotics we use to treat them. Antibiotic resistance in Salmonella has two major consequences that cause the medical profession so much concern. Firstly, patients taking an antibiotic for unrelated infections, for example a chest infection, are more risk of contracting antibiotic-resistant Salmonella infections. Secondly, treatment for salmonella fails more frequently, causing prolonged or more severe illness, increased hospitalisations and more deaths. A recent US review estimated that antimicrobial resistance in Salmonella may result in 30,000 more infections each year, leading to 300 more hospitalisations and 10 deaths. Salmonella is a big risk to the world's economies. Looking into E.coli, the picture is not changing much. Also this gram-negative pathogenic bacterium is able to seriously impair animal and human health. Known to be a major vector for post weaning diarrhoea in piglets it is also affecting humans, especially in developing countries. Infections due to pathogenic strains of E.coli are probably the commonest source of diarrhoea in developing countries; they may be responsible of up to 25% of all diarrhoeal case in infants and children. But also the Western world" is no exception, as the recent outbreak of enterohaemorrhagic E.coli in Germany shows.

But the risks of pathogenic bacteria can be reduced, also without the prophylactic dosage of antibiotics. All along the food chain, experts have identified points at which intervention can help reduce the risk of Salmonella and E.coli infections. While Salmonella cannot be eradicated in pig units, it can be controlled to minimise the risk to consumers. Biosecurity plays a significant role in Salmonella control. In feed compounding, although heat treatment is effective in reducing contamination of feed leaving the feed mill, this effect does not persist during transport, storage and subsequent outfeeding. When conditions within the feed are less conducive to bacterial infection, Salmonella contamination can be reduced. The next critical control point is within the pig's gut itself, where conditions for bacterial growth may once again be optimal. Salmonella growth requires warmth (35-37°C is optimal), a moisture content greater than 12% and a pH between 4.5-9.0. It is no coincidence that the pig gut can provide Salmonella everything it needs to thrive.

Review of data

While biosecurity and hygiene in the feed mill and on farm are essential, the acidification of feed ingredients or finished feeds with organic acids also offers considerable benefits to Salmonella control. Feed acidification is not only effective within the feed; possibly its biggest benefit occurs within the pig itself. Research trials in the UK with potassium diformate (KDF) shows significantly reduced Salmonella count in the feed as well as in the gut of pigs. This effect is particularly well illustrated by data collected on 12 farms in Ireland as part of a joint study undertaken by Teagasc, University College, Dublin and the Department of Agriculture and Food in Co. Kildare (Lynch et al., 2007). The main objective of this investigation was to evaluate the efficacy of Salmonella control measures on highly infected farms. Salmonella control has been compulsory under Irish law since 2002 and farm status is categorised by the percentage of positive pigs in a herd according to the Danish mix-ELISA test. Category 3 (>50% positive) farrow-to-finish farms and their associated fattening units were selected for the study. The effects of including KDF over the 24 months of the study are given in Table 1. All the farms that were treated with the additive alone; or a combination of KDF with improved hygiene and biosecurity measures (farms J and L) had notable improvements in both bacteriological and serological prevalence of Salmonella spp. All but one farm in which KDF was used ended the trial with a much improved Salmonella status, with bacteriological prevalence also low on most farms. Using improved hygiene and biosecurity measures alone also improved Salmonella status, but to a much lesser extent. The reduction in prevalence obtained by potassium diformate alone, compared to the two farms which also implemented additional hygiene and biosecurity, demonstrates the additive's efficacy.

Table 1. Bacteriological and serological prevalence of Salmonella on 7 farms with or without potassium diformate (KDF) inclusion in the feed. Percentage of positive samples. From Lynch et al. (2007).

	Controls		With KDF	
	Bacteriological prevalence	Serological prevalence	Bacteriological prevalence	Serological prevalence
Farm F	100	88	0	50
Farm G	77	63	3	0
Farm H	32	17	3	4
Farm I	71	54	4	4
Farm J*	15	42	15	0
Farm K	37	96	14	4
Farm L*	4	96	0	0

**Farms J & L employed improved hygiene and biosecurity measures as well as KDF*

These findings are not unique, however. Studies by the Danish feed company KFK, a decade ago (Olsen, 1999) and, more recently, in a commercial pig unit in the UK (Dennis and Blanchard, 2004), both concluded potassium diformate, to be an effective tool in a salmonella control strategy in commercial farms, reducing the percentage of salmonella positive pigs by 50% and in pork meat juice ELISA scores by 46%, respectively in grower finisher pigs (Dennis and Blanchard, 2004). The UK trial also showed an improvement in daily gain of 7.7%, reduced mortality and a reduction in medicinal intervention compared to the rolling average for that unit. The economic benefit of implementing salmonella control, as detailed in the Salinpork 2000 research trial, was also evaluated. Excluding reductions in veterinary bills and culling rates that accompany Salmonella outbreaks, improvements in FCR of 3% and in daily live weight gain of 5%, potassium diformate addition to grower/finisher diets and improved hygiene management practices resulted in an estimated net benefit of GB£5850 in an average herd (Blanchard and Burch, 2004).

Visscher et al. (2009) demonstrated the potential of potassium diformate together with coarse feed particle size in supporting a healthy gut while reducing Salmonella prevalence. The study proved that production of the short chain fatty acids propionate and butyrate was stimulated by KDF inclusion in the diet. Higher butyrate concentrations in the distal part of the digestive tract, especially in the colon, also support the growth and development of epithelial cells in the gut, increasing villus length and crypt depth - factors that induce healthy gut function. KDF also contributes to an optimal gut microflora in the last part of the gastro-intestinal tract of the pig via the promotion of butyrate production.

Most recently in France (Correge et al. 2010) demonstrated in a large scale commercial project, that the inclusion of 06.% KDF into the diet of fattening pigs in herds with a high infection level with Salmonella spp. resulted in a significant reduction of Salmonella prevalence at slaughter.

The Danish study (Olsen, 1999), also showed a sustained effect of potassium diformate, even after removal of the additive from the feed. However, as Blanchard and Burch (2004) concluded that even though KDF use can be removed for 3-4 months without detrimental effect to Salmonella status, removal of the additive only proves effective once the original vector animals have been removed from the unit.

Finally, a study by Øverland et al. (1998) proved that KDF exerts significant effects against E. coli at dosages between 0.6% and 1.2% in the duodenum, jejunum, colon and rectum of growing-finishing pigs. The reduction of coliform bacteria is in agreement with several other studies using dietary formic acid. The authors concluded that a reduction in the number of coliforms will result in a better health status of pigs.

Conclusion

The published results described above prove irrefutably how cost-effective Salmonella and E.coli control, a healthy gut and food safety can be secured by dietary means.

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