

Methicillin resistant *S. aureus* (MRSA) in the pork food chain in Germany

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Abstract

This paper gives an overview on studies carried out in Germany on the prevalence of MRSA on different stages of the pork food chain.

Prevalence studies were carried out on herd level for breeding (201 herds) and fattening pigs (290 herds), at abattoirs (n=1026 pigs), in a pork processing facility and in pig meat at retail. MRSA were characterized using spa-typing, SCCmec-typing and testing for antimicrobial resistance.

The highest proportion of positive samples was determined in pigs at slaughter (58% of the pigs, 98% of slaughter batches), followed by fattening herds (52%) and breeding herds (42%). MRSA in primary production was associated with larger pig herds and purchasing pigs of different origins. MRSA were isolated from all stages of the post-harvest production chain. Meat samples at retail were positive for MRSA in both years considered, namely 2008 and 2009 (8.4% and 15.8%). Most isolates were of spa-types associated with the multi-locus sequence type ST398 (t011, t034 and t108). Regional differences in the contribution of different spa-types to the overall burden of MRSA in primary production were identified. Non ST398 strains were isolated from breeding herds (7%) but not from fattening herds or slaughter pigs. However, such strains were also isolated from fresh pork. Most isolates carried SCCmec-types V, III and IVa. Antimicrobial resistance was predominantly observed for beta-lactams, tetracycline, lincosamides, and macrolides. Resistance to fluoroquinolones was present at varying levels. Resistance to vancomycin, fusidic acid and linezolid was only observed in exceptional cases. The results of the studies indicate that MRSA is widespread in pig production and that it is readily transmitted to pork via the food chain. Further studies are needed to elucidate the potential to control MRSA in primary production, at harvest and in the post harvest food chain.

Prevalence studies

Methicillin resistant *Staphylococcus aureus* has been recognized as a nosocomial pathogen for decades. Triggered by findings in the Netherlands, Germany has extensively investigated the prevalence of MRSA in pigs and pig products during recent years.

It was determined, that MRSA have been prevalent in the German pig population at least since 2004 (Fig 1) (Meemken et al. 2010)

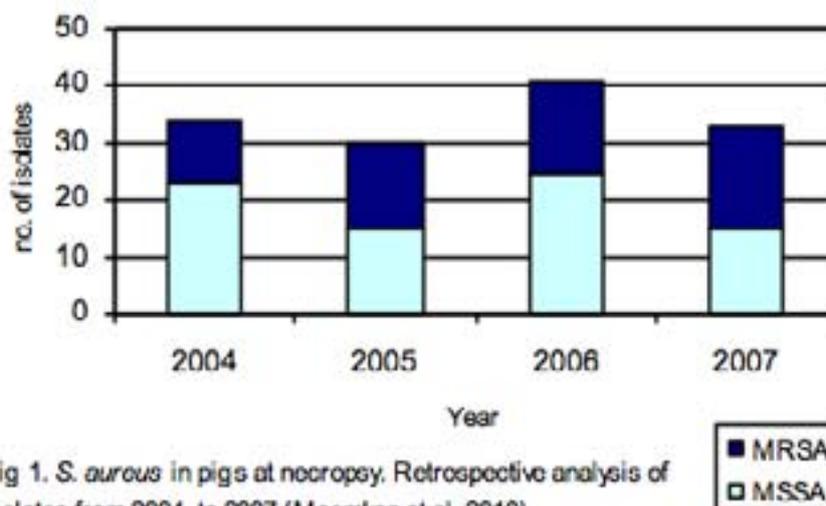


Fig 1. *S. aureus* in pigs at necropsy. Retrospective analysis of isolates from 2004 to 2007 (Meemken et al. 2010)

However, older samples were not available. Therefore, it is not clear, when the first strains of MRSA occurred in the German pig population.

In 2008 and 2009 surveys were carried out to determine the prevalence of MRSA in the breeding and fattening pig population (EFSA 2009; Tenhagen et al. 2009a). Results indicated that MRSA are widespread in the German pig population (Fig 2). In a study at 5 large abattoirs during winter 2007/2008, 1026 pigs nose swabs were investigated. Between 49% and 80% of the pigs were positive per abattoir and most slaughter batches included at least 1 positive pig out of 10 tested. However, it has been pointed out that transport and lairage contribute to the contamination of pigs examined at stunning (Broens et al. 2010).

The distribution of MRSA along the production chain was studied in a slaughterhouse with a connected processing unit producing fresh pork (Beneke et al. 2011). Results indicated that MRSA were frequently found in the noses of pigs (65%), but less frequently on carcasses (16%) and in products ready for marketing (3%).

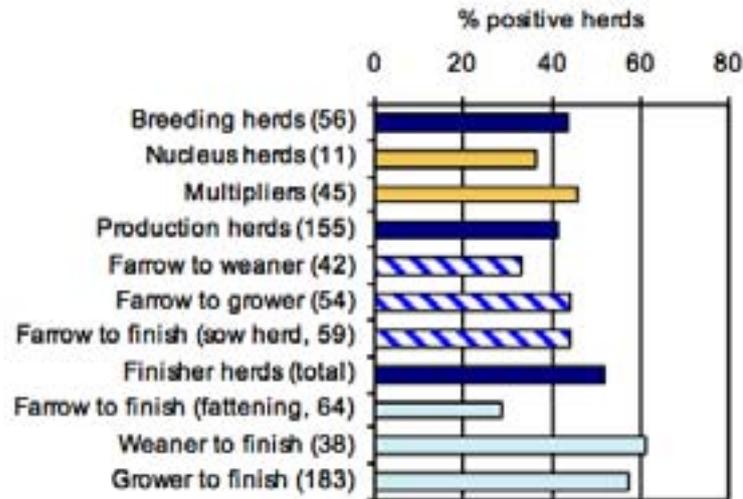


Fig. 2 MRSA in pig herds in Germany 2008/2009

Monitoring at retail level indicated that pork is regularly contaminated with MRSA (Fig 3) with minced meat showing a substantially higher contamination rate than other fresh pork or fresh pork preparations (Tenhagen et al. 2011). The difference in the results of the monitoring and the study in one processing unit point to a potential variation between abattoirs and processing units that needs to be elucidated. Investigations into the quantification of MRSA in food items indicated, that the number of germs (colony forming units) in the food items is low (van Loo et al. 2007; Weese et al. 2010). Currently there is no evidence of spread of MRSA into the human population via food. MRSA ST 398 found in humans were nearly always associated with persons directly or indirectly exposed to livestock, especially pigs (Köck et al. 2009). This includes livestock professionals such as farmers, veterinarians and slaughterhouse workers and their families (Meemken et al. 2008). However, among the latter, prevalence rates were substantially lower than among those directly exposed to pigs (Cuny et al. 2009).

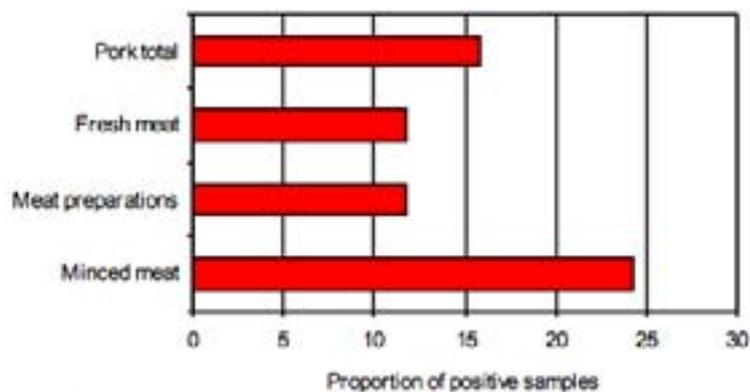


Fig 3. MRSA in pork in Germany 2009 (Tenhagen et al. 2011)

Typing results

Most of the MRSA isolated in the pork production chain were from spa-types associated with the clonal complex CC398 that is typically addressed as livestock associated MRSA. Among those, spa-types t011 and t034 clearly dominated with some regional differences concerning the prevalence of the two.

However, while in fattening pig herds and pigs at slaughter all isolates were from CC398, other spa-types were found occasionally in isolates from some breeding pig herds and from meat at retail. These types were also typed by multi-locus sequence typing (MLST) and assigned to the MLST-types ST39, ST9, etc. While in isolates from meat this finding might result from secondary contamination by workers carrying MRSA it is not clear, why MRSA of non CC398 types were identified in breeding pig herds.

Concerning the SCCmec cassettes identified some association between spa-types and SCCmec types were observed. Isolates from spa-type t011 nearly always carried the SCCmec type V. In contrast, isolates of spa-type t034 more frequently carried the SCCmec type which was assigned to type III by the method of Zhang (Zhang et al. 2005). This association could be observed in the fattening pig and the slaughter pig study.

Virulence factors and antimicrobial resistance

Investigations of virulence factors and resistance patterns have shown that MRSA ST398 from the pig production chain invariably carried only few known virulence factors (Argudin et al. 2011). In line with this, most isolates were derived from apparently healthy pigs and no association between disease occurrence and contamination of the herd with MRSA could be shown in a study in fattening pigs. In contrast, LA-MRSA have also been found as the only identifiable pathogen in lesions of pigs at necropsy. However, this was rarely observed and in some instances MRSA may have been a secondary pathogen rather than the causative agent. MRSA have also been identified in lymphnodes and internal organs of experimentally colonized pigs pointing out that they are not necessarily restricted to mucosal surfaces of the animals (Szabo et al. 2011).

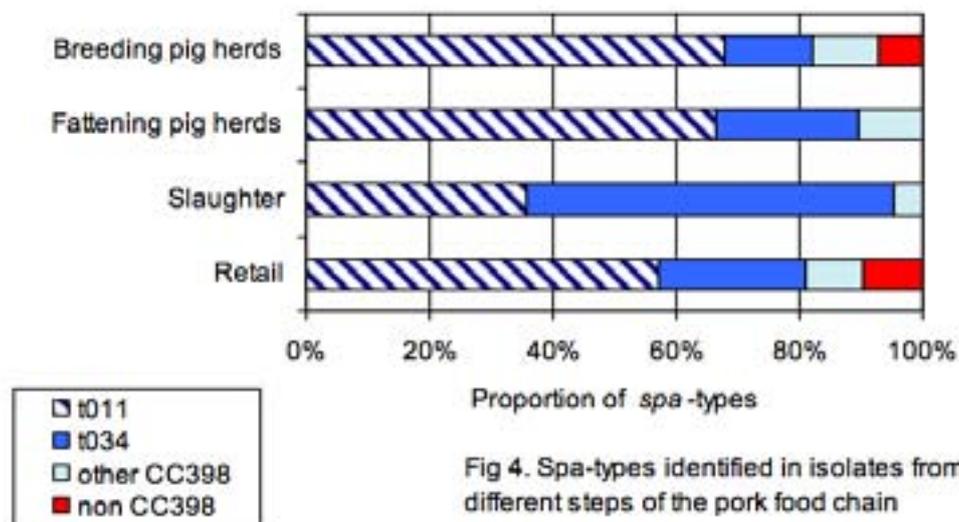


Fig 4. Spa-types identified in isolates from different steps of the pork food chain

In addition to the resistance to beta lactams, resistance to tetracycline, lincosamides, and macrolides are common (Tenhagen et al. 2009b). Remarkably, the resistance pattern is quite different from those observed in hospital associated strains in Germany (Robert Koch Institut 2007). While resistance to fluoroquinolones is common in the latter it is still rare in strains from pigs. Resistance to tetracycline on the other hand, is rare in human hospital acquired strains in Germany, while it is carried by basically all pig strains.

Conclusions

MRSA are widespread in the pig production chain in Germany. Most of the isolates are from the clonal complex 398 and do not carry major virulence factors. Resistance patterns differ substantially from isolates of MRSA-types frequently observed in the hospital setting in Germany.

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