

# Supply chain view to prevention and surveillance of antimicrobial residues in meat

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## Abstract

Residues of antimicrobial origin in meat are unwanted from a consumer and trade perspective. This paper presents the newest achievements regarding design of cost-effective surveillance programs for residues of antimicrobial origin in pig meat using the risk-based principle and a supply-chain view to prevention.

**Keywords:** *Residue, surveillance, risk-based*

## Introduction

Consumers and trade markets value meat without residues of antimicrobials. This requires prevention by the farmer through careful registration of use of antimicrobials, marking of treated animals, and compliance with withdrawal periods.

Moreover, surveillance is needed to ensure and encourage prevention and to verify the system in place. Usually, surveillance for residues of antimicrobial origin takes place through an official program supplemented by the abattoirs' own check. The European Union (EU) defines the sampling intensity of the official program in EU Directive 96/23 (1).

Moreover, maximum residue limits (MRL) and associated withdrawal times are set by the legislation. There is no international agreement on the MRL; in particular for tetracyclines there is a large variation with some trade partners setting lower limits and others setting higher limits than the EU (2). If a country has an export to trade partners outside its own region, then such requirements have to be taken into account when setting up a surveillance program.

Due to trade interests, the Danish pork abattoirs' own check involves many more samples than taken as part of the official program (3). In Denmark, presence of residues in the surveillance/own check results in a follow-up visit in herd within a week to identify causality. Without the visit, the producer is not allowed to send pigs to slaughter. At the time of the visit, information about which antimicrobial was found is often not available. This hampers the possibilities to explain what went wrong.

A new multi-chemical diagnostic method for testing of residues - high-performance liquid chromatography-mass spectrometry (HPLC LC-MS/MS) – is on the market. This laboratory method has a high sensitivity, is quick to use, and provides test results to several antimicrobials at the same

time. However, it is more expensive to use than the traditional biological method – called the four plate method (NMKL 121) – in place in Denmark.

This paper looks into how prevention and surveillance of residues of antimicrobials in pork could be made further cost-effective. This is of value not just for Denmark – but for all countries, among others because the EU Directive 96/23 is up for renegotiation, and international trade requires that the legislation of both the exporting and importing country is complied with.

## Materials and methods

### Study 1

The study consisted of a trial, which was undertaken to evaluate the usefulness of different tools to mark treated sows. Here, the experience of 10 Danish pig producers was collected. Three different tools to put around the angle of a sow were tested: two soft, non-reusable bands and one reusable band made of hard plastic. The price of the latter is €1.6 per band.

### Study 2

This was a risk factor study, containing information about residue cases found during 2.5 years of official surveillance and the abattoirs' own check in pork. Here, not just cases found as part of the surveillance and own check were included but also cases, where the pig producers called in to stop animals delivered too early from being slaughtered. For all cases, type of drug found/suspected, reason for presence, and information from meat inspection was used to identify indicators for high-risk finishing pig herds. Herds with no cases were used as controls.

### Study 3

This consisted of a scenario tree simulation, where the objective was to assess the opportunities and consequences of future surveillance considering: 1) replacing the current bioassay with the multi-chemical method, 2) replacing kidney with muscles as sample matrix, and 3) using indicators to identify high-risk herds and increase sampling intensity in these herds, lowering sampling in the low-risk herds, while aiming at continued detection of similar numbers of test-positives at the lowest possible costs compared to the existing program.

## Results and discussion

Between 0 and 2 positive samples are found in Danish finishing pigs annually in surveillance/own check system involving a total of almost 20,000 samples (Table 1). The substances found between 2005 and 2013 included a total of five cases of penicillin, two cases of doxycycline and one case of tularthromycin – all found as part of the abattoirs' own check.

A slightly higher prevalence has been seen in sows compared to finishing pigs. This is in line with Baptista *et al.* (4), who found that finishing pigs had a 12-26 times lower probability of harboring residues compared to sows, presumably because the slaughter date is not always predetermined for sows. It implies that there is a special need for marking of treated sows. Here, Study 1 showed the usefulness of the new cheap tools. Information to swine producers about how to prevent delivery of treated animals is made available on the home page of SEGES – Danish Pig Research Centre.

**Table 1.** Results of the abattoirs' own check for antimicrobial residues in Danish finishing pigs covering the two largest slaughterhouse companies in Denmark, representing around 88% of the finishing pigs produced annually.

Year	Total no. of samples	No. of confirmed samples a
2005	18,910	0
2006	17,956	1
2007	17,612	1
2008	22,806	2
2009	21,686	1
2010	16,191	2
2011	19,361	0
2012	14,240	1
2013	14,262	0

n.r. = not relevant

a: confirmed above maximum residue level accepted legally

Study 2 revealed a total of nine cases (over 2.5 years), where the producer had called in to prevent animals delivered by mistake from being slaughtered due to suspected presence of residues. Moreover, eight cases were found as part of the surveillance and own check. Several of the 17 cases were caused by inadequate marking of treated animals combined with poor communication.

Finishing herds with a within-herd prevalence of chronic pleuritis above 40% were associated with a two to three times higher probability of finding residues compared to herds with a lower prevalence of chronic pleuritis (3).

Results of simulations undertaken as part of Study 3 showed a risk-based surveillance program using the new multi-chemical method HPLC LC-MS/MS yielded same number of positive samples faster and at equal costs compared to the

current program. In some of the scenarios investigated, the number of samples was halved – and that sampling would be more intensive in the high-risk herds consisting of hers with a prevalence of chronic pleurisy above 40% (5).

It was judged as necessary to also include samples from low-risk herds, because: 1) there are several reasons for presence of residues and a high within-herd prevalence is only one of these as noted in Study 2 (3), and 2) it is important that livestock producers are aware of that all slaughter animals has a probability of being sampled and checked for presence of residues of antimicrobials.

In the original set-up using the biological method, kidney was used as the sample matrix, because the amount of residues - if present - is higher in that organ compared to in the meat. However, most consumers eat meat and not kidneys, and therefore meat should be used as the sample matrix, when possible. The multi-chemical method has a high sensitivity allowing use of meat as sample matrix. Moreover, a new sample can easily be taken in case re-testing is necessary, if the entire carcass is detained until the results from testing is available. This is the case in Denmark.

The EU Residue Directive is up for renegotiation. Hopefully, the update will contain a stronger focus on cost-effect among others by looking at the entire supply chain and making use of the risk-based principle. This would result in a broader understanding of where the efforts should be put to prevent residues in meat; it is not the surveillance but the actions taken on the farm which are pivotal. And here private standards such as the Danish Product Standard are useful instruments. These standards act on top of the national and international legislation and describe specific requirements which must be fulfilled, if swine are to be delivered for slaughter. In Denmark, this among others imply that the withdrawal period for tetracycline is 30 days, and that producers and staff must receive formal instruction on injection technique (6).

According to the current EU Directive, sampling for residues should be targeted and it is specified that species, age, production system and all other relevant background information including prior abuse can be used as indicators (1). However, for an exporter of pork it may be irrelevant to show antimicrobial residue data for sows, if the pork is from finishing pigs. And for the Danish case, prior abuse and production system are not very relevant as there are only few positives found, and the production system is the same for the majority of the indoor pigs. Therefore, any evidence-based contribution pointing to identification of risk factors/indicators, which can be used in a feasible cost-effective surveillance is needed to ensure the future competitiveness of the swine industry, while providing the consumers with the quality of the meat they prefer.

This is relevant not just for the surveillance of residues of antimicrobials but also for the surveillance of prohibited substances and environmental contaminants – also governed by EU Directive 96/23 (1). Here, one important issue to

discuss during the renegotiation is to change the requirement set to the number of animals tested (as currently required) to the number of analyses conducted, because the multi-chemical test used today is able to provide test results of several substances concurrently – as pointed to in a new report by Maarschalkerweerd *et al.* (7).

## Conclusion

Correct registration, clear marking of treated animals as well as proper communication are essential elements of the daily routine in a swine herd taken to prevent animals from being slaughtered too early after treatment. Special emphasize should be on sows, because this age group is at higher risk of being delivered to slaughter before the withdrawal time has passed.

The new multi-chemical method is recommended for surveillance and the abattoirs' own check, since it will enable more effective follow-up visits in relation to findings of residues in a carcass. Moreover, one sample may provide results regarding presence of many antimicrobials in one test round.

To compensate for the higher costs related to using a multi-chemical test compared to a biological test, risk-based sampling leading to a lower total number of samples can be used, pointing to the need to identify risk factors or indicators for residues in a specific population of slaughter animals.

Finally, it should be remembered that surveillance and own check verifies the compliance with the entire system – and it is all the actions taken along the supply chain which determine whether residues will be present or not.

## Epilogue

By January 2016, the Danish swine abattoir companies introduced risk-based surveillance for residues of antimicrobial origin using a multi-chemical method and a risk-based approach to sampling involving a higher sampling intensity in herds with a prevalence of chronic pleuritis (>40%), and a reduction in the total number of samples taken. This is expected to result in costs comparable to those seen in the previous program. The sample matrix is now meat and not kidney.

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