Reliability of information about the use of antibiotics in finishing pigs provided by Dutch pig producers

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Abstract

Sharing relevant information between suppliers and buyers can improve food safety performance of supply chains, but only when it is reliable. This paper investigates reliability of food chain information reported by finishing pig producers about antibiotics usage in pigs during 60 days prior to delivery to a Dutch slaughter company. Detected antibiotics residues were linked to antibiotics usage information. Twice as much producers with as without detected residues reported antibiotics usage. For 89% of deliveries with detected residues 'no antibiotics usage' was reported. Food chain information about antibiotics usage was too unreliable to control absence of antibiotics residues in pork.

Keywords: food chain information, reliability, antibiotic residue, pigs, incentive mechanism

Introduction

Food safety is an important food attribute for consumers, governments and food business operators (FBOs), which has to be further improved constantly. As food safety legislation in the EU at the end of the 20th century was insufficiently equipped to do so, the EU adopted new food safety legislation with the General Food Law (EFSA, 2007). The new legislation states that food safety must be controlled throughout the supply chain starting at primary production, FBOs have primary legal responsibility for food safety, and governments keep the final responsibility to supervise that marketed products are safe (Regulation (EC) No 178/2002). If control points for specific food safety hazards are located within a FBO, it can use control measures to control these hazards. If, however, control points for a hazard are located in production processes of suppliers, buyers have to induce suppliers to control critical food safety attributes of the raw materials in order to receive safe raw materials (Van Wagenberg et al., 2009). But, safety and quality attributes of raw materials are difficult to verify, resulting in information asymmetry about product quality and safety between supplying and buying FBOs in food supply chains. A buyer can reduce information asymmetry by measuring the food quality and safety performance of suppliers with sampling, tests and audits. This can, however, be costly and time consuming (Unnevehr et al., 2004). FBOs are, therefore, searching for more cost-effective strategies to measure performance of a supplier. Provision of relevant performance information by supplying FBOs to the buying FBO can be such a strategy (Van Wagenberg et al., 2009). Performance measurement and provision of relevant performance information by a supplying FBO can be attractive for a buying FBO and the supply chain, because the supplying FBO has access to his own production processes and products, whereas the buying FBO has not, thereby possibly reducing total performance measurement effort and costs through less sampling, testing and auditing in the supply chain. In this way information provision by supplying FBOs about their food safety performance to buying FBOs can cost-effectively improve future food safety.

Sharing relevant information between suppliers and buyers can improve chain performance through better coordination and planning of the supply chain (Lee and Whang, 2000) and increased customer satisfaction (Eggert and Helm, 2003). However, fear of the information being misused (Mohtadi and Kinsey, 2005; Mohtadi, 2008) and expected negative financial consequences (Creane and Davidson, 2008) can result in provision of incomplete or incorrect, or unreliable, information. The usage of unreliable information as if it were reliable by a FBO, can result in food safety and public health problems. For public health and food safety it is, therefore, essential that the information is reliable.

The legislative framework in the EU for food safety prescribes the use of food chain information provided by FBOs in private and public control of animal and public health. All FBOs in the EU have to use appropriate hygiene measures and have to keep records from which relevant information must, on request, be made available to receiving FBOs and the competent authority (Regulation (EC) No 852/2004). They can use this so-called food chain information in the official control of products of animal origin intended for human consumption (Regulation (EC) No 854/2004). For food chain information to be useful in this the control to improve public health and food safety, it is essential that provided food chain information is reliable. However, a literature review indicates a lack of literature on the reliability of food chain information as prescribed by EU legislation. This research aims to fill this gap using the case of information about usage of antibiotics in finishing pigs during the 60 days prior to delivery to a Dutch slaughter company.

The paper is organised as follows. First, it is discussed how information provision by suppliers used in incentive mechanisms can improve future food safety control on supply chain level. Second, the case of food chain information about antibiotics usage in finishing pigs is presented. Third, the analysis shows that reliability of food chain information about antibiotics usage in finishing pigs, as it is currently implemented, is insufficient to be used in controlling the absence of residues of antibiotics in pork and is, therefore, not usable to replace the current measuring for antibiotics residues. Finally, the results and reasons for provision of unreliable information by the finishing pig producers with a detected residue level are discussed to identify possibilities to improve its reliability.

Information provision and incentive mechanisms to improve food safety control

For further improvement of food safety control, new food safety control systems are needed with a focus on supply chain level (Van Wagenberg et al., 2009). Regulation (EC) No 882/2004, prescribing EU member states how to perform official controls, opens possibilities to use private control systems in public food safety control, the so-called “verification of control”-principle. A government verifies if FBOs’ private control systems sufficiently guarantee the safety of marketed products without public control. In this setting FBOs can design and implement effective and efficient solutions on supply chain level that further improve food safety control. But, this requires new relationships between FBOs within the supply chain and between FBOs and government. Van Wagenberg et al. (2009) argue that incentive mechanisms between each of the stages in a supply chain can arrange cost-effective food safety control on supply chain level that meets future EU-targets for food safety. Incentive mechanisms can be private, designed and implemented by FBOs, and public, designed and implemented by a government. Incentive mechanisms consist of a performance measurement and a performance reward (Figure 1).

The *performance reward*, which can be financial and non-financial, provides incentives for the supplier to exert effort that improves performance by rewarding favourable food safety performance and punishing unfavourable food safety performance. The *performance measurement* includes the indicator which is used to measure food safety performance of the supplier, the accuracy of the measurement, and who measures the performance. The performance indicator can be related to the product, such as prevalence of a hazard, and to the process, such as compliance with rules. Only if an indicator and the buyer’s objective respond in exactly the same way to supplier effort, the indicator leads to the best solution for the buyer

(Baker, 1992). The accuracy of the performance measurement can provide incentives to the supplier to exert effort through the financial consequences of false positives and false negatives on the performance reward (Hueth et al., 2007; Starbird, 2007; Van Wagenberg et al., 2008). The buyer, an independent third party, and the supplier can measure supplier performance. If the buyer himself measures performance, the buyer has the food safety performance at his disposal as measured. If performance is measured by an independent third party with tests and audits, this party has to provide information about performance to the buyer. The independence of the third party is assumed to guarantee that the information is reliable, although the quality of the performance measurement can differ between third parties due to size and number of standards that the party is accredited to verify (Souza Monteiro and Anders, 2009). If performance is measured by the supplier, the supplier has to provide the performance information to the buyer. But, the buyer has to rely on the supplier to provide reliable information. Fear of the information being misused (Mohtadi and Kinsey, 2005; Mohtadi, 2008) and expected negative financial consequences (Creane and Davidson, 2008) can result in provision of unreliable information. To determine if supplier provision of information is a cost-effective strategy to measure supplier performance, a buyer has to weigh the gains of information provision by the supplier against the risks resulting from the unreliability of the provided performance information.

Incentive mechanism for food safety control

Performance measurement
- Indicator to measure performance
- Accuracy of performance measurement
- Who measures performance

Performance reward
- Type of reward

Figure 1: Elements of an incentive mechanism for food safety control (Adapted from Van Wagenberg et al., 2009).

Food chain information about antibiotics usage in Dutch finishing pigs

To prevent antibiotics residues to enter the food chain, the Dutch government implemented the National Surveillance Program for the monitoring of antibiotics residues and the slaughter company a monitoring system for detection of antibiotics residues. If antibiotics residues are detected that exceed allowed residue levels, set by maximum residue limits (MRL) in Council Regulation (EEC) 2377/90, the responsible finishing producer is fined. Currently, prior to delivery to a slaughterhouse, finishing pig producers in the EU also have to provide food chain information about the number of finishing pigs in the delivery, the health status of these finishing pigs, the farms the finishing pigs originate from, the usage of antibiotics in these finishing pigs, results of analyses on these finishing pigs of interest to food safety and public health, and the name of the attending veterinarian (Regulation (EC) No 853/2004). The usage of antibiotics is especially interesting, because pigs delivered during the withdrawal period, the period after usage of an antibiotic in which the pig is not allowed for slaughter, can result in products with too high levels of residues posing a risk for public health (Pikkemaat et al., 2009). A large Dutch pig slaughter company, therefore, asks delivering finishing pig producers to provide information about antibiotics usage during the 60 days prior to delivery. If the provided information is reliable, the information 'did not use antibiotics' can identify deliveries which are very likely without antibiotics residues, because the withdrawal periods of the detected antibiotics in finishing pigs are less than 60 days (Table 1). These deliveries then can be subjected to a light control intensity to detect antibiotics residues, whereas other deliveries with the information 'did use antibiotics' can be subjected to a tight control intensity. But, to increase cost-effectiveness of the measurement for antibiotics residues, the information about usage of antibiotics in 60 days prior to delivery must be sufficiently reliable. Because, for public health, detection of deliveries with residues is especially important, the analysis for the reliability of the provided food chain information about antibiotic usage focuses on these deliveries. The indicated usage of antibiotics is expected to be higher for the group of producers with a detected residue than for the group of producers without a detected residue. Furthermore, it can be expected that with reliable information all finishing pig producers with a detected residue indicated antibiotics usage.

Table 1: Withdrawal period of antibiotics found with chemical confirmation in finishing pigs delivered to a Dutch pig slaughter company in 2007 and 2008.

Antibiotic	Withdrawal period (days)[a]
Doxycycline	5 – 28
Oxytetracycline	3 – 53
Tetracycline	3 – 53
Sulfadiazine	5 – 28
Sulfamethoxazol	3 – 12
Dihydrostreptomycine	35 – 49
Penicilline G	5 – 10
Tulathromycine	33

[a] Database veterinary medicines of the Medicine Evaluation Board of the Netherlands (http://www.cbg-meb.nl/CBG/en/veterinary-medicines/database-veterinary-medicines/default.htm).

Material and method

Residues of antibiotics

Finishing pigs with residues of antibiotics were obtained from a dataset with screening results on residues of antibiotics in finishing pigs in 2007 and 2008 of a large Dutch pig slaughter company. The dataset contained screened finishing pigs from multiple slaughter locations. For each slaughter location, screened finishing pigs were selected randomly from deliveries of finishing pigs from farms that had double the lung lesion incidence and pleurisy incidence compared to the average of all farms delivering to that slaughter location. The dataset contained screening results of 22,633 finishing pigs; 11,490 in 2007 and 11,143 in 2008. Residues of antibiotics were determined with the three-step method described in Pikkemaat et al. (2009). First, a Nouws Antibiotics Test-screening (NAT-screening) on pre-urine kidney fluid was carried out. Second, if the NAT-screening indicated the possible presence of antibiotics, two post-screening test on meat juice (NAT-meat test) and on kidney juice (NAT-kidney test) were performed simultaneously. Third, if one or both of the post-screening tests indicated the possible presence of antibiotics, a chemical confirmation with an EU-validated method (Commission Decision 2002/657/EC) was conducted on meat.

Information about the usage of antibiotics

For 141 finishing pigs from the dataset with screening results (93 in 2007, 48 in 2008) chemical confirmation showed residues of antibiotics. Of 45 of the finishing pigs with a chemical confirmation (31 in 2007, 14 in 2008) the laboratory, which conducted the chemical confirmation, only reported compliance with the MRL without reporting the measured quantitative residue level. The results from these pigs were excluded from the analysis, because lack of information about the measured quantitative residue level could also mean that the level was zero, i.e. no residues. The 96 finishing pigs with a quantitative residue level were from 74 producers, of whom 61 producers had one delivery with one positive finishing pig, 12 producers had two deliveries with one positive finishing pig in each delivery, and one producer had 11 finishing pigs in nine deliveries (two deliveries with each two positive finishing pigs). The producer with the nine deliveries was excluded from the analysis, because he was subjected to intensified surveillance and excluded from delivery to the slaughter company in 2008. This resulted in 85 deliveries with each one positive finishing pig in each delivery to be used in the analysis.

Delivery documents (also called transport documents) provided information about the antibiotics usage in the finishing pigs in a delivery. Prior to delivery, for each delivery of finishing pigs arriving at a slaughterhouse the finishing pig producer must fill out a delivery document. By signing the delivery document, a finishing pig producer declares he filled out the receipt truthfully. In 2007 and 2008, different delivery documents concerning treatment statements about antibiotics usage during the 60 days prior to delivery existed. Of the 85 deliveries with a positive finishing pig, 60 delivery documents contained a statement about a group treatment, 22 about treatment of individual finishing pigs, and three did not include a statement. These last three were excluded from the analysis, resulting in 82 deliveries.

The deliveries without residues were selected from the deliveries of the 22,492 screened finishing pigs without a chemical confirmation (11,397 in 2007 and 11,095 in 2008). A sample of 397 deliveries without residues was randomly selected for analysis using an arcsinus-transformation (Cohen, 1977), because the delivery documents were only available on paper. This sample size allows for detection of statistical difference of 5% point between the percentage of finishing pig producers who indicated antibiotics usage in the sample with a quantitative residue level on the one hand and in the sample without a quantitative residue level on the other hand, with a power of 0.95 and an alpha of 0.01 (Cohen, 1977). To exclude a possible bias in slaughter location, year and season, the number of deliveries from each slaughter location, year and month in the sample of deliveries without residues was set proportional to the numbers in the sample of the deliveries with residues. Of the deliveries without residues 299 delivery documents included a statement about a group treatment and 98 about treatment of individual finishing pigs.

Statistical analysis

The Pearson chi-square test of goodness of fit (Pearson, 1900) was used to test if the percentage of finishing pig producers who indicated antibiotics usage was higher for the group of producers with detected antibiotics residues than for the group of producers without detected antibiotics residues for all treatment statements.

A finishing pig producer, however, could have correctly indicated no group treatment with antibiotics, even if a pig in a delivery was found to have antibiotics residues, because he could have treated only this individual pig. A separate analysis was, therefore, conducted for deliveries with only statements about treatment of individual pigs on the delivery document. Because of the low number of deliveries, more than 25% of the expected cell counts had a value of less than five, a Pearson chi-square test of goodness of fit was not appropriate (Fingleton, 1984) and instead a Fisher’s exact test (Agresti, 1992) was performed to test if the percentage of finishing pig producers who indicated antibiotics usage in individual pigs was higher for the group of producers with detected antibiotics residues than for the group of producers without detected antibiotics residues.

If antibiotics residues were detected with chemical confirmation, it can be expected that the finishing pig producer reported ‘did use antibiotics’ on the delivery document. So, the expected number of delivery documents with ‘did not use antibiotics’ would be zero. It is, however, possible that for a delivery with residues the delivery document correctly reported ‘did not use antibiotics’ during 60 days prior to delivery, because it can not be excluded that an individual pig is found to have antibiotics residues at slaughter, even when the finishing pig producer did comply with the withdrawal period. This is because withdrawal periods are set based on probabilistic analysis of medicine clearing times in experiments and for an individual pig the medicine clearing time could exceed 60 days. In other words, it is not possible to univocally set the expected number of delivery documents reporting ‘did not use antibiotics’ in the deliveries with residues at zero, but it is expected to be low. The expected number of delivery documents reporting ‘did not use antibiotics’ was (reasonably but arbitrary) set at 10% of the 82 delivery documents found with residues of antibiotics, which is eight. A Pearson chi-square test of goodness of fit was used to compare the real number of delivery documents reporting ‘did not use antibiotics’ to the expected number of delivery documents reporting ‘did not use antibiotics’. Setting the expected number of delivery documents reporting ‘did not use antibiotics’ at 20% (16) or 30% (25) yielded similar empirical results.

Results

Table 2 provides the number and percentage of finishing pig producers with and without detected antibiotics residues reporting ‘did use antibiotics’ and ‘did not use antibiotics’ during 60 days prior to delivery. The percentage of finishing pig producers who indicated usage of antibiotics was twice as high for the group of producers with a detected residue (11.0%) as for the group of producers without a detected residue (5.5%) ($p=0.0686$). Using the statements about treatment of individual finishing pigs yielded comparable results ($p=0.4066$). The majority of delivery documents of the 82 deliveries with a finishing pig with a detected antibiotic residue (89.0%) and of the 22 deliveries with a finishing pig with a detected residue exceeding the MRL (86.4%) did report “did not use antibiotics” prior to delivery. The real number of delivery documents indicating “did not use antibiotics” (73 of 82 deliveries) in deliveries with residues was significantly higher than the expected eight ($p<0.001$).

Table 2: Number (*n*) and percentage (%) of deliveries of finishing pig producers to a Dutch slaughter company in 2007 and 2008 with the producer reporting ‘did use antibiotics’ and ‘did not use antibiotics’ in the finishing pigs during 60 days prior to delivery for deliveries in which residues of antibiotics were and were not detected per type of treatment statement.

	Delivery documents reporting				
	‘did use antibiotics’		‘did not use antibiotics’		Total
Deliveries	***n***	**%**	***N***	**%**	***n***
Statements about group treatment and treatment of individual pigs					
Without antibiotic residue	22	5.5 [c]	375	94.5	397
With antibiotic residue [a]	9	11.0 [c]	73	89.0	82
- Under MRL [b]	6	10.0	54	90.0	60
- Exceeding MRL [b]	3	13.6	19	86.4	22
Statements about treatment of individual pigs					
Without antibiotic residue	6	6.1 [d]	92	93.9	98
With antibiotic residue [a]	2	10.0 [d]	18	90.0	20

[a] Based on chemical confirmation.

[b] Maximum residue limit.
[c] Statistical difference with Pearson chi-square test of goodness of fit with $p = 0.0686$.
[d] Statistical difference with Fisher's exact test with $p = 0.4066$.

Discussion

The analysis shows that 89% of finishing pig producers with detected antibiotics residues indicated no usage of antibiotics in the pigs during the 60 days prior to delivery to a Dutch slaughter company. This shows that the provided food chain information 'did not use antibiotics' is no guarantee for the absence of antibiotics residues in pork, and that this information is unreliable. The food chain information about antibiotics usage in finishing pigs, as it is currently implemented in the EU-legislation, can not replace the current sampling and testing for antibiotics residues to control the absence of antibiotics residues in pork.

The non-compliance to provide correct information about antibiotics usage hampers control of antibiotics residues in pork. For food chain information about usage of antibiotics in finishing pigs provided on delivery documents to be useful, its reliability needs to be increased and non-compliance to be decreased. Non-compliance for provision of reliable information can be due to errors, because of lack of knowledge or concern, or deliberate actions (Elffers et al., 2003). It was not possible to assess whether or not finishing pig producers with detected antibiotics residues accidently or deliberately reported 'did not use antibiotics'. But, the reasons for the presence of antibiotics residues can be an indication. The reasons were identified through telephone and email contact of slaughter company personnel with the 73 finishing pig producers with detected antibiotics residues. Of 47 (64%) of these producers reasons for presence of antibiotics residues were retrieved (Table 3). Most reasons provided seem related to errors: cross-contamination with medicated water and feed, forgetfulness about the withdrawal period, incorrectly recording and marking of medicated pigs, and the sickness of treated pigs. This is supported by the fact that 73 of the 74 producers, who had deliveries with a pig with antibiotics residues in 2007 and 2008, had one or two deliveries with a pig with residues. The non-compliance with the presence of antibiotics residues thus seems mainly related to errors instead of deliberate actions. However, accidentally providing antibiotics in the 60 days prior to delivery by itself does not prevent deliberately reporting 'did not use antibiotics', because a finishing pig producer could have detected the accidental provision of antibiotics prior to filling out the delivery document.

Table 3: Reasons provided by 47 finishing pig producers for the presence of residues of antibiotics in their deliveries to a Dutch finishing pig slaughter company in 2007 and 2008.

Reason	Number of deliveries
Cross-contamination through water	2
Cross-contamination through feed	10
Incorrectly adjusted feeding system	2
Forgot to close tap of medicated water	5
Forgot to record the use of antibiotics correctly	4
Forgot the withdrawal period	12
Medicated finishing pigs accidently in the delivery	6
Treated finishing pigs were sick	8
Total	49 [a]

[a] Two finishing pig producers provided each two reasons.

To improve compliance with the law to provide correct food chain information about antibiotics usage, factors that induce non-compliance have to be solved. To analyse compliance with regulatory laws of Dutch primary producers the Table-of-Eleven (T^{11}) can be used (Elffers et al., 2003). The T^{11} includes six spontaneous compliance dimensions and five induced compliance dimensions promoting and opposing compliance with a law (Elffers et al., 2003). The spontaneous compliance dimensions, which are not under direct control of a law-enforcing agency, include lack of knowledge about and clarity of rules, costs and benefits associated with compliance and non-compliance, acceptability of rules, general conformity with respect to laws and authorities, informal control by the social environment, and spontaneous detection. The induced compliance dimensions, which focus on activities of a law-enforcing agency, include the probability that an arbitrary producer will be controlled (control density), the conditional probability of detecting non-compliance given that a non-compliant producer is checked (control depth), targeting of control activities towards producers with increased risk of non-compliance, sanction certainty if non-compliance is detected, and sanction severity. Most finishing pig producers did provide correct information, indicating that the spontaneous compliance dimensions sufficiently induced them to comply with food law. Further improvement of compliance could come from increased knowledge and clarity about the rules. Specifically, some finishing pig producers, who provided reasons for a detected residue, seemed to have interpreted the 60 day period in the question on the delivery document as the (usually shorter) withdrawal period. Concerning the induced compliance dimensions, in practice in the period considered in this research only the National Surveillance Program for the monitoring of antibiotics residues and a private monitoring system of the slaughter company for antibiotics residues were in place. Although mentioned in Regulation (EC) No 854/2004, laying down specific rules for usage of food chain information in the official control of products of animal origin intended for human consumption, the reliability of the provided food chain information about antibiotics usage was not actively enforced. A sanctioning system on the provision of incomplete and incorrect information could improve reliability of the provided information. A sanctioning system could be implemented to improve reliability of the provided information. However, for cost-effective control, benefits of such a system in terms of public health improvement should outweigh cost of control and sanctioning. Difficulty for the government or a slaughter company to verify actual antibiotics usage by finishing pig producers and relating this to the information provided on the delivery documents, would probably result in high costs. Further research is needed to determine the benefits and costs of such a system and to design it.

Conclusion

This paper showed that the food chain information provided by finishing pig producers about the usage of antibiotics during the 60 days prior to delivery to a Dutch finishing pig slaughter company, as it is currently implemented in the EU-legislation, was unreliable, did not provide useful information to control the absence of residues of antibiotics in pork, and can not be used as performance measure in an incentive mechanism to control the absence of antibiotics residues in pork. A sanctioning system could be implemented to improve reliability of the provided information. Further research is needed to determine whether the benefits of such a system outweigh its costs.

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