NORM-VET 1999

Usage of antimicrobial agents in animals and occurrence of antimicrobial resistance in bacteria from animals, feed, and food in Norway 1999

Working group

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NORM-VET is the **NO**rwegian monitoring program for **R**esistance in **M**icrobes – **VET**erinary medicine (from animals, feed, and food).

Preface

Worldwide antimicrobial resistance is a steadily increasing problem that affects treatment of infectious diseases both in humans and in animals resulting in increased morbidity and mortality, and increased costs. The occurrence of resistance varies among others with pathogen, source, country, environment, and management practices. For many human and animal pathogens a significant increase in the prevalence of resistance to various antimicrobials have been observed following the introduction of different agents in the various disciplines. It is well established that there is an association between the usage of antimicrobial agents and the occurrence of resistance and that resistant bacteria may be a source for further spread of resistance genes. Thus, a key issue in the epidemiology of antimicrobial resistance is the selective pressure.

Resistance can be disseminated through the spread of the resistant pathogenic bacteria themselves or by horizontal gene transfer from one type of bacteria to another. Resistance genes can be transferred not only between closely related bacteria, but also between bacteria of different evolutionary and/or ecological origin. Thus, antimicrobial usage and resistance in one compartment may have consequences for the occurrence of resistance in another compartment. Consequently, when addressing antimicrobial resistance – the occurrences, causes, consequences, and preventive measures – one must take a holistic view encompassing human and veterinary medicine, as well as the food production sector.

In recent years, the number of foodborne infections caused by resistant bacteria has increased. In regard to zoonotic bacteria, such as *Salmonella* sp. and *Campylobacter* sp., it has been documented that resistant isolates can be transferred from animals to humans through foods and in this way contribute to the resistance problem in human medicine. Use of antimicrobials in food animals is considered the principal cause of resistance in foodborne zoonotic bacteria. It is emphasized, however, that antimicrobial use in human medicine also contributes to the occurrence of resistance in zoonotic pathogens and that zoonotic bacteria also can be transferred between humans either directly by person-to-person contact or indirectly, for example through food handling. For non-zoonotic foodborne pathogens, the most important factors contributing to the development and spread of resistance are the use of antimicrobials in human medicine and the sanitary and public health infrastructure.

Also bacteria other than pathogens can develop resistance and thus be a source of resistance genes that can be further spread to pathogenic bacteria. Examples include *Enterococcus* sp. and *Escherichia coli,* which are commonly isolated from food products usually as a result of direct or indirect contact with fecal materials of human or animal origin. Still little is known regarding the impact on the epidemiology of antimicrobial resistance of resistant «indicator bacteria» in food. However, also in this area it has been shown that there is an association between the occurrence of resistance and the usage of antimicrobial agents, especially in animal husbandry.

In order to understand the epidemiology of antimicrobial resistance and perform risk assessments in this area, it is crucial to have information about the usage of the various antimicrobials in the different compartments. The importance of monitoring all usage of antimicrobials has been emphasized by among others the WHO and the EU.

In recent years, several countries have implemented monitoring programs aiming at collecting data on the occurrence of resistance in various bacteria from humans, and in some countries also from animals and even from food. Relevant pathogens are included, and in some programs also indicator bacteria are included. Currently, Denmark has implemented the most comprehensive monitoring program, DANMAP, which covers pathogens and indicator bacteria from humans, animals, and food.

The Norwegian national action plan against antimicrobial resistance, issued by the Norwegian Ministry of Health and Social Affairs in 2000, stressed the importance of implementing a monitoring program in regard to antimicrobial resistance in both the human and veterinary sector, including food production. A monitoring program for antimicrobial resistance in human pathogens was established in Norway in 1999. In the veterinary and food sector, surveys regarding antimicrobial resistance in relevant bacteria from various sources, including pathogens and/or indicator bacteria, have been conducted annually in recent years. A continuous monitoring program in the veterinary and food sector (NORM-VET) was established in the fall of 2000. In this program samples from animals, feed, and food are being collected and analyzed in a systematic and representative manner. The results will be presented in annual NORM-VET reports to document and follow the resistance situation.

The present report presents published data on the consumption in Norway of veterinary antimicrobial agents in the period 1995-1999 and official data on the occurrence of antimicrobial resistance in bacteria from animals, feed, and foods in Norway in 1999. These data can serve as a basis for the interpretation and evaluation of trends in the resistance situation in Norway in the future. The results from this report are not directly comparable with results reported from other countries' monitoring programs due to more or less different sampling schemes, methodology, and breakpoints. However, the data indicate some tendencies in the resistance patterns and how these tendencies relate to trends in the usage of antimicrobials.

This report was produced in collaboration between the various participants of the working group. It is emphasized, however, that also the efforts by many other people in various institutions have been important in order to make the data available, including personnel involved in sampling, submission of samples, and laboratory work.

Conclusions

This report documents the usage of veterinary antimicrobial agents approved for use in animals in Norway. The total annual sale of veterinary antibacterial drugs for therapeutic use is relatively low, and the sale has decreased substantially during the past few years. Moreover, the data shows that the pattern of use of these drugs is rather favourable, benzylpenicillin being the most frequently prescribed drug for treatment of infections in animals, a trend that has been strengthened during the last years. The low consumption of veterinary antibacterial drugs is explained by the restrictive drug legislation. Antibacterial drugs for therapeutic use in animals and farmed fish in Norway are prescription drugs only, and antibacterial drugs have to be dispensed through pharmacies or authorised feed mills. Thus, sale of antibacterial drugs does not represent a source of income for the veterinarians. The reduced usage and the favourable prescribing patterns of antibacterial drugs is partly attributed to a campaign initiated in 1996 by the Norwegian livestock farming organizations, the main aims being to reduce the overall consumption of antimicrobial drugs in food producing animals and to use these drugs more prudently. Nevertheless, there is still a potential for improvement.

The report also presents data on the occurrence of antimicrobial resistance among zoonotic bacteria, pathogenic bacteria from infections in animals, and indicator bacteria from selected food products. For those categories of bacteria with a Norwegian source where the number of isolates included is not too limited, the results indicate that the occurrence of resistance is relatively favourable, although there is a potential for improvement. Some resistance to antimicrobial substances that have been or still are being used therapeutically in the respective animal categories were observed among bacteria with a Norwegian source. However, the occurrence of resistance to newer antibacterial drugs was low. This relatively favourable resistance situation may be explained by the low usage and the favourable prescribing patterns of antibacterial drugs in veterinary medicine in Norway.

Sammendrag

Forbruk av antimikrobielle midler

Avoparcin ble i utstrakt grad brukt som antibakterielt vekstfremmende fôrtilsetningsstoff i norsk broiler- og kalkunproduksjon fra 1986 inntil det ble forbudt i 1995. Etter 1995 har det praktisk talt ikke blitt brukt antibakterielle vekstfremmere i norsk husdyrproduksjon. I 1998 og 1999 var forbruket av slike midler lik null.

Totalforbruket av koksidiostatika har vært på samme nivå de siste fem årene, selv om forbruksmønsteret har endret seg. Narasin har dominert siden 1996, mens bruken av andre ionofore koksidiostatika har sunket tilsvarende.

Det totale salget av veterinære antibakterielle midler godkjent for terapeutisk bruk til dyr (fisk unntatt) i Norge var 6 303 kg i 1999, noe som utgjør en 33% reduksjon siden 1995. I 1999 utgjorde penicilliner den største andelen av forbruket (44%), fulgt av sulfa (27%), aminoglykosider (19%), tetracykliner (3%), trimetoprim og derivater (3%), og andre antibakterielle midler (4%). Andelen penicilliner av det totale forbruket økte fra 36% i 1995 til 44% i 1999. I samme periode sank aminoglykosidenes andel av det totale forbruket fra 27% til 19%.

Det totale salget av veterinære antibakterielle midler godkjent for terapeutisk bruk til oppdrettsfisk i Norge utgjorde 591 kg i 1999, og kinoloner representerte 85% av dette forbruket. I løpet av de siste 12 årene har forbruket av antibakterielle midler i oppdrettsnæringen blitt redusert med 99% samtidig som produksjonen av oppdrettsfisk er mangedoblet. Denne reduksjonen tilskrives først og fremst innføring av effektive vaksiner, men også bedrede miljøforhold i oppdrettsnæringen har hatt betydning.

Resistens

Zoonotiske bakterier
Da kun et lite antall isolater er blitt undersøkt, er det ikke mulig å trekke konklusjoner ut ifra resultatene.

Ingen av 22 isolater av *Salmonella* sp. fra fôr, dyr og næringsmidler av norsk opprinnelse ble klassifisert som resistente overfor de antimikrobielle midlene som inngikk i undersøkelsene.

Ingen av 13 isolater av *Campylobacter* sp. fra prøver av norske fjørfeprodukter eller storfe var resistente. Av 10 isolater fra importerte fjørfeprodukter var 30% tetracyklin-resistente, 30% nalidixinsyre-resistente, 20% ciprofloxacin-resistente og 10% ampicillin-resistente.

Bakterier fra infeksjoner hos dyr
Av mer enn 1 000 *Staphylococcus aureus* fra akutt mastitt hos kyr var 4.2% resistente mot penicillin G, 2.6% mot streptomycin, 0.2% mot tetracyklin og 0.2% mot sulfa+trimetoprim. Av mer enn 7 000 *S. aureus* fra subklinisk mastitt var 18% resistente mot penicillin G.

Av mer enn 100 koagulase-negative stafylokokker (KNS) fra akutt mastitt hos kyr var 22% resistente mot penicillin G, 23% mot streptomycin, 3% mot tetracyklin og 1% mot sulfa+trimetoprim. Av mer enn 1 400 KNS fra subklinisk mastitt var 26% resistente mot penicillin G.

Av mer enn 400 *E. coli* fra akutt mastitt hos kyr var 19% resistente mot streptomycin, 3% mot tetracyklin og 3% mot sulfa+trimetoprim.

Forekomsten av resistens mot de ulike antimikrobielle midler hos bakterier fra mastitt hos kyr har vært på samme nivå gjennom hele 1990-tallet.

Av 40 *E. coli* fra enteritt hos svin var 58% resistente mot streptomycin, 50% mot tetracyklin, 15% mot ampicillin, 10% mot sulfa+trimetoprim og 5% mot kloramfenikol. Det ble ikke påvist isolater med resistens overfor cefalosporiner eller enrofloxacin.

Av 135 beta-hemolytiske stafylokokker fra hud- og øre-infeksjoner hos hund var 79% resistente mot penicillin G, 49% mot tetracyklin, 34% mot fusidin, 22% mot linkomycin og 1% mot kloramfenikol. Det ble ikke påvist resistens mot sulfa+trimetoprim eller cefalosporiner. Siden 1993-1994 har andelen isolater fra hudinfeksjoner som er resistente mot penicillin G eller fusidin, økt betraktelig.

Bakterier fra matvarer
Av 55 *E. coli* fra vegetabilske produkter (norske og importerte grønnsaker, bær og sopp) var 7% resistente mot ett eller to antimikrobielle midler.

Av 82 *E. coli* fra importert dansk svinekjøtt var 28% resistente mot minst ett antimikrobielt middel og 7% mot tre eller flere midler. Resistens mot streptomycin, tetracyklin og sulfa var hyppigst, henholdsvis 20%, 15% og 13%, fulgt av resistens mot trimetoprim (9%), ampicillin (6%), neomycin (1%), kloramfenikol (1%) og kanamycin (1%). Disse funnene samsvarer godt med DANMAPs data for dansk svinekjøtt i 1999.

Av 22 *E. coli* fra importert fjørfekjøtt var 64% resistente mot minst ett antimikrobielt middel og 41% mot tre eller flere midler. Sytten av isolatene kom fra fransk andekjøtt. Av disse var 76% resistente mot minst ett antimikrobielt middel og 53% mot tre eller flere midler. Blant andekjøttisolatene ble resistens mot tetracyklin og

trimetoprim hyppigst registrert, henholdsvis 71% og 53%, fulgt av resistens mot ampicillin (47%), sulfa (41%), nalidixinsyre (35%), streptomycin (18%) og kloramfenikol (12%).

Av 233 enterokokker fra vegetabilske produkter (norske og importerte grønnsaker, bær og sopp) var 15% resistente mot minst ett antimikrobielt middel og 4% (alle fra spirer) mot tre eller flere midler. Resistens overfor tetracyklin og streptomycin (høygradig) ble hyppigst registrert, henholdsvis 9% og 5%. Tre prosent av isolatene var resistente mot både spiramycin og erytromycin. Kloramfenikol-resistens ble påvist hos 2% av isolatene. Ett isolat, *E. faecium* fra norsk fersk oregano, var vankomycin-resistent.

Av 157 enterokokker fra importert dansk svinekjøtt var 31% resistente mot minst ett antimikrobielt middel og 11% mot tre eller flere. Tetracyklin-resistens var mest vanlig (21%), fulgt av resistens mot streptomycin (høygradig) (17%), spiramycin (13%), erytromycin (12%), trimetoprim (5%) og kloramfenikol (3%).

Av 38 enterokokker fra importert fjørfekjøtt var 63% resistente mot minst ett antimikrobielt middel og 24% mot tre eller flere. Av de 29 enterokokkene fra importert fransk andekjøtt var 62% resistente mot minst ett antimikrobielt middel og 24% mot tre eller flere midler. Tetracyklin-resistens var mest vanlig (62%), fulgt av resistens mot streptomycin (høygradig) (24%), erytromycin (17%), spiramycin (14%), trimetoprim (10%) og kloramfenikol (10%).

MIC-verdiene for bacitracin blant enterokokker fra alle typer næringsmiddelprøver viste stor spredning.

Av 33 koagulase negative stafylokokker fra vegetabilske produkter (norske og importerte grønnsaker, bær og sopp) ble resistens mot penicillin G og oxacillin (MIC 0.125 – 8 µg/ml) hyppigst registrert, for begge midler 64%, fulgt av resistens mot sulfa (21%), tetracyklin (12%), trimetoprim (6%), klindamycin (3%) og kloramfenikol (3%).

Av 45 *S. aureus* fra melkeprodukter av upasteurisert norsk kumelk var 27% resistente mot ett middel og 7% mot to midler. Totalt 18% av isolatene var resistente mot sulfa og 18% mot penicillin G. Oxacillin-resistens i form av lett forhøyede MIC-verdier (3µg/ml) ble påvist hos 4%.

Av 25 *S. aureus* fra melkeprodukter av upasteurisert norsk geitemelk var 32% resistente mot ett middel og 8% mot to midler. Totalt 24% av isolatene var resistente mot sulfa, 16% mot penicillin G, 4% mot oxacillin (MIC >256µg/ml) og 4% mot streptomycin.

De observerte resistensprevalensene for stafylokokkene fra melkeprodukter av upasteurisert norsk melk samsvarer med resistensdataene som rapporteres fra norske laboratorier som undersøker prøver fra dyr med mastitt. Dataene samsvarer også med tidligere og nåværende forbruksmønster av antibakterielle midler som brukes til behandling av mastitt i Norge.

Summary

Usage of antimicrobial agents

The antibacterial growth promoter avoparcin was widely used in the Norwegian broiler and turkey production from 1986 until this substance was prohibited for such use in May 1995. After 1995, there has been almost no use of antibacterial growth promoters in Norwegian animal food production. In both 1998 and 1999, the consumption of antibacterial growth promoters was zero.

The total use of coccidiostats has remained at the same level during the last five years, while the patterns of use have changed. Since 1996, narasin has been the most extensively used coccidiostat. In the same period, the use of other ionophores has decreased correspondingly.

The total sale of veterinary antibacterial drugs approved in Norway for therapeutic use in animals (fish excluded) was 6 303 kg in 1999, a 33% decrease since 1995. In 1999, penicillins represented the most frequently used drugs, followed by sulfonamides (27%), aminoglycosides (19%), tetracyclines (3%), trimethoprim and derivates (3%), and others (4%). The proportion of penicillins of the total use increased from 36% in 1995 to 44% in 1999. In the same period, the proportion accounted for by aminoglycosides decreased from 27% to 19%.

The total sale in Norway of veterinary antibacterial drugs for therapeutic use in farmed fish was 591 kg in 1999, of which quinolones accounted for 85%. During the last 12 years, the total use of antibacterial drugs in farmed fish has decreased by 99%. In the same period, the total production has increased enormously. This decrease in antibacterial consumption is mainly attributed to the introduction of effective vaccines, although improved management and husbandry in aquaculture also play a role.

Resistance

Zoonotic bacteria
As only a limited number of isolates was included, no conclusions can be drawn.

None of 22 Norwegian isolates of *Salmonella* sp. from feed, animals, or food that were susceptibility tested were resistant to any of the antimicrobials included.

None of 13 isolates of *Campylobacter* sp. from Norwegian poultry products and cattle that were susceptibility tested were resistant to any of the antimicrobials included. Of 10 isolates from imported products, 30% were resistant to tetracycline, 30% to nalidixic acid, 20% to ciprofloxacin, and 10% to ampicilllin.

Bacteria from infections in animals
Among more than 1 000 *Staphylococcus aureus* from acute mastitis in cows, 4.2% were resistant to penicillin G, 2.6% to streptomycin, 0.2% to tetracycline, and 0.2% to sulfonamides+trimethoprim. Among more than 7 000 *S. aureus* isolates from subclinical mastitis, 18% were resistant to penicillin G.

Among more than 100 coagulase negative staphylococci (CNS) from acute mastitis in cows, 22% were resistant to penicillin G, 23% to streptomycin, 3% to tetracycline, and 1% to sulfonamides+trimethoprim. Among more than 1 400 CNS from subclinical mastitis, 26% were resistant to penicillin G.

Among more than 400 *E. coli* from acute mastitis in cows, 19% were resistant to streptomycin, 3% to tetracycline, and 3% to sulfonamides+trimethoprim.

The above mentioned resistance prevalences in bacteria from mastitis in cows have remained almost constant during the 1990s.

Of 40 *E. coli* from enteritis in swine, 58% were resistant to streptomycin, 50% to tetracycline, 15% to ampicillin, 10% to sulfonamides+trimethoprim, and 5% to chloramphenicol. No resistance to cephalosporins or enrofloxacin was observed.

Of 135 beta-haemolytic staphylococci from skin and ear infections in dogs, 79% were resistant to penicillin G, 49% to tetracycline, 34% to fusidic acid, 22% to lincomycin, and 1% to chloramphenicol. Resistance to sulfonamides+trimethoprim or cephalosporins were not detected. Since 1993-1994, the proportion of isolates from skin infections being resistant to penicillin G or fusidic acid has increased significantly.

Bacteria from food products
Of 55 *E. coli* isolates from fresh produce (Norwegian and imported vegetables, berries, and champignons), 7% were classified as resistant to one or two of the antimicrobials included.

Of 82 *E. coli* isolates from imported Danish pork, 28% were classified as resistant to at least one antimicrobial and 7% to three or more antimicrobials. Resistance to streptomycin, tetracycline, and sulfonamides was most frequently observed; 23%, 15%, and 13%, respectively, followed by resistance to trimethoprim (9%), ampicillin (6%), neomycin (1%), chloramphenicol (1%), and kanamycin (1%). These data correspond well with the data reported for Danish pork by DANMAP (1999).

Of 22 *E. coli* isolates from imported poultry, 64% were classified as resistant to at least one antimicrobial and 41% to three or more antimicrobials. Seventeen of the isolates originated from French duck meat. Of these, 76% isolates were resistant to at least one antimicrobial and 53% to three or more antimicrobials. Resistance to tetracycline and trimethoprim was most commonly detected among the isolates from French duck meat, 71% and 53%, respectively, followed by resistance to ampicillin (47%), sulfonamides (41%), nalidixic acid (35%), streptomycin (18%), and chloramphenicol (12%).

Of 233 enterococci isolated from fresh produce (Norwegian and imported vegetables, berries, and champignons), 15% were classified as resistant to at least one antimicrobial and 4% (all from sprouts) to three or more antimicrobials. Resistance to tetracycline (9%) and streptomycin (high level) (5%) was most frequently observed. Three percent of the isolates were contemporaneously resistant to erythromycin and spiramycin. Chloramphenicol resistance was detected in 2% of the isolates. One isolate, *E. faecium* from a sample of Norwegian fresh oregano, was resistant to vancomycin.

Of 157 enterococci from imported Danish pork, 31% were resistant to at least one antimicrobial and 11% to three or more antimicrobials. Tetracycline resistance (21%) and high-level streptomycin resistance (17%) was most frequently observed, followed by resistance to spiramycin (13%), erythromycin (12%), trimethoprim (5%), and chloramphenicol (3%).

Of 38 enterococci from imported poultry, 63% were resistant to at least one antimicrobial and 24% to three or more antimicrobials. Twenty-nine isolates originated from French duck meat. Of these, 62% were resistant to at least one antimicrobial and 24% to three or more. Tetracycline resistance (62%) and high-level streptomycin resistance (24%) was most commonly observed among the isolates from French duck meat, followed by resistance to erythromycin (17%), spiramycin (14%), chloramphenicol (10%), and trimethoprim (10%).

The MIC-values for bacitracin for enterococci isolated from all categories of food samples were widely distributed.

Of 33 coagulase negative staphylococci from fresh produce (Norwegian and imported vegetables, berries, and champignons), resistance to penicillin G and oxacillin (MIC 0.125 – 8 µg/ml) was most frequently observed, 64% of the isolates for both drugs, followed by resistance to sulfonamides (21%), tetracycline (12%), trimethoprim (6%), clindamycin (3%), and chloramphenicol (3%).

Of 45 *S. aureus* from Norwegian cow milk products, 27% were resistant to one and 7% to two antimicrobials. Altogether, 18% of the isolates were resistant to sulfonamides and 18% to penicillin G. Oxacillin resistance due to slightly elevated MIC-values (3µg/ml) was observed in 4% of the isolates.

Among 25 *S. aureus* from Norwegian goat milk products, 32% were resistant to one antimicrobial and 8% to two antimicrobials. Altogether, 24% of the isolates were resistant to sulfonamides, 16% to penicillin G, 4% to oxacillin (MIC >256µg/ml), and 4% to streptomycin.

The prevalences of resistance observed among the staphylococci from Norwegian milk products match the resistance data reported from the Norwegian mastitis laboratories being responsible for examining isolates from animals with mastitis. Moreover, these figures also correspond with the previous and current patterns of antimicrobial use for mastitis treatment in Norway.

Demographic data

Table 1. Livestock population in Norway as of 31.12.1999
(data provided by Statistics Norway)

Animal category	Animals	Herds
Cattle, total	1 030 962	30 043
Dairy cows (incl. in above total)	312 143	22 591
Goats, total	78 010	1 328
Dairy goats (incl. in above total)	51 329	748
Winter-fed sheep, total	953 621	22 811
Breeding sheep >1 year	922 371	22 776
Breeding swine > 6 months	90 200	3 677
Fattening pigs for slaughter	1 378 400	6 324
Egg laying hens (>20 weeks of age)	3 181 286	4 045
Broilers, total no. for slaughter	23 355 600	approx. 400
Turkeys, total no. for slaughter		111
Ducks/geese, total no. for slaughter		approx. 200

Table 2. Animals slaughtered in 1999
(data provided by Statistics Norway, except*)

	Slaughtered	
Animal category	No. of animals	Tons of fish
Horse	2 373	
Cattle	388 199	
Goats	21 034	
Sheep	1 149 633	
Swine	1 404 382	
Poultry	33 402 377	
Reindeer	45 857	
Farmed salmon*		420 000
Farmed trout*		44 000

* Data from the Directorate of Fisheries

Usage of antimicrobial agents

Antibacterial growth promoters and coccidiostats

The approval of and monitoring of sale of feed additives i.e. antibacterial growth promoters and coccidiostats, in Norway is in charge of the Norwegian Agricultural Inspection Service (NAIS). Detailed data on the usage of the different substances and categories of feed additives can be obtained from NAIS. Table 3 summarizes the total sale of antibacterial growth promoters and coccidiostats in Norway for the period 1995 – 1999.

In 1995 the glycopeptide avoparcin that had been on the Norwegian market since 1986 as a growth promoter in poultry production was prohibited because an association between the use of this antibacterial feed additive and the occurrence of vancomycin resistant enterococci in animal husbandry was reported. The same year the Norwegian food animal production industries voluntarily abandoned the use of all antibacterial growth promoters. Since then there has been almost no use of antibacterial growth promoters in Norwegian food animal production. In 1998 the streptogramin virginiamycin was officially prohibited due to reports from other countries of an association between the use of this drug and the occurrence of enterococci being resistant to quinupristin-dalfopristin, a streptogramin combination preparation used in human medicine.

Coccidiostats, however, are still being used in Norwegian poultry production. The total sales, in kg active substance, are at the same level as before the ban of the antibacterial growth promoters were implemented. However, the pattern of use has changed. Narasin has since 1996 dominated the use of coccidiostats whereas the use of other ionophores has decreased correspondingly.

Table 3. Total sale of antibacterial growth promoters and coccidiostats in Norway for the period 1994 - 1999.

	Total sale in kg active substance					
Compound	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Antibacterial growth promoters – total	1 216	548	64	27	0	0
Avoparcin	982	419*	Prohibited	Prohibited	Prohibited	Prohibited
Zincbacitracin	234	129	64	27	0	0
Virginiamycin	0	0	0	0	0*	Prohibited
Ionophore coccidiostats – total	5 222	4 656	4 906	4 375	4 208	4 854
Lasalocid	3 896	996	480	471	193	208
Monensin	844	3 422	891	561	485	557
Salinomycin	482	214	27	0	0	27
Narasin	0	24	3 508	3 343	3 530	4 062
Other coccidiostats – total	165	156	116	582	174	201
Amprolium/etopabat	165	156	116	582	174	201

***** Prohibited part of the year

Veterinary antibacterial drugs approved for therapeutic use

In Norway, veterinary antibacterial drugs for therapeutic use in domestic animals or farmed fish are prescription drugs only. Moreover, veterinary antibacterial drugs have to be dispensed through pharmacies, which are supplied solely by drug wholesalers. An exemption from the pharmacy/wholesalers monopoly has been granted for medicated feed (i.e. feeds into which drugs for therapeutic use are mixed prior to sale). Medicated feed have to be prescribed by veterinarians, and are produced and delivered by feed mills authorised by the Directorate of Health. In Norway, medicated feeds produced and supplied by feed mills are used only in farmed fish. The reason why feed mill production of medicated feed for use in livestock is not practiced in Norway is the small size of livestock herds compared to most other European countries. Herd/flock treatment of livestock with antibacterial drugs is, however, possible, but such practice is subjected to veterinary prescription, drugs being administered either through drinking water or in medicated feed prepared on the farm.

The sales figures of veterinary antibacterial drugs from wholesalers and feed mills are thought to roughly equal the use of these drugs. Veterinary antibacterial drug use and usage are therefore used as synonyms of sales figures of veterinary antibacterial drugs.

The majority of the substances included in this report are approved as pharmaceutical specialities both for food producing animals, horses, and/or dogs and cats. Therefore, the sales figures presented represents overall sales data of veterinary antibacterial drugs.

In small animal practice, human antibacterial drugs are also prescribed. However, data about usage of these drugs in animals are yet not available.

On behalf of the Norwegian Board of Health, overall sales data, representing sales from the Norwegian drug wholesalers to pharmacies and from feed mills to fish farms, are recorded by the Norwegian Medicinal Depot

AS, a state-owned drug wholesaler. Although this report primarily presents resistance data for 1999, trends in the prescribing patterns of veterinary antibacterial drugs for the period 1995-1999 are included to show the preceding antibacterial load in the domestic animal population and in Norwegian fish farming.

In Norway, the Anatomical Therapeutic Chemical (ATC) classification system is used to classify veterinary medicinal products (ATCvet). All veterinary antibacterial specialities included in this report belong to the following ATCvet groups: gastrointestinal infections (QA07AA), uterine infections (QG01AA+AE), and antibacterial drugs for systemic use (QJ), including intramammary dose applicators (QJ51)

The amounts, in kg active substance, of veterinary antibacterial specialities supplied by wholesalers to pharmacies and by feed mills, were calculated from sales figures. The data for benzyl penicillin salts and esters (procaine penicillin and penethamate hydriodide) were converted to the corresponding values for benzyl penicillin. Amount of active substance, in kg, was chosen as the unit of measurement.

Table 4 summarizes the sales (in kilograms of active substance) in 1999 of veterinary antibacterial drugs approved for therapeutic use in domestic animals in Norway. The data are organized according to the main groups of substances and show the usage for the various routes of administration. The total usage for each group of substance is given in Figure 1, while Figure 2 illustrates the proportion of the total sale for the various main groups of antibacterial substances. Both figures present annual sales data for the period 1995 – 1999.

In 1999 the total sale of veterinary antibacterial substances approved in Norway for therapeutic use in animals was 6303 kg, a 33% decrease since 1995. Penicillins were the most frequently used drugs (44%), followed by sulfonamides (27%), aminoglycosides (19%), tetracyclines (3%), trimethoprim and derivatives (3%), and others (4%). The proportion of penicillins used increased from 36% in 1995 to 44% in 1999. In the same period, the proportion accounted for by aminoglycosides decreased from 27% to 19%.

Table 4. Sales (in kilograms of active substance) in 1999 of veterinary antibacterial drugs approved in Norway for therapeutic use in animals, fish not included. Data were obtained from the Norwegian drug wholesalers.

Groups of substances	ATCVet code	Active substance or combinations of substances	Gastro-intestinal (QA07)	Uterine (QG01)	Systemic - individ. (QJ01)	Systemic – herds (QJ01)	Intra-mammary (QJ51)
Tetracyclines	QG01 AA 07	Oxytetracycline		3			
	QJ01 AA 02	Doxycycline			0,2		
	QJ01 AA 06	Oxytetracycline			98	116	
Beta-lactam	QJ01 CA 01	Ampicillin			27		
Antibacterials	QJ01 CA 04	Amoxycillin			53	47	
	QJ01 CE 01	Benzylpenicillin			5		
	QJ01 CE 09	Procaine penicillin*			2 042		
	QJ01 CE 90	Penethamate hydroiodide*			25		22
	QJ01 CR 02	Amoxicillin+clavulanic acid			83		4
	QJ51 CA 51	Ampicillin+cloxacillin					7
Sulfonamides	QJ01 EQ 03	Sulfadimidine+baquiloprim			4		
And trimethoprim	QJ01 EQ 09	Sulfadimetoxine+baquiloprim			2		
or baquiloprim	QJ01 EQ 10	Sulfadiazine+trimethoprim			880		
	QJ01 EQ 13	Sulfadoxine+trimethoprim			150		
	QJ01 EQ 15	Sulfamethoxypyridazine			610		
Macrolides and	QJ01 FA 02	Spiramycin			8		
Lincosamides	QJ01 FF 02	Lincomycin			7		
Aminoglycoside	QA07 AA 01	Neomycin	23				
Antibacterials	QA07 AA 90	Dihydrostreptomycin (DHS)	175				
Antibacterial quinolones	QJ01 MA 90	Enrofloxacin			15		
Other antibacterials	QJ01 XX 92	Tiamulin			11	198	
Combinations of	QG01 AE 99	Sulfadimidine+procaine penicillin*+DHS		267			
Antibacterials	QJ01 RA 01	Procaine penicillin*+DHS			715		
	QJ01 RA 01	Spiramycin+metronidazole			1		
	QJ51 RC 23	Procaine penicillin*+DHS					664
	QJ51 RC 25	Penethamate hydroiodide*+ DHS					41
		Total per route of administration:	198	270	4 736	361	738
							Total: 6303

*Calculated as benzylpenicillin

In Norway, medicated feeds for farmed fish are approved by the drug authorities and classified as pharmaceutical specialities. Sales figures of these products and premixes are presented in Table 5, divided into groups of substances. In 1999 the total sale of veterinary antibacterial drugs in Norway for therapeutic use in farmed fish was 591 kg, quinolones accounting for 85% of the total use. The annual use of antibacterial drugs declined 99% during the period 1987-1999. In the same period, the total production of farmed fish increased enormously. This decrease in the use of antibacterial drugs is mainly attributed to the introduction of effective vaccines and improved environmental conditions in aquaculture.

Table 5. Sales (in kilograms of active substance) for the period 1995 - 1999 of veterinary antibacterial drugs approved for therapeutic use in farmed fish in Norway. Data were obtained from the Norwegian drug wholesalers and feed mills.

	Total sale in kg active substance				
Groups of substances	**1995**	**1996**	**1997**	**1998**	**1999**
Tetracyclines	70	27	42	55	25
Amphenicols	64	64	123	135	65
Antibacterial quinolones	2 982	946	581	489	501
Total	**3 116**	**1 037**	**746**	**679**	**591**

Figure 1. Sales (in kilograms of active substance) for the period 1995-1999 of veterinary antibacterial drugs for therapeutic use in domestic animals in Norway (fish excluded). Data were obtained from the Norwegian drug wholesalers.

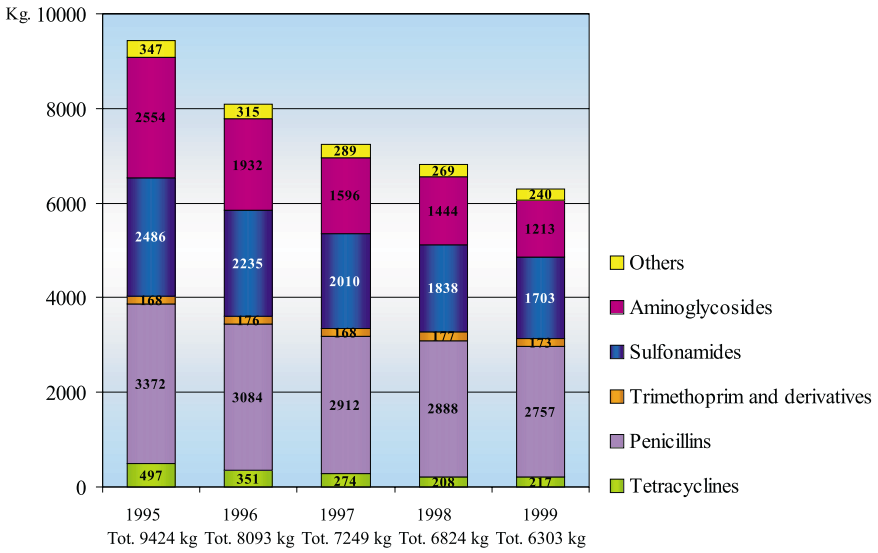
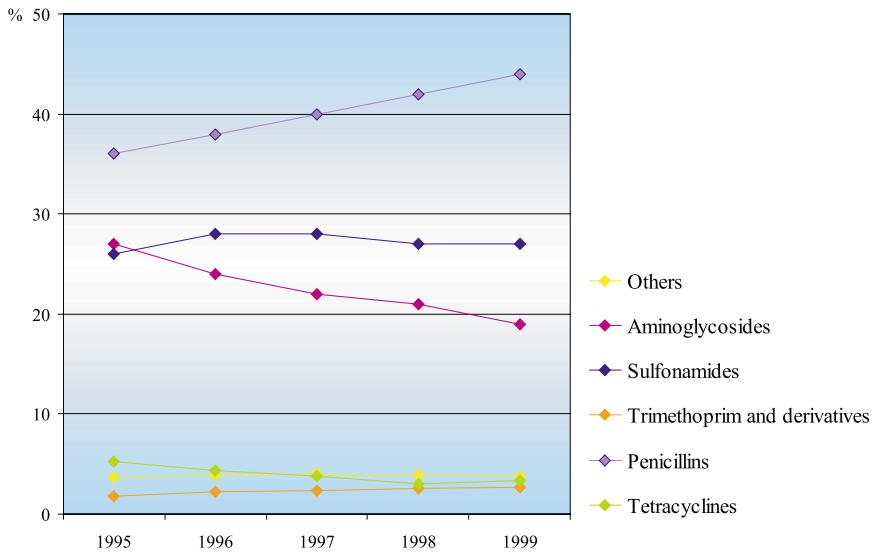


Figure 2. Sales (as percentages of the total sales) for the period 1995-1999 of veterinary antibacterial drugs for therapeutic use in domestic animals in Norway (fish excluded). Data were obtained from the Norwegian drug wholesalers.



Resistance in zoonotic bacteria

Salmonella sp.

Materials and methods

Samples
Feedingstuffs for both terrestrial animals and fish were collected according to the official surveillance programs, internal control procedures, and import control legislations. Samples from animals were collected according to *The Norwegian Salmonella control program for live animals, eggs and meat*. Additionally faecal samples were obtained from live animals in relation to clinical examinations, and samples from organs were obtained at autopsy. Food and water samples were collected in relation to routine controls and outbreak investigations.

Isolation and identification
Isolation and identification of *Salmonella* sp. were carried out according to the Nordic Committee on Food Analyses (NMKL), method no. 71, or ISO no. 6579. Confirmation, including serotyping, as well as susceptibility testing was performed at the National Reference Laboratory at the National Institute of Public Health.

Susceptibility testing
The isolates of *Salmonella* sp. were tested for antimicrobial susceptibility by agar disk diffusion using PDM II agar plates (AB Biodisk) and Neo-Sensitabs (Rosco). The following antimicrobials were included; tetracycline, chloramphenicol, ampicillin, cefotaxime (or cefoxitin for seven of the 21 isolates), sulfonamides+trimethoprim, gentamicin, and ciprofloxacin. The results were interpreted using the breakpoints presented in Appendix Table A1.

Results and discussion

***Salmonella* sp. from feed**
Only two isolates were susceptibility tested; one *S.* Livingstone from meat- and bone meal and one *S.* Agona from fish feed.

None of the isolates were classified as resistant to any of the antimicrobials included in the susceptibility testing. The number of isolates tested is too small in order to draw any conclusions.

***Salmonella* sp. from animals**
A total of 15 isolates were susceptibility tested; four *S.* Typhimurium (two from swine, one from cattle and one from horse), three *S. diarizonae* from sheep, one *S.* Livingstone from poultry, one *S.* Infantis from swine, one *S.* Saintpaul from swine, one *S.* Muenchen from turkey, two *S.* Braendrup from reptiles, one *S.* Oslo from a snake and one *S. houtenae* from a snake. Except for the four reptile samples, which originated from the same zoo, all samples were from different herds.

None of the isolates were classified as resistant to any of the antimicrobials included in the susceptibility testing. The number of isolates tested is too small in order to draw any conclusions.

***Salmonella* sp. from food**
A total of four isolates of *Salmonella* sp. from Norwegian food products were susceptibility tested; one *S.* Typhimurium from water, one *S.* Poona from dried milk, and two *S.* Senftenberg from fish and egg powder, respectively.

None of the isolates were classified as resistant to any of the antimicrobials included in the susceptibility testing.

One outbreak of salmonellosis in humans was reported in Norway in 1999. This outbreak was traced to drinking water contaminated with *S.* Typhimurium. The *S.* Typhimurium isolates from the patients were identical to an isolate from seagull feathers found at the brim of the lake supplying the water. This outbreak strain was not resistant to any of the antimicrobials included in the susceptibility testing.

The number of isolates tested is too small in order to draw any conclusions.

Campylobacter sp.

Materials and methods

Samples
As a part of official surveys performed by the Norwegian Food Control Authority, samples of Norwegian poultry products were tested for the presence of *Campylobacter* sp.

Samples were also taken from Norwegian cattle faeces, and from imported poultry products.

Isolation and identification
Isolation and identification of *Campylobacter* sp. were carried out according to the NMKL, method no. 119. Confirmation, including typing, as well as susceptibility testing was performed at the National Reference Laboratory at the National Institute of Public Health.

Susceptibility testing
The isolates belonging to *Campylobacter* sp. were tested for antimicrobial susceptibility by agar disk diffusion using D.S.T agar plates (Oxoid) and Neo-Sensitabs (Rosco). The following antimicrobials were included; tetracycline, ampicillin, erythromycin, gentamicin, ciprofloxacin, and nalidixic acid. The results were interpreted using the breakpoints presented in Appendix Table A1.

Results and discussion

A total of 23 isolates were susceptibility tested, six *C. jejuni* from faecal samples from Norwegian cattle, seven *C. jejuni* from poultry of Norwegian origin, and three *C. jejuni* and seven *C. coli* from imported poultry. Table 6 shows the prevalence of resistance to the various antimicrobials among the 23 isolates.

The number of isolates tested is too small in order to draw any conclusions. It is, however, noted that the usage of quinolones in food animal production in Norway is very low.

Table 6. Prevalence of resistance to various antimicrobials among *Campylobacter* sp. isolated from cattle faeces and poultry products in 1999.

Antimicrobials	% resistance			
	C. jejuni			*C. coli*
	Norwegian cattle (No of isolates = 6)	Norwegian poultry (No. of isolates = 7)	Imported poultry (No. of isolates = 3)	Imported poultry (No. of isolates = 7)
Tetracycline	0	0	33	29
Ampicillin	0	0	0	14
Erythromycin	0	0	0	0
Gentamicin	0	0	0	0
Ciprofloxacin	0	0	33	14
Nalidixic acid	0	0	66	14

Resistance in bacteria from infections in animals

Staphylococcus sp. and *Escherichia coli* from mastitis in cows

Materials and methods

Samples
Milk samples were collected by veterinary practitioners (acute clinical mastitis) or by advisors from the National Production Recording Scheme (subclinical mastitis) and sent to the National Veterinary Institute (central and regional laboratories) or the Mastitis Laboratory in Molde. Information about the animals such as health status was given on a standardized scheme.

Isolation and identification
Secretions (0,01 ml) were plated on Heart infusion agar (Difco) containing 5 % washed bovine erythrocytes (blood agar). The plates were incubated in 5% CO_2 atmosphere at 37°C for 24 and 48 h. When growth was not detected after incubation for 24 h, the original secretion sample was preincubated for 4 h at 37°C, and an increased inoculum (0,05 ml) was cultivated on another blood agar as described above. Identification of bacteria was performed in accordance with guidelines from the International Dairy Federation.

Susceptibility testing
The isolates were tested for antimicrobial susceptibility by a standard agar disk diffusion test using Mueller-Hinton agar plates (Difco) and Neo-Sensitabs (Rosco). The following antimicrobials were included; tetracycline, penicillin G, sulfonamides+trimethoprim, and streptomycin. The results were interpreted using the breakpoints presented in Appendix Table A2.

Results and discussion

Table 7 shows the prevalence of antimicrobial resistance among *Staphylococcus aureus,* coagulase negative *Staphylococcus* sp. (CNS), and *Escherichia coli* isolated from acute mastitis in cows in 1999. Table 8 shows the prevalence of penicillin G resistance among bacteria isolated from subclinical mastitis.

Among more than 1 000 *S. aureus* from acute mastitis in cows, 4.2% were resistant to penicillin G, 2.6% to streptomycin, 0.2% to tetracycline, and 0.2% to sulfonamides+trimethoprim.

Among more than 100 CNS collected from cows with acute mastitis, 22% were resistant to penicillin G, 23% to streptomycin, 3% to tetracycline, and 1% to sulfonamides+trimethoprim. The occurrence of resistance was considerable higher among CNS as compared to *S. aureus,* a phenomenon that has been observed throughout the 1990s for staphylococci from acute mastitis in Norwegian cows.

Among more than 400 *E. coli* collected from cows with acute mastitis, 19% were resistant to streptomycin, 3% to tetracycline, and 3% to sulfonamides+trimethoprim. These resistance prevalences have remained almost constant during the 1990s.

Among the 7 167 *S. aureus* from subclinical mastitis, 18% were resistant to penicillin G. This figure has remained at the same level during the 1990s.

Among the 1 416 CNS isolates from subclinical mastitis, 26% were resistant to penicillin G. Also this figure has remained at the same level during the 1990s.

Table 7. Prevalence of resistance to various antimicrobials among bacteria isolated from acute clinical mastitis in Norwegian cows in 1999.

	Staphylococcus aureus		Coagulase negative *Staphylococcus* sp.		*Escherichia coli*	
Antimicrobials	No. of isolates	% resistance	No. of isolates	% resistance	No. of isolates	% resistance
Tetracycline	1 608	0.2	237	3	512	3
Penicillin G	1 608	4.2	239	22	-	-
Sulfonamides+trimethoprim	1 115	0.2	130	1	440	3
Streptomycin	1 608	2.6	237	23	512	19

- = Not tested

Table 8. Prevalence of resistance to penicillin G among bacteria isolated from subclinical mastitis in Norwegian cows in 1999.

Bacteria	No. of isolates	% resistance
Staphylococcus aureus	7 167	18
Coagulase negative *Staphylococcus* sp.	1 416	26

Pathogenic *Escherichia coli* from swine

Materials and methods

Samples
Faecal swabs were collected by veterinary practitioners from animals with a history of enteritis, mainly piglets and weaning pigs. The samples were sent to the National Veterinary Institute and examined within three days following the sampling. Samples from jejunum or colon from swine with enteritis were obtained at autopsy and submitted to the National Veterinary Institute for bacteriological examination.

Isolation and identification
Sample material was cultivated on blood agar and on bromthymol blue lactose-saccharose agar (BLSA). Blood agar plates were incubated both in 5% CO_2 atmosphere and anaerobically at 37°C for 16-24 hrs. BLSA plates were incubated aerobically at 37°C for 16-24 hrs. In those cases pure cultures were obtained, material from colonies was tested for indol production. Indol positive isolates were identified as *E. coli.*

Serotyping was carried out for the O-antigens O8, O9, O45, O64, O101, O138, O139, O141, O147, O149, and O147, and for the F-antigens F4, F5, and 987P.

Susceptibility testing
The *E. coli* isolates were tested for antimicrobial susceptibility by agar disk diffusion using Mueller-Hinton agar plates (Difco) and Neo-Sensitabs (Rosco). The following antimicrobials were included; tetracycline, chloramphenicol, ampicillin, cefalexin, sulfonamides+trimethoprim, neomycin, streptomycin, and enrofloxacin. The results were interpreted using the breakpoints presented in Appendix Table A2.

Results and discussion

A total of 17 isolates belonging to serogroup *E. coli* O149 and 23 isolates belonging to other pathogenic serogroups were included. The results from the susceptibility testing are shown in table 9.

Among the 40 *E. coli* from enteritis in swine, 58% were resistant to streptomycin, 50% to tetracycline, 15% to ampicillin, 10% to sulfonamides+trimethoprim, and 5% to chloramphenicol. No resistance to cephalosporins or enrofloxacin was observed.

Streptomycin, tetracycline, and ampicillin have been and still are commonly used for clinical purposes in Norwegian swine production. Among the non-O149, a considerable proportion of the isolates were resistant to the combination sulfonamides+trimethoprim and some isolates showed reduced susceptibility to chloramphenicol. There is some use of sulfonamides+trimethoprim for treatment of infectious diseases in Norwegian swine production. However, all veterinary preparations containing chloramphenicol was withdrawn from the Norwegian market in 1992. Nevertheless, various surveys have shown that *E. coli* with reduced susceptibility to chloramphenicol still can be found in areas where chloramphenicol was used in earlier years.

No reduced susceptibility to enrofloxacin was observed among the isolates. Although enrofloxacin is registered in Norway for therapeutic use in animals, the consumption is very low. No reduced susceptibility to cefalexin was observed which might be explained by the fact that no veterinary antimicrobial systemic preparations with cephalosporins are registered in Norway. No resistance to neomycin was observed. However, a few isolates showed intermediate susceptibility to neomycin (data not shown). There was some use of neomycin for gastrointestinal infections in earlier years. Currently, dihydrostreptomycin is the only aminoglycoside registered for therapeutic use in animals in Norway, an agent that for many years has been widely used, mostly in combination with penicillin G (as procaine penicillin).

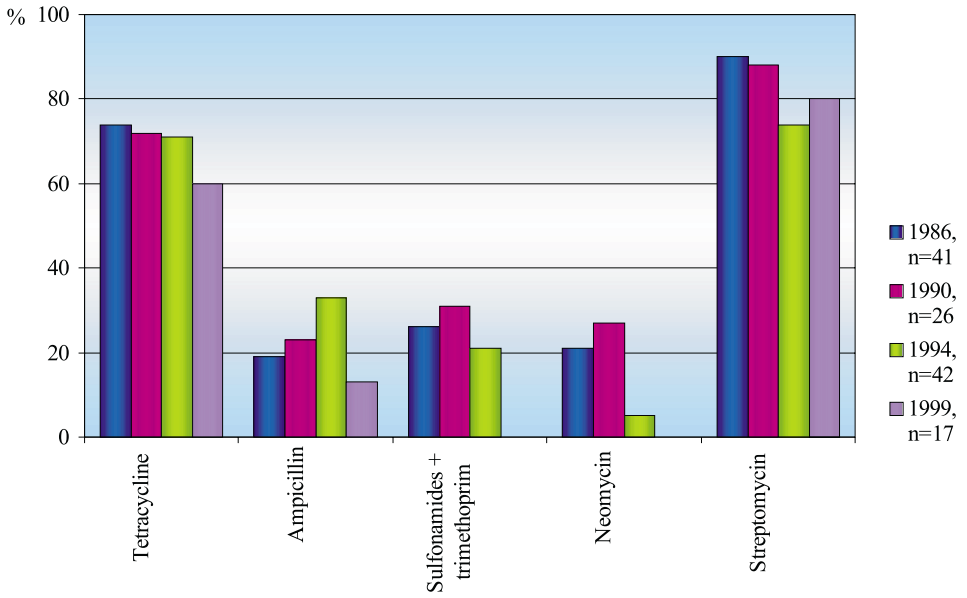
Table 9. Prevalence of resistance to various antimicrobials among pathogenic isolates of *Escherichia coli* from swine in 1999.

Antimicrobials	% resistance		
	E. coli O149 (No. of isolates = 17)	*E. coli* other than O149 (No. of isolates = 23)	*E. coli* O149 + non-O149 (No. of isolates = 40)
Tetracycline	59	43	50
Chloramphenicol	0	9	5
Ampicillin	18	13	15
Cefalexin	0	0	0
Sulfonamides+trimethoprim	0	17	10
Neomycin	0	0	0
Streptomycin	82	39	58
Enrofloxacin	0	0	0

Figure 3 shows the proportion classified as resistant to five different classes of antimicrobials among clinical isolates of *E. coli* O149 tested at the National Veterinary Institute in Oslo for the years 1986, 1990, 1994, and 1999.

From 1995 to 1999, there was a significant (33%) decrease in the total sale of veterinary antimicrobial substances approved in Norway for therapeutic use in animals.

Figure 3. Prevalence of resistance to various antimicrobials among *Escherichia coli* O149 from Norwegian swine for the years 1986, 1990, 1994, and 1999.



Staphylococcus sp. from dogs

Materials and methods

Samples
Veterinary practitioners provided samples from skin and ear lesions from animals with a history of furunculosis, other skin infections, or otitis externa. The samples were sent to the National Veterinary Institute and examined within three days following sampling.

Isolation and identification
The samples were cultivated on blood agar and BLSA. Blood agar plates were incubated both in 5% CO_2 atmosphere and anaerobically at 37°C for 16-24 hrs. BLSA plates were incubated aerobically at 37°C for 16-24 hrs. Greyish white colonies with a beta-haemolytic zone on blood agar were identified as beta-haemolytic *Staphylococcus* sp.

Susceptibility testing
Material from four different colonies were pooled and tested for their antimicrobial susceptibility by agar disk diffusion using Mueller-Hinton agar plates (Difco) and Neo-Sensitabs (Rosco). The following antimicrobials were included; tetracycline, chloramphenicol, penicillin G, cefalexin, sulfonamides+trimethoprim, lincomycin, neomycin, enrofloxacin, fusidic acid, and polymyxin. The results were interpreted using the breakpoints presented in Appendix Table A2.

Results and discussion

A total of 107 isolates from skin and 28 isolates from ear were included. The results from the susceptibility testing are shown in table 10. The data show that beta-haemolytic staphylococci from skin and ear infections in dogs were frequently resistant to penicillin G and tetracycline. Also, a considerable proportion of the isolates were resistant to lincomycin and fusidic acid. Although the number of isolates is limited, the data indicate that staphylococci from ear infections tend to be more frequently resistant to the abovementioned antimicrobials compared to the staphylococci from skin infections.

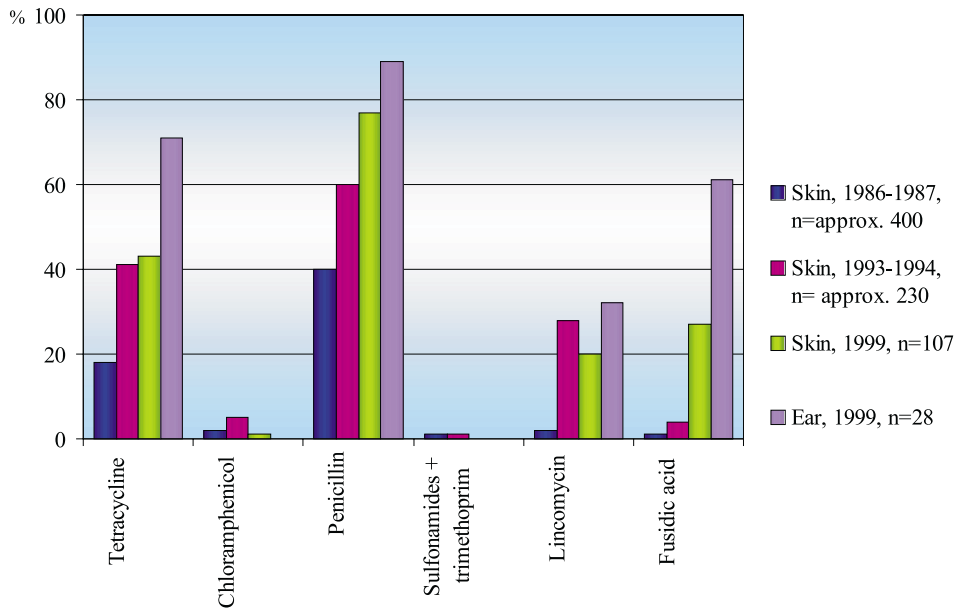
Compared to the periods 1986-1987 and 1993-1994, the prevalence of resistance to penicillin G and fusidic acid among staphylococci from skin seems to have increased (Figure 4). Resistance to lincomycin increased from 1986-87 to 1993-94 parallel to a presumed increase in the frequency of usage of lincosamides and macrolides in pet animal practice.

Resistance to the combination preparation sulfonamides+trimethoprim has remained very low although this combination is commonly used for therapeutical purposes in dogs. Resistance to cephalosporins and fluoroquinolones has also remained negligible. The usage of fluoroquinolones to pets in Norway is limited, probably explaining the high susceptibility to this group of substances. No veterinary formulations with cephalosporins are approved for use in animals in Norway. There is reason to believe there is some therapeutic use in pets of cephalosporins approved for human medicine, but the amount of such use is unknown.

Table 10. Prevalence of resistance to various antimicrobials among beta-haemolytic *Staphylococcus* sp. isolated from infections in dogs in 1999.

Antimicrobials	% resistance		
	From skin (No. of isolates = 107)	From ear (No. of isolates = 28)	From skin + ear (No. of isolates = 135)
Tetracycline	43	71	49
Chloramphenicol	1	0	1
Penicillin G	77	89	79
Cefalexin	0	0	0
Sulfonamides+trimethoprim	0	0	0
Lincomycin	20	32	22
Neomycin	0	0	0
Enrofloxacin	0	0	0
Fusidic acid	27	61	34
Polymyxins	0	0	0

Figure 4. Prevalence of resistance to various antimicrobials among beta-haemolytic *Staphylococcus* sp. isolated from infections in dogs.



Resistance in bacteria from food products

Materials and methods

In 1999 a survey regarding the occurrence of resistance in bacteria from food products on the Norwegian market was initiated and funded by the Norwegian Food Control Authority as part of their official monitoring activities. The samples were collected by the Municipal Food Control Authorities and analyzed at the National Veterinary Institute. Similar surveys were also conducted in 1997 and 1998.

Samples

Escherichia coli and *Enterococcus* sp.

In 1999 a total of 602 samples of fresh produce were collected for isolation of the indicator bacteria *E. coli* and *Enterococcus* sp.; 482 samples of vegetables (428 of Norwegian origin), 54 samples of berries (44 of Norwegian origin), 56 samples of champignons (23 of Norwegian origin), and 10 samples of dried fruits (all imported).

In this report, results from examinations of samples collected during surveys performed in 1997-1998 are also included; 182 samples of pork (180 of Danish origin), 80 samples of duck meat (70 of French origin), 10 samples of French hen meat, and five samples of Danish broiler meat.

Staphylococcus sp.

Included in the 1999 survey were also 109 cultures of staphylococci of which 72 were isolated from Norwegian milk products made from unpasteurised milk and 37 from Norwegian and imported fresh produce.

Isolation and identification

Escherichia coli and *Enterococcus* sp.

Five gram of material was incubated with 45 ml of MacConkey broth (Oxoid) (for isolation of *E. coli*) and 45 ml of Azide dextrose broth (Oxoid) (for isolation of *Enterococcus* sp.). After incubation at 44°C for 24h a small amount of broth was plated onto the surface of a selective medium; either lactose agar (Difco) (for isolation of *E. coli*) or Slanetz & Bartley agar (Oxoid) (for isolation of *Enterococcus* sp.). After incubation at 37°C for 24h (for isolation of *E. coli*) or 48h (for isolation of *Enterococcus* sp.), a typical colony was plated onto blood agar. If bacteria with typical morphology of either *E. coli* or *Enterococcus* sp. were detected, further identification was performed.

Colonies were identified as *E. coli* if they had a typical colony appearance, were lactose fermenting and indole positive. Colonies were identified as *Enterococcus* sp. if they had a typical colony appearance and were catalase negative. The enterococci were further identified using either ddlID-PCR (multiplex PCR) or rapid ID32 STREP-kit. The bacteria's ability to produce pigment and their motility were also considered.

Staphylococcus sp.

Samples of fresh produce were tested for the presence of staphylococci by the NMKL method no 66, 3rd edition, 1999. Presumptive staphylococci were tested for coagulase production and further identified using one of two kits, either RapiDec Staph or API Staph.

Cultures from products made from unpasteurised milk were sent to the laboratory and identified as described above.

Susceptibility testing

One isolate of each type per sample was tested for antimicrobial susceptibility using Mueller-Hinton agar plates and Etest (AB Biodisk) as described by the manufacturer. For those antimicrobial agents for which Etest was not available, NeoSensitabs (Rosco) were used. When testing for vancomycin resistance in enterococci, Brain Heart Infusion agar (Difco) was used instead of Mueller-Hinton agar. The antimicrobials included and the breakpoints used for interpretation are presented in Appendix Table A3.

Escherichia coli

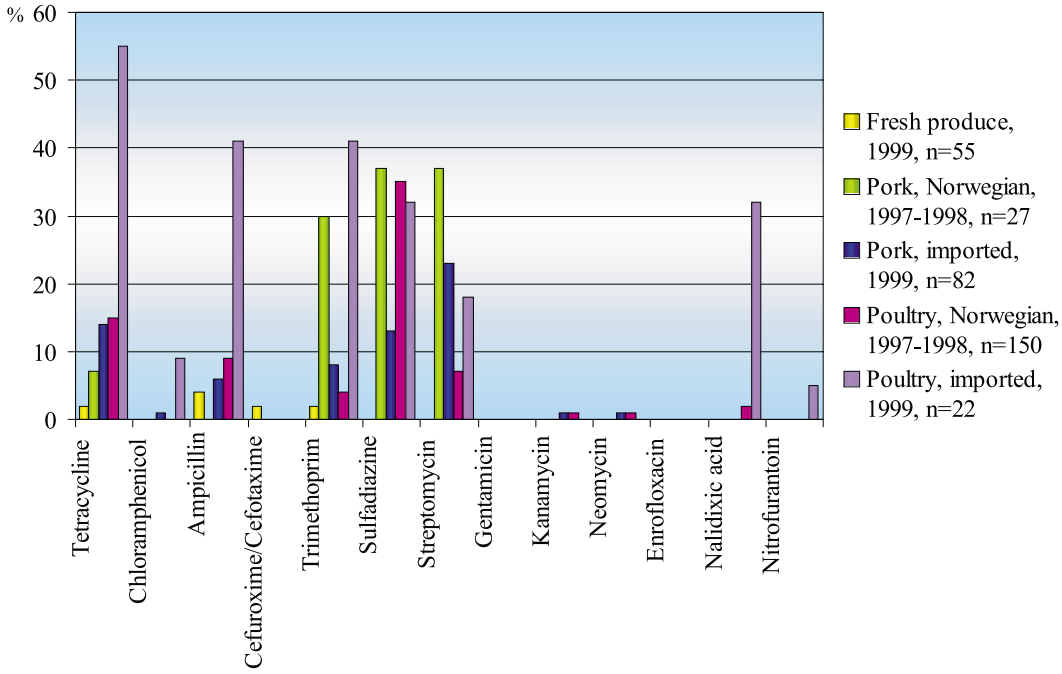
Results and discussion

E. coli were isolated from a total of 159 samples; 50 samples of vegetables (44 of Norwegian origin), two champignon samples (both Norwegian origin), three samples of berries (all imported), 82 samples of Danish pork, 17 samples of French duck meat, and five samples of Danish broiler meat. *E. coli* were isolated relatively more frequently from sprouts (21% of samples positive) as compared to the other types of fresh produce (0-13%).

Table 11 shows the prevalence of antimicrobial resistance as well as the MIC range, MIC50 and MIC 90 for isolates of *E. coli* from fresh produce, imported pork, and imported poultry in 1999.

The prevalence figures are illustrated in Figure 5. Included in the figure are also the prevalence of resistance among *E. coli* isolated from Norwegian pork and poultry (broiler and hen meat) in 1997-1998.

Figure 5. Prevalence of resistance to various antimicrobials among *Escherichia coli* isolated from different food products. Data for pork and poultry collected in 1999 represent imported products, whereas data from 1997-1998 represent pork an poultry produced in Norway. The fresh produce represent both domestic and imported products.



Of the 55 *E. coli* isolates from fresh produce, 7% (four isolates) were classified as resistant to one or more of the antimicrobials included in the susceptibility testing. Three of these four isolates were resistant to only one antimicrobial; one isolate, from Norwegian champignon, was ampicillin resistant, one isolate, from Norwegian lettuce, was trimethoprim resistant, and one isolate, from Norwegian bean sprouts, was tetracycline resistant. In Norway, these antimicrobials are used for therapeutical purposes in both human and veterinary medicine. The fourth isolate, from French iceberg lettuce, was resistant to two antimicrobials, ampicillin and cefuroxime. The data from this survey indicates that resistance was not widespread among *E. coli* from the products of fresh produce included.

Of the 82 *E. coli* isolates from imported Danish pork, 28% were classified as resistant to one or more of the antimicrobials included, and 7% were resistant to three or more antimicrobials. Resistance to streptomycin, tetracycline, and sulfonamides was most commonly observed; 23%, 15%, and 13%, respectively, followed by resistance to trimethoprim (9%), ampicillin (6%), neomycin (1%), chloramphenicol (1%), and kanamycin (1%). These data correspond well with the data reported for Danish pork by DANMAP (1999).

Of the 22 *E. coli* isolates from imported poultry, 60% were classified as resistant to at least one of the antimicrobials included, and 41% were resistant to three or more antimicrobials. Six out of seven nalidixic acid resistant isolates from poultry also showed reduced susceptibility to enrofloxacin.

Of the 22 *E. coli* isolates from imported poultry, 17 came from French duck meat. A high proportion of these isolates were resistant; 76% isolates were resistant to at least one of the antimicrobials included, and 53% were resistant to three or more antimicrobials. Resistance to tetracycline and trimethoprim was found most frequently, 71% and 53%, respectively, followed by resistance to ampicillin (47%), sulfonamides (41%), nalidixic acid (35%), streptomycin (18%), and chloramphenicol (12%).

Enterococcus sp.

Results and discussion

Enterococci were isolated from a total of 430 samples; 224 samples of vegetables (203 of Norwegian origin), seven champignon samples (four of Norwegian origin), two samples of berries (both imported), 159 samples of pork (157 of Danish origin), 30 samples of duck meat (29 of French origin), three samples of French hen meat, and five samples of Danish broiler meat. Enterococci were isolated more frequently from sprouts (99% of the samples were positive) compared to the other types of fresh produce (0-37%).

Table 12, 13, and 14 shows, respectively, the prevalence of antimicrobial resistance, MIC range, MIC 50, and MIC 90 among *E. faecalis*, *E. faecium,* and *Enterococcus* sp. other than *E. faecium* and *E. faecalis* isolated from food products in 1999. Figure 6, 7, and 8 illustrate the prevalences of resistance for the different bacteria. Included in the figures are also the prevalences of resistance among enterococci isolated from Norwegian pork and poultry (broiler and hen meat) in 1997-1998.

E. faecalis is reported to express a naturally low susceptibility to the streptogramines pristinamycin and virginiamycin, whereas *E. faecium* is reported to be susceptible. This phenomenon was also observed in this material, although there was some overlap for a few isolates within each category. Regarding enterococci other than *E. faecalis* and *E. faecium*, most of the isolates were susceptible to pristinamycin and virginiamycin. In the following, the results for pristinamycin and virginiamycin are not included in the reported data on prevalences of resistance.

As there are no breakpoints available for bacitracin, the observed MIC-values for bacitracin have not been classified into resistant and susceptible. Therefore, the results for bacitracin are not included in the reported data on prevalences of resistance.

Of the 233 enterococci from fresh produce, 15% were classified as resistant to at least one of the antimicrobials included in the susceptibility testing. A total of 7% of the isolates were only resistant to one antimicrobial, 3% to two, 4% to three, and 0.4% to four antimicrobials. Resistance to tetracycline and streptomycin (high level) was most frequently found; in 9% and 5% of the isolates, respectively. Three percent of the isolates were contemporaneously resistant to erythromycin and spiramycin. Cross-resistance is common among the macrolides erythromycin, spiramycin, and tylosin. All isolates that were resistant to three or more antimicrobials, originated from sprouts (7% of isolates from sprouts).

Chloramphenicol resistance was detected in 2% of the isolates, all originating from Norwegian sprouts. Hence, 3% of the 148 isolates from sprouts were chloramphenicol resistant. One (0.4%) isolate, *E. faecium* from a sample of Norwegian fresh oregano was resistant to vancomycin. The *vanA*-gene was detected by PCR. *vanA*-type vancomycin resistant enterococci are relatively common in Norwegian poultry production as a result of former use of the growth promoter avoparcin. There is a cross-resistance between the glycopeptides avoparcin and vancomycin.

Of the 157 enterococci from imported Danish pork, 31% were resistant to at least one of the antimicrobials included, and 11% to three or more antimicrobials. Tetracycline resistance (21%) and high-level streptomycin resistance (17%) was most frequently observed, followed by resistance to spiramycin (13%), erythromycin (12%), trimethoprim (5%), and chloramphenicol (3%).

Of the 38 enterococci from imported poultry, 63% were resistant to at least one of the antimicrobials included in the susceptibility testing. A total of 34% of the isolates were resistant to only one antimicrobial, 5% to two, and 24% to three or more antimicrobials. Tetracycline resistance was most frequently observed (61% of the isolates), followed by resistance to streptomycin (high-level) (21%), erythromycin (21%), spiramycin (13%), trimethoprim (8%), and chloramphenicol (8%).

A high proportion of the 29 isolates from imported French duck meat were resistant; 62% to at least one of the antimicrobials included, and 24% to three or more antimicrobials. Tetracycline resistance was most frequently observed; all the 18 resistant isolates from French duck meat were tetracycline resistant (62% of the isolates). High-level streptomycin resistance was detected in 24% of the isolates. Resistance to erythromycin, spiramycin, trimethoprim, and chloramphenicol was seen in 17%, 14%, 10%, and 10% of the isolates, respectively.

For all sample types, the MIC-values for bacitracin among the enterococci were widely distributed. Enterococci with MIC-values ≥256 µg/ml for bacitracin were isolated relatively frequently from fresh produce and duck meat.

Figure 6. Prevalence of resistance to various antimicrobials among *Enterococcus faecalis* isolated from different food products. Data for pork and poultry collected in 1999 represent imported products, whereas data from 1997-1998 represent pork and poultry produced in Norway. The fresh produce represent both domestic and imported products.

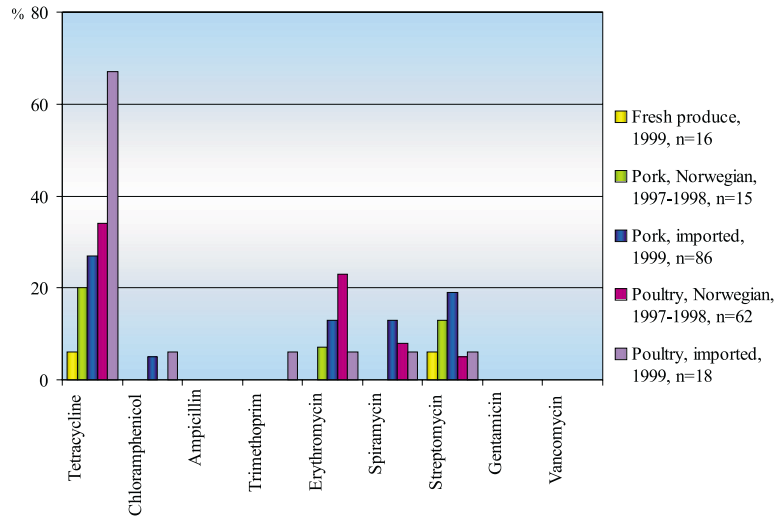


Figure 7. Prevalence of resistance to various antimicrobials among *Enterococcus faecium* isolated from different food products. Data for pork and poultry collected in 1999 represent imported products, whereas data from 1997-1998 represent pork and poultry produced in Norway. The fresh produce represent both domestic and imported products.

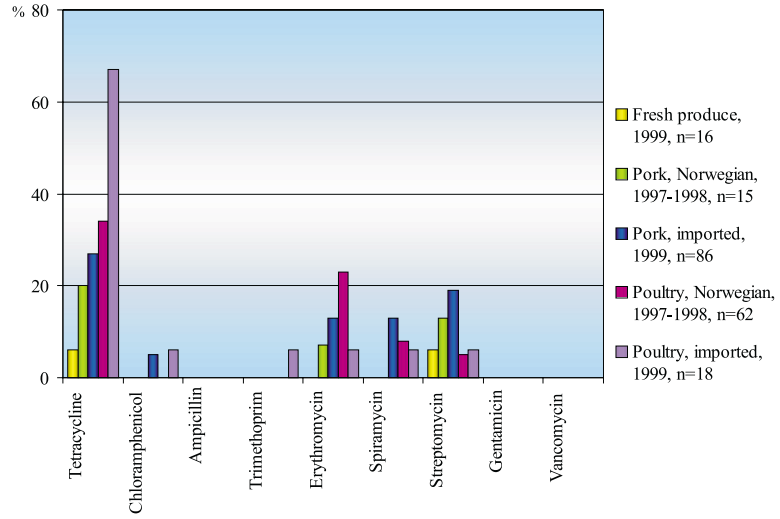


Figure 8. Prevalence of resistance to various antimicrobials among *Enterococcus* sp. other than *E. faecalis* and *E. faecium* isolated from different food products. Data for pork and poultry collected in 1999 represent imported products, whereas data from 1997-1998 represent pork and poultry produced in Norway. The fresh produce represent both domestic and imported products.

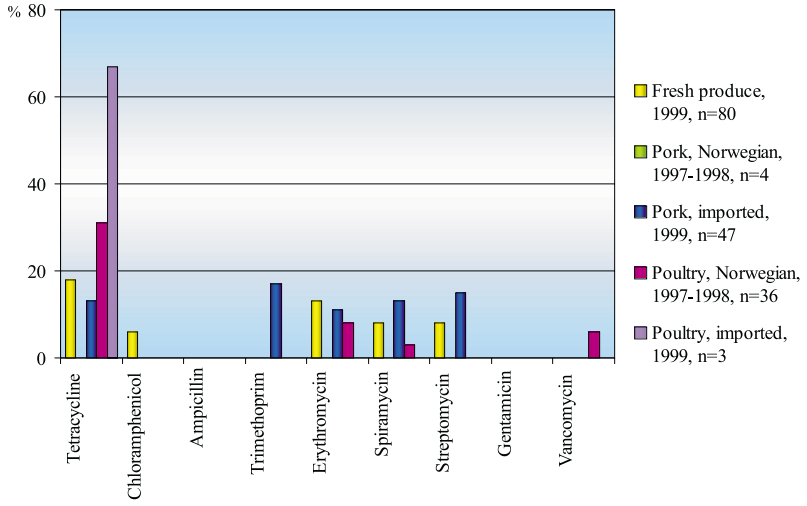


Table 11. Prevalence of resistance to various antimicrobials among *Escherichia coli* isolated from different food products in 1999.

Antimicrobials	Fresh produce (No. of samples = 602, no. of isolates = 55)					Imported pork (No. of samples = 182, no. of isolates = 82)					Imported poultry (No. of samples = 95, no. of isolates = 22)				
	MIC (µg/ml)			% of isolates		MIC (µg/ml)			% of isolates		MIC (µg/ml)			% of isolates	
	Range	50%	90%	Resistant	Intermediate	Range	50%	90%	Resistant	Intermediate	Range	50%	90%	Resistant	Intermediate
Tetracycline	1 – 256	1,5	2	2	0	0,75 - >256	1	>256	15	0	1 - >256	32	256	55	0
Chloramphenicol	1,5 – 8	4	6	0	0	2 – 32	4	6	1	1	1,5 - >256	4	6	9	0
Ampicillin	1,5 - >256	3	6	4	0	1 - >256	2	4	6	0	1 - >256	3	>256	41	0
Cefuroxime	1,5 – 24	3	4	2	0	1 – 6	2	4	0	0	1,5 – 4	3	4	0	0
Trimethoprim	0,047 - >32	0,38	0,75	2	0	0,125 - >32	0,5	1	9	0	0,094 - >32	0,75	>32	41	0
Sulfadiazine	12 – 128	48	96	0	0	8 - >256	48	>256	13	0	8 - >256	64	>256	32	0
Streptomycin	2 – 6	3	3	0	2	1,5 - >256	3	64	23	2	2 - >256	3	32	18	14
Gentamicin	0,38 – 0,75	0,5	0,75	0	0	0,38 – 1	0,75	0,75	0	0	0,38 – 1	0,5	0,75	0	0
Kanamycin	2 – 4	3	3	0	0	1 - >256	2	3	1	0	2 – 4	3	4	0	0
Neomycin	NR*	NR	NR	0	0	NR	NR	NR	1	0	NR	NR	NR	0	0
Enrofloxacin	0,032 – 0,19	0,064	0,125	0	0	0,016 – 0,094	0,047	0,064	0	0	0,016 – 1	0,064	0,5	0	27
Nalidixic acid	2 – 12	6	12	0	0	0,5 – 12	1,5	3	0	0	0,75 - >256	6	>256	32	0
Nitrofurantoin	6 – 48	12	24	0	2	4 – 64	12	16	0	2	6 – 192	16	48	5	14

*NR = not relevant as MIC-values were not obtained by the method used.

Table 12. Prevalence of resistance to various antimicrobials among *Enterococcus faecalis* isolated from different food products in 1999.

Antimicrobials	Fresh produce (No. of samples = 602, no. of isolates = 16)					Imported pork (No. of samples = 182, no. of isolates = 86)					Imported poultry (No. of samples = 95, no. of isolates = 18)				
	MIC (µg/ml)			% of isolates		MIC (µg/ml)			% of isolates		MIC (µg/ml)			% of isolates	
	Range	50%	90%	Resistant	Intermediate	Range	50%	90%	Resistant	Intermediate	Range	50%	90%	Resistant	Intermediate
Tetracycline	0,125 – 32	0,25	0,75	6	0	0,19 - >256	0,38	64	27	1	0,25 – 192	32	192	67	0
Chloramphenicol	2 – 12	4	6	0	6	3 – 128	6	8	5	0	3 – 192	4	12	6	6
Ampicillin	0,5 – 1,5	0,75	1	0	0	0,38 – 1,5	1	1,5	0	0	0,75 – 1	0,75	1	0	0
Trimethoprim	0,19 – 0,75	0,38	0,75	0	0	0,032 – 1	0,19	0,38	0	0	0,094 - >32	0,19	8	6	6
Erytromycin	0,125 – 4	1,5	4	0	81	0,125 - >256	3	>256	13	66	0,19 - >256	2	3	6	72
Spiramycin	NR*	NR	NR	0	6	NR	NR	NR	13	0	NR	NR	NR	6	0
Pristinamycin	NR	NR	NR	25	69	NR	NR	NR	73	24	NR	NR	NR	28	61
Streptomycin	64 - >1024	128	>1024	6	0	24 - >1024	192	>1024	19	0	48 - >1024	128	>1024	6	0
Gentamicin	8 – 16	12	16	0	0	4 – 24	12	12	0	0	4 – 16	8	12	0	0
Vancomycin	2 - 12	3	12	0	19	2 – 12	4	8	0	20	2 - 12	3	12	0	28
Virginiamycin	NR	NR	NR	88	13	NR	NR	NR	99	0	NR	NR	NR	89	0
Bacitracin	32 – 128	64	128			0,75 - >256	32	64			8 - >256	32	96		

*NR = not relevant as MIC-values were not obtained by the method used.

Table 13. Prevalence of resistance to various antimicrobials among *Enterococcus faecium* isolated from different food products in 1999.

Antimicrobials	Fresh produce (No. of samples = 602, no. of isolates = 137)					Imported pork (No. of samples = 182, no. of isolates = 26)					Imported poultry (No. of samples = 95, no. of isolates = 17)				
	MIC (µg/ml)			% of isolates		MIC (µg/ml)			% of isolates		MIC (µg/ml)			% of isolates	
	Range	50%	90%	Resistant	Intermediate	Range	50%	90%	Resistant	Intermediate	Range	50%	90%	Resistant	Intermediate
Tetracycline	0,125 - >256	0,25	0,38	5	0	0,094 – 64	0,25	48	19	0	0,25 - >256	12	>256	53	0
Chloramphenicol	2 – 8	3	4	0	0	1 – 8	3	6	0	0	2 – 48	4	32	12	0
Ampicillin	0,094 – 8	2	3	0	0	0,5 – 6	2	4	0	0	0,094 – 6	2	6	0	0
Trimethoprim	0,012 - >32	0,047	0,094	1	0	0,004 – 1,5	0,064	0,094	0	0	0,008 – >32	0,032	>32	12	0
Erytromycin	0,094 - >256	4	4	5	86	0,125 - >256	3	>256	15	81	0,094 - >256	1	>256	41	29
Spiramycin	NR*	NR	NR	1	0	NR	NR	NR	15	0	NR	NR	NR	24	0
Pristinamycin	NR	NR	NR	0	0	NR	NR	NR	0	0	NR	NR	NR	6	0
Streptomycin	24 - >1024	48	96	3	0	32 - >1024	64	>1024	15	0	32 - >1024	64	>1024	41	0
Gentamicin	3 – 32	6	8	0	0	2 – 12	6	8	0	0	3 – 24	6	8	0	0
Vancomycin	1 - >256	1,5	2	1	0	1 – 3	1,5	2	0	0	1 - 2	1,5	2	0	0
Virginiamycin	NR	NR	NR	0	1	NR	NR	NR	0	19	NR	NR	NR	6	0
Bacitracin	3 - >256	64	96			3 - >256	48	96			3 - >256	48	>256		

*NR = not relevant as MIC-values were not obtained by the method used.

Table 14. Prevalence of resistance to various antimicrobials among *Enterococcus* sp. other than *E. faecalis* and *E. faecium* isolated from different food products in 1999.

Antimicrobials	Fresh produce (No. of samples = 602, no. of isolates = 80)					Imported pork (No. of samples = 182, no. of isolates = 47)					Imported poultry (No. of samples = 95, no. of isolates = 3)				
	MIC (µg/ml)			% of isolates		MIC (µg/ml)			% of isolates		MIC (µg/ml)			% of isolates	
	Range	50%	90%	Resistant	Intermediate	Range	50%	90%	Resistant	Intermediate	Range	50%	90%	Resistant	Intermediate
Tetracycline	0,125 - >256	0,38	>256	18	0	0,25 - >256	0,5	96	13	0	0,25 – 256	16	256	67	0
Chloramphenicol	1,5 – 48	3	6	6	0	3 – 8	4	8	0	0	4 – 6	4	6	0	0
Ampicillin	0,125 – 4	0,75	1,5	0	0	0,032 – 8	1	4	0	0	0,19 – 1,5	1	1,5	0	0
Trimethoprim	<0,001 – 0,19	0,016	0,094	0	0	0,008 - >32	0,125	>32	17	0	0,047 – 0,19	0,19	0,19	0	0
Erytromycin	0,032 - >256	2	6	13	59	0,094 - >256	0,19	>256	11	6	0,094 – 0,19	0,094	0,19	0	0
Spiramycin	NR*	NR	NR	8	0	NR	NR	NR	13	9	NR	NR	NR	0	0
Pristinamycin	NR	NR	NR	0	0	NR	NR	NR	0	13	NR	NR	NR	0	0
Streptomycin	8 - >1024	48	128	8	0	16 - >1024	96	>1024	15	0	32 – 64	64	64	0	0
Gentamicin	2 – 16	4	12	0	0	3 – 12	6	8	0	0	3 – 6	4	6	0	0
Vancomycin	0,5 - 16	2	6	0	3	0,75 – 6	1,5	2	0	0	1,5 – 1,5	1,5	1,5	0	0
Virginiamycin	NR	NR	NR	1	20	NR	NR	NR	6	11	NR	NR	NR	0	33
Bacitracin	1 - >256	96	>256			3 – 48	4	8			3 – 96	3	96		

*NR = not relevant as MIC-values were not obtained by the method used.

Staphylococcus sp.

Results and discussion

Table 15 and 16 summarize the occurrence of resistance to the various classes of antimicrobials among the staphylococci from fresh produce and milk products.

The 37 staphylococci from fresh produce included 33 coagulase negative staphylococci (CNS) (22 of Norwegian origin) and four *S. aureus* (one of Norwegian origin). A total of 97% of the CNS were resistant to one or more of the antimicrobials included in the susceptibility testing. A total of 33% CNS were resistant to only one antimicrobial, 52% to two, and 12% (all from Norwegian products) to three antimicrobials. Resistance to penicillin G and oxacillin (MIC 0,38 - 8 µg/ml) was most common, for both drugs 64%, followed by resistance to sulfonamides (21%), tetracycline (12%), trimethoprim (6%), clindamycin (3%), erythromycin (3%), and chloramphenicol (3%). Of the four *S. aureus* isolates, two were resistant to one antimicrobial, sulfonamides, whereas one was resistant to two antimicrobials (sulfonamides and penicillin G). Sources of staphylococci in fresh produce include manure, irrigation water, run-off from sewage, farms etc., wild and domestic animals, and human handling.

Table 15. Prevalence of resistance to various antimicrobials among *Staphylococcus* sp. isolated from fresh produce in 1999.

Antimicrobials	Coagulase negative staphylococci (No. of isolates = 33)					*S. aureus* (No. of isolates = 4)				
	MIC (µg/ml)			% of isolates		MIC (µg/ml)			% of isolates	
	Range	50%	90%	Resistant	Intermediate	Range	50%	90%	Resistant	Intermediate
Bacitracin	4 - >256	48	>256	0	0	32 - >256	32	>256	0	0
Cefalotin	0,047 – 1	0,19	0,38	0	0	0,25 – 0,38	0,25	0,38	0	0
Chloramphenicol	0,125 – 24	3	6	3	0	2 - 8	6	8	0	0
Clindamycin	0,047 – 3	0,125	0,38	3	3	0,094 – 0,125	0,094	0,125	0	0
Enrofloxacin	0,094 – 0,5	0,19	0,38	0	0	0,094 – 0,125	0,125	0,125	0	0
Erythromycin	0,023 – 4	0,19	0,38	3	0	0,19	0,38	0,38	0	0
Gentamicin	0,008 – 0,19	0,047	0,064	0	0	0,064 – 0,5	0,38	0,5	0	0
Oxacillin	0,125 – 8	0,38	1	64	0	0,25 – 0,38	0,25	0,38	0	0
Penicillin G	0,008 – 2	0,19	0,38	64	0	0,047 – 0,75	0,047	0,75	25	0
Pristinamycin	NR	NR	NR	0	0	NR	NR	NR	0	0
Streptomycin	0,75 – 4	1,5	3	0	0	3 - 4	3	4	0	0
Sulfadiazine	1,5 - >256	64	>256	21	0	128 - >256	>256	>256	75	0
Tetracyclines	0,064 - 96	0,19	24	12	0	0,125 – 0,25	0,25	0,25	0	0
Trimethoprim	0,125 – 6	0,5	1,5	6	0	0,75 – 1,5	1	1,5	0	0
Vancomycin	1 - 8	4	6	3	0	2 - 3	3	3	0	0

*NR = not relevant as MIC-values were not obtained by the method used.

The 72 staphylococci from milk products made from unpasteurised milk included 70 *S. aureus* and two CNS. Of the 70 isolates of *S. aureus*, 45 came from cow milk products and 25 from goat milk products.

Table 16 shows the prevalences of resistance among the 70 *S. aureus* isolates from milk products.

A total of 33% of the 45 *S. aureus* from cow milk products were resistant to one or more of the antimicrobials; 27% to one and 7% to two antimicrobials. Altogether, 18% of the *S. aureus* from cow milk products were resistant to sulfonamides and 18% to penicillin G. Oxacillin resistance due to slightly elevated MIC-values (3 µg/ml) was observed in 4% (two) of the isolates.

Among the 25 *S. aureus* from goat milk products, 40% were resistant to one or more of the antimicrobials included; 32% to one and 8% to two antimicrobials. Altogether, 24% of the *S. aureus* from goat milk products were resistant to sulfonamides, 16% to penicillin G, 4% (one isolate) to oxacillin (MIC > 256 µg/ml), and 4% to streptomycin.

The two CNS from cow milk products were oxacillin resistant (MIC 1 – 2 µg/ml), and one was also resistant to penicillin G (data not shown). Both were susceptible to all the other antimicrobials included. Slightly elevated MIC-values to oxacillin are frequently seen in CNS and there is reason to believe this is not caused by a selective pressure.

Penicillin G (as procaine penicillin), mainly in combination with dihydrostreptomycin, are commonly used in mastitis treatment in cows and goats in Norway. In goats, sulfonamides are also commonly used. There is also some use of the combination preparation sulfonamides+trimethoprim. Cloxacillin, in combination with ampicillin, is approved as an intramammary product in Norway, but the usage is rather limited.

The prevalence of resistance observed among the staphylococci from milk products correlates well to the resistance data reported from the Norwegian laboratories examining samples from animals with mastitis. Moreover, the data also correspond with the former and current pattern of antimicrobial use for mastitis treatment in Norway.

Table 16. Prevalence of resistance to various antimicrobials among *Staphylococcus aureus* isolated from milk products in 1999.

Antimicrobials	Cow milk products (No. of isolates = 45)					Goat milk products (No. of isolates = 25)				
	MIC (µg/ml)			% of isolates		MIC (µg/ml)			% of isolates	
	Range	50%	90%	Resistant	Intermediate	Range	50%	90%	Resistant	Intermediate
Bacitracin	2 – 128	48	96	0	0	4 – 192	48	64	0	0
Cefalotin	0,125 – 1	0,25	0,5	0	0	0,19 – 0,5	0,25	0,5	0	0
Chloramphenicol	0,125 - 8	6	6	0	0	3 – 8	6	8	0	0
Clindamycin	0,008 – 0,19	0,125	0,19	0	0	0,094 – 0,19	0,125	0,19	0	0
Enrofloxacin	0,094 – 0,38	0,125	0,25	0	0	0,064 – 0,19	0,125	0,19	0	0
Erythromycin	0,125 – 0,38	0,25	0,38	0	0	0,19 – 0,5	0,25	0,38	0	0
Gentamicin	0,25 – 0,75	0,38	0,5	0	0	0,25 – 1	0,38	0,75	0	0
Oxacillin	0,38 – 3	1,5	2	4	0	0,38 - >256	1	2	4	0
Penicillin G	0,032 – 16	0,064	4	18	0	0,047 – 6	0,047	3	16	0
Pristinamycin	NR	NR	NR	0	0	NR	NR	NR	0	0
Streptomycin	3 – 4	3	4	0	0	2 - >256	3	4	4	4
Sulfadiazine	24 - >256	96	>256	18	0	64 - >256	128	>256	24	0
Tetracycline	0,032 – 0,25	0,19	0,25	0	0	0,094 – 0,38	0,19	0,25	0	0
Trimethoprim	0,25 – 2	1	1,5	0	0	0,38 – 1,5	0,75	1	0	0
Vancomycin	2 - 4	3	3	0	0	2 - 4	3	3	0	0

*NR = not relevant as MIC-values were not obtained by the method used.

References

Borgen, K., G.S. Simonsen, A. Sundsfjord, Y. Wasteson, Ø. Olsvik, and H. Kruse, 2000. Continuing high prevalence of VanA-type vancomycin-resistant enterococci on Norwegian poultry farms three years after avoparcin was banned. Journal of Applied Microbiology 89:478-85.

Brun, E., V. Edge, G. Holstad, H. Kruse, H. Ween, and J. Jarp, 2000. Variation in occurrence of resistance to different antibiotics among faecal *Escherichia coli* from two swine herds in Norway. Microbial Drug Resistance *(submitted)*.

Etest manual, AB Biodisk, Solna, Sverige.

Fossum, K., 1995. Antibiotikaresistens hos *Escherichia coli* i feces fra slaktegris. [Antibiotic resistance in *Escherichia coli* from faeces in finishing pigs]. Norsk Veterinærtidsskrift 107;837-844.

Grave, K. and M. Rønning, 2000. Forbruk av veterinære antibakterielle midler i Norge i perioden 1995–1999 med spesiell vekt på produksjonsdyr. [Usage of veterinary antibacterial drugs in Norway in the period 1995–1999 with special emphasis on production animals]. Norsk Veterinærtidsskrift 112;235-240.

Hofshagen, M. and H. Stenwig, 1993. Resistens mot antibakterielle midler hos bakterier isolert fra gris i perioden 1986-1992. [Resistance to antibacterial drugs in bacteria isolated from pigs in the period 1986-1992]. Norsk Veterinærtidsskrift 105;536-541.

Kruse, H., 1998. Kartlegging av forekomst av antibiotikaresistente bakterier i norske kjøtt og kjøttprodukter. Rapport til Statens næringsmiddeltilsyn. Veterinærinstituttet, August 1998 (SNT rapport nr. 1, 1999). [The occurrence of antimicrobial resistant bacteria in Norwegian meat and meat products. Report to the Norwegian Food Control Authority. National Veterinary Institute, August 1998 (SNT report no. 1, 1999)].

Kruse, H., 1999. Forekomst av antibiotikaresistente bakterier i utvalgte næringsmidler på det norske markedet, Rapport til Statens næringsmiddeltilsyn, Veterinærinstituttet, juni 1999. [The occurrence of antimicrobial resistant bacteria in some selected food products on the Norwegian market. Report to the Norwegian Food Control Authority. National Veterinary Institute, June 1999.]

Kruse, H., B.K. Johansen, L.M. Rørvik, and G. Schaller, 1999. The Use of avoparcin as a growth promoter and the occurrence of vancomycin resistant *Enterococcus* species (VRE) in Norwegian poultry and swine production. Microbial Drug Resistance 5:135-139.

Kruse H. og J. Schau, 2000. Forekomst av antibiotikaresistente bakterier i utvalgte næringsmidler på det norske markedet. Rapport til Statens næringsmiddeltilsyn, Veterinærinstituttet, august 2000. [The occurrence of antimicrobial resistant bacteria in some selected food products on the Norwegian market. Report to the Norwegian Food Control Authority. National Veterinary Institute, August 2000.]

Kruse, H., M. Hofshagen, S.I. Thoresen, W.P. Bredal, I. Vollset, and N.E. Søli, 1996. The antimicrobial susceptibility of *Staphylococcus* species isolated from canine dermatitis. Veterinary Research Communication 20:205-214.

Landsverk, K. (ed.), 1999. Friskere dyr og mindre bruk av antibiotika. Sluttrapport 1999. [Healthier animals and decreased use of antimicrobial agents. Final report 1999.]

NCCLS M7-A5: Methods for Dilution Antimicrobial Susceptibility Tests for Bacteria That Grow Aerobically; Approved Standard - Fifth Edition. Vol. 20 No. 2.

NCCLS M31-A: Performance Standards for Antimicrobial Disk and Dilution Susceptibility Tests for Bacteria Isolated from Animals; Approved Standard. Vol. 19 No. 11.

NCCLS M100-S10: MIC Testing Supplemental Tables.

Neo-Sensitabs, Susceptibility testing, User's guide, 10th Ed. 1998. A/S Rosco, Taastrup, Denmark.

Norwegian Ministry of Health and Social Affairs, 2000. Tiltaksplan: Tiltak for å motvirke antibiotikaresistens (2000-2004). [Strategic plan: Efforts to counteract antibiotic resistance (2000-2004)]

The Norwegian Salmonella Control Programs for Live Animals, Eggs, and Meat. Nation-wide official control programs for Salmonella sp. launched in 1995.

Ørskov F. and L. Ørskov, 1984. Serotyping of *Escherichia coli*. Methods in Microbiology 14:43-112.

Appendix - Breakpoints

Table A1.Breakpoints used for *Salmonella* sp. and *Campylobacter* sp.

Antimicrobials	*Salmonella* sp. Breakpoint zone[1], mm				*Campylobacter* sp. Breakpoint zone[1], mm			
	4	3	2	1	4	3	2	1
Tetracycline (80 µg)	≤ 23	-	24-27	≥ 28	≤ 23	-	24-27	≥ 28
Chloramphenicol (60 µg)	≤ 26	-	27-31	≥ 32				
Ampicillin (33 µg)	≤ 13	14-22	23-27	≥ 28	≤ 23	-	24-27	≥ 28
Cefoxitin (60 µg)	≤ 14	15-20	21-27	≥ 28				
Cefotaxime (30 µg)	≤ 12	13-18	19-27	≥ 28				
Sulfonamides + trimethoprim (240 +5.2 µg)	≤ 23	24-27	-	≥ 28				
Erythromycin (78 µg)					≤ 23	-	24-29	≥ 30
Gentamicin (40 µg)	≤ 20	-	21-25	≥ 26	≤ 23	-	24-27	≥ 28
Ciprofloxacin (10 µg)	≤ 18	19-23	24-27	≥ 28	≤ 18	-	19-22	≥ 23
Nalidixic acid (130 µg)					≤ 16	-	17	≥ 18

[1] Values from Rosco 2000: Norwegian AFA-group 1994, inoculum according to ICS, PDM II agar (Salmonella), D.S.T. agar (Campylobacter).

Table A2. Breakpoints used for *Escherichia coli* and *Staphylococcus* sp. from animals.

Antimicrobials	*Escherichia coli* Breakpoint zone[1], mm			*Staphylococcus* sp. Breakpoint zone[1], mm		
	R	I	S	R	I	S
Tetracycline (80 µg)	≤ 23	24-27	≥ 28	≤ 23	24-27	≥ 28
Chloramphenicol (60 µg)	≤ 23	24-27	≥ 28	≤ 23	24-27	≥ 28
Ampicillin (33 µg)	≤ 22	23-25	≥ 26			
Penicillin G (5 µg)				≤ 27	-	≥28
Cefalexin (30 µg)	≤ 18	19-25	≥ 26	≤ 18	19-25	≥ 26
Sulfonamides + trimethoprim (240 + 5.2 µg)	≤ 23	24-27	≥ 28	≤ 23	24-27	≥ 28
Lincomycin (19 µg)				≤ 23	24-27	≥ 28
Neomycin (120 µg)	≤ 19	20-22	≥ 23	≤ 19	20-22	≥ 23
Streptomycin (100 µg)	≤ 23	24-27	≥ 28	≤ 23	24-27	≥ 28
Enrofloxacin (10 µg)	≤ 20	21-23	≥ 24	≤ 20	21-23	≥ 24
Fusidic acid (400 µg)				≤ 23	24-27	≥ 28
Polymyxins (150 µg)				≤ 19	-	≥ 20

[1] Values from Rosco 1994: Veterinary practice, Semi-confluent growth, ICS standard for fast growing bacteria, Mueller-Hinton agar.

Table A3. Breakpoints used for *Escherichia coli, Enterococcus* sp. and *Staphylococcus* sp. from food products.

Antimicrobials	*Escherichia coli* MIC values[1], µg/ml		*Escherichia coli* Breakpoint zone, mm		*Enterococcus* sp. MIC values[1], µg/ml		*Enterococcus* sp. Breakpoint zone, mm		*Staphylococcus* sp. MIC values[1], µg/ml		*Staphylococcus* sp. Breakpoint zone, mm	
	R	S	R	S	R	S	R	S	R	S	R	S
Tetracycline	≥ 16	≤ 4			≥ 16	≤ 4			≥ 16	≤ 4		
Chloramphenicol	≥ 32	≤ 8			≥ 32	≤ 8			≥ 32	≤ 8		
Ampicillin	≥ 32	≤ 8			≥ 16	≤ 8						
Penicillin G									≥ 0.25	≤ 0.125		
Oxacillin									≥ 4(0.4)*	≤ 2(0.25)		
Cefalotin									≥ 32	≤ 8		
Cefuroxime	≥ 32	≤ 8										
Sulfonamides	≥ 512	≤ 256							≥ 512	≤ 256		
Trimethoprim	≥ 4	≤ 2			≥ 16	≤ 4			≥ 4	≤ 2		
Erythromycin					≥ 8	≤ 0,5			≥ 8	≤ 0,5		
Pristinamycin (30 µg)[2]							≤ 19	≥ 23			≤ 19	≥ 23
Spiramycin (200 µg)[2]							≤ 22	≥ 26				
Clindamycin									≥ 4	≤ 0.5		
Gentamicin[3]	≥ 16	≤ 4			> 512	≤ 512			≥ 16	≤ 4		
Kanamycin	≥ 64	≤ 16										
Neomycin (120 µg)[2]			≤ 20	≥ 25								
Streptomycin[3]	≥ 32	≤ 4			> 1024	≤ 1024			≥ 32	≤ 4		
Enrofloxacin	≥ 2	≤ 0,25							≥ 4	≤ 0.5		
Vancomycin					≥ 32	≤ 4			≥ 32	≤ 4		
Virginiamycin (30 µg)[2]							≤ 19	≥ 23				
Bacitracin[4]					-	-			-	-		
Nalidixic acid	≥ 32	≤ 16										
Nitrofurantoin	≥ 128	≤ 32										

[1] All values from NCCLS table M100-S9, except:
[2] No Etest available. NeoSensitabs from Rosco, and their breakpoints, were used.
[3] For *Enterococcus* sp.: Gentamicin High and Streptomycin High. Breakpoints from Etest Application Sheet 009.
[4] No breakpoints available.
* Numbers in brackets for coagulase negative staphylococci, others for *S. aureus*.

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