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# Contaminants and micro-organisms in Dutch organic food products;

## Comparison with conventional products

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### Abstract

Organic products were analysed for the presence of contaminants, micro-organisms and antibiotic resistance, and compared with those from conventional products. No differences were observed in the *Fusarium* toxins deoxynivalenol and zearalenone in organic and conventional wheat, both during a dry period and a very wet period which promoted the production of these toxins. Nitrate levels in head lettuce produced organically in the open field were much lower than those in conventional products. In iceberg lettuce and head lettuce from the green house no differences were detected. Organically produced carrots contained higher nitrate levels than conventional products. Both organic and conventional products contained no residues of non-polar pesticides above the legal limits, although some were detected in conventional lettuce. Organic products contained no elevated levels of heavy metals. *Salmonella* was detected in 30% of pig faeces samples obtained from 30 organic farms, similar to the incidence at conventional farms. At farms that switched to organic production more than 6 years ago, no *Salmonella* was detected, with the exception of one

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3 stable with young pigs recently purchased from another farm. No *Salmonella* was detected in  
4  
5 faeces at the nine farms with organic broilers, and at one out of 10 farms with laying hens.  
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7  
8 This is comparable to conventional farms where the incidence for *Salmonella* lies around  
9  
10 10%. *Campylobacter* was detected in faeces at all organic broiler farms, being much higher  
11  
12 than at conventional farms. One of the most remarkable results was the fact that faeces from  
13  
14 organic pigs and broilers showed a much lower incidence of antibiotic resistant bacteria,  
15  
16 except for *Campylobacter* in broilers. It is concluded that the organic products investigated  
17  
18 scored as equally well as conventional products with regard to food safety and at the same  
19  
20 time show some promising features with respect to antibiotic resistance.  
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### 29 **Key words**

30  
31 Organic, lettuce, carrots, pigs, broilers, antibiotic resistance, *Salmonella*, *Campylobacter*  
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## Introduction

Organic production differs from conventional production in a number of ways. The use of synthetic pesticides is e.g. prohibited, the use of antibiotics is restricted and under strict control, only animal manure is used for fertilization and animals are allowed to forage outside. Theoretically this may result in a different composition of the products, both in terms of natural ingredients, but also with regard to contaminants and micro-organisms. It has e.g. been suggested that wheat may contain higher levels of mycotoxins, since no fungicides are used during production. On the other hand, the mechanical treatment of the soil against weeds, which is not so common in conventional practice, and the much poorer fertilization may create less advantageous conditions for survival of moulds during the winter. Foraging outside might expose the animals to higher levels of environmental contaminants, which end up in the edible products. This has e.g. been demonstrated in the case of organic eggs, which may contain elevated levels of dioxins and dioxin-like PCBs (Traag et al. 2005, Schoeters and Hoogenboom 2006, Van Overmeire et al. 2006, Kijlstra et al. 2007). The use of animal manure may also result in increased levels of heavy metals in organically produced vegetables and the presence of dangerous micro-organisms like *Salmonella* and *E. coli* O157. The restricted use of antibiotics might be expected to result in a decreased antibiotic resistance, especially against the newer generation of antibiotics.

A number of studies have focussed on potential differences between organic and conventional products, but these are still limited (Woese et al. 1997, Soil Association 2001, Magkos et al. 2006). The aim of the present study was first to examine the food safety aspects of organic products and secondly to look for potential differences with conventional products, focussing on a limited number of contaminants and micro-organisms. A major issue in this type of studies is the sampling of the products, since various factors may influence the results. It was decided to focus on Dutch products and to sample these as much as possible at the

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2  
3 farms, thus allowing a check on the source. Furthermore it allowed an analysis of factors that  
4  
5 might contribute to the occurrence or levels of certain contaminants or micro-organisms.  
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8 Certain conventional products were sampled at stores. In other cases data were compared with  
9  
10 data from existing monitoring programmes. The study included the most important organic  
11  
12 vegetable products in The Netherlands, being lettuce, wheat, carrots and potatoes. In addition,  
13  
14 eggs, broilers, pigs and cows were studied. Investigated were factors like mycotoxins, nitrate,  
15  
16 heavy metals, pesticides and *E. coli* O157 in vegetables, and *Salmonella*, *E. coli* O157,  
17  
18 antibiotic resistant bacteria, heavy metals and veterinary drugs in animals or their products.  
19  
20 As such the study contributes to the essential and fortunately growing amount of information  
21  
22 about the food safety of organically produced food products.  
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## 29 **Materials and Methods**

### 30 ***Sampling of products***

#### 31 *Vegetables*

32  
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34 Samples of 1 kg organic or conventional wheat were collected in August 2003 and  
35  
36 August/September 2004 at processing plants. Due to limited availability, this comprised in  
37  
38 2003 nine samples conventional winter wheat and 9 samples organic summer wheat, and in  
39  
40 2004 fourteen samples conventional winter wheat, 17 samples conventional summer wheat  
41  
42 and 22 samples organic summer wheat. Samples came from several provinces in the  
43  
44 Netherlands, with the exception of the organic summer wheat in 2004 that came primarily  
45  
46 from the centre of the Netherlands, Flevoland.  
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53 Organic lettuce was collected in 2003 and 2004 at 3 distribution centres and at small  
54  
55 farms. Samples came from various locations in The Netherlands. Conventional lettuce was  
56  
57 sampled at super markets. Each sample contained 3-8 pieces of lettuce. The lettuce produced  
58  
59 in the field was sampled in 2003 in September/October, and in 2004 in June/July. Lettuce  
60

1  
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3 from the greenhouse was sampled in January till March in 2004. In each case similar numbers  
4  
5 of samples were taken from both types of production.  
6  
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8 Organic carrots were sampled in 2003 at farms shortly after the harvest (October-  
9  
10 November). In addition, organic and conventional carrots were sampled at farms (15 organic,  
11  
12 4 conventional), distribution centres (4 conventional) and shops (7 conventional) in March-  
13  
14 April 2004. Although spread all over the Netherlands, most farms were located in Flevoland.  
15  
16 Each sample contained 40 carrots.  
17  
18

19 Organic potatoes were to a large extent sampled at the same farms as the carrots in  
20  
21 October-November 2004 shortly after the harvest. Each sample contained 40 potatoes.  
22  
23

#### 24 *Animal products*

25  
26 In the case of pigs, 31 organic pig farms were visited, 10 in December 2003-January 2004 and  
27  
28 21 in April-May 2005. For analysis on *Salmonella* and *E. coli* O157, at each farm faeces  
29  
30 sampled from 12 pigs, short before slaughter, were pooled into a combined sample. On farms  
31  
32 with more stables, 2 or 3 pooled samples were taken. To study the incidence of antibiotic-  
33  
34 resistant bacteria, faecal samples were taken from 5 pigs per farm. All samples were  
35  
36 immediately sent to the laboratories. Pig kidneys and diaphragm from 20 animals of 20  
37  
38 different organic farms were sampled at the slaughterhouse.  
39  
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41  
42

43 Samples of bovine faeces were collected at 10 organic farms according to routine  
44  
45 procedures of the Food and Consumer Products Safety Authority. The ten farms were visited  
46  
47 in October-November 2003. One farm with a positive result on *E. coli* O157 was revisited in  
48  
49 June 2004. Each pooled sample consisted of faeces from 12 cows. The number of samples per  
50  
51 farm was 2 for less than 40 cows, 3 for 40-59 cows, 4 for 60-199 cows and 5 for more than  
52  
53 200 cows. Samples were put in polystyrene boxes and shipped immediately to the laboratory.  
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56 Ten bovine kidneys from 10 organic farms were sampled at the slaughterhouse.  
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3 For examining *Salmonella* in faeces of laying hens and broilers, respectively 10 (April-  
4 May 2004) and 9 (April-June 2005) organic farms were visited and 5 pooled samples, each  
5  
6 from 12 fresh droppings, were collected and sent immediately to the laboratory, according to  
7  
8 the protocol of the Product Boards for Livestock, Meat and Eggs (PVE). For antibiotic-  
9  
10 resistant bacteria in broilers, 5 samples of 1 fresh dropping per farm were collected and send  
11  
12 to the laboratory, according to standard protocols. At 10 organic farms with eggs, 30 fresh  
13  
14 eggs per farm were collected and mixed at the laboratory into one pooled sample per farm.  
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### 22 *Analysis of samples*

23  
24 For chemical analysis, lettuces, carrots and potatoes were frozen in liquid nitrogen and  
25  
26 homogenized. Wheat was milled with a sieve of 1 mm. For microbiological examination  
27  
28 samples were not pre-treated.  
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### 34 *Mycotoxins in wheat*

35  
36 The 71 wheat samples were analyzed for mycotoxins using an LC-MS/MS multi-method,  
37  
38 including aflatoxin B<sub>1</sub>, fumonisins B<sub>1</sub> and B<sub>2</sub>, ochratoxin A, zearalenone, deoxynivalenol, T-2  
39  
40 and HT-2 toxins. Zearalenone was also examined with an HPLC method and fluorescence  
41  
42 detection. In short, from each sample two portions of 10 g were taken. One portion was  
43  
44 extracted with water and the other portion with a mixture of acetonitrile/water (84:16 v./v).  
45  
46 Both portions were extracted by shaking intensively for at least 3 hours. After filtering from  
47  
48 each extract 250 µL was mixed and injected on a LC-MS-MS system in multiple reaction  
49  
50 monitoring (MRM) mode. To diminish matrix influences, the analytical method was  
51  
52 performed by a standard addition protocol. The analysis of mycotoxins was performed on a  
53  
54 Waters Ultima LC-MS/MS system in the MRM-mode. A water (5 mM formic  
55  
56 acid)/acetonitrile (5 mM formic acid) gradient was run at a flow of 0.20 ml/min on a  
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3 Phenomenex Synergy HydroRP column (150 x 2 mm, 5 µm). All mycotoxins were analysed  
4  
5 under ESI+ conditions with the exception of zearalenone which was analysed under ESI-  
6  
7 conditions. Reference substances (>95% purity) were obtained from Biopure Reference  
8  
9 Substanzen GmbH (Tulln, Austria). Reference materials (Test materials) were obtained from  
10  
11 FAPAS (Central Science Laboratory, York, Great-Britain). Detection limits were 0.1 mg/kg  
12  
13 for deoxynivalenol and T-2 toxin, 0.1 mg/kg for HT-2 and fumonisins B<sub>1</sub> and B<sub>2</sub>, 5 µg/kg for  
14  
15 aflatoxin B<sub>1</sub>, and 50 µg/kg for ochratoxin A and zearalenone.  
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### 22 *Heavy metals and arsenic*

23  
24 Samples were treated with 70% HNO<sub>3</sub> in a microwave oven (MARS 5). An aliquot was  
25  
26 subsequently analyzed in an electrothermal atomic absorption spectrophotometer (ETAAS,  
27  
28 SIMAA 6100) for cadmium, lead and arsenic by atomic adsorption at 228.8, 283.3 and 193.7  
29  
30 nm. Concentration measurements were determined from a working curve (linear) after  
31  
32 calibrating the instrument with standards of known concentration.  
33  
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35  
36 Another aliquot was analyzed for mercury in a Flow Injection Mercury System, FIMS 100  
37  
38 (Perkin Elmer, Groningen, The Netherlands). In short, the mercury in the digested samples  
39  
40 was reduced to the elemental state by tin (II) chloride solution and liberated from solution in a  
41  
42 closed vessel system, cold vapor technique (CV AAS). The mercury vapor passed through a  
43  
44 cell positioned in the light path of an atomic absorption spectrometer (FIMS). Its absorbance  
45  
46 is measured at a wavelength of 253.7 nm. The absorbance signal is a function of the mercury  
47  
48 concentration in the samples.  
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### 55 *Nitrate*

56  
57 Samples of lettuce, carrots and potatoes were analyzed according to the SKALAR method. In  
58  
59 short, any debris (e.g. soil) from the sample was removed (without water) and a representative  
60

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3 part of the sample was heated with water for 10-15 min on a boiling water bath. After cooling  
4  
5 down, the volume was fixed to a known amount and the samples filtered. The method  
6  
7 procedure for the determination of nitrate is based on the hydrazinium reduction method  
8  
9 (Skalar Methods, catnr. 455-311) In short, the nitrate in the sample was reduced to nitrite with  
10  
11 hydrazinium sulphate and the nitrite was determined by diazotizing with sulphanilamide and  
12  
13 coupling with naphthylethylenediamine dihydrochloride to form a highly coloured azo dye.  
14  
15 This dye was measured at 540 nm in a continuous flow detector (Skalar, Breda, The  
16  
17 Netherlands).

### 21 22 23 24 *Pesticides*

25  
26 Pesticides were analyzed by a multi-method based on Anastassiades et al. (2003). Samples  
27  
28 were extracted by a modified Quechers method (Díez et al. 2006). After addition of  
29  
30 magnesium sulphate and salt, the mixture was centrifuged and an aliquot of the acetonitrile  
31  
32 was purified with primary-secondary amine. After cleaning by dispersive solid-phase  
33  
34 extraction the extracts were analysed on an Agilent Technologies 6890N GC (Waldbronn,  
35  
36 Germany) equipped with an ATAS Optic 3 PTV injector (Veldhoven, The Netherlands) and a  
37  
38 LECO Pegasus III TOF-MS (St. Joseph, MI, USA). A Restek RTX-CL Pesticides column  
39  
40 (30m x 0.25 mm, 0.25  $\mu$ m, Bellefonte, PA, USA) was employed with helium as carrier gas  
41  
42 and a linear programmed temperature program from 40°C to 280°C with 10°C/min. All  
43  
44 analytes were measured in EI+ mode. Reference substances were obtained from Dr.  
45  
46 Ehrenstorfer (Augsburg, Germany). The method quantifies a number of selected pesticides  
47  
48 and detects a large number of others qualitatively. If detected, these pesticides are quantified  
49  
50 by injection of standards. LOQs vary between 0.01 and 0.5 mg/kg. The method is able to  
51  
52 detect over 300 pesticides, including the major organophosphates, organochlorines and  
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54 pyrethroids.  
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*Veterinary drugs*

Eggs, kidneys and meat were investigated for the presence of antibiotics (macrolides, aminoglycosides, sulphonamides, tetracyclines, quinolones, colistin) using microbial methods (Nouws et al. 1999, Pikkemaat et al. 2007a). Test systems consisted of a series of agar plates, each one specific for a group of residues and optimized for a particular matrix (Pikkemaat et al. 2007b). Methods were validated conform 657/2002/EC. Detection limits (CC $\beta$ ) were below the EC maximum residue limits, except for valnemulin, cloxacillin and dicloxacillin in kidney and valnemulin, cefapirin, cefalexin, kanamycin, cloxacillin and dicloxacillin in meat ( 1 to 4 times the MRL).

Eggs were analysed for residues of toltrazuril and its metabolite ponazuril by LC-UV according to the method described by Mulder et al. (2005). In brief, homogenized whole egg was extracted with ethyl acetate. The solvent was evaporated and the residue dissolved in 0.02 M trisodium phosphate buffer. Purification was carried out by solid phase extraction on an Oasis<sup>®</sup> HLB cartridge. LC-UV analysis was performed on a Symmetry<sup>®</sup> C18 150 x 3.0 mm column with a methanol/water/acetic acid gradient and UV detection at 245 nm. The detection limit was 25  $\mu\text{g}/\text{kg}$  for toltrazuril and 10  $\mu\text{g}/\text{kg}$  for ponazuril.

Livers from broilers were analysed for residues of nitrofurans metabolites by LC-MS/MS based on the method of Hoogenboom et al., 1991 as modified by Cooper et al, 2005. In brief, homogenized liver samples were treated overnight with 0.1 M hydrochloric acid in the presence of 2-nitrobenzaldehyde. The samples were extracted twice with ethyl acetate. After evaporation the residue was dissolved in mobile phase. LC-MS/MS analysis was performed on a Symmetry<sup>®</sup> C18 150 x 3.0 mm column with a acetonitrile/water/acetic acid gradient and detection with positive ESI in multiple reaction monitoring mode. The detection limit for

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3 furazolidone and furaltadone metabolites was 0.5 µg/kg and for nitrofurazone and  
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5 nitrofurantoin 1.0 µg/kg. Quantification was performed by isotope dilution.  
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#### 10 *Salmonella and E coli O157*

11  
12 Lettuce was examined for *Salmonella* using two methods. An aliquot of 25 gram of sample  
13 (outer leaves) was incubated in 225 mL buffered peptone water (BPW) for 18 h at 37°C. This  
14 pre-enrichment broth was subcultured in 2 selective enrichment media: Rappaport Vassiliadis  
15 soya broth (RVS) and Müller-Kaufmann tetrathionate novobiocin broth (MKTTn). After 24 h  
16 incubation at respectively 41.5 and 37°C aliquots of the selective media were streaked at both  
17 XLD and BGA selective media. After 24 h incubation at 37°C the plates were evaluated for  
18 the presence of specific *Salmonella* colonies. Suspected colonies were confirmed using  
19 biochemical and serological methods. The VIDAS screenings method, based on an Enzyme  
20 Linked Fluorescent Assay, was started from the selective enrichment broths after 6-8 h.  
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22 VIDAS-negative samples do not require confirmation and can be considered “*Salmonella* not  
23 detected”. VIDAS-positive samples were further treated as described above.  
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39 Lettuce was examined for *E. coli* O157 as follows. An aliquot of 25 gram of sample (outer  
40 leaves) was incubated in 225 mL modified tryptone soy bouillon at 41.5°C. After both 6 h and  
41 18-24 h an immunomagnetic separation was carried out with Dynabeads® anti-*E.coli* O157.  
42 Aliquots were plated on 2 selective plates (CT-SMAC and Chromagar O157™). After 18-24  
43 h incubation at 37°C the plates were evaluated for the presence of specific colonies.  
44  
45 Suspected colonies were confirmed based on indole-production and agglutination with  
46 specific antiserum. Positive isolates were also confirmed by the RIVM (Bilthoven, The  
47 Netherlands).  
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57 Faeces samples were examined for *Salmonella* according to both the VIDAS method or  
58 the ISO 6579:2002 method, as described for lettuce. From February 2004 faeces samples,  
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1  
2  
3 after enrichment in BPW, were also inoculated in modified semi-solid Rappaport Vassiliadis  
4 medium (MSRV) with 0.01 g novobiocin/L. After incubation for 24 and 48 h at 41.5°C, plates  
5  
6 were evaluated for specific growth areas, if necessary inoculated at selective growth media  
7  
8 XLD and BGA, and further treated as described above. *E. coli* O157 in faeces was examined  
9  
10 as described above for lettuce.  
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#### 15 16 17 *Antibiotic resistant bacteria*

18  
19 The isolation of *E. coli*, *Enterococcus faecium*, and *Campylobacter* spp. was started directly  
20 upon arrival of the samples at CIDC-Lelystad by making a 1:10 w/v suspension of the faeces  
21  
22 in buffered peptone water with 20% glycerol, from which on the same day selective media  
23  
24 were inoculated. Subsequently the suspensions were stored at -20°C. *E. coli* and *E. faecium*  
25  
26 were isolated on respectively MacConkey agar and Slanetz and Bartley agar by inoculating 50  
27  
28 µL of a serial dilution series of the 1:10 diluted sample with a spiral plater (*E. faecium*) or by  
29  
30 direct inoculation of the plates with sterile swabs (*E. coli*). The MacConkey plates were  
31  
32 incubated overnight aerobically at 37°C and the Slanetz Bartley plates during two days  
33  
34 aerobically at 42°C. From each sample, an *E. coli* colony with the typical morphology was  
35  
36 subcultured on Heart Infusion agar with 5% sheep blood and a colony typical of *E. faecium* on  
37  
38 Columbia agar with 5% sheep blood. Both were incubated overnight at 37°C. Subsequently  
39  
40 the strains were suspended in buffered peptone water with 20% glycerol and stored at -80°C.  
41  
42 All *E. coli* isolates were identified biochemically by the Indole reaction. The species  
43  
44 identification of *E. faecium* was performed with a Polymerase Chain Reaction (PCR)  
45  
46 described by Dutka Malen et al. (1995). For the isolation of *Campylobacter* spp. CCDA-agar  
47  
48 was used with 32 µg/mL cefoperazone and 10 µg/mL amphotericine B to suppress the growth  
49  
50 of Gramnegative bacteria and moulds. Plates were inoculated directly upon arrival of the  
51  
52 samples with a swab. The CCDA-plates were incubated for 48 h in microaerophilic conditions  
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3 at 42°C. Typical colonies were streaked on HIS-plates and again incubated for 48 h  
4  
5 microaerophilically at 37°C. The isolates were all identified as *Campylobacter coli* by PCR.  
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7

8 The susceptibility of the isolates was determined quantitatively using a broth micro  
9  
10 dilution method according to CLSI guidelines (M31-A2 and M100-S16), with cation-adjusted  
11  
12 Mueller Hinton broth. Microtiter plates with dehydrated dilution series of a panel of  
13  
14 antibiotics (see Figures 1 and 2) were provided by Trek Diagnostic Systems (Basingstoke,  
15  
16 UK). For *Campylobacter* spp. the plates, after inoculation with 50 µL per well of a 200-fold  
17  
18 diluted 0.5 McFarland suspension in NaCl 0.85% solution, were incubated microaerophilic in  
19  
20 a shaking incubator at 37°C for 24 h. ATCC strains *E. coli* 25922, *E. faecalis* 29212 and *C.*  
21  
22 *jejuni* ATCC 33560 were tested daily to control the quality of the results.  
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26  
27 The minimum inhibitory concentrations (MICs) were defined as the lowest antibiotic  
28  
29 concentration at which visually bacterial growth was observed. Strains with MICs higher than  
30  
31 the MIC breakpoints defined by CLSI were classified as resistant. For those antibiotics (e.g.  
32  
33 neomycin and florfenicol for *E. coli*, the former growth promoters for the enterococci) and  
34  
35 bacterial species (*Campylobacter* spp.), for which CLSI has not defined clinical MICs,  
36  
37 breakpoints used in the Dutch Resistance Monitoring Programme were used (Maran 2004).  
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39 Subsequently resistance proportions were calculated for each individual antibiotic tested.  
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41 Moreover, proportions of fully susceptible isolates and resistant to 1, 2, 3, 4 and more than 4  
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43 different antibiotic classes were calculated.  
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## Results and Discussion

The present study focussed on a limited number of contaminants and micro-organisms in organic products and organic production systems. Selection was based on a report of the Expertise Centre for Agriculture in the Netherlands, and information on other projects already running in this area. Contaminants already studied in ongoing studies, like dioxins in eggs (Kijlstra et al. 2007), were not included in this study. Results were subsequently compared with those from conventional agriculture, partly coming from this project and partly from other monitoring programmes in the Netherlands. In addition a comparison was made with results from other studies.

A very important issue is the sampling strategy and in particular the site of sampling; the farm or the shop/supermarket (Magkos et al. 2006). Samples taken at a shop, give information on the products actually bought by the consumer. However, in this study the choice was made to collect data as much as possible at the farm, thus allowing the control on the origin of the product and a survey on the actual farming conditions. This would also allow an investigation on potential causes for undesirable contaminants or micro-organisms. It should be stressed that organic farming in the Netherlands is a growing market and that most of the organic farms switched to organic practices only recently. In cases where sampling at the farms was not possible, due to logistic or hygienic reasons, samples were taken at distribution centres and slaughterhouses. At the time of this study there were about 500 farms involved in the organic production of vegetables, potatoes and grains. In the present study 24, 35 and 21 farms were sampled for lettuce, carrots and potatoes respectively. Results will be described and discussed for each type of product investigated.

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3 *Wheat (pesticides, mycotoxins, heavy metals)*  
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6 Wheat was collected in 2003 and 2004. Twelve of the 20 organic samples came from farms  
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8 that switched to organic less than 5 years ago. The organic wheat covered races like Melon,  
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10 Lavett and Pasteur, the conventional wheat was not inventoried. Yield of organic wheat varied  
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12 between 4300 and 7900 kg/hectare. Eighteen pooled samples of organic wheat were  
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14 investigated for non-polar pesticides but none of the more than 300 different compounds  
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16 could be detected.  
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20 The levels of the 7 examined mycotoxins in wheat were below detection limits in the  
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22 conventional and organic wheat samples, with the exception of the *Fusarium* toxins  
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24 deoxynivalenol (DON) and zearalenone (ZON) (Table 1). In most of the samples collected in  
25  
26 2003, levels of DON were below the action limit of 0.1 mg/kg, with the exception of 6  
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28 conventional products showing levels between 0.1 and 1 mg/kg. Of the samples collected in  
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30 2004 before the end of August, nine out of 14 samples (64%) of conventional winter wheat  
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32 and 8 out of 11 samples (73%) of conventional summer wheat, contained DON levels above  
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34 the action limit (range 0.1-1.5 mg/kg), as compared to five out of seven (71%) samples  
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36 organic summer wheat (range 0.1-1.8 mg/kg). However, after a period with heavy rain fall by  
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38 the end of August 2004, DON was detected in all samples at levels up to 11 mg/kg. In these  
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40 samples also zearalenone was increased with levels up to 5.7 mg/kg. Overall there was no  
41  
42 significant difference between organic and conventional wheat. This is contradictory to  
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44 studies by Malmauret et al. (2002) who did find higher levels of the *Fusarium* toxins DON,  
45  
46 nivalenol and zearalenone in organic wheat and barley. However, Döll et al. (2002), Bernhoft  
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48 et al. (2003), Schneweis et al. (2005), Rossi et al. (2006) and Pussemier et al. (2006) also  
49  
50 observed lower average levels in organic cereals. Czerwiecki et al. (2002), analyzing various  
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52 cereals in Poland in two subsequent years for ochratoxin A, observed higher frequencies of  
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54 contamination of organic cereals in one year, but the opposite in the next year with some very  
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3 high levels in some conventional wheat. In general, there is a tendency for organic cereals to  
4 contain lower mycotoxins levels but differences appear to be rather small (Magkos et al.  
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6 2006) and factors like climate may play a much more crucial role than the type of production.  
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10 Lead, mercury and arsenic levels in most samples were below the detection limits of  
11  
12 respectively 0.1, 0.01 and 0.1 mg/kg. In 4 organic wheat samples mercury levels just above  
13 the LOD were detected, i.e. levels of 0.013, 0.011, 0.016 and 0.016 mg/kg. Cadmium could  
14  
15 be detected in most samples but the highest level of 0.077 mg/kg was well below the EU-limit  
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17 of 0.2 mg/kg. There was no difference in cadmium levels between organic and conventional  
18  
19 wheat (data not shown). This is contrary to Rossi et al. (2006), who found slightly lower  
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21 cadmium but higher lead levels in organic wheat, although not at levels exceeding the EU-  
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23 limits.  
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29 *Lettuce (micro-organisms, pesticides, nitrate, heavy metals)*  
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31 Organic lettuce was sampled at 3 distribution centres, responsible for 70% of the organic  
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33 lettuce. Half of the farms produced organically for two decades or more, the other half for less  
34  
35 than ten years. Conventional lettuce was obtained from local stores. None of the samples  
36  
37 tested positive for *Salmonella* or *E. coli* O157, two types of micro-organisms that might be  
38  
39 introduced through the use of animal dung. This shows that this is not a common problem but  
40  
41 cannot exclude the presence of these pathogenic micro-organisms in a small fraction of the  
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43 products. To minimize the potential risk of contamination, several countries like the US and  
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45 Canada do not allow the use of non-composted manure.  
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50 Ten pooled samples of organic and conventional lettuce were examined for non-polar  
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52 pesticides but none of the organic products tested positive. Two pooled samples of  
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54 conventional lettuce contained residues of the permitted pesticide vinclozolin and one of these  
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56 in addition malathion and piperonylbutoxide. Levels were below the residue limits.  
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3 In both organic and conventional iceberg lettuce produced outside, nitrate levels were  
4 below the limits, with a range of 370 to 1759 mg/kg for organic and 652 to 1367 mg/kg for  
5 conventional products (Table 2). In the case of organic head lettuce produced outside (19  
6 samples) and the greenhouse (10 samples), one sample of each exceeded the limit. In the case  
7 of conventional head lettuce, this frequency was much higher. Levels above the limit were  
8 detected in 18 out of 19 samples grown outside and 4 out of 14 samples from the greenhouse.  
9 In comparison with conventional head lettuce, nitrate levels were much lower for organic  
10 products. This confirms results from previous studies (Consumentenbond 2002, Woese et al.  
11 1997, Soil Association 2001). In the case of iceberg lettuce, no differences were observed.  
12 Levels of arsenic and the heavy metals lead, cadmium and mercury were below the limits.  
13 Cadmium levels showed a large variation, as shown in Table 2. However, no differences were  
14 observed between organic and conventional products.  
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#### 34 *Carrots (pesticides, nitrate, heavy metals)*

35 Organic carrots were sampled at farms with varying experience, ranging from 2-18 years.  
36 Most of them switched to organic less than 5 years ago. More than 11 different varieties were  
37 used but Nerac was most popular. Yields varied between 35 and 75 tons/hectare. Four pooled  
38 samples of organic carrots were investigated for non-polar pesticides but none of the more  
39 than 300 different compounds could be detected.  
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48 Nitrate levels in organic carrots showed a large variation, with a range in 2004 of 11 to  
49 864 mg/kg and a median of 244 mg/kg (Table 3). This was 3 times higher than in  
50 conventional carrots harvested in the same year, showing a median of 58 mg/kg and a range  
51 from 16 to 180 mg/kg. Previous studies showed lower levels in organic carrots  
52 (Consumentenbond, 2002) but the present data confirm those from other studies showing an  
53 increase in nitrate levels in organic carrots (Bokhorst, personal communication). Malmauret et  
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3 al. (2002) also observed higher levels in organic carrots, i.e. 394 versus 113 mg/kg product in  
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5 conventional carrots. Studies at the farms showed that a relatively high use of dung and plant  
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7 waste materials, as compared to previous years, is probably the cause of the rise in nitrate  
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9 levels. This is partly related to farms that switched only recently to organic practices.  
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12 Heavy metals and arsenic were only analyzed in the organic carrots samples in 2003.  
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14 None of the levels exceeded the limits, although some cadmium levels were close to the limit  
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16 of 0.1 mg/kg.  
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#### 22 *Potatoes (pesticides, nitrate, heavy metals)*

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24 Organic potatoes were sampled at the farms, conventional potatoes were not investigated.  
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26 Most of the farms were also sampled for carrots, again most of them with less than 5 years of  
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28 experience. Agria and Sante were the most popular races with yields between 23 and 47  
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30 tons/hectare. Four pooled samples of organic potatoes were investigated for non-polar  
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32 pesticides but none of the more than 300 different compounds could be detected.  
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36 The nitrate level in organic potatoes was low with an average of 87 mg/kg but the  
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38 variation was quite large (range 8-390 mg/kg). There were no Dutch data on conventional  
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40 potatoes for comparing the data. However, levels were lower than those reported by Hajšlová  
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42 et al. (2005) for organic potatoes. In that study levels in conventional potatoes were higher  
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44 than in organic ones.  
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48 None of the samples levels exceeded the limits for heavy metals, although some cadmium  
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50 levels were close to the limit of 0.1 mg/kg.  
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#### 55 *Pigs (veterinary drugs, heavy metals, micro-organisms, antibiotic resistance)*

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3 In total 31 organic farms with pigs were visited, representing 53% of the organic pig farms in  
4 the Netherlands. Fourteen farms were more experienced (6-14 years), the other 17 switched to  
5 organic only recently (1-4 years). The number of pigs varied between 20 and 1100 (Table 4).  
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10 No residues of antibiotics were detected with a bacterial test in samples of kidneys and  
11 meat of 20 organic pigs, sampled at the slaughterhouse. Only one kidney sample showed a  
12 slight inhibition of bacterial growth on the macrolides plate but below the action level. Levels  
13 of arsenic in meat were below the detection limit of 0.1 mg/kg. Similar was true for levels of  
14 led and mercury in the kidneys of these animals, being below respectively 0.05 and 0.005  
15 mg/kg with one exception, being a mercury level of 0.008 mg/kg. Cadmium levels varied  
16 between less than 0.005 and 0.38 mg/kg (median 0.11 mg/kg), all of them being below the  
17 EU-limit of 1 mg/kg.  
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30 Initially 10 farms were visited in the winter of 2003 and all the pooled faeces samples of  
31 the 12 animals per farm scored negative for *Salmonella*. Another set of 20 farms was sampled  
32 in the spring of 2005 and this time 8 farms were positive for *Salmonella*. Interestingly, this  
33 included 7 farms that only recently switched to organic (3 years or less). The other farm  
34 turned to organic in 1996 and on this farm 3 barns were sampled. One of these samples,  
35 derived from a stable with young pigs that were purchased elsewhere, was positive. Overall  
36 the incidence of *Salmonella* was 27% and comparable to data known from conventional farms  
37 in the Netherlands. However, the fact that *Salmonella* could not be isolated from dung  
38 collected at the more experienced organic pig farms, is of potential interest. Possible causes  
39 could be the use of more rough fibre rich and more diverse feeds at organic farms compared  
40 to conventional pig farms, which may influence the colonisation of *Salmonella* in the GI-tract  
41 (Knudsen et al. 2001).  
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58 *Campylobacter* was one of the bacteria generally used for the assessment of antibiotic  
59 resistance and could be isolated from 56% of the faeces samples, being similar to  
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3 conventional farms. When focussing on the farms, *Campylobacter* could be isolated from one  
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5 or more of the 5 sampled pigs at 81% of the farms. *E. coli* O157 was not detected in any of  
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7 the samples, but this was only analysed in samples from the first 10 farms. This was decided  
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9 because the data were in line with conventional farms where the prevalence of *E. coli* O157 is  
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11 0-2%.  
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15 The use of antibiotics at organic farms is restricted although 19 of the 31 farms mentioned  
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17 the occasional use of antibiotics. The resistance level to a number of antibiotics was  
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19 investigated in *E. coli*, *E. faecium* and *Campylobacter* spp., isolated from faeces of the 5  
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21 animals per farm (1 isolate per sample). *E. coli* could be isolated from all 155 animals and  
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23 resistance was only observed for older drugs like amoxicillin, neomycin, tetracycline,  
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25 sulfamethoxazole, trimethoprim and chloramphenicol. No resistance was observed in *E. coli*  
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27 from organic farms against newer drugs like cefotaxim, gentamicin, the quinolones  
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29 ciprofloxacin and nalidixinic acid, and florfenicol. Figure 1A shows that in general the  
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31 resistance in organic pigs is lower than observed in conventional pigs, based on data from the  
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33 Dutch regular monitoring program (MARAN, 2004). In this program one animal per slaughter  
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35 batch is sampled, according to guidelines of the European Food Safety Authority. Regarding  
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37 the limited number of farms, it was decided to use five animals per farm in the present study,  
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39 which could have some influence on the results. *E. Faecium* was isolated from 80% of the  
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41 samples or on 97% of the farms. Significant resistance was only observed against doxycyclin,  
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43 quinupristin/dalfopristin (Synercid<sup>®</sup>) and bacitracin, and to flavomycin but this *Entorococcus*  
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45 species is intrinsically resistant to this drug. Figure 1B shows that also for this species in  
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47 general the resistance is lower than in conventional pigs, in particular true for erythromycin  
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49 and salinomycin. Bacitracin has been used as a growth promoter until 1999 and resistance is  
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51 rather widespread in conventional pigs, and apparently also in organic pigs. Synercid is  
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53 related to virginiamycin, also used as a growth promoter until 1999.  
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3 As mentioned above, *Campylobacter* (*jejuni* and *coli*) could be isolated from 80% of the  
4 samples, or at 77% of the farms. In comparison to *E. coli* and *E. faecium*, *Campylobacter*  
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6 showed resistance to many of the tested drugs (9 out of 12). Remarkable was the resistance  
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8 against the quinolones ciprofloxacin and nalidixinic acid, since this type of drugs is only used  
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10 to treat individual pigs. In general, resistance in organic pigs was lower than in conventional  
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12 pigs (Figure 1C). When looking at the fraction of bacteria resistant to 1, 2, 3, 4 or more than 4  
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14 antibiotics, 32% of the *E. coli* isolates from organic pigs were multiple drug resistant  
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16 (resistant to 2 or more independent classes of antibiotics), as compared to 55% in  
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18 conventional pigs (Table 5). For *E. faecium* figures were similar for organic and conventional,  
19  
20 being respectively 75% and 74%, but for *Campylobacter* spp. lower for organic, i.e. 45%  
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22 versus 80%. Although the lack of difference for *E. faecium* seems remarkable, differences  
23  
24 became more clear when focussing on multiple resistance against 3 or more antibiotic classes,  
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26 showing 33% resistance for organic versus 46% for conventional. Furthermore, low level  
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28 resistance (<10%) was observed in *Enterococci* isolated from organic farms for erythromycin  
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30 and salinomycin compared to the resistance levels found in conventional animals.  
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#### 41 *Lactating cows (veterinary drugs, micro-organisms)*

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43 Ten kidney samples of cows, reared in organic farms, were collected at the slaughterhouse  
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45 and tested for bacterial growth inhibition. Three samples showed a slight inhibition at the  
46  
47 aminoglycosides plate but below the action limit.  
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51 Ten farms with lactating cows were visited in September-November 2003 and samples of  
52  
53 dung were collected. Farm size varied between 35-74 cows and one bigger farm with 250  
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55 animals. *E. coli* O157 was detected in all three samples of one farm and in one of four  
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57 samples of another farm, the latter collected at a pasture with non-lactating cows and young  
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3 animals. The first farm was revisited in September 2004 and found negative than, as was the  
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5 case for the second farm revisited in June 2004.  
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10 *Laying hens (veterinary drugs, micro-organisms, heavy metals)*

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12 Ten farms out of a total of 100 were visited and both eggs and dung collected. Number of  
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14 hens per farm varied between 170 and 10900, and farms switched to organic between 1994  
15  
16 and 2003. Dung was tested for the presence of *Salmonella* using different methods, including  
17  
18 the standard MSRV method. Most samples scored negative, except for one farm where one of  
19  
20 the two barns tested positive. Except for one, hens were vaccinated against *Salmonella*, but  
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22 antibiotics were reported not to be applied. All eggs tested negative for toltrazuril, and for the  
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24 presence of aminoglycosides, sulfonamides, beta-lactam, tetracyclins, quinolones and colistin.  
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26 Levels of cadmium, led, arsenic and mercury were below the detection limits of respectively  
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28 0.005, 0.05, 0.1 and 0.005 mg/kg. This is in contrast to the rather high levels of heavy metals  
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30 observed by Van Overmeire et al. (2006) in eggs from private owners in Belgium, indicating  
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32 that heavy metals may be transferred to eggs, as previously shown for dioxins.  
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41 *Broilers (veterinary drugs, micro-organisms, heavy metals, antibiotic resistance)*

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43 The number of organic farms with broilers is rather limited in the Netherlands and these were  
44  
45 all visited. Most farms turned organic since 1998 and the number of animals varied between  
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47 380 and 8000. Animals belonged to slow-growing varieties, as reflected by the age at  
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49 slaughter of 70-81 days (for conventional broilers this is around 40 days). Antibiotics were  
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51 reported not to be used. Other veterinary drugs and anthelmintics were used on 2 and 1 farms,  
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53 respectively. Livers were checked for nitrofurans and all tested negative. Led, arsenic  
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55 and mercury in livers was below the detection limits of respectively 0.05, 0.1 and 0.01 mg/kg.  
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3 Cadmium levels varied between <0.005 and 0.029 mg/kg, well below the EU-limit of 0.5  
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5 mg/kg.  
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8 On none of the 9 organic farms, animals were carriers of *Salmonella* as determined with  
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10 the MSRV-method. Of course, the number of farms is very small but the data are in line with  
11  
12 those observed by the VWA in 2003 and 2004 in meat, showing an incidence of 2 and 3%  
13  
14 respectively, as compared to 11 and 7% in meat from conventional broilers (VWA 2004b,  
15  
16 2005). *Campylobacter* was detected in faeces samples at all farms, and overall could be  
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18 isolated from 32 of the 45 samples. In conventional broilers the incidence is much lower, in  
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20 2000, 2001 and 2002 respectively 24, 16 and 27% (VWA 2004a). The VWA detected  
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22 *Campylobacter* in 36 and 44% of the meat products of organic broilers, as compared to 26 and  
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24 29% of the conventional products (VWA 2004b, 2005). Heuer et al. (2001) examined organic  
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26 and conventional farms in Denmark and detected *Campylobacter* in respectively 49 and 100%  
27  
28 of the faeces samples collected during slaughter. Remarkable was the high incidence of 91%  
29  
30 for *Campylobacter jejuni* and only 9% *C. coli*, whereas Rodenburg et al. (2004), who also  
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32 observed a high incidence of *Campylobacter* in organic broilers, reported incidences of 30%  
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34 for *C. jejuni* and 70% for *C. coli*. This is relevant since in particular *C. jejuni* is responsible  
35  
36 for infections in humans. Our data are however in line with those of Heuer et al. (2001), also  
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38 reporting primarily *C. jejuni*, independent of the type of production.  
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45 In *Campylobacter* highest resistance against antibiotics was found against amoxicillin,  
46  
47 doxycyclin, metronidazole and the quinolones nalidixinic acid and ciprofloxacin (Figure 2C).  
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49 There were no clear differences in resistance proportions with data from 57 samples from  
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51 conventional broilers. This was also the case for multi drug resistance (resistant against 2 or  
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53 more independent classes of antibiotics) showing figures of 72 and 63% in organic versus  
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55 conventional broilers (Table 6).  
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3 *E. coli* could be isolated from all 45 faecal samples, *E. faecium* from 89% of the samples..  
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5 Considerable resistance was observed in *E. coli* against amoxicillin, tetracycline,  
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7 sulfamethoxazole, trimethoprim and to a lesser extent nalidixinic acid, but not against the  
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9 newer antibiotics. Figure 2A shows a comparison with data from conventional broilers,  
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11 demonstrating that in conventional broilers resistance occurred much more frequently than in  
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13 organic animals. *E. faecium* showed considerable resistance against doxycyclin, bacitracin,  
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15 synergid, and to a lesser extent to erythromycin, salinomycin and streptomycin but again  
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17 much lower than in conventional broilers. This organism is known to be resistant against  
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19 flavomycin as shown in Figure 2B. Overall, 27% of the *E. coli*'s were multiple resistant (2 or  
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21 more independent classes of antibiotics) as compared to 81% of the conventional broilers. For  
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23 *E. faecium* figures are respectively 69 and 94% (Table 6). The observed reduced resistance  
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25 against antibiotics confirms previous studies by the Dutch Food and Consumer Products  
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27 Safety Authority in the Netherlands (VWA, 2005).  
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34 The fact that in organic broilers in the commensal gut flora (*E. coli* and *E. faecium*) less  
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36 antimicrobial resistance occurs than in conventional broilers can mainly be explained by the  
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38 absence of selection pressure in organic animals. The fact that in *Campylobacter* spp. this  
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40 difference was not observed is likely to be caused by the fact that in broilers *Campylobacter*  
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42 colonisation occurs after environmental contamination with this organism. In a densely  
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44 populated country like the Netherlands it can be speculated that the *Campylobacter* spp.  
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46 isolated from the organic broilers originate from conventionally reared poultry and were  
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48 already resistant at the moment of colonisation.  
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## 55 **Conclusions**

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57 Although some of the results suggest a difference between organic and conventional, it should  
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59 be stressed that the present study was only a survey focussing on one set of samples and one  
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3 or two production years. However, in a number of cases the results are similar to those from  
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5 other studies, like the lower nitrate levels in head lettuce, the lack of increased mycotoxin  
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7 levels in organically produced grains, less *Salmonella* but more *Campylobacter* in broilers,  
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9 and less antibiotic-resistant bacteria in pigs and broilers. In the case of nitrate in carrots there  
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11 are indications for increasing levels in organic cultivation and further studies are required to  
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13 confirm this. Also the lower incidence of antibiotic resistant bacteria in pigs and the lower  
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15 incidence of *Salmonella* in more experienced pig farms deserve more attention.  
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3 Figure 1. Incidence of antibiotic resistant *E. coli*'s (A), *E. faecium* (B) and *Campylobacter* (C)  
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5 in faeces of organic (blue bars) and conventional (red bars) pigs. Five and one faeces samples  
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7 were collected at each organic and conventional farm respectively. *E. coli*'s were isolated  
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9 from respectively 155 and 296 samples, *E. faecium* from 105 and 110 samples,  
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11 *Campylobacter* from 84 and 198 samples.  
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17 Figure 2. Incidence of antibiotic resistant *E. coli*'s (A), *E. faecium* (B) and *Campylobacter* (C)  
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19 in faeces of organic (blue bars) and conventional (red bars) broilers. Five and one faeces  
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21 samples were collected at each organic and conventional farm respectively. *E. coli*'s were  
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23 isolated from respectively 45 and 300 samples, *E. faecium* from 45 and 180 samples,  
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25 *Campylobacter* from 32 and 57 samples.  
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Table 1. Levels of DON and ZON (median and range) in organic and conventional wheat sampled in 2003 and 2004.

Sample date	Production type		DON (mg/kg)	ZON (mg/kg)	Number of samples
2003	Organic	Summer	<0.1 (<0.1-0.2)	<0.05	9
	Conventional	Winter	0.3 (<0.1-1.0)	<0.05	9
2004, until 24 <sup>th</sup> August	Organic	Summer	0.2 (<0.1-1.8)	<0.05 (<0.05-0.12)	7
	Conventional	Summer	0.2 (<0.1-1.5)	<0.05 (<0.05-0.13)	11
	Conventional	Winter	<0.1 (<0.1-0.4)	<0.05	14
2004, after 24 <sup>th</sup> August	Organic	Summer	1.7 (<0.1-11.0)	2.6 (<0.05-5.7)	15
	Conventional	Summer	2.0 (0.5-6.3)	0.7 (<0.05-5.2)	6

No significant differences between conventional and organic (Student t-test, two-sided)



Table 2. Nitrate and cadmium levels in organic (O) and conventional (C) iceberg and head lettuce produced outside and in the greenhouse.

Type	production		Nitrate** (mg NO <sub>3</sub> /kg)		n	Cadmium (mg/kg)	
			median	range		range	n
Iceberg	field	O	939	370-1759	13	<0.02-0.022	5
Iceberg	field	C	966	652-1367	13	<0.02-0.038	4
Head lettuce	field	O	1275*	139-3212	19	<0.02-0.042	6
Head lettuce	field	C	3280*	1818-4357	19	<0.02-0.052	8
Head lettuce	greenhouse	O	3223	946-4129	10	<0.02-0.043	9
Head lettuce	greenhouse	C	3515	2439-5197	14	<0.02-0.066	8

\* Differences between nitrate in conventional and organic head lettuce from the field were statistically significant (Student t-test,  $p < 0.001$ )

\*\* EU-limits for head lettuce from the field are 2500 mg/kg, harvested between 1<sup>st</sup> April and 30<sup>th</sup> September, and 4000 mg/kg when harvested between 1<sup>st</sup> October and 31<sup>st</sup> March; for head lettuce from the greenhouse 3500 mg/kg, when harvested between 1<sup>st</sup> April and 30<sup>th</sup> September, and 4500 mg/kg when harvested between 1<sup>st</sup> October and 31<sup>st</sup> March; for iceberg lettuce from the field 2000 mg/kg (EC 2001, 2002).

Tabel 3. Nitrate levels in organic (O) and conventional (C) carrots.

Production	Year	Nitrate (mg NO <sub>3</sub> /kg)		n
		median	range	
Organic	2003	192	34-449	20
Organic	2004	244	11-864	15
Conventional	2004	58	16-180	15

Differences between nitrate in conventional and organic carrots from 2004 were statistically significant (Student t-test,  $p < 0.001$ ).

Table 4. Description of the farms with organic pigs, including the results from the studies on *Salmonella* and *Campylobacter*.

Farm number	Organic since	Animals	<i>Salmonella</i>	<i>Campylobacter</i> *	Rough fiber-rich feed
1	1997	340	negative	5/5	+
2	1990	75	negative	5/5	+++
3	1998	500	negative	4/5	+
4	1998	122	negative	3/5	++
5	1998	200	negative	2/5	+
6	1995	140	negative	4/5	+
7	1999	120	negative	5/5	+
8	1999	525	negative	5/5	+
9	1997	850	negative	5/5	+
10	1990	450	negative	0/5	+
11	2003	500	positive	3/5	+
12	2004	700	negative	4/5	±
13	1996	460	positive	3/5	-
14	2003	400	positive	2/5	+
15	2002	325	negative	5/5	+
16	2002	257	positive	3/5	+
17	2002	950	negative	5/5	-
18	2004	400	positive	3/5	-
19	2003	106	negative	5/5	±
20	2002	620	negative	1/5	+
21	2001	400	negative	2/5	-
22	2002	120	positive**	2/5	+
23	1998	400	negative	5/5	-
24	2003	1100	positive**	0/5	-
25	2003	450	positive	0/5	+
26	2002	80	negative	4/5	+
27	2002	440	negative	1/5	+
28	1998	700	negative	0/5	-
29	1998	300	negative	0/5	+
30	2002	450	negative	1/5	+
31	1999	20	ni***	0/5	-

\* number of faeces samples from which *Campylobacter* could be isolated for antibiotic resistance

\*\* negative with the MSR/V method

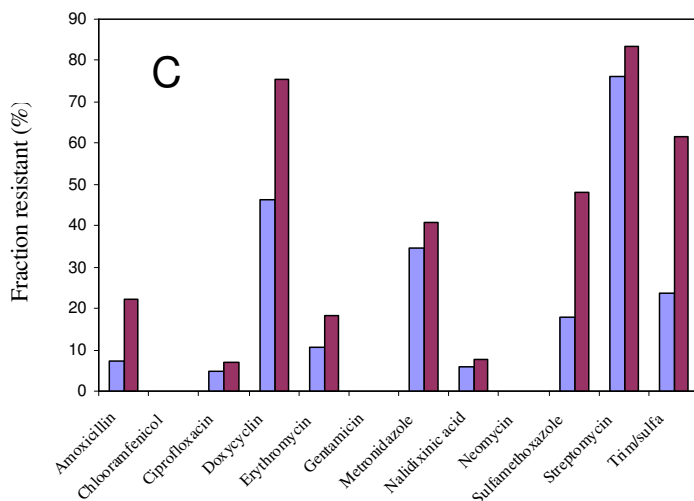
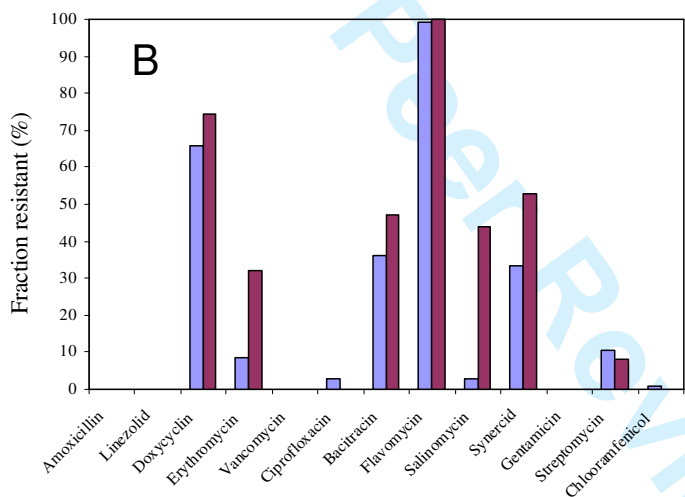
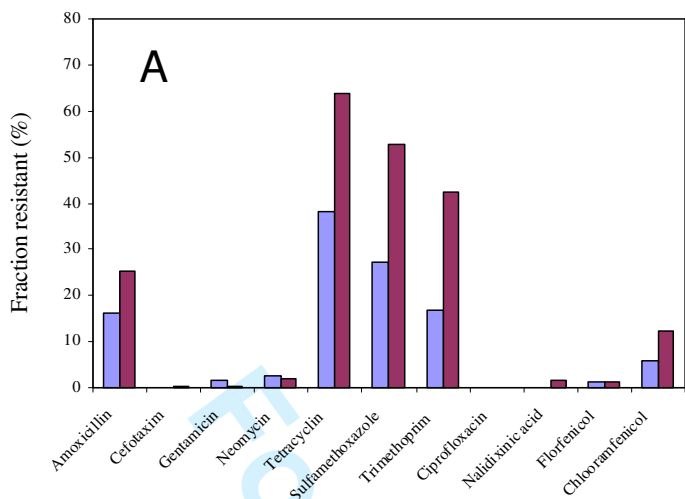
\*\*\* ni: not investigated due to loss of sample

Table 5. Resistance of bacteria from pig faeces against different classes of antibiotics. Data expressed as the percentage of bacteria resistant against 0, 1, 2, 3, 4 or more than 4 classes of antibiotics. Conventional data from the MARAN study (MARAN, 2004).

Resistant to classes	<i>E. coli</i>		<i>E. faecium</i>		<i>Campylobacter</i>	
	Organic	Conventional	Organic	Conventional	Organic	Conventional
0	43	27	3	5	22	5
1	25	19	22	21	33	15
2	15	14	43	28	22	26
3	7	16	22	17	14	25
4	6	17	9	17	4	16
>4	4	8	2	12	5	13

Table 6. Resistance of bacteria from broiler faeces against different classes of antibiotics. Data expressed as the percentage of bacteria resistant against 0, 1, 2, 3, 4 or more than 4 classes of antibiotics. Conventional data from the MARAN study (MARAN, 2004).

Resistant to classes	<i>E. coli</i>		<i>E. faecium</i>		<i>Campylobacter</i>	
	Organic	Conventional	Organic	Conventional	Organic	Conventional
0	53	10	3	1	28	19
1	20	9	30	6	0	18
2	16	8	38	10	31	23
3	2	13	20	16	22	26
4	9	22	8	22	13	7
>4	0	38	3	46	6	7



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Figure 1

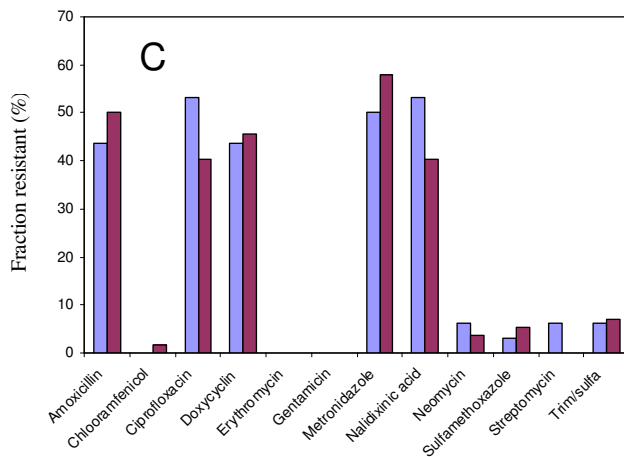
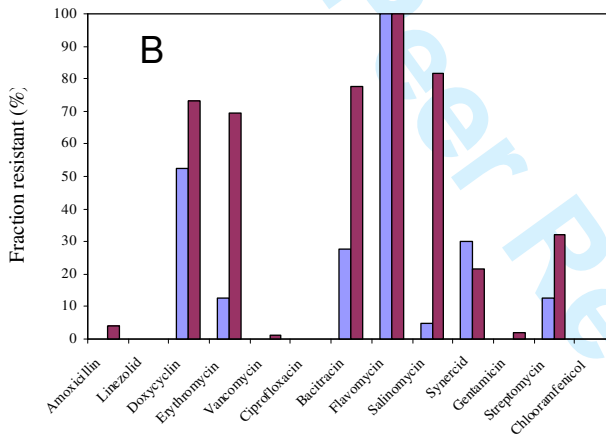
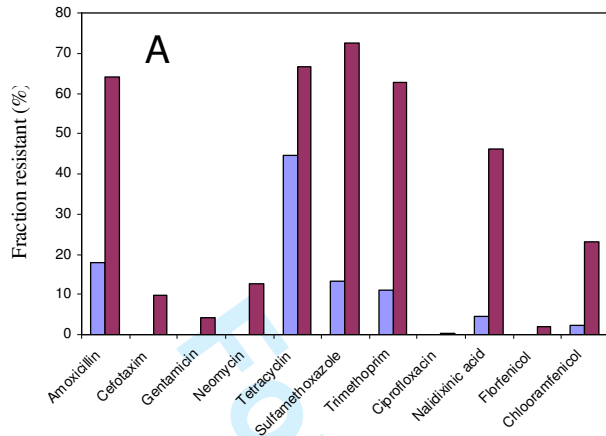


Figure 2.