

## Retail pork – *E. coli*

A total of 92 *E. coli* were isolated during the 12 month sampling period. The overall prevalence of *E. coli* in retail pork was 18.1% and ranged during monthly sampling from 5.9% to 26.5%. The 92 *E. coli* isolates were tested for AMR. The reduction in pork / *E. coli* isolates available for AMR testing correspondingly results in a minor decrease from 95% to approximately 93.5% probability of detecting 1 AMR isolate in 92 if AMR prevalence nominally occurs at 3% prevalence (see FRSC communication note Appendix C).

*Antimicrobial drug resistance:* The prevalence of multiple drug resistance in *E. coli* is presented in Figure 9. The distribution of MICs and resistance in *E. coli* is presented in Table 18. Resistance to one or more antimicrobials was observed in 80.4% of isolates. Resistance to tetracycline (44.5%), ampicillin (28.2%), streptomycin (17.4%), chloramphenicol (13%) and trimethoprim / sulfamethoxazole (13%) were most often observed. Resistance to florfenicol (8.7%), amoxicillin / clavulanic acid (3.3%), cefazolin (3.3%), kanamycin (3.3%) and gentamicin (1.1%) were also observed.

*AMR patterns:* A total of 24 AMR patterns were identified (Table 14). Resistance to tetracycline alone was the most commonly observed AMR pattern (13%). Twenty-two percent of isolates were resistant to 3 or more antimicrobials and comprised 14 of the 24 AMR patterns identified. Five of the 14 patterns were found in multiple isolates. The largest AMR patterns identified included resistance to ampicillin-streptomycin-tetracycline-trimethoprim / sulfamethoxazole in conjunction with combinations of chloramphenicol, florfenicol and kanamycin resistance.

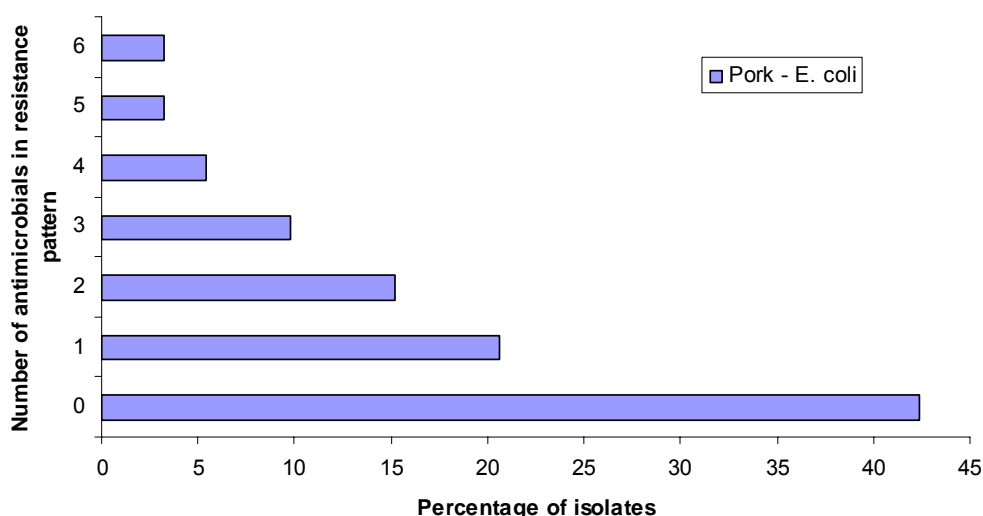


Figure 9. Multiple drug resistance in *E. coli* from retail pork samples (n=92)

Table 14. Multiple antimicrobial resistance phenotypes present in *E. coli* from retail pork.

Pattern	Resistance phenotype*	Percentage
0	No pattern	42
1	tet	13
1	amp	4
1	str	2
1	ffn	1
2	amp tet	8
2	str tet	3
2	gen str	1
2	aug faz	1
2	tet sxt	1
2	chl tet	1
3	amp chl tet	3
3	aug amp faz	2
3	amp str tet	2
3	amp chl sxt	1
3	amp kan tet	1
4	chl str tet sxt	2
4	amp str tet sxt	1
4	amp chl ffn tet	1
4	chl ffn tet sxt	1
5	chl ffn str tet sxt	2
5	amp chl ffn tet sxt	1
6	amp ffn kan str tet sxt	1
6	amp chl ffn str tet sxt	1
6	amp chl kan str tet sxt	1

\* Amoxicillin / Clavulanic acid, aug; Ampicillin, amp; Cefazolin, faz; Cefotaxime, fot; Cefoxitin, fox; Ceftiofur, xnl; Ceftriaxone, axo; Chloramphenicol, Ciprofloxacin, cip; Florfenicol, ffn; Gentamicin, gen; Meropenem, mer; Nalidixic Acid, nal; Streptomycin, str; Tetracycline, tet; Trimethoprim / Sulfamethoxazole, sxt.

### Retail pork – *Enterococcus*

A total of 178 *Enterococcus* were isolated during the 12 month sampling period. The overall prevalence of *Enterococcus* in retail pork was 86.0% and ranged during monthly sampling from 70.6% to 94.7%. Screening of *Enterococcus* isolates by PCR determined that 83.1% of isolates were *E. faecalis*. *E. faecium* was not identified using PCR. One hundred *E. faecalis* isolates were randomly selected for AMR testing.

*Antimicrobial drug resistance:* The prevalence of multiple drug resistance in *Enterococcus* is presented in Figure 10. The distribution of MICs and resistance in *Enterococcus* is presented in Table 15. Resistance to one or more antimicrobials was observed in 22% of isolates. Resistance to tetracycline (17%) was observed most often. Isolates with resistance to chloramphenicol, erythromycin, flavomycin, kanamycin, streptomycin and tigecycline were observed with a prevalence  $\leq 7\%$ . Resistance to the clinically significant antimicrobials gentamicin, linezolid and vancomycin was not observed.

*AMR patterns:* A total of 11 AMR patterns were identified (Table 16). Resistance to 2 or more antimicrobials was observed in 11% of isolates. The largest AMR patterns observed were resistance to chloramphenicol-erythromycin-kanamycin -streptomycin-tetracycline (5 antimicrobials; 2 isolates; 2%) and erythromycin-flavomycin-kanamycin- streptomycin-tetracycline (5 antimicrobials; 1 isolate; 1%).

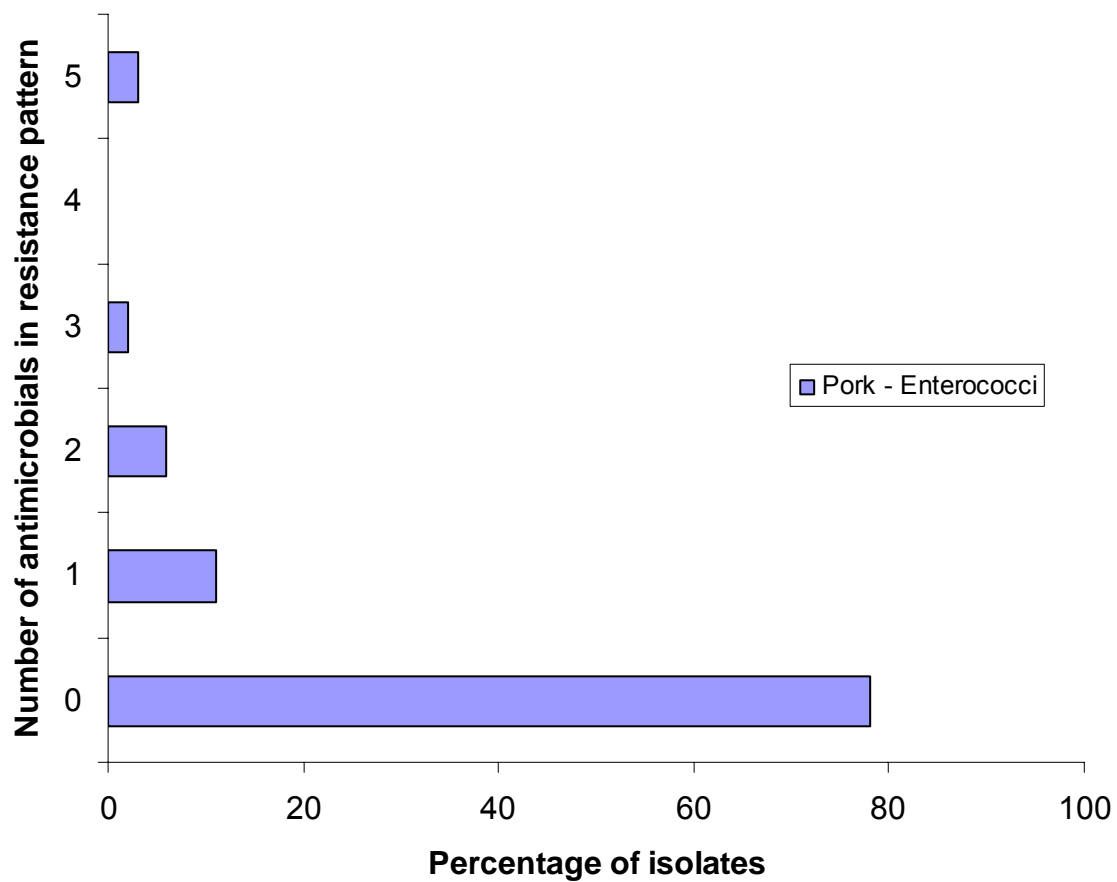


Figure 10. Multiple drug resistance in *Enterococcus faecalis* from retail pork samples (n=100)

Table 15. Distribution of MICs and resistance in *Enterococcus faecalis* from retail poultry, beef, and pork.

Antimicrobial	Product	N =	% Resistant	[95% CI]	Distribution (%) of MICs																								
					0.015	0.03	0.06	0.12	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024	2048	>2048						
Ampicillin	Poultry	100	0.0	[0.00 – 3.62]											98.0	2.0													
	Beef	100	0.0	[0.00 – 3.62]											96.0	4.0													
	Pork	100	0.0	[0.00 – 3.62]											98.0	2.0													
Chloramphenicol	Poultry	100	1.0	[0.03 – 5.45]										6.0	1.0	74.0	18.0	1.0											
	Beef	100	3.0	[0.62 – 8.52]									9.0	15.0	66.0	7.0		3.0											
	Pork	100	2.0	[0.24 – 7.04]									4.0	4.0	86.0	4.0	1.0	1.0											
Daptomycin	Poultry	100	0.0	[0.00 – 3.62]						16.0	39.0	42.0	3.0																
	Beef	100	0.0	[0.00 – 3.62]						39.0	32.0	22.0	7.0																
	Pork	100	0.0	[0.00 – 3.62]						34.0	26.0	36.0	4.0																
Erythromycin	Poultry	100	48.0	[37.90 – 58.22]						45.0	7.0		2.0	3.0			43.0												
	Beef	100	6.0	[2.23 – 12.60]						85.0	7.0	2.0	1.0				5.0												
	Pork	100	7.0	[2.86 – 13.89]						84.0	8.0	1.0					7.0												
Flavomycin	Poultry	100	3.0	[0.62 – 8.52]						12.0	53.0	29.0	3.0				3.0												
	Beef	100	7.0	[2.86 – 13.89]						12.0	39.0	28.0	12.0	2.0		2.0	5.0												
	Pork	100	7.0	[2.86 – 13.89]						84.0	8.0	1.0					7.0												
Gentamicin	Poultry	100	0.0	[0.00 – 3.62]													100.0												
	Beef	100	1.0	[0.03 – 5.45]													99.0										1.0		
	Pork	100	0.0	[0.00 – 3.62]													99.0		1.0										
Kanamycin	Poultry	100	9.0	[4.20 – 16.40]														88.0	3.0	1.0	1.0					7.0			
	Beef	100	3.0	[0.62 – 8.52]														97.0									3.0		
	Pork	100	4.0	[1.10 – 9.93]														96.0									4.0		
Linezolid	Poultry	100	0.0	[0.00 – 3.62]						4.0	7.0	89.0																	
	Beef	100	0.0	[0.00 – 3.62]						10.0	2.0	87.0	1.0																
	Pork	100	0.0	[0.00 – 3.62]						5.0	7.0	87.0	1.0																
Penicillin	Poultry	100	0.0	[0.00 – 3.62]						9.0	20.0	35.0	36.0																
	Beef	100	0.0	[0.00 – 3.62]						30.0	17.0	21.0	32.0																
	Pork	100	0.0	[0.00 – 3.62]						16.0	23.0	22.0	36.0	3.0															
Streptomycin	Poultry	100	5.0	[1.64 – 11.28]																						95.0		1.0	4.0
	Beef	100	3.0	[0.62 – 8.52]																						97.0		2.0	1.0
	Pork	100	5.0	[1.64 – 11.28]																						95.0		2.0	3.0
Teicoplanin	Poultry	100	0.0	[0.00 – 3.62]						99.0	1.0																		
	Beef	100	0.0	[0.00 – 3.62]						100.0																			
	Pork	100	0.0	[0.00 – 3.62]						99.0	1.0																		
Tetracycline	Poultry	100	76.0	[66.43 – 83.98]									23.0	1.0	1.0	3.0	72.0												
	Beef	100	15.0	[8.65 – 23.53]									82.0	3.0	2.0		13.0												
	Pork	100	17.0	[10.23 – 25.82]									81.0	2.0	4.0	2.0	11.0												
Tigecycline	Poultry	100	6.0	[2.23 – 12.60]							3.0	5.0	12.0	34.0	40.0	6.0													
	Beef	100	10.0	[4.90 – 17.62]						2.0	9.0	22.0	40.0	17.0	10.0														
	Pork	100	3.0	[0.62 – 8.52]						2.0	4.0	7.0	22.0	34.0	28.0	3.0													
Vancomycin <sup>1</sup>	Poultry	100	0.0	[0.00 – 3.62]						4.0	10.0	60.0	26.0																
	Beef	100	0.0	[0.00 – 3.62]						3.0	36.0	40.0	21.0																
	Pork	100	0.0	[0.00 – 3.62]						1.0	26.0	45.0	28.0																

Vertical lines indicate breakpoints for resistance.

The white fields denote range of dilutions tested for each antimicrobial. Values above the range denote MIC values greater than the highest concentration in the range. MICs equal to or lower than the lowest concentration tested are given as the lowest concentration.

<sup>1</sup>Five vancomycin resistant *E. faecalis* isolates from each retail meat source (N=15) were randomly chosen and tested for the presence of *vanA* and *vanB* genes using Polymerase Chain Amplification. All 15 vancomycin resistant *E. faecalis* isolates were negative for both *vanA* and *vanB* (Bradbury and Collignon, pers. comm.).

Table 16. Multiple antimicrobial resistance phenotypes present in *Enterococcus faecalis* from retail pork.

Pattern	Resistance phenotype*	Percentage
0	No pattern	78
1	flv	2
1	tet	6
1	tgc	2
1	flv	1
2	flv tet	1
2	str tet	2
2	ery tet	3
3	flv tet tgc	1
3	ery kan tet	1
5	ery flv kan str tet	1
5	chl ery kan str tet	2

\* Ampicillin, amp; Chloramphenicol, chl; Daptomycin, dap; Erythromycin, ery; Flavomycin, flv; Gentamicin, gen; Kanamycin, kan; Linezolid, lzd; Penicillin, pen; Streptomycin, str; Teicoplanin, tei; Tetracycline, tet; Tigecycline, tgc; Vancomycin, van.

### Retail lettuce – *E. coli*

A total of seven *E. coli* were isolated during the 12 month sampling period. The overall prevalence of *E. coli* in retail lettuce was 1.0% and ranged from during monthly sampling 0.0% to 2.5%. The seven *E. coli* isolates were tested for AMR.

*Antimicrobial drug resistance:* The prevalence of multiple drug resistance in *E. coli* is presented in Figure 11. The distribution of MICs and resistance in *E. coli* is presented in Table 18.

Resistance to one or more antimicrobials was observed in 5 of 7 isolates (71%). Resistance to ampicillin (57.1%) was observed most often. Resistance to amoxicillin / clavulanic acid (28.6%), cefazolin (28.6%), streptomycin (14.3%), tetracycline (28.6%) and trimethoprim / sulfamethoxazole (14.3%) was also identified.

*AMR patterns:* A total of 4 AMR patterns were identified in 5 isolates (Table 17). Resistance to ampicillin alone was identified in two isolates. The largest AMR patterns identified were resistance to ampicillin-streptomycin-tetracycline-trimethoprim / sulfamethoxazole (4 antimicrobials; 1 isolate; 14.3%) and amoxicillin / clavulanic acid-ampicillin-cefazolin-tetracycline (4 antimicrobials; 1 isolate; 14.3%).

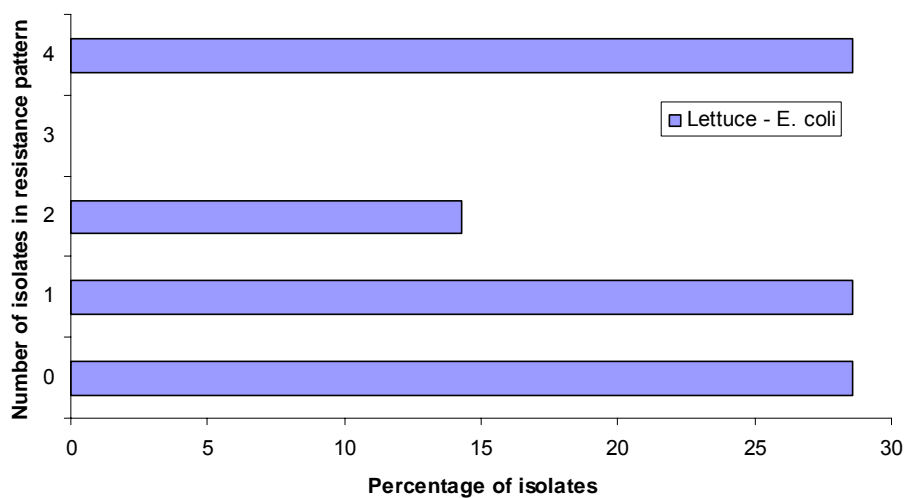


Figure 11. Multiple drug resistance in *E. coli* from retail lettuce samples (n=7)

Table 17. Multiple antimicrobial resistance phenotypes present in *E. coli* from retail lettuce.

Pattern	Resistance phenotype*	Percentage
0	No pattern	29
1	amp	29
2	aug faz	14
4	amp str tet sxt	14
4	aug amp faz tet	14

\* Amoxicillin / Clavulanic acid, aug; Ampicillin, amp; Cefazolin, faz; Cefotaxime, fot; Cefoxitin, fox; Ceftiofur, xnl; Ceftriaxone, axo; Chloramphenicol, Ciprofloxacin, cip; Florfenicol, fn; Gentamicin, gen; Meropenem, mer; Nalidixic Acid, nal; Streptomycin, str; Tetracycline, tet; Trimethoprim / Sulfamethoxazole, sxt.

Table 18. Distribution of MICs and resistance in *E. coli* from retail poultry, beef, pork and lettuce.

Antimicrobial	Product	N =	% Resistant	[95% CI]	Distribution (%) of MICs										
					0.125	0.25	0.5	1	2	4	8	16	32	64	128
Amoxicillin / Clavulanic acid <sup>a</sup>	Poultry	100	1.0	[0.03 – 5.45]				3.0	16.0	57.0	22.0	1.0	1.0		
	Beef	100	3.0	[0.62 – 8.52]				3.0	20.0	63.0	9.0	2.0	2.0	1.0	
	Pork	92	3.3	[0.68 – 9.23]				4.1	7.6	55.4	26.1	6.5	2.2	1.1	
	Lettuce	7	14.3	[0.36 – 57.87]				14.3	42.9		28.6		14.3		
Ampicillin	Poultry	100	38.0	[29.09 – 47.80]					35.0	24.0	1.0	2.0	1.0	3.0	34.0
	Beef	100	11.0	[5.62 – 18.83]					46.0	35.0	3.0	5.0	2.0	2.0	7.0
	Pork	92	28.2	[19.36 – 38.61]					26.1	40.2	3.3	2.2	4.3		23.9
	Lettuce	7	57.2	[18.41 – 90.10]						28.6	14.3			14.3	42.9
Cefazolin	Poultry	100	2.0	[0.24 – 7.04]							96.0	2.0	2.0		
	Beef	100	3.0	[0.62 – 8.52]							90.0	7.0	3.0		
	Pork	92	3.3	[0.68 – 9.23]							90.2	6.5	3.3		
	Lettuce	7	28.6	[3.67 – 70.96]							71.4		28.6		
Cefotaxime	Poultry	100	0.0	[0.00 – 3.62]		100.0									
	Beef	100	0.0	[0.00 – 3.62]		98.0		2.0							
	Pork	92	0.0	[0.00 – 3.93]		100.0									
	Lettuce	7	0.0	[0.00 – 40.96]		71.4	28.6								
Cefoxitin	Poultry	100	0.0	[0.00 – 3.62]					25.0	55.0	17.0	3.0			
	Beef	100	0.0	[0.00 – 3.62]					21.0	55.0	22.0	2.0			
	Pork	92	0.0	[0.00 – 3.93]					8.7	57.6	29.3	4.3			
	Lettuce	7	0.0	[0.00 – 40.96]					42.9	14.3	42.9				
Ceftiofur	Poultry	100	0.0	[0.00 – 3.62]			99.0	1.0							
	Beef	100	0.0	[0.00 – 3.62]			98.0	1.0	1.0						
	Pork	92	0.0	[0.00 – 3.93]			100.0								
	Lettuce	7	0.0	[0.00 – 40.96]			100.0								
Ceftriaxone	Poultry	100	0.0	[0.00 – 3.62]		98.0	2.0								
	Beef	100	0.0	[0.00 – 3.62]		97.0	1.0	2.0							
	Pork	92	0.0	[0.00 – 3.93]		97.8		2.2							
	Lettuce	7	0.0	[0.00 – 40.96]		100.0									
Chloramphenicol	Poultry	100	1.0	[0.03 – 5.45]						37.0	59.0	3.0	1.0		
	Beef	100	0.0	[0.00 – 3.62]					6.0	26.0	67.0	1.0			
	Pork	92	13.0	[6.93 – 21.68]					2.2	18.5	58.7	7.6	8.7	4.3	
	Lettuce	7	0.0	[0.00 – 40.96]					28.6	57.1	14.3				
Ciprofloxacin	Poultry	100	0.0	[0.00 – 3.62]	98.0	2.0									
	Beef	100	0.0	[0.00 – 3.62]	99.0	1.0									
	Pork	92	0.0	[0.00 – 3.93]	97.8	1.1	1.1								
	Lettuce	7	0.0	[0.00 – 40.96]	85.7	14.3									
Florfenicol	Poultry	100	2.0	[0.24 – 7.04]					8.0	62.0	28.0	2.0			
	Beef	100	0.0	[0.00 – 3.62]					7.0	40.0	53.0				
	Pork	92	8.7	[3.83 – 16.42]					3.3	41.3	46.7	8.7			
	Lettuce	7	0.0	[0.00 – 40.96]					42.9	42.9	14.3				
Gentamicin	Poultry	100	4.0	[1.10 – 9.93]				83.0	13.0				4.0		
	Beef	100	0.0	[0.00 – 3.62]				93.0	7.0						
	Pork	92	1.1	[0.03 – 5.91]				87.0	10.9		1.1		1.1		
	Lettuce	7	0.0	[0.00 – 40.96]				100.0							
Kanamycin	Poultry	100	8.0	[3.52 – 15.16]							84.0	8.0			8.0

Antimicrobial	Product	N =	% Resistant	[95% CI]	Distribution (%) of MICs											
					0.125	0.25	0.5	1	2	4	8	16	32	64	128	
	Beef	100	2.0	[0.24 – 7.04]								94.0	4.0			2.0
	Pork	92	3.3	[0.68 – 9.23]								83.7	12.0	1.1	1.1	2.2
	Lettuce	7	0.0	[0.00 – 40.96]								85.7	14.3			
Meropenem	Poultry	100	0.0	[0.00 – 3.62]				99.0	1.0							
	Beef	100	0.0	[0.00 – 3.62]				100.0								
	Pork	92	0.0	[0.00 – 3.93]				100.0								
	Lettuce	7	0.0	[0.00 – 40.96]				100.0								
Nalidixic Acid	Poultry	100	0.0	[0.00 – 3.62]					52.0	47.0	1.0					
	Beef	100	0.0	[0.00 – 3.62]					44.0	54.0	2.0					
	Pork	92	0.0	[0.00 – 3.93]					29.3	66.3	4.3					
	Lettuce	7	0.0	[0.00 – 40.96]						85.7	14.3					
Streptomycin	Poultry	100	19.0	[11.84 – 28.07]										81.0	4.0	15.0
	Beef	100	7.0	[2.86 – 13.89]										93.0	4.0	3.0
	Pork	92	17.4	[10.28 – 26.70]										82.6	8.7	8.7
	Lettuce	7	14.3	[0.36 – 57.87]										85.7	14.3	
Tetracycline	Poultry	100	47.0	[36.94 – 57.24]						53.0		5.0	8.0		34.0	
	Beef	100	7.0	[2.86 – 13.89]						91.0	2.0				7.0	
	Pork	92	44.5	[34.19 – 55.30]						54.3	1.1	1.1	4.3		39.1	
	Lettuce	7	28.6	[3.67 – 70.96]						71.4			14.3		14.3	
Trimethoprim / Sulfamethoxazole	Poultry	100	22.0	[14.33 – 31.39]	65.0	9.0	3.0	1.0				22.0				
	Beef	100	5.0	[1.64 – 11.28]	90.0	2.0	2.0		1.0	3.0		2.0				
	Pork	92	13.0	[6.93 – 21.68]	67.4	16.3	3.3			4.3		8.7				
	Lettuce	7	14.3	[0.36 – 57.87]	85.7							14.3				

Vertical lines indicate breakpoints for resistance

The white fields denote range of dilutions tested for each antimicrobial. Values above the range denote MIC values greater than the highest concentration in the range. MICs equal to or lower than the lowest concentration tested are given as the lowest concentration

<sup>a</sup> Concentration of amoxicillin given, tested with clavulanic acid in concentration 2:1