# FINAL REPORT

# FS102109 - EU Harmonised Surveillance of Antimicrobial Resistance (AMR) *in E. coli* Bacteria from Retail Meats (Year 5 - Beef and Pork, 2019)

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# 1. Liability statement

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## 2. Lay person's summary

In accordance with European Directive **2003/99/EC** on the monitoring of bacteria that can pass from animals to humans and causes disease (zoonoses and zoonotic agents), Member States (MS) are obliged to ensure that procedures are in place to monitor and report on the occurrence of antimicrobial resistance (AMR) in such bacteria.

The requirements (with additional detailed guidance from the EU Reference Laboratory for Antimicrobial Resistance) state that 300 retail beef and 300 retail pork should be tested by culture for the bacterium *E. coli. E. coli* bacteria are a normal part of the gut flora of mammals and as such can be useful "indicator" bacteria for AMR. Whilst some strains of *E. coli* can cause disease, most strains of *E. coli* can be present in healthy animals and humans.

The EU requirements state that samples should be tested on an agar that will select for a resistance to antibiotics known as third generation cephalosporins, and such antibiotics are important for treating infections in humans. *E. coli* from this agar normally show two main types of resistance types known as Extended Spectrum β-lactamase (ESBL) or AmpC type resistance. Isolates from this agar were then tested by performing Minimum Inhibitory Concentrations (MICs) to determine the susceptibility / resistance of isolates to a panel of antibiotics.

EU requirements also state that samples should be tested on two agars that will select for bacterial resistance to a group of antibiotics known as carbapenems. Carbapenem antibiotics are also really important in human medicine, and are termed "last resort" antibiotics, used to treat infections when all or almost all other treatment options are non-viable, due to the target bacteria being resistant to most / all other relevant antibiotics.

The numbers or counts of *E. coli* bacteria on meat samples are also tested using EU methods. These bacterial counts are determined using an agar to detect all *E. coli* as well as the EU specified agar to detect ESBL or AmpC type *E. coli*. These counts are to determine what the levels of all *E. coli* and ESBL AmpC type *E. coli* are on the meat samples.

At the request of the FSA, other agars were used to test UK samples (UK non-harmonised additional test) for *E. coli* isolates with ESBL phenotype and / or colistin resistance. Colistin is another “last resort” antibiotic, so it is important to monitor if *E. coli* with resistance to this type of antibiotic is occurring in food samples.

Other additional work, outside of the scope of the EU survey (UK non-harmonised additional tests), also requested by the FSA, included genetic tests to determine what antibiotic resistance genes were associated with ESBL and colistin resistance in *E. coli* isolates. For colistin resistance, mobile colistin resistance genes referred to as *as mcr-1, mcr-2 and mcr-3* were discovered in the last few years so colistin resistant *E. coli* were tested for these three genes. The *mcr* genes are considered particularly important as they encode resistance to the “last resort” antibiotic colistin, and as they are mobile they have the potential to transfer resistance in the gut to other bacteria.

The survey required representative random colletion of a range of chilled, fresh beef and pork meats from retail premises across the UK, as outlined in some detail later in the report.

The aim was to collect 315 beef samples and 315 pork samples, 300 of each meat type with 5% extra. Between January and December 2019, 315 beef and 313 pork samples were collected as one pork sample was received by the laboratory after the ‘use by date’ whilst another pork sample was duplicated.

Due to a technical issue with selective agar affecting some of the samples tested in December 2019, it was decided, following discussion with the FSA, to exclude all meat samples tested in that month from analysis. As such, of the 315 and 313 beef and pork samples tested for the entire year, 289 and 285 beef and pork samples (collected from January to November 2019) were considered eligible for reporting.

Overall, results were very similar to the 2015 and 2017 surveys (no statistically significant differences), in that only 0.35% of beef and 1.05% of pork UK retail meats tested in 2019 were positive for AmpC- or ESBL-producing *E. coli* (third generation cephalosporin resistance) respectively using a sensitive detection method. Additionally, none of the samples gave rise to viable counts of *E. coli* above the detection limit of 100 bacteria per gram of meat on the two agars used, indicating numbers of total and resistant *E. coli* in these samples were either absent or very low (less that 100 *E. coli* per gram of meat). It is possible that a sample can be negative by counts but positive following enrichment, as enrichment is a more sensitive detection method, capable in theory of detecting one target *E. coli* from 25 grams of meat.

None of the samples in the survey were found to be contaminated with *E. coli* resistant to the last resort carbapenem antibiotics ertapenem, imipenem and meropenem, or with *E. coli* positive for the plasmid mediated colistin resistance genes *mcr1, mcr2 or mcr-3.*

In 2017, EU monitoring of beef and pork for presumptive ESBL-/AmpC-/carbapenemase-producing *E. coli* was performed by 28 Member States (MSs) and three non-MSs on meat. Results in 2019 for UK beef and pork compared favourably with results for beef and pork from other countries in 2017. In 2017, of 6,621 and 6,803 beef and pork samples tested by all countries that took part in testing, 4.8% and 6% of samples respectively yielded AmpC or ESBL or Amp+ESBL phenotype *E. coli*, compared to 0.35% for beef and 1.05% for pork from the UK in 2019.

## 3. Project summary

In accordance with European Directive **2003/99/EC** on the monitoring of zoonoses and zoonotic agents, Member States (MS) are obliged to ensure that procedures are in place to monitor and report on the occurrence of antimicrobial resistance (AMR) in zoonotic organisms. The European Commission Implementing Decision **2013/652/EU**, which came into force on **1 January 2014**, outlines the technical requirements for AMR testing, as well as the organisms and livestock species in which AMR must be monitored and reported. Mandatory requirements are set out for MS to monitor and report AMR data for *Salmonella* spp., *Campylobacter jejuni*, indicator commensal *Escherichia coli*, AmpC and extended-spectrum beta-lactamase (ESBL) *E. coli* and carbapenemase producing *E. coli.*

This report outlines the procedures put in place to fulfil these requirements for UK retail beef and pork in 2019 for AmpC, ESBL and carbapenem resistant *E. coli*, following European Union (EU) guidelines and methods. The requirements (with additional detailed guidance from the EU Reference Laboratory for Antimicrobial Resistance) state that 300 retail beef and 300 retail pork samples should be tested by culture for *E. coli* on MacConkey agar containing 1 mg/L of the cephalosporin antibiotic cefotaxime (MCA-CTX). *E. coli* isolates cultured from such media are expected to show resistance to third generation cephalosporin antibiotics. Samples were also tested for carbapenem resistant *E. coli* by plating to chromID® CARBA (CARBA) and chromID® OXA-48 (OXA-48) agars as recommended by the EU.

Finally, viable counts as colony forming units per gram of meat (cfu/g) of all *E. coli* and AmpC and ESBL-phenotype *E. coli* for all samples were also determined on MacConkey agar (MCA) and MCA-CTX agars, respectively.

Isolates from MCA-CTX were tested by performing Minimum Inhibitory Concentrations (MICs) to determine their susceptibility to a panel of antibiotics.

At the specific request of the FSA (outside of the remit of Decision **2013/652/EU**), all samples were also plated to CHROMagar™ ESBL (CA-ESBL), for specific detection of Extended Spectrum β-lactamase-producing (ESBL) *E. coli* and to MacConkey agar containing 2 mg/L colistin (MCA-COL), for detection of colistin resistant *E. coli*. Other additional work included a multiplex PCR to detect $bla_{CTX-M}$, $bla_{OXA}$, $bla_{SHV}$ and $bla_{TEM}$ genes [1] for *E. coli* isolated from CA-ESBL agar, and sequencing of the $bla_{CTX-M}$ genes in CTX-M positive isolates from this agar.

Presumptive *E. coli* from MCA-COL were also tested for the presence of plasmid mediated colistin resistance genes *mcr1*, *mcr2* and *mcr3* [2].

For this study, the Animal and Plant Health Agency (APHA) worked in collaboration with Hallmark Veterinary Compliance Services, who arranged sampling, collection and posting of retail meat samples to APHA, and have reported separately on the sample details.

The survey required representative random collection across the UK of different chilled beef and pork fresh meat categories, outlined in some details later in the report.

A bespoke 'in-house' APHA Standard Operating Procedure (SOP) based on published EU test methods was used as per previous survey years. The method involved homogenisation of 27 grams of meat in 243 mls of Buffered Peptone Water (BPW), prior to removal of 20 mls of BPW homogenate for viable bacteria counts, and subsequent incubation of 250 mls BPW homogenate for enrichment prior to plating to selective agars.

The method has the theoretical potential to detect one target *E. coli* (e.g. AmpC or ESBL or carbapenem resistant or colistin resistant depending on final agar) in 25 grams of meat.

Homogenisation, in agreement with the FSA and EURL, was performed in BPW only, and not saline also, as per the EU method for counts [3]. This was done so that only one meat aliquot per meat sample required homogenisation and only after equivalent results were shown following homogenisation in saline and BPW for a subset of samples.

Due to a technical issue with MacConkey + 1 mg/L cefotaxime agar affecting some of the samples tested in December 2019, it was decided, following discussion with the FSA, to exclude all meat samples tested in that month from analysis. As such, of the 315 and 313 beef and pork samples tested for the entire year, 289 and 285 beef and pork samples (collected between January and November 2019) were considered eligible for reporting (96.3% and 95% of required beef and pork number respectively).

Overall, results were very similar to the 2015 and 2017 surveys (no statistically significant differences), in that only one beef sample (0.35%, 95% confidence interval 0.06% to 1.90%) and three pork samples (1.05%, 95% confidence interval 0.36% to 3.05%) tested were positive for AmpC-/ESBL-producing *E. coli* (third generation cephalosporin resistance) on MCA-CTX agar, using a sensitive detection method.

The beef sample and one of the pork samples that were positive on MCA-CTX agar were also positive on CA-ESBL agar (UK non-harmonised additional test). The resulting isolates tested were found to be positive for CTX-M 14 (beef) and CTX-M 24 (pork). Two additional pork samples not positive on MCA-CTX was also positive on CA-ESBL agar, and the resulting isolate tested were found to be positive for CTX-M 1 and CTX-14.

None of the beef and pork samples gave rise to viable counts of *E. coli* above the detection limit of 100 bacteria per gram of meat on the two agars used, indicating numbers of total and AmpC/ESBL-phenotype *E. coli* in these samples were either absent or very low (less that 100 *E. coli* per gram of meat).

None of the meat samples tested (n=574) were found to have carbapenem resistant *E. coli* on CARBA and OXA-48 agars by the EU harmonised method.

None of the meat samples (n=574) were found to be contaminated with *E. coli* resistant to the last resort carbapenem antibiotics ertapenem, imipenem and meropenem, or with *E. coli* positive for the plasmid mediated colistin resistance genes *mcr1, mcr2* or *mcr-3.*

Determination of the susceptibility of *E. coli* from MCA-CTX agar to a panel of relevant antibiotics allowed phenotypic characterisation of third generation cephalosporin resistance [4].

For an isolate to be designated as ESBL-phenotype it had to be resistant to cefotaxime and / or ceftazidime, but susceptible to cefoxitin. Additionally, the isolate needed to show increased sensitivity to cefotaxime and / or ceftazidime in the presence of the beta-lactamase inhibitor clavulanic acid [4].

For an isolate to be designated as AmpC-phenotype it had to be resistant to cefoxitin and also resistant to cefotaxime or ceftazidime. Additionally, the isolate needed to show no increased sensitivity to cefotaxime and / or ceftazidime in the present of the beta-lactamase inhibitor clavulanic acid [4].

One of the pork isolates from MCA-CTX agar had an AmpC-phenotype, whilst the remaining three isolates from MCA-CTX agar (one from beef and two from pork) had an ESBL-phenotype.

The percentages of 285 pork samples therefore that were positive for AmpC-phenotype *E. coli* were 0.35% (95% confidence interval 0.06% to 1.96%). The percentages of 289 beef and 285 pork samples therefore that were positive for an ESBL-phenotype were 0.35% (95% confidence interval 0.06% to 1.90%) and 0.70% (95% confidence interval 0.19% to 2.52%) respectively.

As would be expected, all isolates from MCA-CTX agar were microbiologically resistant using EUCAST ECOFFs [5] to the beta-lactam antibiotic ampicillin, since they were isolated on agar with the beta-lactam antibiotic cefotaxime, and resistance to cefotaxime would also confer resistance to ampicillin. All of the isolates from MCA-CTX agar were also resistant to the cephalosporin antibiotics cefotaxime and ceftazidime, and for the AmpC isolate to cefoxitin also.

None of the isolates from MCA-CTX agar were resistant to the last resort antibiotics colistin, ertapenem, imipenem or meropenem.

Overall, results showed that less than 1% of retail beef and pork samples in the UK that were tested were positive for AmpC-/ESBL-phenotype *E. coli* using a sensitive detection method. These results were similar to previous UK surveys of 2015 and 2017.

In 2017, EU monitoring of beef and pork for presumptive AmpC-/ESBL-/carbapenemase-phenotype *E. coli* was performed on a mandatory basis by 28 member states (MSs) and three non-MSs [6]. Of 6,621 beef samples tested, 1.1% and 3.9% were positive for AmpC- and ESBL-phenotype *E. coli* respectively [6] 1.6% and 4.7% of the 6,803 pork samples were positive for AmpC- and ESBL-phenotype *E. coli*, respectively [6].

Beef samples positive for AmpC- and ESBL-phenotype *E. coli* in 2017 ranged from 0% in Estonia, Finland, Iceland and Norway to low or moderate levels in most other countries, up to a maximum of 13.1% of samples in Malta [6].

For pork samples in 2017, samples from Finland, Luxembourg, Sweden and Iceland were negative, and in most other countries levels of samples positive were low to moderate, up to a maximum of 14.4% of samples positive for AmpC- and ESBL-phenotype *E. coli* in Romania [6].

The levels of beef and pork samples positive for AmpC-/ESBL-phenotype *E. coli* in the UK in 2019 compared favourably to the levels of samples positive other European countries that took part in testing in 2017.

## 4. Glossary

**AmpC phenotype** – Antimicrobial resistance profile type with resistance typically to cephalosporin antimicrobials including cefoxitin and also to β-lactamase inhibitor-β-lactam combinations

**AmpC enzyme** – Enzyme conferring AmpC type resistance

**AMR** – Antimicrobial resistance

**APHA** – Animal and Plant Health Agency

**BPW** – Buffered Peptone broth, a liquid media widely used to grow bacteria

**CRL** – Community Reference Laboratory

**CTX-M** – group of ESBL enzymes that give bacteria resistance to cephalosporin antimicrobials.

**Enterobacteriaceae** – Family of bacteria including many common gut bacteria such as *Escherichia coli* or *E. coli*

**CA-ESBL** - CHROMagar™ ESBL, for isolation of ESBL-producing *E. coli*

**CARBA** - ChromID® CARBA agar, for isolation of carbapenemase resistant *E. coli*

**COL** - Colistin

**CTX** – Cefotaxime

**ECOFF** – Epidemiological Cut Off value (with respect to antimicrobial resistance)

**EN** - Norme Européenne /Europäische Norm (European Standard)

**ESBL** – Extended Spectrum β-lactamase. Enzymes that are capable of breaking down many penicillin type antimicrobials, including cephalosporin antimicrobials.

**ESBL phenotype** – Antimicrobial resistance profile type with resistance typically to cephalosporin antimicrobials but excluding resistance to cefoxitin and β-lactamase inhibitor-β-lactam combinations

**EU** – European Union

**EUCAST** - European Committee on Antimicrobial Susceptibility Testing

**EURL** - European Union reference laboratories.

**FSA** – Food Standards Agency

**HCCA** - α-Cyano-4-hydroxycinnamic acid

**ISO** - International Organisation for Standardisation

**MALDI ToF** – Matrix-Assisted Laser Desorption / Ionization Time-of-Flight

**MCA** – MacConkey agar

**MCA-COL** – MacConkey agar + 2 mg/L colistin

**MCA-CTX** - MacConkey agar + 1 mg/L cefotaxime

**MIC** – Minimum Inhibitory Concentration

**MS** – Member States

**NUTS** - Nomenclature of Units for Territorial Statistics

**OXA-48** - ChromID® OXA-48 agar, for isolation of carbapenemase resistant *E. coli*

**PBS** – Phosphate Buffered saline

**PHENOTYPE** – In this context, antimicrobial resistance type

**QC** – Quality control

**SOP** – Standard Operating Procedure

# 5. Materials and Methods

## 5.1 Sampling criteria - taken from the HallMark report

The survey required representative random collection of a range of different chilled, fresh beef and pork retail meats across the UK; totalling 600 retail meat samples plus an additional 5% for contingency purposes [7].

The samples were allocated in proportion to market-share for outlet type and to population (NUTS-3) [7]. The sampling was split equally between the four quarters of the year, spreading out the collection days within each quarter to further increase the temporal coverage of the survey [7]. Due to the requirement to use the latest and most relevant data, the sampling plan for the 2017 red meat survey was updated; however, the same basic approach was used [7].

The 2019 red meat sampling plan used "proportionate stratified sampling" to allocate samples to NUTS3 areas and the samples were distributed almost in proportion to population size [7]. Eighty NUTS-3 locations with representation of England, Scotland, Wales and Northern Ireland that covers at least 80% of the total population were selected [7].

Samples were taken from all but the smallest NUTS 3 regions in the UK [7]. The population of GB NUTS3 regions was calculated from the latest MYE2 mid-year population estimates published by the Office of National Statistics [7]. For Northern Ireland, equivalent statistics produced by NISRA were used [7]. The number of samples allocated in each NUTS-3 area were proportional to the population size [7].

FSA suggested limiting sampling for 2019 to the same 11 supermarkets plus "Shops not on the list" [7]. This accounts for 94% of market share as based on the 2016/17 Family Food data which were provided by the FSA Statistics Branch [7].

The relevant fresh meat cut categories sampled repeated the cuts collected during the same study in 2017 [7]. Processed meat, minced meat, joints or meat with added herbs/spices were all excluded from sampling [7].

The pork samples categories were chops, fillets & steaks or other diced/sliced pork [7]. Each sample was randomly assigned to a cut category, according to the consumption data which maximise the power of detecting different AMR between these cut categories [7].

The beef samples categories were less expensive steaks, expensive steaks or other diced/sliced beef [7]. Steaks that cost under £2/100g were considered less expensive [7]. Each sample was randomly assigned to a cut category according to the consumption data [7]. The sampling of the beef and pork cuts were based on the proportions provided by FSA [7].

## 5.2 Work performed at APHA Weybridge

The methodology with respect to the work performed is detailed in ten internal APHA Standard operating procedures (SOPs, not included in this report).

These SOPs are:

- Isolation of background (indicator commensal) and antibiotic resistant Enterobacteriaceae from meats and caecal contents according to CRL, EU and / or APHA protocols (CBU 0278).
- Microbank -70ºC Bacterial Storage System (CBU 0155).
- Identification of Bacteria by Oxidase (BA 050) and Indole Spot Test – a Rapid Method for Bacteria (BA0130) and by MALDI ToF (BAC 0334).
- Minimum Inhibitory Concentration (MIC) – The Sensititre Method (BA0604).
- Oxidase (BA 050)
- Identification of bacteria by MALDI ToF (BAC0334)
- Real Time PCR for plasmid mediated colistin resistance genes *mcr-1*, *mcr-2* and *mcr3* (BAC0415).

The methodology is summarised briefly below.

### 5.2.1 Isolation of background (indicator commensal) and antibiotic resistant Enterobacteriaceae from meats and caecal contents according to EU and / or APHA protocols.

The methodology follows that outlined in EU documents. The SOP CBU 0278 is based on these EU methods as below.

- **EU method -** Isolation of ESBL, AmpC and carbapenemase producing *E. coli* from fresh meat – December 2017
- **EU method -** Validation of selective MacConkey agar plates supplemented with 1 mg/L cefotaxime for monitoring of ESBL and AmpC-producing *E. coli* in meat and animals - November 2017
- **EU method** - Validation of selective and indicative agar plates for monitoring of carbapenemase-producing *E. coli* - January 2015
- **EU method -** Quantification of ESBL/AmpC-producing *E. coli* in caecal content and fresh meat samples - December 2017

Pdf files of the most recent versions of the above EU methods can be found on-line at EU protocols.

In agreement with the EURL and the FSA, a minor modification of the EU method for the quantification of ESBL/AmpC-producing *E. coli* in caecal content and fresh meat samples was made. This modification was made so that only one aliquot per meat sample was homogenised in chilled BPW.

The rationale for this change was that:

i. Counts should be identical for homogenisation in chilled BPW or chilled saline.
ii. Homogenisation of two different meat sample samples could in theory give rise to slightly different counts, as such if possible, it is better to homogenise one sample.

iii. There would be savings in media costs and staff time.

The change was only implemented after a number of samples tested with homogenisation in both BPW and saline gave identical results.

Thus, rather than homogenisation of 25 grams of meat in 225 mls of saline (for counts) and homogenisation of a further 25 grams of meat in 225 mls BPW (for enrichment), one lot of 27 grams of meat was homogenised in 243 mls BPW and 20 mls of the meat:BPW homogenate was taken for counts. This leaves 250 mls meat: BPW homogenate as per the original method.

In brief, 27 grams of retail meat sample collected, transported and stored under conditions as stipulated by the EU protocols, was homogenised in ~ 100 ml (from 243 ml sterile chilled BPW) of sterile chilled BPW, before adding this homogenate to the remaining BPW and gently mixing, providing 270 ml of BPW homogenate.

From this 270 ml BPW homogenate, 20 mls was taken for the viable bacterial counts, which were performed as per the EU protocol on MacConkey agar (MCA) and MacConkey agar containing 1 mg/L cefotaxime (MCA-CTX). MCA and MCA-CTX plates for counts were incubated for 18-22 hours at 44 ± 0.5 °C before checking for lactose fermenting colonies.

The remaining 250 mls of BPW homogenate (e.g. 25 grams of meat and 225 mls of BPW as per EU protocols) was incubated at 37 ± 1ºC for 18-22 hours. The incubated BPW / meat homogenate was used to inoculate (10μl) MacConkey agar containing 1 mg/L cefotaxime (MCA-CTX), chromID® CARBA (CARBA) and chromID® OXA-48 (OXA-48).

Samples were also plated to CHROMagar™ ESBL (CA-ESBL), for specific detection of ESBL-producing *E. coli* and to MacConkey agar containing 2 mg/L colistin (MCA-COL), for detection of colistin resistant *E. coli*, and these were additional non-EU stipulated screening agars added at the request of the FSA (**UK non-harmonised tests**).

All plates were quality control (QC) tested prior to use and the week of use, according to EU or APHA methods as appropriate, as outlined in the SOP.

MCA-CTX and MCA-COL plates from enrichment broths were incubated for 18-22 hours at 44 ± 0.5 °C before checking for lactose fermenting colonies. Other media were incubated at 37 ± 1ºC for 18-22 hours, before checking for presumptive *E. coli.*

Lactose fermenters from MCA-CTX were assumed to be presumptive AmpC-/EBSL-producing *E. coli,* red/purple colonies from CA-ESBL were assumed to be presumptive ESBL-producing *E. coli* and pink to burgundy colour colonies from CARBA and OXA-48 agars were assumed to be presumptive carbapenem resistant *E. coli.*

One single presumptive *E. coli* from each of these agars was plated again to the agar of origin and for a further two passages on blood agar, to ensure purity prior to confirmation as *E. coli* and storage pending further tests. If the first presumptive *E. coli* was found not to be *E. coli,* a further two colonies were passaged and tested as above. If neither of these colonies were *E. coli*, the sample was considered negative.

Overall, this method has the theoretical potential to detect one *E. coli* of interest per 25 grams of meat.

From MCA-COL plates, a sweep of ~ 10 to 20 lactose fermenters (based on SOP BAC 0415) was used to prepare a crude DNA sample for detection of *mcr-1, mcr-2* and *mcr-3* plasmid mediated colistin resistance genes by real time PCR. A sweep was taken to increase the sensitivity of detection of the *mcr* genes.

### 5.2.2 Storage of purified presumptive AMPC / EBSL *E. coli* prior to further tests

Isolates will be stored for up to five years to comply with EU requirements. Isolates were stored in duplicate, on “beads” (frozen in cryogenic material at -70ºC).

For “beads”, purified bacterial culture was aseptically transferred using a 10 µl loop from the pure culture on agar to a commercial “beads” tube. The cryogenic liquid and bacterial growth was mixed in the tube, before removing most of the supernatant cryogenic liquid, and then storing the tube at - 70ºC.

### 5.2.3 Identification of Bacteria by MALDI ToF or confirmation of lactose fermenters as *E. coli* using oxidase and indole tests

For lactose fermenters isolated from MCA-CTX at 44ºC, combined use of oxidase and indole tests as described by in-house SOPs, was used to confirm isolates as *E. coli.* Presumptive *E. coli* from other agars, such as CA-ESBL, CARBA and OXA-48, were first streaked to MCA and incubated for 18-22 hours at 44 ± 0.5 °C to confirm isolates as lactose fermenters. If isolates were lactose fermenters, they were then identified as *E. coli* by combined use of oxidase and indole tests as described by in-house SOPs.

For the oxidase test and indole tests, a single well isolated colony was taken from MCA or MCA-CTX agar, plated onto blood agar and incubated overnight at 37ºC. Growth from the blood agar was then used to perform oxidase and indole tests.

For the oxidase test, in-brief, a portion of bacterial colony to be tested was taken with a sterile plastic loop and rubbed onto filter paper impregnated with oxidase reagent. A deep purple colour developing within 10 seconds was taken to be “oxidase positive".

The indole test was performed in the same way but using filter paper impregnated with James reagent (BioMerieux). Within 10 seconds, a positive reaction was indicated by the presence of a colour change to pink/red. Lactose fermenter colonies from MCA-CTX that grew at 44ºC were confirmed as *E. coli* if oxidase negative and indole positive.

MALDI ToF was used for identification of problem isolates giving equivocal results by other tests only if required, or for mucoid lactose fermenting colonies that can be *Klebsiella,* even if oxidase negative and indole positive.

MALDI ToF was used as described by an in-house SOP and based on that previously described [8].

For MALDI ToF identifications, isolates were also grown on blood agar. A small amount of bacterial growth was applied to the metal target plate and overlaid with 1 µl of 70% formic acid to perform a partial protein extraction and allowed to dry.

Each spot was then overlaid with 1 µl of HCCA matrix and allowed to dry before the target plate was loaded into the MALDI ToF machine.

Using Biotyper software, resulting spectra from the MALDI ToF run were searched against the Bruker database of spectra, and if the resulting score was ≥ 2.000, this was taken as reliable identification to the species level, dependant also on consistency score and caveats that might apply for some bacteria species.

### 5.2.4 Determination of Minimum Inhibitory Concentrations (MICs) by broth micro dilution.

MICs were performed as described in our in-house SOP (BA0604), based on EN ISO 20776-1:2006.

*E. coli* isolates were inoculated into Mueller Hinton broth at a suitable dilution for application to commercially prepared plates containing two-fold dilution series of antimicrobial compounds in accordance with Decision 2013/652/EU. After incubation at 37$^{o}$C for 18 hours, the plates were examined and growth end points established for each antimicrobial to provide MIC’s. Microbiologically resistant and susceptible interpretation for the MIC’s were obtained by comparison with ECOFF’s published by EUCAST.

For *E. coli*, the presence of carbapenemase producing strains, ESBL or AmpC enzyme producers was determined by assessing isolate MIC’s against the microbiological breakpoints for meropenem, cefotaxime and ceftazidime.

Any isolates showing a meropenem MIC’s greater than 0.125mg/l, cefotaxime MIC’s greater than 0.25mg/l or ceftazidime MIC’s greater than 0.5mg/l were tested against a further panel of antimicrobials containing cefotaxime, ceftazidime, cefotaxime / clavulanate, ceftazidime / clavulanate, imipenem, ertapenem, temocillin, cefoxitin, cefepime and meropenem.

Isolates confirmed resistant to meropenem were to be considered to carry a carbapenemase.

### 5.2.5 Determination of isolates as AmpC- or ESBL-phenotype

The presence of ESBL-producing *E. coli* strains was determined as follows: Isolates resistant to one or both of cefotaxime and ceftazidime that also had an MIC of greater than 0.125mg/l against cefepime and also showed a reduction in MIC of ≥ 8 fold against combined cefotaxime / clavulanate or ceftazidime / clavulanate when compared with the cephalosporin alone were considered to carry an ESBL.

AmpC-phenotype isolates were resistant to cefotaxime or ceftazidime but also to cefoxitin and showed no reduction to MIC's, or a reduction of less than three dilution steps for cefotaxime or ceftazidime in the presence of clavulanate.

### 5.2.6 Identification of $bla_{CTX\text{-}M}$, $bla_{OXA}$, $bla_{SHV}$ and $bla_{TEM}$ and sequencing of $bla_{CTX\text{-}M}$ genes

Isolates from CA-ESBL were tested for $bla_{CTX\text{-}M}$, $bla_{OXA}$, $bla_{SHV}$ and $bla_{TEM}$ genes using a multiplex PCR as previously described [1]. For $bla_{CTX\text{-}M}$ positive isolates, the sequence type of the $bla_{CTX\text{-}M}$ gene was determined by sequencing of $bla_{CTX\text{-}M}$ amplicons as previously described [9, 10].

### 5.2.7 Real time PCR for plasmid mediated *mcr-1, mcr-2* and *mcr-3* genes

Samples that gave rise to lactose fermenting colonies on MCA-COL were tested for the presence of plasmid-mediated colistin resistance genes *mcr-1, mcr-2* and *mcr-3* by real time (RT) PCR, according to an in-house SOP (BAC0415). To make detection more sensitive, a "sweep" of ~ 10 to 20 colonies was taken to prepare the crude DNA for RT-PCR.

### 5.2.8 Statistical evaluation of positives (AMPC / EBSL *E. coli*) between years

The numbers of positive samples were too small to allow comparison between years using generic methods such as the chi-square contingency table test. Instead, the probability of the observed or more extreme outcomes was exactly calculated, assuming a null hypothesis that samples of each meat from different years were equivalent. Since the numbers of samples from each year were roughly equal, a given number of positive samples from any year was treated as an equivalent outcome to the same number of positive samples from either of the other two years. For example, the observed numbers of positive pork samples (6 in 2015, 1 in 2017 and 3 in 2019) were treated as 6 from any one year, 3 from another year and 1 from the remaining year.

# 6. Results

## 6.1 General considerations

An excellent collaborative partnership continued with the company contracted by FSA to supply the meat samples (HallMark Veterinary and Compliance Services). Communication between the two organisations and all other aspects of the partnership were excellent.

## 6.2 Details of the meat samples tested.

The background details of the meat samples tested have been provided as part of the report produced by HallMark Veterinary Compliance Services [7]. The main details of each meat sample tested are listed in Tables 1 and 2 of this report for beef and pork respectively, with anonymised codes for all shops and brands if two or more samples were obtained for the brand.

As stated in the methods, the survey required representative random collection across the year of a range of different chilled, fresh beef and pork retail meats across the UK; totalling 300 of each meat type plus an additional 5% for contingency purposes [7].

Due to a technical issue with selective agar affecting some of the samples tested in December 2019, it was decided, following discussion with the FSA, to exclude all meat samples tested in that month from analysis. As such, of the 315 and 313 beef and pork samples tested for the entire year, 289 and 285 beef and pork samples (collected from January to November 2019) were considered eligible for reporting.

The different countries of origin of the meats samples is summarised in Table 3. Meat samples originated mainly in the UK, but were also from Argentina, Belgium, Denmark, the EU (country not stated), France, Germany, Ireland, the Netherlands and Spain. After the UK, the second highest number of beef samples came from Ireland, whilst the second highest number of pork samples came from Germany (Table 3).

The origin of the meat samples in relation to the different supermarkets (in code) is shown in Table 4. There was a relatively even distribution of beef and pork obtained from the different supermarkets. Most meats samples (at least 30 samples of both beef and pork from one supermarket) originated from supermarkets B, C and H and the fewest of samples (less than 10) originated from supermarkets D and F.

As for supermarkets, there was also a relatively even spread of beef and pork across different brands (Table 5). Most samples (at least 20 for both beef and pork for a specific brand) were from brands C2, G1, H1 and Q2.

## 6.3 Samples positive on MacConkey agar + 1 mg/L cefotaxime – EU harmonised method

One beef sample (0.35%, 95% confidence interval 0.06% to 1.90%) and three pork samples (1.05%, 95% confidence interval 0.36% to 3.05%) tested were positive for AmpC- or ESBL-producing *E. coli* (third generation cephalosporin resistance) on MCA-CTX agar using a sensitive detection method (Table 6).

Based on MIC results, it was possible to determine if *E. coli* were AmpC- or ESBL-phenotype. One *E. coli* from pork was AmpC-phenotype, whilst the remaining three *E. coli* were ESBL-phenotype (Table 6).

The percentages of 285 pork samples therefore that were positive for AmpC-phenotype *E. coli* were 0.35% (95% confidence interval 0.06% to 1.96%).

The percentages of 289 beef and 285 pork samples therefore that were positive for an ESBL-phenotype were 0.35% (95% confidence interval 0.06% to 1.90%) and 0.70% (95% confidence interval 0.19% to 2.52%), respectively.

## 6.4 Samples positive on CHROMagar™ ESBL - UK non-harmonised additional test

The beef sample and one of the pork samples positive on MCA-CTX agar were also positive on CA-ESBL agar.

The resulting isolates tested were found to be positive for CTX-M 14 (beef) and CTX-M 24 (pork) (Table 6). Two additional pork samples not positive on MCA-CTX was positive on CA-ESBL agar, and the resulting isolate tested was found to be positive for CTX-M 14 and CTX-1 (Table 6).

### 6.5 Samples positive for carbapenem resistance — EU harmonised method

None of the samples tested (n=574) were positive for carbapenem resistant *E. coli* on CARBA and OXA-48 agars by the EU harmonised method.

### 6.6 MIC results for isolates from MCA-CTX agar - EU harmonised method

A summary of resistances derived from MIC results for the different phenotypes of the four *E. coli* isolated from MCA-CTX agar shown in Table 7.

Individual MIC results for each of the four isolates tested are shown in Table 8.

As would be expected, since the isolates were obtained from agar containing 1 mg/L of the beta-lactam antibiotic cefotaxime, all isolates were resistant to the beta-lactam antibiotic ampicillin, and to the cephalosporin antibiotics cefepime, cefotaxime and ceftazidime (Tables 7 and 8).

None of the isolates were resistant to chloramphenicol, ciprofloxacin, gentamycin, nalidixic acid, temocillin or tigecycline (Tables 7 and 8).

Additionally, none of the isolates were resistant to the last resort carbapenem antibiotics ertapenem, imipenem and meropenem or to colistin (Tables 7 and 8).

## 6.7 Bacterial counts - EU harmonised method

None of the beef and pork samples gave rise to viable counts of *E. coli* above the detection limit on MCA (total *E. coli*) and MCA-CTX (AmpC-/ESBL-phenotype *E. coli*) agars. This indicated that the numbers of total and AmpC-/ESBL-phenotype *E. coli* on these samples were either absent or low.

## 6.8 Samples positive for colistin resistant *E. coli* - UK non-harmonised additional test

A total of 45 samples gave rise to lactose fermenting colistin resistant colonies on colistin agar (MCA-COL).

Positives comprised 22/289 (7.60%, 95% confidence interval 5.08% to 11.26%) beef samples and 23/285 (8.07%, 95% confidence interval 5.44% to 11.82%) pork samples.

PCR tests from ~ 10 to 20 lactose fermenter colonies from this agar for plasmid mediated colistin resistance genes *mcr1, mcr2* or *mcr-3* were all negative.

### 6.8.1 Statistical evaluation of positives (AMPC / EBSL *E. coli*) between years

Overall, results were consistent with the 2015 and 2017 EU surveys, in that only one beef sample (0.35%, 95% confidence interval 0.017% to 1.69%) and three pork samples (1.05%, 95% confidence interval 0.27% to 2.84%) tested were positive for AmpC-/ESBL-producing *E. coli* (third generation cephalosporin resistance) on MCA-CTX.

There was no significant evidence that the frequency of positive samples differed between years: assuming the null hypothesis that all samples were equivalent regardless of year, exact calculation, using the binomial probability distribution and the observed overall frequency of positives, found that the probability that two years would have at least 2 positive samples, while one year would have no more than 1 positive sample, as observed in beef = 0.373. For the observations in pork, the probability that one year would have at least 6 positive samples, one year would have no more than 1 positive sample, and the third year would have no more than 3 positive samples = 0.064, which, as the less likely of two test outcomes, cannot be considered significant.

# 7. Discussion

The discussion from the 2017 report on “EU Harmonised Surveillance of Antimicrobial Resistance (AMR) in *E. coli* from Retail Meats (Year 3 – Beef and Pork)” is given in the appendix of this report [11]. Much of the discussion relating to previous studies of ESBL-producing *E. coli* in raw beef and pork in the UK and other countries is of relevance for this 2019 survey. It is recommended to read this previous discussion if a wider background overview is required. The discussion below focuses on results from the 2019 survey.

The EFSA have now reported the prevalence of AmpC and ESBL producing *E. coli* in beef and pork from 23/24 member states and 2/2 non-member states in 2015 [12] and from 28 member states and 3 non-member states in 2017 [6]. In total from all states, in 2015/2017, 5,329/6,621 retail beef samples and 5,350/6,803 retail pork samples were tested.

From beef, the EFSA data for all results shows that for 2015/2017, 5.0%/3.9%, 1.8%/1.1% and 0.3%/0.1% of all samples were positive for ESBL or AmpC or AmpC+ESBL phenotype *E. coli* respectively (Figure 1).

From pork, the EFSA data for all results shows that for 2015/2017, 7.0%/4.7%, 2.3%/1.6% and 0.4%/0.3% of all samples were positive for ESBL or AmpC or AmpC+ESBL phenotype *E. coli* respectively (Figure 1).

These results suggest a slight decline in AmpC-/ESBL-producing *E. coli* overall in beef and pork in the EU and member states that participated between 2015 and 2017.

In both 2015 and 2017 there was variation of levels or AMR *E. coli* isolated from beef and pork from different countries. For example, this ranged from no AmpC-/ESBL-producing *E. coli* detected from beef and or pork samples from some countries, to maximum levels of 11.5%/17.3% of beef samples from Bulgaria being positive for AmpC-/ESBL-producing *E. coli* in 2015 and in the same year 6.6%/21.3% of pork samples from the Czech Republic and Portugal respectively being positive for AmpC-/ESBL-producing *E. coli.*

In 2017 the maximum levels of beef and pork samples positive for AmpC-/ESBL-producing *E. coli* in different countries had fallen compared to the 2015 results.

As such in 2017 for beef, the maximum levels of samples positive for AmpC-/ESBL-producing *E. coli* per country was 5.0%/10.5% for the Czech Republic and Portugal respectively. For pork, these values in 2017 were 4.7%/10.1% for AmpC-/ESBL-producing *E. coli* from the Romania and the Czech Republic, respectively.

For beef this represent a fall in the maximum positivity of AmpC/ESBL *E. coli* of all countries tested of 11.5%/17.3% to 5.0%/10.5%, whilst for pork the fall was from 6.6%/21.3% to 4.7%/10.1%, between 2015 and 2017, as summarised in Figure 3.

Across the UK, the evidence shows that the levels of AmpC-/ESBL-phenotype *E. coli* in beef and pork have remained at a low stable level over the years 2015, 2017 and 2019 (no statistically significant differences in positives across these years). These levels have been 0.35% to 0.64% for beef and 0.32% to 1.92% for pork (Figure 3).

There was a drop in the numbers of samples that gave rise to lactose fermenters on colistin agar (MCA-COL) in 2019 compared to 2017. In 2017 21.4% of beef samples and 14.8% of pork samples were positive on MCA-COL agar. This dropped to 7.60% of beef samples and 8.07% of pork samples positive in 2019.

In 2017, one beef steak sample (expensive steak) of foreign providence was found to be positive for *mcr-1* plasmid mediated colistin resistant *E. coli*. However, for the 2019 samples, although some samples gave rise to lactose fermenters on MCA-COL agar, none were positive for *mcr-1,2,3* plasmid mediated colistin resistant *E. coli*.

Since the discovery of plasmid mediated colistin resistance in pigs in China in 2015[13], there has been a decrease of use of colistin in veterinary medicine in the UK.

In 2015, 0.12 mg/kg of colistin was used in food producing animals in the UK, but has reduced to 0.0007 mg/kg in 2018. In particular, colistin use in pigs dropped from 0.86 mg/kg in 2015 to 0.004 mg/kg in 2018, representing a reduction of 99.6% [14].

During this time period colistin was not reported to be used in beef cattle, although its use in dairy cattle dropped from 0.007 to 0 mg/kg between 2017 and 2018 [14].

It is possible that the overall reduction of use of colistin on farms in the last few years may have contributed to the slight reduction in colistin resistant lactose fermenting colonies isolated from beef and pork between 2017 and 2019.

As for the 2017 results, none of the meats were positive for carbapenem resistant *E. coli.*

With respect to bacterial counts, in 2017, for the 624 beef and pork retail samples tested, none gave rise to presumptive *E. coli* counts on MCA-CTX agar and / or CA-ESBL agars above the detection limit of 40 cfu/gram of meat. The count results were overall the same for 2019 samples as for 2017 samples, but there were differences in the method between these two years. For the 2019 meats, the bacterial counts method was harmonised to the EU testing method. As such, MCA-CTX agar was still used, but instead of CA-ESBL, MCA (MacConkey agar without supplements) was used.

MCA agar does not contain antibiotics, whilst both agars used for the 2017 study contained agents to select for either AmpC-/ESBL-producing *E. coli* or ESBL-producing *E. coli.* As such, for the 2019 counts, results show that the levels of both AmpC-/ESBL-producing *E. coli* and background *E. coli* were below detection levels.

Finally, for the 2017 report for beef and pork samples it was discussed that the predominant *E. coli* strain associated with human infections is the pandemic O25-ST131 CTX-M-15-producing clone [15, 16]. For 2019 samples, one beef sample was positive for CTX-M 14, and three pork samples were positive for CTX-M 1 or 14 or 24. As such none of the samples were positive for the human pandemic O25-ST131 CTX-M-15- producing *E. coli* clone. Previous UK studies have isolated CTX-M 14 from cattle [17], CTX-M 1 from pork [18] and CTX-M 1 and 14 from pigs [19]. A German study has isolated CTX-M 24 from pigs [20].

## 8. Conclusions

- Results of the UK 2019 EU harmonised surveillance of antimicrobial resistance (AMR) in retail beef and pork were similar (no statistically significant differences) to results from the 2015 and 2017 surveys, with ~ 1% of beef and pork samples tested positive for AmpC-/ESBL-phenotype *E. coli*.

- None of the beef and pork samples were positive for *E. coli* with resistance to last resort carbapenem or colistin antibiotics.

- None of the meat samples prior to enrichment had background or AmpC-/ESBL-phenotype *E. coli* counts above the EU detection levels indicating very low numbers of these bacteria

- Results compare favourably to results from other countries that participated in these EU monitoring surveys in 2015 and 2017, as published by EFSA.

## 9. Tables

**Table 1.** Beef samples (sorted by sample ID) tested at APHA (excludes December 2019 samples).

| Unique Sample ID | Date of testing at APHA | Food Category | Country of origin | Brands if ≥ 2 samples | Super-market code |
|---|---|---|---|---|---|
| 6194 | 08/11/2019 | Beef steaks-expensive | United Kingdom | Q2 | G |
| 6276 | 10/10/2019 | Beef steaks-less expensive | United Kingdom | I1 | I |
| 6440 | 12/09/2019 | Beef steaks-expensive | United Kingdom | X1 | G |
| 6491 | 08/10/2019 | Beef steaks-less expensive | Ireland | G1 | B |
| 267422 | 12/07/2019 | Beef steaks-less expensive | United Kingdom | H1 | C |
| 343397 | 12/08/2019 | Beef steaks-less expensive | United Kingdom | E1 | A |
| 343432 | 20/08/2019 | All other beef and veal | United Kingdom | C2 | H |
| 381037 | 18/01/2019 | Beef steaks-expensive | United Kingdom | Q2 | G |
| 381078 | 21/01/2019 | Beef steaks-less expensive | United Kingdom | H1 | C |
| 540467 | 04/06/2019 | Beef steaks-expensive | United Kingdom | I1 | I |
| 540468 | 04/06/2019 | Beef steaks-less expensive | United Kingdom | C2 | H |
| 540490 | 15/04/2019 | Beef steaks-expensive | United Kingdom | G1 | B |
| 540491 | 15/04/2019 | Beef steaks-expensive | United Kingdom | H1 | C |
| 540492 | 15/04/2019 | Beef steaks-less expensive | United Kingdom | A2 | C |
| 540663 | 10/06/2019 | Beef steaks-expensive | United Kingdom | Z1 | J |
| 540668 | 12/04/2019 | Beef steaks-expensive | United Kingdom | Q2 | G |
| 540669 | 12/04/2019 | Beef steaks-less expensive | United Kingdom | A2 | C |
| 540701 | 08/05/2019 | Beef steaks-less expensive | Ireland | G1 | B |
| 540766 | 08/05/2019 | Beef steaks-expensive | United Kingdom | B1 | H |

| Unique Sample ID | Date of testing at APHA | Food Category | Country of origin | Brands if ≥ 2 samples | Super-market code |
|---|---|---|---|---|---|
| 540771 | 07/05/2019 | Beef steaks-less expensive | United Kingdom | C2 | H |
| 540781 | 11/04/2019 | Beef steaks-less expensive | United Kingdom | C2 | H |
| 540799 | 11/04/2019 | Beef steaks-less expensive | United Kingdom | B2 | A |
| 540800 | 11/04/2019 | Beef steaks-expensive | United Kingdom | F1 | G |
| 540905 | 09/05/2019 | Beef steaks-expensive | United Kingdom | H1 | C |
| 558274 | 07/05/2019 | Beef steaks-less expensive | United Kingdom | C2 | H |
| 558308 | 13/03/2019 | Beef steaks-expensive | United Kingdom | B1 | H |
| 558561 | 07/08/2019 | Beef steaks-less expensive | United Kingdom | I1 | I |
| 558576 | 06/03/2019 | Beef steaks-less expensive | United Kingdom | G1 | B |
| 558578 | 06/03/2019 | Beef steaks-less expensive | Ireland | G1 | B |
| 1562500 | 04/06/2019 | Beef steaks-expensive | United Kingdom | P1 | ? |
| 1562501 | 04/06/2019 | Beef steaks-less expensive | United Kingdom | G1 | B |
| 1562505 | 04/06/2019 | Beef steaks-expensive | United Kingdom | W1 | E |
| 1562508 | 04/06/2019 | Beef steaks-less expensive | United Kingdom | X1 | G |
| 1562511 | 04/06/2019 | Beef steaks-expensive | United Kingdom | Q2 | J |
| 1562512 | 04/06/2019 | Beef steaks-less expensive | United Kingdom | I1 | I |
| 1562513 | 04/06/2019 | Beef steaks-less expensive | United Kingdom | H1 | C |
| 1562730 | 15/04/2019 | Beef steaks-less expensive | United Kingdom | I1 | I |
| 1563634 | 21/01/2019 | Beef steaks-less expensive | United Kingdom | L1 | F |
| 1614500 | 15/04/2019 | Beef steaks-expensive | United Kingdom | C2 | H |
| 2447770 | 05/03/2019 | Beef steaks-less expensive | United Kingdom | I1 | I |
| 2447771 | 05/03/2019 | Beef steaks-expensive | United Kingdom | N1 | F |

| Unique Sample ID | Date of testing at APHA | Food Category | Country of origin | Brands if ≥ 2 samples | Super-market code |
|---|---|---|---|---|---|
| 2447772 | 05/03/2019 | Beef steaks-less expensive | United Kingdom | P1 | ? |
| 2447782 | 05/03/2019 | Beef steaks-expensive | United Kingdom | G1 | B |
| 2447783 | 05/03/2019 | Beef steaks-less expensive | United Kingdom | ? | ? |
| 2447784 | 05/03/2019 | Beef steaks-less expensive | United Kingdom | W1 | E |
| 2447785 | 05/03/2019 | Beef steaks-expensive | United Kingdom | I2 | C |
| 2447786 | 12/03/2019 | Beef steaks-expensive | United Kingdom | B2 | A |
| 2447789 | 12/03/2019 | Beef steaks-expensive | United Kingdom | H1 | C |
| 2447794 | 05/03/2019 | Beef steaks-less expensive | United Kingdom | M1 | I |
| 2447795 | 05/03/2019 | Beef steaks-expensive | United Kingdom | Z1 | J |
| 2447797 | 05/03/2019 | Beef steaks-expensive | United Kingdom | I2 | C |
| 2447798 | 08/02/2019 | Beef steaks-less expensive | United Kingdom | U1 | B |
| 2447799 | 08/02/2019 | Beef steaks-less expensive | United Kingdom | C2 | H |
| 2447800 | 08/02/2019 | Beef steaks-less expensive | United Kingdom | W1 | E |
| 2447801 | 08/02/2019 | Beef steaks-less expensive | United Kingdom | M1 | I |
| 2447802 | 08/02/2019 | Beef steaks-less expensive | United Kingdom | I1 | I |
| 2447807 | 12/03/2019 | Beef steaks-expensive | United Kingdom | Z1 | J |
| 2447809 | 08/02/2019 | Beef steaks-expensive | United Kingdom | Q2 | G |
| 2447811 | 08/02/2019 | Beef steaks-less expensive | United Kingdom | C2 | H |
| 2447812 | 08/02/2019 | Beef steaks-expensive | United Kingdom | L1 | F |
| 2447813 | 08/02/2019 | Beef steaks-expensive | United Kingdom | F1 | G |
| 2447815 | 06/02/2019 | Beef steaks-less expensive | United Kingdom | C2 | H |
| 2447817 | 06/02/2019 | Beef steaks-less expensive | United Kingdom | W1 | E |

| Unique Sample ID | Date of testing at APHA | Food Category | Country of origin | Brands if ≥ 2 samples | Super-market code |
|---|---|---|---|---|---|
| 2447818 | 06/02/2019 | Beef steaks-expensive | United Kingdom | D1 | ? |
| 2447820 | 07/02/2019 | Beef steaks-expensive | United Kingdom | M2 | D |
| 2447821 | 07/02/2019 | Beef steaks-expensive | United Kingdom | W1 | E |
| 2447823 | 07/02/2019 | Beef steaks-less expensive | United Kingdom | ? | ? |
| 2447830 | 12/03/2019 | Beef steaks-expensive | United Kingdom | Q2 | G |
| 2447832 | 07/02/2019 | Beef steaks-less expensive | United Kingdom | H1 | C |
| 2447833 | 07/02/2019 | Beef steaks-expensive | United Kingdom | B2 | A |
| 2447834 | 12/03/2019 | Beef steaks-expensive | United Kingdom | I1 | I |
| 2447835 | 07/02/2019 | Beef steaks-less expensive | United Kingdom | U1 | B |
| 2447836 | 07/02/2019 | Beef steaks-expensive | United Kingdom | Q2 | G |
| 2447839 | 06/02/2019 | Beef steaks-expensive | United Kingdom | Q2 | J |
| 2447840 | 06/02/2019 | Beef steaks-expensive | United Kingdom | Q2 | J |
| 2447842 | 06/02/2019 | Beef steaks-less expensive | United Kingdom | H1 | C |
| 2447843 | 06/02/2019 | Beef steaks-less expensive | United Kingdom | M1 | I |
| 2447844 | 06/02/2019 | Beef steaks-less expensive | United Kingdom | B2 | A |
| 2447845 | 07/02/2019 | Beef steaks-less expensive | United Kingdom | W1 | E |
| 2447846 | 07/02/2019 | Beef steaks-expensive | Ireland | H1 | C |
| 2447847 | 07/02/2019 | Beef steaks-expensive | United Kingdom | Q2 | J |
| 2447850 | 06/03/2019 | Beef steaks-less expensive | United Kingdom | C2 | H |
| 2447851 | 06/03/2019 | Beef steaks-expensive | Ireland | H1 | C |
| 2447852 | 06/03/2019 | Beef steaks-expensive | Ireland | G1 | B |
| 2447856 | 06/03/2019 | Beef steaks-less expensive | Ireland | H1 | C |

| Unique Sample ID | Date of testing at APHA | Food Category | Country of origin | Brands if ≥ 2 samples | Super-market code |
|---|---|---|---|---|---|
| 2447863 | 21/01/2019 | Beef steaks-less expensive | United Kingdom | P1 | ? |
| 2447864 | 21/01/2019 | Beef steaks-expensive | United Kingdom | P1 | ? |
| 2447867 | 18/01/2019 | Beef steaks-less expensive | United Kingdom | G1 | B |
| 2447868 | 18/01/2019 | Beef steaks-expensive | United Kingdom | W1 | E |
| 2447870 | 18/01/2019 | Beef steaks-expensive | United Kingdom | G1 | B |
| 2447871 | 18/01/2019 | Beef steaks-expensive | United Kingdom | H1 | C |
| 2447873 | 18/01/2019 | Beef steaks-less expensive | United Kingdom | C1 | ? |
| 2447878 | 18/01/2019 | Beef steaks-less expensive | United Kingdom | Q2 | J |
| 2447880 | 18/01/2019 | Beef steaks-less expensive | United Kingdom | W1 | E |
| 2447881 | 18/01/2019 | Beef steaks-expensive | United Kingdom | P1 | ? |
| 2447883 | 18/01/2019 | Beef steaks-less expensive | Ireland | G1 | B |
| 2447885 | 18/01/2019 | Beef steaks-expensive | United Kingdom | C2 | H |
| 2447886 | 18/01/2019 | Beef steaks-expensive | United Kingdom | Q2 | J |
| 2447888 | 16/01/2019 | Beef steaks-less expensive | United Kingdom | H1 | C |
| 2447889 | 16/01/2019 | Beef steaks-expensive | United Kingdom | G2 | E |
| 2447890 | 16/01/2019 | Beef steaks-expensive | United Kingdom | Z1 | J |
| 2447898 | 16/01/2019 | Beef steaks-expensive | United Kingdom | I2 | C |
| 2447899 | 16/01/2019 | Beef steaks-expensive | United Kingdom | I2 | C |
| 2447902 | 29/01/2019 | Beef steaks-expensive | United Kingdom | E2 | ? |
| 2447903 | 29/01/2019 | Beef steaks-expensive | United Kingdom | E2 | ? |
| 2447906 | 21/01/2019 | Beef steaks-expensive | United Kingdom | H2 | ? |
| 2447907 | 21/01/2019 | Beef steaks-expensive | United Kingdom | H2 | ? |

| Unique Sample ID | Date of testing at APHA | Food Category | Country of origin | Brands if ≥ 2 samples | Super-market code |
|---|---|---|---|---|---|
| 2558197 | 12/03/2019 | Beef steaks-expensive | United Kingdom | C2 | H |
| 2558278 | 12/03/2019 | Beef steaks-expensive | United Kingdom | B2 | A |
| 2558546 | 21/01/2019 | Beef steaks-less expensive | Ireland | G1 | B |
| 2664450 | 05/11/2019 | Beef steaks-expensive | United Kingdom | P1 | ? |
| 2664451 | 05/11/2019 | Beef steaks-less expensive | United Kingdom | Q2 | G |
| 2664461 | 05/11/2019 | Beef steaks-less expensive | United Kingdom | R1 | H |
| 2664464 | 05/11/2019 | Beef steaks-less expensive | Ireland | M2 | D |
| 2664466 | 05/11/2019 | Beef steaks-less expensive | United Kingdom | W1 | E |
| 2664468 | 05/11/2019 | Beef steaks-expensive | Ireland | H1 | C |
| 2664469 | 05/11/2019 | Beef steaks-less expensive | Ireland | H1 | C |
| 2664470 | 05/11/2019 | Beef steaks-less expensive | Argentina | ? | ? |
| 2664472 | 05/11/2019 | Beef steaks-less expensive | United Kingdom | U1 | B |
| 2664476 | 05/11/2019 | Beef steaks-expensive | United Kingdom | C2 | H |
| 2664477 | 05/11/2019 | Beef steaks-less expensive | United Kingdom | Q2 | J |
| 2664482 | 08/11/2019 | Beef steaks-expensive | United Kingdom | W1 | E |
| 2664485 | 08/11/2019 | Beef steaks-expensive | United Kingdom | B2 | A |
| 2664486 | 08/11/2019 | Beef steaks-expensive | United Kingdom | S1 | ? |
| 2664487 | 08/11/2019 | Beef steaks-expensive | United Kingdom | S1 | ? |
| 2664492 | 11/11/2019 | Beef steaks-expensive | United Kingdom | I2 | C |
| 2664493 | 11/11/2019 | Beef steaks-expensive | United Kingdom | I2 | C |
| 2664498 | 11/11/2019 | Beef steaks-expensive | United Kingdom | Z1 | J |
| 2664500 | 25/11/2019 | Beef steaks-less expensive | United Kingdom | U1 | B |

| Unique Sample ID | Date of testing at APHA | Food Category | Country of origin | Brands if ≥ 2 samples | Super-market code |
|---|---|---|---|---|---|
| 2664501 | 25/11/2019 | Beef steaks-expensive | United Kingdom | B2 | A |
| 2664503 | 25/11/2019 | Beef steaks-expensive | United Kingdom | P1 | ? |
| 2664504 | 08/11/2019 | All other beef and veal | United Kingdom | L1 | F |
| 2664508 | 08/11/2019 | Beef steaks-expensive | United Kingdom | U1 | B |
| 2664510 | 08/11/2019 | Beef steaks-expensive | United Kingdom | W1 | E |
| 2664511 | 08/11/2019 | Beef steaks-expensive | Spain | ? | ? |
| 2664516 | 10/10/2019 | Beef steaks-expensive | United Kingdom | X1 | G |
| 2664517 | 10/10/2019 | Beef steaks-expensive | United Kingdom | H1 | C |
| 2664518 | 10/10/2019 | Beef steaks-less expensive | United Kingdom | C2 | H |
| 2664531 | 10/10/2019 | Beef steaks-expensive | United Kingdom | C2 | H |
| 2664532 | 10/10/2019 | Beef steaks-expensive | United Kingdom | B2 | A |
| 2664534 | 10/10/2019 | Beef steaks-less expensive | United Kingdom | X1 | G |
| 2664631 | 09/10/2019 | Beef steaks-expensive | United Kingdom | ? | ? |
| 2664633 | 09/10/2019 | Beef steaks-less expensive | United Kingdom | A2 | C |
| 2664636 | 09/10/2019 | Beef steaks-less expensive | United Kingdom | P1 | ? |
| 2664637 | 09/10/2019 | Beef steaks-less expensive | United Kingdom | P1 | ? |
| 2664638 | 09/10/2019 | Beef steaks-expensive | United Kingdom | Z1 | J |
| 2664639 | 09/10/2019 | Beef steaks-expensive | United Kingdom | Z1 | J |
| 2664641 | 09/10/2019 | Beef steaks-less expensive | Ireland | H1 | C |
| 2664646 | 08/10/2019 | Beef steaks-less expensive | United Kingdom | ? | ? |
| 2664647 | 08/10/2019 | Beef steaks-expensive | United Kingdom | G2 | E |
| 2664649 | 08/10/2019 | Beef steaks-expensive | United Kingdom | Z1 | J |

| Unique Sample ID | Date of testing at APHA | Food Category | Country of origin | Brands if ≥ 2 samples | Super-market code |
|---|---|---|---|---|---|
| 2664652 | 09/10/2019 | Beef steaks-expensive | United Kingdom | G2 | E |
| 2664653 | 09/10/2019 | Beef steaks-expensive | United Kingdom | H1 | C |
| 2664654 | 12/09/2019 | Beef steaks-less expensive | United Kingdom | P1 | ? |
| 2664656 | 12/09/2019 | Beef steaks-expensive | United Kingdom | U1 | B |
| 2664658 | 12/09/2019 | Beef steaks-expensive | United Kingdom | Z1 | J |
| 2664663 | 12/09/2019 | Beef steaks-expensive | United Kingdom | ? | ? |
| 2664664 | 12/09/2019 | Beef steaks-less expensive | United Kingdom | ? | ? |
| 2664665 | 12/09/2019 | All other beef and veal | United Kingdom | X1 | G |
| 2664682 | 12/09/2019 | Beef steaks-expensive | United Kingdom | L2 | ? |
| 2664683 | 12/09/2019 | Beef steaks-expensive | United Kingdom | I2 | C |
| 2664686 | 12/09/2019 | Beef steaks-less expensive | United Kingdom | Q2 | J |
| 2664687 | 12/09/2019 | Beef steaks-less expensive | United Kingdom | W1 | E |
| 2664708 | 09/10/2019 | Beef steaks-expensive | United Kingdom | I1 | I |
| 2664709 | 09/10/2019 | Beef steaks-expensive | United Kingdom | I1 | I |
| 2672334 | 10/07/2019 | Beef steaks-expensive | United Kingdom | I2 | C |
| 2672335 | 10/07/2019 | Beef steaks-less expensive | United Kingdom | M1 | I |
| 2672346 | 16/05/2019 | Beef steaks-expensive | United Kingdom | C2 | H |
| 2672350 | 14/05/2019 | Beef steaks-expensive | United Kingdom | Z1 | J |
| 2672351 | 16/05/2019 | Beef steaks-expensive | United Kingdom | W1 | E |
| 2672353 | 16/05/2019 | Beef steaks-expensive | United Kingdom | X1 | G |
| 2672357 | 16/09/2019 | Beef steaks-expensive | United Kingdom | N1 | F |
| 2672358 | 16/09/2019 | Beef steaks-expensive | United Kingdom | P2 | ? |

| Unique Sample ID | Date of testing at APHA | Food Category | Country of origin | Brands if ≥ 2 samples | Super-market code |
|---|---|---|---|---|---|
| 2672360 | 16/09/2019 | Beef steaks-less expensive | United Kingdom | W1 | E |
| 2672361 | 16/09/2019 | Beef steaks-expensive | Ireland | H1 | C |
| 2672364 | 14/05/2019 | Beef steaks-expensive | United Kingdom | J1 | I |
| 2672365 | 14/05/2019 | Beef steaks-less expensive | United Kingdom | H1 | C |
| 2672369 | 12/07/2019 | Beef steaks-expensive | United Kingdom | ? | ? |
| 2672370 | 12/07/2019 | Beef steaks-expensive | United Kingdom | Z1 | J |
| 2672371 | 12/07/2019 | Beef steaks-expensive | United Kingdom | Z1 | J |
| 2672373 | 10/06/2019 | Beef steaks-expensive | United Kingdom | C2 | H |
| 2672374 | 10/06/2019 | Beef steaks-expensive | United Kingdom | C2 | H |
| 2672376 | 10/06/2019 | Beef steaks-expensive | United Kingdom | C2 | H |
| 2672377 | 10/06/2019 | Beef steaks-less expensive | United Kingdom | J2 | D |
| 2672381 | 15/05/2019 | Beef steaks-less expensive | United Kingdom | P1 | ? |
| 2672382 | 15/05/2019 | Beef steaks-expensive | United Kingdom | P1 | ? |
| 2672383 | 15/05/2019 | Beef steaks-expensive | United Kingdom | Z1 | J |
| 2672385 | 10/06/2019 | Beef steaks-expensive | United Kingdom | G1 | B |
| 2672386 | 10/06/2019 | Beef steaks-expensive | United Kingdom | Q2 | J |
| 2672398 | 11/07/2019 | Beef steaks-less expensive | United Kingdom | C2 | H |
| 2672403 | 10/07/2019 | Beef steaks-less expensive | United Kingdom | C2 | H |
| 2672405 | 10/07/2019 | Beef steaks-less expensive | United Kingdom | W1 | E |
| 2672406 | 10/07/2019 | Beef steaks-expensive | United Kingdom | I1 | I |
| 2672409 | 10/07/2019 | Beef steaks-expensive | United Kingdom | Z1 | J |
| 2672411 | 10/07/2019 | Beef steaks-expensive | United Kingdom | Q2 | J |

| Unique Sample ID | Date of testing at APHA | Food Category | Country of origin | Brands if ≥ 2 samples | Super-market code |
|---|---|---|---|---|---|
| 2672414 | 04/07/2019 | Beef steaks-expensive | United Kingdom | I1 | I |
| 2672415 | 04/07/2019 | Beef steaks-less expensive | United Kingdom | Q2 | J |
| 2672418 | 11/07/2019 | Beef steaks-less expensive | United Kingdom | H1 | C |
| 2672420 | 11/07/2019 | Beef steaks-less expensive | United Kingdom | U1 | B |
| 2672423 | 12/07/2019 | Beef steaks-less expensive | United Kingdom | P1 | ? |
| 2672426 | 12/07/2019 | Beef steaks-expensive | United Kingdom | I1 | I |
| 2672429 | 12/07/2019 | Beef steaks-expensive | United Kingdom | Z1 | J |
| 2672431 | 12/07/2019 | Beef steaks-expensive | United Kingdom | G1 | B |
| 2672432 | 12/07/2019 | Beef steaks-less expensive | United Kingdom | H1 | C |
| 2672469 | 11/07/2019 | Beef steaks-expensive | United Kingdom | H1 | C |
| 2672470 | 11/07/2019 | Beef steaks-expensive | United Kingdom | H1 | C |
| 2672472 | 11/07/2019 | Beef steaks-expensive | United Kingdom | P1 | ? |
| 2672473 | 11/07/2019 | All other beef and veal | Ireland | P1 | ? |
| 2672669 | 13/08/2019 | Beef steaks-less expensive | United Kingdom | B2 | A |
| 2672672 | 13/08/2019 | Beef steaks-less expensive | United Kingdom | M1 | I |
| 2672681 | 07/08/2019 | Beef steaks-less expensive | United Kingdom | Q1 | G |
| 2672683 | 07/08/2019 | Beef steaks-expensive | United Kingdom | P1 | ? |
| 2672685 | 07/08/2019 | Beef steaks-expensive | United Kingdom | I2 | C |
| 2672687 | 07/08/2019 | Beef steaks-expensive | United Kingdom | G1 | B |
| 2672689 | 20/08/2019 | Beef steaks-less expensive | United Kingdom | H1 | C |
| 2672690 | 20/08/2019 | Beef steaks-expensive | United Kingdom | B1 | H |
| 2672692 | 20/08/2019 | Beef steaks-expensive | United Kingdom | G1 | B |

| Unique Sample ID | Date of testing at APHA | Food Category | Country of origin | Brands if ≥ 2 samples | Super-market code |
|---|---|---|---|---|---|
| 2672695 | 20/08/2019 | Beef steaks-expensive | United Kingdom | B2 | A |
| 2672717 | 07/08/2019 | Beef steaks-less expensive | Netherlands | ? | ? |
| 2672722 | 07/08/2019 | Beef steaks-expensive | United Kingdom | G2 | E |
| 2672723 | 07/08/2019 | Beef steaks-expensive | United Kingdom | Z1 | J |
| 2672735 | 12/08/2019 | Beef steaks-expensive | United Kingdom | H1 | C |
| 2672737 | 12/08/2019 | Beef steaks-less expensive | United Kingdom | J2 | D |
| 2672738 | 12/08/2019 | Beef steaks-less expensive | United Kingdom | P1 | ? |
| 2672740 | 12/08/2019 | Beef steaks-expensive | United Kingdom | Z1 | J |
| 2672755 | 12/08/2019 | Beef steaks-less expensive | United Kingdom | F2 | E |
| 2672756 | 12/08/2019 | Beef steaks-expensive | United Kingdom | P1 | ? |
| 2672760 | 07/08/2019 | Beef steaks-expensive | United Kingdom | C2 | H |
| 2672762 | 07/08/2019 | Beef steaks-expensive | United Kingdom | C2 | H |
| 2672765 | 07/08/2019 | Beef steaks-less expensive | United Kingdom | ? | ? |
| 2672766 | 07/08/2019 | Beef steaks-less expensive | United Kingdom | Q2 | G |
| 2672800 | 13/09/2019 | Beef steaks-expensive | United Kingdom | A1 | ? |
| 2672807 | 16/09/2019 | Beef steaks-expensive | United Kingdom | G1 | B |
| 2672808 | 16/09/2019 | Beef steaks-less expensive | United Kingdom | X1 | G |
| 2672809 | 16/09/2019 | Beef steaks-expensive | United Kingdom | Q2 | G |
| 2672810 | 16/09/2019 | Beef steaks-expensive | United Kingdom | C2 | H |
| 2672812 | 16/09/2019 | Beef steaks-less expensive | United Kingdom | Q2 | J |
| 2685587 | 09/05/2019 | Beef steaks-expensive | United Kingdom | G1 | B |
| 2685589 | 09/05/2019 | Beef steaks-expensive | United Kingdom | B1 | H |

| Unique Sample ID | Date of testing at APHA | Food Category | Country of origin | Brands if ≥ 2 samples | Super-market code |
|---|---|---|---|---|---|
| 2685590 | 07/06/2019 | Beef steaks-expensive | United Kingdom | U1 | B |
| 2685592 | 07/05/2019 | Beef steaks-expensive | United Kingdom | W1 | E |
| 2685594 | 07/06/2019 | Beef steaks-expensive | United Kingdom | I2 | C |
| 2685596 | 07/06/2019 | Beef steaks-expensive | United Kingdom | H1 | C |
| 2685622 | 12/04/2019 | Beef steaks-expensive | United Kingdom | L1 | F |
| 2685623 | 12/04/2019 | Beef steaks-less expensive | United Kingdom | C2 | H |
| 2685624 | 12/04/2019 | Beef steaks-less expensive | United Kingdom | U1 | B |
| 2685631 | 11/04/2019 | Beef steaks-expensive | United Kingdom | D2 | ? |
| 2685632 | 11/04/2019 | Beef steaks-expensive | Ireland | O1 | B |
| 2685633 | 11/04/2019 | Beef steaks-less expensive | United Kingdom | O2 | ? |
| 2685639 | 08/05/2019 | Beef steaks-less expensive | United Kingdom | G1 | B |
| 2685641 | 15/04/2019 | Beef steaks-expensive | United Kingdom | G1 | B |
| 2685644 | 15/04/2019 | Beef steaks-less expensive | United Kingdom | Q2 | J |
| 2685645 | 15/04/2019 | Beef steaks-expensive | United Kingdom | ? | ? |
| 2685647 | 10/07/2019 | Beef steaks-expensive | United Kingdom | C2 | H |
| 2685656 | 12/04/2019 | Beef steaks-less expensive | United Kingdom | Q2 | J |
| 2685660 | 07/06/2019 | Beef steaks-expensive | United Kingdom | W1 | E |
| 2685664 | 13/09/2019 | Beef steaks-less expensive | United Kingdom | C2 | H |
| 2685665 | 13/09/2019 | Beef steaks-expensive | United Kingdom | W1 | E |
| 2685667 | 13/09/2019 | Beef steaks-expensive | United Kingdom | I2 | C |
| 2685669 | 13/09/2019 | Beef steaks-expensive | United Kingdom | C2 | H |
| 2685671 | 13/09/2019 | Beef steaks-less expensive | United Kingdom | X1 | G |

| Unique Sample ID | Date of testing at APHA | Food Category | Country of origin | Brands if ≥ 2 samples | Super-market code |
|---|---|---|---|---|---|
| 2685673 | 12/04/2019 | Beef steaks-expensive | United Kingdom | ? | ? |
| 2685678 | 08/05/2019 | Beef steaks-expensive | United Kingdom | Z1 | J |
| 2685680 | 08/05/2019 | Beef steaks-less expensive | United Kingdom | I2 | C |
| 2685683 | 09/05/2019 | Beef steaks-expensive | United Kingdom | B1 | H |
| 2685684 | 09/05/2019 | Beef steaks-less expensive | United Kingdom | C2 | H |
| 2685685 | 09/05/2019 | Beef steaks-less expensive | United Kingdom | Q2 | J |
| 2685686 | 09/05/2019 | Beef steaks-less expensive | United Kingdom | P1 | ? |
| 2685687 | 09/05/2019 | Beef steaks-less expensive | United Kingdom | P1 | ? |
| 2685689 | 09/05/2019 | Beef steaks-less expensive | Non European Union | P1 | ? |
| 2685696 | 25/04/2019 | Beef steaks-expensive | United Kingdom | I1 | I |
| 2685699 | 25/04/2019 | Beef steaks-expensive | United Kingdom | Z1 | J |
| 2685700 | 25/04/2019 | Beef steaks-expensive | United Kingdom | Q2 | J |
| 2685705 | 04/06/2019 | Beef steaks-less expensive | United Kingdom | Q2 | J |
| 2685706 | 04/06/2019 | Beef steaks-less expensive | United Kingdom | H1 | C |
| 2685710 | 10/07/2019 | Beef steaks-less expensive | United Kingdom | G1 | B |
| 2685713 | 15/05/2019 | Beef steaks-less expensive | United Kingdom | W1 | E |
| 2685714 | 15/05/2019 | All other beef and veal | United Kingdom | W1 | E |
| 2685725 | 10/06/2019 | Beef steaks-expensive | United Kingdom | G1 | B |
| 2685737 | 10/06/2019 | Beef steaks-expensive | United Kingdom | B2 | A |
| 2685739 | 10/06/2019 | Beef steaks-expensive | United Kingdom | ? | ? |
| 2685740 | 09/05/2019 | Beef steaks-less expensive | United Kingdom | C2 | H |
| 2685900 | 10/10/2019 | Beef steaks-expensive | United Kingdom | N1 | F |

| Unique Sample ID | Date of testing at APHA | Food Category | Country of origin | Brands if ≥ 2 samples | Super-market code |
|---|---|---|---|---|---|
| 2685911 | 10/10/2019 | Beef steaks-expensive | United Kingdom | T1 | ? |
| 2685913 | 10/10/2019 | Beef steaks-expensive | United Kingdom | B2 | A |
| 2686013 | 13/03/2019 | Beef steaks-expensive | United Kingdom | G1 | B |
| 2686065 | 07/02/2019 | Beef steaks-expensive | United Kingdom | U1 | B |
| 2686066 | 12/03/2019 | Beef steaks-expensive | United Kingdom | I1 | I |
| 2686069 | 12/03/2019 | Beef steaks-less expensive | United Kingdom | C2 | H |

? – Shop not on list

**Table 2.** Pork samples (sorted by sample ID) tested at APHA (excludes December 2019 samples).

| Unique Sample ID | Date of testing at APHA | Food Category | Country of origin | Brands if ≥ 2 samples | Super-market code |
|---|---|---|---|---|---|
| 6196 | 08/11/2019 | Pork chops | United Kingdom | W1 | E |
| 6207 | 11/11/2019 | Pork fillets & steaks | Netherlands | H1 | C |
| 6208 | 08/11/2019 | All other pork | United Kingdom | H1 | C |
| 6209 | 08/11/2019 | Pork chops | United Kingdom | W1 | E |
| 6275 | 10/10/2019 | All other pork | United Kingdom | Q2 | J |
| 6282 | 10/10/2019 | Pork fillets & steaks | United Kingdom | X1 | G |
| 6315 | 10/10/2019 | Pork fillets & steaks | United Kingdom | C2 | H |
| 6441 | 12/09/2019 | Pork fillets & steaks | United Kingdom | W1 | E |
| 6442 | 12/09/2019 | Pork fillets & steaks | United Kingdom | X1 | G |
| 6443 | 12/09/2019 | Pork fillets & steaks | Netherlands | H1 | C |
| 6444 | 12/09/2019 | Pork chops | Netherlands | K2 | C |
| 6481 | 12/09/2019 | Pork chops | United Kingdom | H1 | C |
| 6482 | 12/09/2019 | Pork fillets & steaks | United Kingdom | H1 | C |
| 6486 | 09/10/2019 | Pork chops | United Kingdom | Q2 | J |
| 6487 | 09/10/2019 | Pork fillets & steaks | Germany | G1 | B |
| 6488 | 09/10/2019 | Pork fillets & steaks | Spain | P1 | ? |
| 6489 | 09/10/2019 | All other pork | United Kingdom | C2 | H |
| 6492 | 08/10/2019 | Pork fillets & steaks | United Kingdom | W1 | E |
| 6493 | 12/09/2019 | Pork chops | United Kingdom | ? | ? |
| 6550 | 09/10/2019 | Pork fillets & steaks | United Kingdom | W1 | E |
| 6551 | 09/10/2019 | Pork fillets & steaks | United Kingdom | W1 | E |
| 343260 | 13/09/2019 | Pork chops | United Kingdom | W1 | E |
| 343261 | 13/09/2019 | Pork fillets & steaks | United Kingdom | W1 | E |
| 343298 | 16/09/2019 | All other pork | United Kingdom | M1 | I |
| 343433 | 20/08/2019 | All other pork | Netherlands | K2 | C |
| 343434 | 20/08/2019 | Pork chops | Denmark | H1 | C |
| 343467 | 11/07/2019 | All other pork | United Kingdom | E1 | A |
| 343468 | 11/07/2019 | All other pork | Netherlands | K2 | C |
| 343592 | 12/07/2019 | All other pork | Netherlands | K1 | B |
| 343593 | 12/07/2019 | Pork chops | United Kingdom | H1 | C |
| 343619 | 07/08/2019 | Pork fillets & steaks | United Kingdom | E1 | A |
| 343622 | 07/08/2019 | Pork fillets & steaks | United Kingdom | G1 | B |
| 343648 | 10/07/2019 | Pork fillets & steaks | United Kingdom | F1 | G |
| 364647 | 08/02/2019 | All other pork | United Kingdom | K1 | B |
| 380952 | 05/03/2019 | Pork fillets & steaks | United Kingdom | H1 | C |

| Unique Sample ID | Date of testing at APHA | Food Category | Country of origin | Brands if ≥ 2 samples | Super-market code |
|---|---|---|---|---|---|
| 380953 | 05/03/2019 | Pork fillets & steaks | United Kingdom | C2 | H |
| 380966 | 12/07/2019 | All other pork | United Kingdom | W1 | E |
| 380968 | 12/07/2019 | Pork chops | Netherlands | K1 | B |
| 380973 | 08/02/2019 | Pork fillets & steaks | United Kingdom | J2 | D |
| 380974 | 08/02/2019 | Pork chops | United Kingdom | W1 | E |
| 380975 | 08/02/2019 | Pork chops | United Kingdom | Q2 | J |
| 380976 | 06/02/2019 | Pork fillets & steaks | United Kingdom | G1 | B |
| 380977 | 06/02/2019 | Pork chops | United Kingdom | H1 | C |
| 380978 | 06/02/2019 | Pork fillets & steaks | Denmark | H1 | C |
| 380979 | 06/02/2019 | Pork chops | United Kingdom | C2 | H |
| 381029 | 06/03/2019 | Pork fillets & steaks | United Kingdom | H1 | C |
| 381038 | 18/01/2019 | Pork fillets & steaks | United Kingdom | B2 | A |
| 381041 | 16/01/2019 | Pork chops | Germany | H1 | C |
| 381043 | 16/01/2019 | Pork fillets & steaks | United Kingdom | K2 | C |
| 381044 | 16/01/2019 | Pork fillets & steaks | United Kingdom | K2 | C |
| 381063 | 05/03/2019 | Pork chops | United Kingdom | L1 | F |
| 381064 | 05/03/2019 | Pork chops | United Kingdom | F1 | G |
| 381073 | 05/03/2019 | Pork fillets & steaks | United Kingdom | H1 | C |
| 381113 | 29/01/2019 | Pork chops | United Kingdom | W1 | E |
| 381114 | 29/01/2019 | Pork chops | United Kingdom | W1 | E |
| 381235 | 08/02/2019 | Pork chops | United Kingdom | W1 | E |
| 540425 | 14/05/2019 | Pork chops | Germany | K1 | B |
| 540434 | 16/09/2019 | All other pork | Netherlands | K1 | B |
| 540450 | 11/07/2019 | All other pork | United Kingdom | H1 | C |
| 540451 | 11/07/2019 | Pork chops | United Kingdom | H1 | C |
| 540458 | 16/05/2019 | Pork fillets & steaks | Denmark | K2 | C |
| 540465 | 04/06/2019 | Pork fillets & steaks | United Kingdom | P1 | ? |
| 540466 | 04/06/2019 | Pork fillets & steaks | United Kingdom | W1 | E |
| 540488 | 15/04/2019 | Pork chops | United Kingdom | Q2 | J |
| 540489 | 15/04/2019 | Pork chops | United Kingdom | F1 | G |
| 540493 | 15/04/2019 | Pork fillets & steaks | United Kingdom | K2 | C |
| 540664 | 10/06/2019 | All other pork | United Kingdom | C2 | H |
| 540670 | 09/05/2019 | Pork fillets & steaks | United Kingdom | C2 | H |
| 540733 | 25/04/2019 | All other pork | United Kingdom | E1 | A |
| 540764 | 15/04/2019 | All other pork | United Kingdom | W1 | E |
| 540765 | 15/04/2019 | Pork fillets & steaks | Germany | G1 | B |
| 540769 | 12/04/2019 | All other pork | Denmark | H1 | C |
| 540770 | 12/04/2019 | Pork chops | Germany | K1 | B |

| Unique Sample ID | Date of testing at APHA | Food Category | Country of origin | Brands if ≥ 2 samples | Super-market code |
|---|---|---|---|---|---|
| 540779 | 11/04/2019 | Pork chops | United Kingdom | Q2 | J |
| 540780 | 11/04/2019 | All other pork | Denmark | H1 | C |
| 540782 | 11/04/2019 | Pork chops | United Kingdom | F1 | G |
| 540783 | 11/04/2019 | Pork chops | Germany | G1 | B |
| 540797 | 11/04/2019 | All other pork | Netherlands | K2 | C |
| 540798 | 11/04/2019 | All other pork | Belgium | P1 | ? |
| 540801 | 11/04/2019 | Pork fillets & steaks | Germany | G1 | B |
| 540902 | 10/06/2019 | Pork fillets & steaks | United Kingdom | F1 | G |
| 540906 | 09/05/2019 | All other pork | Denmark | H1 | C |
| 540948 | 07/08/2019 | All other pork | United Kingdom | C2 | H |
| 540949 | 10/06/2019 | Pork chops | United Kingdom | C2 | H |
| 541031 | 08/05/2019 | All other pork | United Kingdom | W1 | E |
| 541032 | 14/05/2019 | All other pork | United Kingdom | F1 | G |
| 541033 | 14/05/2019 | Pork chops | United Kingdom | C2 | H |
| 558559 | 10/07/2019 | Pork fillets & steaks | United Kingdom | G1 | B |
| 558560 | 07/08/2019 | Pork fillets & steaks | United Kingdom | F1 | G |
| 558562 | 12/03/2019 | Pork fillets & steaks | United Kingdom | K2 | C |
| 558563 | 12/03/2019 | Pork fillets & steaks | United Kingdom | G1 | B |
| 558574 | 06/03/2019 | Pork fillets & steaks | Germany | G1 | B |
| 561033 | 05/11/2019 | Pork fillets & steaks | United Kingdom | G1 | B |
| 1562499 | 04/06/2019 | All other pork | United Kingdom | ? | G |
| 1562502 | 04/06/2019 | All other pork | United Kingdom | M1 | I |
| 1562503 | 04/06/2019 | Pork fillets & steaks | United Kingdom | K2 | C |
| 1562504 | 04/06/2019 | Pork fillets & steaks | United Kingdom | H1 | C |
| 1562506 | 04/06/2019 | Pork fillets & steaks | United Kingdom | Q2 | J |
| 1562507 | 04/06/2019 | All other pork | United Kingdom | J2 | D |
| 1562509 | 04/06/2019 | All other pork | United Kingdom | Q2 | J |
| 1562510 | 04/06/2019 | All other pork | United Kingdom | Q2 | J |
| 1562514 | 04/06/2019 | Pork fillets & steaks | United Kingdom | P1 | ? |
| 1563552 | 21/01/2019 | Pork chops | United Kingdom | Q2 | J |
| 1563633 | 21/01/2019 | Pork fillets & steaks | United Kingdom | P1 | ? |
| 1614373 | 07/02/2019 | Pork chops | United Kingdom | Q2 | J |
| 1614388 | 07/02/2019 | Pork fillets & steaks | United Kingdom | W1 | E |
| 1614390 | 07/02/2019 | Pork chops | Germany | G1 | B |
| 2447768 | 12/03/2019 | Pork fillets & steaks | Denmark | H1 | C |
| 2447769 | 05/03/2019 | Pork fillets & steaks | United Kingdom | F1 | G |
| 2447780 | 05/03/2019 | All other pork | United Kingdom | F1 | G |
| 2447781 | 05/03/2019 | Pork fillets & steaks | United Kingdom | E1 | A |

| Unique Sample ID | Date of testing at APHA | Food Category | Country of origin | Brands if ≥ 2 samples | Super-market code |
|---|---|---|---|---|---|
| 2447787 | 12/03/2019 | Pork chops | United Kingdom | ? | ? |
| 2447796 | 05/03/2019 | Pork fillets & steaks | United Kingdom | B2 | A |
| 2447803 | 08/02/2019 | Pork fillets & steaks | European Union | P1 | ? |
| 2447804 | 08/02/2019 | Pork fillets & steaks | United Kingdom | C2 | H |
| 2447808 | 08/02/2019 | All other pork | United Kingdom | C2 | H |
| 2447810 | 08/02/2019 | All other pork | United Kingdom | C2 | H |
| 2447816 | 06/02/2019 | Pork fillets & steaks | United Kingdom | L1 | F |
| 2447819 | 06/02/2019 | Pork fillets & steaks | United Kingdom | D1 | ? |
| 2447822 | 07/02/2019 | Pork fillets & steaks | United Kingdom | G2 | E |
| 2447824 | 07/02/2019 | All other pork | United Kingdom | K1 | B |
| 2447825 | 07/02/2019 | Pork fillets & steaks | Germany | G1 | B |
| 2447827 | 06/02/2019 | Pork chops | United Kingdom | G1 | B |
| 2447828 | 06/02/2019 | Pork fillets & steaks | United Kingdom | K2 | C |
| 2447829 | 12/03/2019 | Pork fillets & steaks | United Kingdom | ? | ? |
| 2447831 | 12/03/2019 | Pork fillets & steaks | France | J2 | D |
| 2447837 | 07/02/2019 | All other pork | United Kingdom | H1 | C |
| 2447841 | 07/02/2019 | Pork fillets & steaks | United Kingdom | F1 | G |
| 2447849 | 07/02/2019 | Pork fillets & steaks | United Kingdom | Q2 | J |
| 2447853 | 06/03/2019 | All other pork | United Kingdom | W1 | E |
| 2447854 | 06/03/2019 | All other pork | United Kingdom | Q2 | J |
| 2447855 | 06/03/2019 | Pork fillets & steaks | Germany | G1 | B |
| 2447861 | 21/01/2019 | All other pork | United Kingdom | K2 | C |
| 2447862 | 21/01/2019 | Pork fillets & steaks | United Kingdom | K2 | C |
| 2447869 | 18/01/2019 | Pork fillets & steaks | United Kingdom | G1 | B |
| 2447872 | 18/01/2019 | Pork fillets & steaks | United Kingdom | C1 | ? |
| 2447874 | 18/01/2019 | Pork fillets & steaks | Germany | G1 | B |
| 2447875 | 18/01/2019 | Pork chops | United Kingdom | ? | ? |
| 2447876 | 18/01/2019 | Pork fillets & steaks | United Kingdom | W1 | E |
| 2447877 | 18/01/2019 | Pork fillets & steaks | United Kingdom | H1 | C |
| 2447879 | 18/01/2019 | Pork fillets & steaks | United Kingdom | Q2 | J |
| 2447882 | 18/01/2019 | Pork fillets & steaks | United Kingdom | I2 | C |
| 2447884 | 18/01/2019 | All other pork | Ireland | G1 | B |
| 2447887 | 16/01/2019 | All other pork | United Kingdom | W1 | E |
| 2447897 | 16/01/2019 | Pork fillets & steaks | United Kingdom | Q2 | J |
| 2447908 | 21/01/2019 | Pork fillets & steaks | United Kingdom | Q2 | J |
| 2448058 | 21/01/2019 | Pork fillets & steaks | United Kingdom | H1 | C |
| 2558547 | 21/01/2019 | All other pork | United Kingdom | M1 | I |
| 2664460 | 05/11/2019 | Pork fillets & steaks | United Kingdom | C2 | H |

| Unique Sample ID | Date of testing at APHA | Food Category | Country of origin | Brands if ≥ 2 samples | Super-market code |
|---|---|---|---|---|---|
| 2664462 | 05/11/2019 | Pork fillets & steaks | United Kingdom | E1 | A |
| 2664463 | 05/11/2019 | All other pork | United Kingdom | C2 | H |
| 2664465 | 05/11/2019 | Pork fillets & steaks | United Kingdom | X1 | G |
| 2664467 | 05/11/2019 | Pork fillets & steaks | United Kingdom | G2 | E |
| 2664471 | 05/11/2019 | Pork fillets & steaks | United Kingdom | ? | ? |
| 2664473 | 05/11/2019 | Pork fillets & steaks | United Kingdom | ? | ? |
| 2664478 | 05/11/2019 | Pork fillets & steaks | United Kingdom | Q2 | J |
| 2664479 | 05/11/2019 | Pork fillets & steaks | United Kingdom | Q2 | J |
| 2664480 | 05/11/2019 | Pork fillets & steaks | United Kingdom | Q2 | J |
| 2664481 | 05/11/2019 | Pork fillets & steaks | United Kingdom | X1 | G |
| 2664483 | 08/11/2019 | Pork fillets & steaks | Germany | G1 | B |
| 2664484 | 08/11/2019 | All other pork | United Kingdom | M1 | I |
| 2664491 | 11/11/2019 | All other pork | United Kingdom | C2 | H |
| 2664494 | 11/11/2019 | Pork fillets & steaks | United Kingdom | X1 | G |
| 2664496 | 11/11/2019 | All other pork | Netherlands | K2 | C |
| 2664497 | 11/11/2019 | Pork fillets & steaks | United Kingdom | L1 | F |
| 2664499 | 11/11/2019 | Pork fillets & steaks | United Kingdom | ? | I |
| 2664502 | 25/11/2019 | All other pork | United Kingdom | I1 | I |
| 2664505 | 08/11/2019 | All other pork | Netherlands | K1 | B |
| 2664506 | 08/11/2019 | All other pork | Netherlands | K2 | C |
| 2664507 | 08/11/2019 | Pork fillets & steaks | United Kingdom | C2 | H |
| 2664509 | 08/11/2019 | All other pork | United Kingdom | C2 | H |
| 2664514 | 10/10/2019 | All other pork | United Kingdom | Y1 | ? |
| 2664519 | 10/10/2019 | Pork fillets & steaks | Germany | G1 | B |
| 2664533 | 10/10/2019 | All other pork | United Kingdom | Y1 | ? |
| 2664632 | 09/10/2019 | All other pork | United Kingdom | H1 | C |
| 2664634 | 09/10/2019 | Pork fillets & steaks | Spain | N2 | ? |
| 2664635 | 09/10/2019 | Pork chops | Germany | G1 | B |
| 2664640 | 09/10/2019 | All other pork | United Kingdom | C2 | H |
| 2664644 | 08/10/2019 | All other pork | United Kingdom | H1 | C |
| 2664645 | 08/10/2019 | Pork chops | France | J2 | D |
| 2664648 | 08/10/2019 | All other pork | United Kingdom | W1 | E |
| 2664655 | 12/09/2019 | Pork fillets & steaks | United Kingdom | P1 | ? |
| 2664662 | 12/09/2019 | Pork fillets & steaks | United Kingdom | I1 | I |
| 2664681 | 12/09/2019 | Pork fillets & steaks | United Kingdom | L2 | ? |
| 2664688 | 12/09/2019 | All other pork | United Kingdom | H1 | C |
| 2664710 | 09/10/2019 | All other pork | United Kingdom | W1 | E |
| 2664711 | 09/10/2019 | Pork fillets & steaks | United Kingdom | P1 | ? |

| Unique Sample ID | Date of testing at APHA | Food Category | Country of origin | Brands if ≥ 2 samples | Super-market code |
|---|---|---|---|---|---|
| 2672345 | 16/05/2019 | Pork fillets & steaks | United Kingdom | C2 | H |
| 2672348 | 14/05/2019 | Pork fillets & steaks | United Kingdom | W1 | E |
| 2672349 | 14/05/2019 | Pork fillets & steaks | Germany | G1 | B |
| 2672352 | 16/05/2019 | All other pork | United Kingdom | W1 | E |
| 2672356 | 16/09/2019 | Pork fillets & steaks | United Kingdom | X1 | G |
| 2672359 | 16/09/2019 | Pork chops | United Kingdom | P2 | ? |
| 2672362 | 16/09/2019 | All other pork | United Kingdom | C2 | H |
| 2672368 | 12/07/2019 | Pork fillets & steaks | United Kingdom | M1 | I |
| 2672372 | 10/06/2019 | Pork chops | United Kingdom | ? | ? |
| 2672375 | 10/06/2019 | All other pork | United Kingdom | C2 | H |
| 2672379 | 10/06/2019 | Pork fillets & steaks | Spain | ? | ? |
| 2672380 | 15/05/2019 | Pork chops | United Kingdom | ? | ? |
| 2672384 | 15/05/2019 | All other pork | United Kingdom | H1 | C |
| 2672387 | 10/06/2019 | Pork fillets & steaks | United Kingdom | G2 | E |
| 2672388 | 10/06/2019 | All other pork | United Kingdom | W1 | E |
| 2672390 | 10/06/2019 | All other pork | United Kingdom | H1 | C |
| 2672404 | 10/07/2019 | Pork fillets & steaks | United Kingdom | G2 | E |
| 2672407 | 10/07/2019 | Pork fillets & steaks | Netherlands | G1 | B |
| 2672408 | 10/07/2019 | Pork fillets & steaks | United Kingdom | C2 | H |
| 2672410 | 10/07/2019 | All other pork | United Kingdom | X1 | G |
| 2672413 | 04/07/2019 | Pork fillets & steaks | United Kingdom | J1 | I |
| 2672419 | 11/07/2019 | Pork chops | United Kingdom | H1 | C |
| 2672425 | 12/07/2019 | All other pork | United Kingdom | M1 | I |
| 2672427 | 12/07/2019 | Pork fillets & steaks | United Kingdom | ? | ? |
| 2672428 | 12/07/2019 | Pork fillets & steaks | United Kingdom | X1 | G |
| 2672430 | 12/07/2019 | Pork chops | United Kingdom | B1 | H |
| 2672471 | 11/07/2019 | Pork fillets & steaks | United Kingdom | H1 | C |
| 2672667 | 13/08/2019 | All other pork | Ireland | G1 | B |
| 2672668 | 13/08/2019 | Pork fillets & steaks | Germany | J2 | D |
| 2672670 | 13/08/2019 | Pork fillets & steaks | United Kingdom | I1 | I |
| 2672671 | 13/08/2019 | Pork fillets & steaks | United Kingdom | H1 | C |
| 2672682 | 07/08/2019 | Pork fillets & steaks | United Kingdom | C2 | H |
| 2672684 | 07/08/2019 | Pork chops | United Kingdom | P1 | ? |
| 2672686 | 07/08/2019 | All other pork | Germany | K2 | C |
| 2672691 | 20/08/2019 | Pork fillets & steaks | United Kingdom | C2 | H |
| 2672693 | 20/08/2019 | All other pork | Netherlands | K1 | B |
| 2672694 | 20/08/2019 | Pork fillets & steaks | Denmark | G1 | B |
| 2672724 | 07/08/2019 | All other pork | Belgium | ? | ? |

| Unique Sample ID | Date of testing at APHA | Food Category | Country of origin | Brands if ≥ 2 samples | Super-market code |
|---|---|---|---|---|---|
| 2672733 | 12/08/2019 | Pork fillets & steaks | United Kingdom | L1 | F |
| 2672734 | 12/08/2019 | Pork chops | United Kingdom | M1 | I |
| 2672736 | 12/08/2019 | Pork chops | Germany | G1 | B |
| 2672739 | 12/08/2019 | Pork fillets & steaks | United Kingdom | W1 | E |
| 2672754 | 12/08/2019 | Pork chops | Germany | G1 | B |
| 2672757 | 12/08/2019 | Pork fillets & steaks | United Kingdom | Q2 | J |
| 2672758 | 12/08/2019 | All other pork | United Kingdom | Q2 | J |
| 2672761 | 07/08/2019 | Pork chops | United Kingdom | C2 | H |
| 2672763 | 07/08/2019 | Pork fillets & steaks | Germany | G1 | B |
| 2672764 | 07/08/2019 | Pork fillets & steaks | Spain | N2 | ? |
| 2672767 | 07/08/2019 | Pork fillets & steaks | Germany | J2 | D |
| 2672799 | 13/09/2019 | Pork fillets & steaks | United Kingdom | G1 | B |
| 2672801 | 13/09/2019 | Pork fillets & steaks | United Kingdom | A1 | ? |
| 2672802 | 13/09/2019 | All other pork | United Kingdom | A1 | ? |
| 2672804 | 16/09/2019 | Pork fillets & steaks | United Kingdom | H1 | C |
| 2672805 | 16/09/2019 | All other pork | United Kingdom | H1 | C |
| 2672806 | 16/09/2019 | Pork fillets & steaks | United Kingdom | E1 | A |
| 2672811 | 16/09/2019 | All other pork | United Kingdom | ? | ? |
| 2685586 | 09/05/2019 | Pork chops | Germany | G1 | B |
| 2685588 | 09/05/2019 | All other pork | United Kingdom | W1 | E |
| 2685591 | 07/06/2019 | Pork chops | Germany | G1 | B |
| 2685595 | 07/06/2019 | All other pork | United Kingdom | Q2 | J |
| 2685597 | 07/06/2019 | Pork chops | United Kingdom | P1 | ? |
| 2685625 | 12/04/2019 | Pork fillets & steaks | Belgium | ? | ? |
| 2685626 | 12/04/2019 | All other pork | Netherlands | K2 | C |
| 2685627 | 09/05/2019 | Pork fillets & steaks | United Kingdom | C2 | H |
| 2685628 | 11/04/2019 | Pork fillets & steaks | Ireland | O1 | B |
| 2685629 | 11/04/2019 | Pork fillets & steaks | United Kingdom | O2 | ? |
| 2685630 | 11/04/2019 | All other pork | United Kingdom | D2 | ? |
| 2685640 | 15/04/2019 | Pork fillets & steaks | United Kingdom | G1 | B |
| 2685642 | 15/04/2019 | Pork fillets & steaks | United Kingdom | H1 | C |
| 2685646 | 10/07/2019 | Pork fillets & steaks | United Kingdom | L1 | F |
| 2685661 | 07/06/2019 | All other pork | United Kingdom | F1 | G |
| 2685666 | 13/09/2019 | All other pork | United Kingdom | ? | ? |
| 2685668 | 13/09/2019 | All other pork | United Kingdom | C2 | H |
| 2685670 | 13/09/2019 | Pork fillets & steaks | United Kingdom | ? | ? |
| 2685672 | 12/04/2019 | All other pork | United Kingdom | H1 | C |
| 2685674 | 12/04/2019 | All other pork | Germany | K1 | B |

| Unique Sample ID | Date of testing at APHA | Food Category | Country of origin | Brands if ≥ 2 samples | Super-market code |
|---|---|---|---|---|---|
| 2685675 | 12/04/2019 | All other pork | United Kingdom | C2 | H |
| 2685676 | 14/05/2019 | All other pork | United Kingdom | P1 | ? |
| 2685682 | 08/05/2019 | All other pork | United Kingdom | Q2 | J |
| 2685688 | 09/05/2019 | Pork fillets & steaks | United Kingdom | P1 | ? |
| 2685690 | 14/05/2019 | Pork chops | United Kingdom | Q2 | J |
| 2685698 | 25/04/2019 | All other pork | United Kingdom | H1 | C |
| 2685701 | 25/04/2019 | All other pork | Netherlands | H1 | C |
| 2685702 | 04/06/2019 | All other pork | Netherlands | K2 | C |
| 2685704 | 04/06/2019 | All other pork | United Kingdom | H1 | C |
| 2685707 | 11/07/2019 | Pork chops | United Kingdom | C2 | H |
| 2685709 | 10/07/2019 | Pork chops | United Kingdom | C2 | H |
| 2685711 | 15/05/2019 | Pork fillets & steaks | United Kingdom | C2 | H |
| 2685712 | 15/05/2019 | All other pork | United Kingdom | W1 | E |
| 2685736 | 10/06/2019 | Pork fillets & steaks | United Kingdom | G1 | B |
| 2685738 | 10/06/2019 | All other pork | Denmark | H1 | C |
| 2685849 | 15/05/2019 | All other pork | United Kingdom | C2 | H |
| 2685912 | 10/10/2019 | All other pork | United Kingdom | T1 | ? |
| 2685914 | 10/10/2019 | Pork fillets & steaks | United Kingdom | Q2 | J |
| 2685915 | 10/10/2019 | All other pork | United Kingdom | Q1 | G |
| 2686012 | 13/03/2019 | Pork chops | Germany | G1 | B |
| 2686022 | 13/03/2019 | Pork fillets & steaks | United Kingdom | I2 | C |
| 2686070 | 12/03/2019 | Pork fillets & steaks | Denmark | H1 | C |

? – Shop not on list

**Table 3.** Country of origin of samples (excludes December 2019 samples).

| Food Group (beef/ pork) | Country of Origin | No. of samples tested |
|---|---|---|
| Beef | Argentina | 1 |
| Beef | Ireland | 16 |
| Beef | Netherlands | 1 |
| Beef | Non-European Union | 1 |
| Beef | Spain | 1 |
| Beef | United Kingdom | 269 |
| Pork | Belgium | 3 |
| Pork | Denmark | 10 |
| Pork | European Union | 1 |
| Pork | France | 2 |
| Pork | Germany | 26 |
| Pork | Ireland | 3 |
| Pork | Netherlands | 17 |
| Pork | Spain | 4 |
| Pork | United Kingdom | 219 |

**Table 4.** Number of beef and pork samples tested per supermarket (excludes December 2019 samples).

| Supermarket code | Food Group (beef/ pork) | No. of samples tested |
|---|---|---|
| ? | Beef | 35 |
| ? | Pork | 25 |
| A | Beef | 13 |
| A | Pork | 8 |
| B | Beef | 34 |
| B | Pork | 44 |
| C | Beef | 43 |
| C | Pork | 60 |
| D | Beef | 4 |
| D | Pork | 6 |
| E | Beef | 25 |
| E | Pork | 32 |
| F | Beef | 7 |
| F | Pork | 5 |
| G | Beef | 20 |
| G | Pork | 20 |
| H | Beef | 37 |
| H | Pork | 33 |
| I | Beef | 21 |
| I | Pork | 11 |
| J | Beef | 36 |
| J | Pork | 24 |

? – Shop not on list

**Table 5.** Number of beef and pork samples tested per brand if two or more samples per brand (excludes December 2019 samples).

| Brands if two or more samples per brand | Food Group (beef/ pork) | No. of samples tested |
|---|---|---|
| A1 | Beef | 1 |
| A1 | Pork | 2 |
| A2 | Beef | 3 |
| B1 | Beef | 5 |
| B1 | Pork | 1 |
| B2 | Beef | 12 |
| B2 | Pork | 2 |
| C1 | Beef | 1 |
| C1 | Pork | 1 |
| C2 | Beef | 31 |
| C2 | Pork | 32 |
| D1 | Beef | 1 |
| D1 | Pork | 1 |
| D2 | Beef | 1 |
| D2 | Pork | 1 |
| E1 | Beef | 1 |
| E1 | Pork | 6 |
| E2 | Beef | 2 |
| F1 | Beef | 2 |
| F1 | Pork | 11 |
| G1 | Beef | 23 |
| G1 | Pork | 33 |
| G2 | Beef | 4 |
| G2 | Pork | 4 |
| H1 | Beef | 28 |
| H1 | Pork | 40 |
| H2 | Beef | 2 |
| I1 | Beef | 15 |
| I1 | Pork | 3 |
| I2 | Beef | 12 |
| I2 | Pork | 2 |
| J1 | Beef | 1 |
| J1 | Pork | 1 |
| J2 | Beef | 2 |
| J2 | Pork | 6 |
| K1 | Pork | 10 |
| K2 | Pork | 18 |
| L1 | Beef | 4 |

| Brands if two or more samples per brand | Food Group (beef/ pork) | No. of samples tested |
|---|---|---|
| L1 | Pork | 5 |
| L2 | Beef | 1 |
| L2 | Pork | 1 |
| M1 | Beef | 5 |
| M1 | Pork | 7 |
| M2 | Beef | 2 |
| N1 | Beef | 3 |
| N2 | Pork | 2 |
| O1 | Beef | 1 |
| O1 | Pork | 1 |
| O2 | Beef | 1 |
| O2 | Pork | 1 |
| P1 | Beef | 21 |
| P1 | Pork | 12 |
| P2 | Beef | 1 |
| P2 | Pork | 1 |
| Q1 | Beef | 1 |
| Q1 | Pork | 1 |
| Q2 | Beef | 26 |
| Q2 | Pork | 24 |
| S1 | Beef | 2 |
| T1 | Beef | 1 |
| T1 | Pork | 1 |
| U1 | Beef | 10 |
| W1 | Beef | 20 |
| W1 | Pork | 28 |
| X1 | Beef | 8 |
| X1 | Pork | 8 |
| Y1 | Pork | 2 |
| Z1 | Beef | 19 |

**Table 6.** Summary of samples positive for *E. coli* from MacConkey agar + 1 mg/L cefotaxime (MCA-CTX) or CHROMagar™ ESBL (CA-ESBL)

| Sample ID | Date tested APHA | Meat type | Meat cut | Brand code | Retail store code | Sampling Location | Country of Origin | Growth on MCA-CTX [a] | Resistance Phenotype [a] | Growth on CA-ESBL [b] | CA-ESBL PCR result [b] | CA-ESBL CTX gene sequence [b] | Batch/Lot Number |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 381029 | 06/03/2019 | Pork | Pork fillets & steaks | H1 | C | Kent Thames Gateway | UK | Yes | AmpC | No | NA | NA | 2 001 058 18:47 1115 |
| 2685696 | 25/04/2019 | Beef | Beef steaks-expensive | I1 | I | Buckinghamshire CC | UK | Yes | ESBL | Yes | C | CTX-M 14 | A903 14:34 L7 108 |
| 2685676 | 14/05/2019 | Pork | All other pork | P1 | ? | Tyneside | UK | Yes | ESBL | Yes | CT | CTX-M 24 | - |
| 1562514 | 04/06/2019 | Pork | Pork fillets & steaks | P1 | ? | Haringey and Islington | UK | No | NA | Yes | C | CTX-M 14 | - |
| 2664655 | 12/09/2019 | Pork | Pork fillets & steaks | P1 | ? | Gloucestershire | UK | Yes | ESBL | No | NA | NA | - |
| 2664465 | 05/11/2019 | Pork | Pork fillets & steaks | X1 | G | Birmingham | UK | No | NA | Yes | C | CTX-M 1 | 9295 19:15 |

*a* – EU harmonised test method

*b* - UK non-harmonised additional test

? – Shop not on list

NA – Not applicable for the isolate, e.g. MICs are not performed for isolates from CA-ESBL

C – isolate positive for *bla*$_{CTX-M}$ gene, T - isolate positive for *bla*$_{TEM}$ gene

**Table 7.** Summary of resistances of *E. coli* isolated on MCA CTX agar

| Antibiotic | No. Resistant[a] / no. tested | | |
|---|---|---|---|
| | Beef ESBL | Pork ESBL | Pork AmpC |
| Ampicillin | 1/1 | 2/2 | 1/1 |
| Azithromycin | 0/1 | 0/2 | 0/1 |
| Cefepime[b] | 1/1 | 2/2 | 1/1 |
| Cefotaxime[b] | 1/1 | 2/2 | 1/1 |
| Cefoxitin[b] | 0/1 | 0/2 | 1/1 |
| Ceftazidime[b] | 1/1 | 2/2 | 1/1 |
| Chloramphenicol | 0/1 | 0/2 | 0/1 |
| Ciprofloxacin | 0/1 | 0/2 | 0/1 |
| Colistin[c] | 0/1 | 0/2 | 0/1 |
| Ertapenem[c] | 0/1 | 0/2 | 0/1 |
| Gentamicin | 0/1 | 0/2 | 0/1 |
| Imipenem[c] | 0/1 | 0/2 | 0/1 |
| Meropenem[c] | 0/1 | 0/2 | 0/1 |
| Nalidixic Acid | 0/1 | 0/2 | 0/1 |
| Sulfamethoxazole | 1/1 | 1/2 | 0/1 |
| Temocillin | 0/1 | 0/2 | 0/1 |
| Tetracycline | 0/1 | 1/2 | 1/1 |
| Tigecycline | 0/1 | 0/2 | 0/1 |
| Trimethoprim | 0/1 | 1/2 | 1/1 |

*a* – Microbiologically resistant using EUCAST ECOFFS.
*b* – Crtitically important cephalosporin antibiotics
*c* – Last resort antibiotics - three carbapenem antibiotics ertapenem, imipenem and meropenem and colistin

**Table 8a.** MIC results for AmpC *E. coli* isolate from MacConkey agar + 1 mg/L cefotaxime (MCA-CTX) from UK pork sample 381029.

| Antibiotic | Indicator for MIC | MIC (µg/ml) | Interpretation of MIC[a] |
|---|---|---|---|
| Ampicillin | > | 64 | R |
| Azithromycin | = | 8 | S |
| Cefepime[b] | = | 0.25 | R |
| Cefotaxime[b] | > | 16 | R |
| Cefotaxime / Clavulanate[c] | = | 8 | No synergy |
| Cefoxitin[b] | > | 16 | R |
| Ceftazidime[b] | = | 16 | R |
| Ceftazidime / Clavulanate[c] | = | 8 | No synergy |
| Chloramphenicol | <= | 8 | S |
| Ciprofloxacin | <= | 0.015 | S |
| Colistin[d] | <= | 1 | S |
| Ertapenem[d] | = | 0.03 | S |
| Gentamicin | <= | 0.5 | S |
| Imipenem[d] | = | 0.25 | S |
| Meropenem[d] | <= | 0.03 | S |
| Nalidixic Acid | <= | 4 | S |
| Sulfamethoxazole | = | 32 | S |
| Temocillin | = | 16 | S |
| Tetracycline | > | 64 | R |
| Tigecycline | <= | 0.25 | S |
| Trimethoprim | <= | 0.25 | S |

R- resistant, S – sensitive

*a* – Microbiologically resistant or sensitive using EUCAST ECOFFS.
*b* – Critically important cephalosporin antibiotics.
*c* – Last resort antibiotics - carbapenem antibiotics ertapenem, imipenem and meropenem and colistin.
*d* – cephalosporin antibiotics with the beta-lactamase inhibitor clavulanic acid.

**Table 8b.** MIC results for ESBL *E. coli* isolate from MacConkey agar + 1 mg/L cefotaxime (MCA-CTX) from UK beef sample 2685696.

| Antibiotic | Indicator if not = | MIC (µg/ml) | Interpretation of MIC[a] |
|---|---|---|---|
| Ampicillin | > | 64 | R |
| Azithromycin | = | 4 | S |
| Cefepime[b] | = | 4 | R |
| Cefotaxime[b] | = | 64 | R |
| Cefotaxime / Clavulanate[c] | <= | 0.06 | Synergy |
| Cefoxitin[b] | = | 4 | S |
| Ceftazidime[b] | = | 1 | R |
| Ceftazidime / Clavulanate[c] | = | 0.25 | Synergy |
| Chloramphenicol | <= | 8 | S |
| Ciprofloxacin | <= | 0.015 | S |
| Colistin[d] | <= | 1 | S |
| Ertapenem[d] | <= | 0.015 | S |
| Gentamicin | = | 2 | S |
| Imipenem[d] | <= | 0.12 | S |
| Meropenem[d] | <= | 0.03 | S |
| Nalidixic Acid | <= | 4 | S |
| Sulfamethoxazole | > | 1024 | R |
| Temocillin | = | 8 | S |
| Tetracycline | <= | 2 | S |
| Tigecycline | <= | 0.25 | S |
| Trimethoprim | <= | 0.25 | S |

R- resistant, S – sensitive

*a* – Microbiologically resistant or sensitive using EUCAST ECOFFS.
*b* – Critically important cephalosporin antibiotics.
*c* – Last resort antibiotics - carbapenem antibiotics ertapenem, imipenem and meropenem and colistin.
*d* – cephalosporin antibiotics with the beta-lactamase inhibitor clavulanic acid.

**Table 8c.** MIC results for ESBL *E. coli* isolate from MacConkey agar + 1 mg/L cefotaxime (MCA-CTX) from UK pork sample 2685676.

| **Antibiotic** | **Indicator if not =** | **MIC (µg/ml)** | **Interpretation of MIC[a]** |
|---|---|---|---|
| Ampicillin | > | 64 | R |
| Azithromycin | <= | 2 | S |
| Cefepime[b] | = | 4 | R |
| Cefotaxime[b] | = | 32 | R |
| Cefotaxime / Clavulanate[c] | <= | 0.06 | Synergy |
| Cefoxitin[b] | = | 4 | S |
| Ceftazidime[b] | = | 1 | R |
| Ceftazidime / Clavulanate[c] | <= | 0.12 | Synergy |
| Chloramphenicol | <= | 8 | S |
| Ciprofloxacin | <= | 0.015 | S |
| Colistin[d] | <= | 1 | S |
| Ertapenem[d] | <= | 0.015 | S |
| Gentamicin | <= | 0.5 | S |
| Imipenem[d] | <= | 0.12 | S |
| Meropenem[d] | <= | 0.03 | S |
| Nalidixic Acid | <= | 4 | S |
| Sulfamethoxazole | > | 1024 | R |
| Temocillin | = | 4 | S |
| Tetracycline | = | 64 | R |
| Tigecycline | <= | 0.25 | S |
| Trimethoprim | > | 32 | R |

R- resistant, S – sensitive

*a* – Microbiologically resistant or sensitive using EUCAST ECOFFS.
*b* – Critically important cephalosporin antibiotics.
*c* – Last resort antibiotics - carbapenem antibiotics ertapenem, imipenem and meropenem and colistin.
*d* – cephalosporin antibiotics with the beta-lactamase inhibitor clavulanic acid.

**Table 8d.** MIC results for ESBL *E. coli* isolate from MacConkey agar + 1 mg/L cefotaxime (MCA-CTX) from UK pork sample 2664655.

| **Antibiotic** | **Indicator if not =** | **MIC (µg/ml)** | **Interpretation of MIC**[a] |
|---|---|---|---|
| Ampicillin | > | 64 | R |
| Azithromycin | = | 4 | S |
| Cefepime[b] | = | 4 | R |
| Cefotaxime[b] | = | 32 | R |
| Cefotaxime / Clavulanate[c] | <= | 0.06 | Synergy |
| Cefoxitin[b] | = | 8 | S |
| Ceftazidime[b] | = | 1 | R |
| Ceftazidime / Clavulanate[c] | = | 0.25 | Synergy |
| Chloramphenicol | <= | 8 | S |
| Ciprofloxacin | <= | 0.015 | S |
| Colistin[d] | <= | 1 | S |
| Ertapenem[d] | <= | 0.015 | S |
| Gentamicin | = | 1 | S |
| Imipenem[d] | <= | 0.12 | S |
| Meropenem[d] | <= | 0.03 | S |
| Nalidixic Acid | <= | 4 | S |
| Sulfamethoxazole | <= | 8 | S |
| Temocillin | = | 8 | S |
| Tetracycline | <= | 2 | S |
| Tigecycline | <= | 0.25 | S |
| Trimethoprim | = | 0.5 | S |

R- resistant, S – sensitive

*a* – Microbiologically resistant or sensitive using EUCAST ECOFFS.
*b* – Critically important cephalosporin antibiotics.
*c* – Last resort antibiotics - carbapenem antibiotics ertapenem, imipenem and meropenem and colistin.
*d* – cephalosporin antibiotics with the beta-lactamase inhibitor clavulanic acid.

**Table 9.** Samples positive on MacConkey agar + 2 mg/L colistin (excludes December 2019 samples) sorted by date.

| Date of testing at APHA | Unique Sample ID | Food Group (beef/ pork) | Country of Origin | Growth MCA - COL | Growth MCA- CTX | Growth CA- ESBL | *mcr*-1 PCR | *mcr*-2 PCR | *mcr*-3 PCR | Super-market codes | Brands if two or more samples per brand |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 18/01/2019 | 2447871 | Beef | UK | + | - | - | - | - | - | C | H1 |
| 18/01/2019 | 2447876 | Pork | UK | + | - | - | - | - | - | E | W1 |
| 18/01/2019 | 2447884 | Pork | Ireland | + | - | - | - | - | - | B | G1 |
| 18/01/2019 | 2447878 | Beef | UK | + | - | - | - | - | - | J | Q2 |
| 21/01/2019 | 2447862 | Pork | UK | + | - | - | - | - | - | C | K2 |
| 21/01/2019 | 1563634 | Beef | UK | + | - | - | - | - | - | F | L1 |
| 21/01/2019 | 2558546 | Beef | Ireland | + | - | - | - | - | - | B | G1 |
| 21/01/2019 | 381078 | Beef | UK | + | - | - | - | - | - | C | H1 |
| 21/01/2019 | 2558547 | Pork | UK | + | - | - | - | - | - | I | M1 |
| 06/02/2019 | 2447843 | Beef | UK | + | - | - | - | - | - | I | M1 |
| 06/02/2019 | 2447816 | Pork | UK | + | - | - | - | - | - | F | L1 |
| 06/02/2019 | 380976 | Pork | UK | + | - | - | - | - | - | B | G1 |
| 07/02/2019 | 2447832 | Beef | UK | + | - | - | - | - | - | C | H1 |
| 07/02/2019 | 2447846 | Beef | Ireland | + | - | - | - | - | - | C | H1 |
| 07/02/2019 | 2447824 | Pork | UK | + | - | - | - | - | - | B | K1 |
| 07/02/2019 | 2686065 | Beef | UK | + | - | - | - | - | - | B | U1 |
| 07/02/2019 | 2447841 | Pork | UK | + | - | - | - | - | - | G | F1 |
| 07/02/2019 | 1614373 | Pork | UK | + | - | - | - | - | - | J | Q2 |
| 06/03/2019 | 2447855 | Pork | Germany | + | - | - | - | - | - | B | G1 |
| 06/03/2019 | 2447856 | Beef | Ireland | + | - | - | - | - | - | C | H1 |
| 06/03/2019 | 558578 | Beef | Ireland | + | - | - | - | - | - | B | G1 |
| 12/03/2019 | 2558197 | Beef | UK | + | - | - | - | - | - | H | C2 |
| 12/03/2019 | 2447834 | Beef | UK | + | - | - | - | - | - | I | I1 |
| 12/03/2019 | 2447768 | Pork | Denmark | + | - | - | - | - | - | C | H1 |
| 12/03/2019 | 2447831 | Pork | France | + | - | - | - | - | - | D | J2 |
| 11/04/2019 | 540797 | Pork | Netherlands | + | - | - | - | - | - | C | K2 |
| 11/04/2019 | 2685630 | Pork | UK | + | - | - | - | - | - | ? | D2 |
| 12/04/2019 | 2685622 | Beef | UK | + | - | - | - | - | - | F | L1 |
| 12/04/2019 | 2685623 | Beef | UK | + | - | - | - | - | - | H | C2 |
| 15/04/2019 | 540490 | Beef | UK | + | - | - | - | - | - | B | G1 |
| 15/04/2019 | 2685640 | Pork | UK | + | - | - | - | - | - | B | G1 |
| 15/04/2019 | 2685644 | Beef | UK | + | - | - | - | - | - | J | Q2 |
| 15/04/2019 | 2685641 | Beef | UK | + | - | - | - | - | - | B | G1 |
| 25/04/2019 | 2685696 | Beef | UK | + | + | + | - | - | - | I | I1 |

| Date of testing at APHA | Unique Sample ID | Food Group (beef/ pork) | Country of Origin | Growth MCA - COL | Growth MCA-CTX | Growth CA-ESBL | *mcr*-1 PCR | *mcr*-2 PCR | *mcr*-3 PCR | Super-market codes | Brands if two or more samples per brand |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 25/04/2019 | 540733 | Pork | UK | + | - | - | - | - | - | A | E1 |
| 08/05/2019 | 2685682 | Pork | UK | + | - | - | - | - | - | J | Q2 |
| 14/05/2019 | 2672348 | Pork | UK | + | - | - | - | - | - | E | W1 |
| 16/05/2019 | 2672345 | Pork | UK | + | - | - | - | - | - | H | C2 |
| 10/06/2019 | 2685738 | Pork | Denmark | + | - | - | - | - | - | C | H1 |
| 10/06/2019 | 540664 | Pork | UK | + | - | - | - | - | - | H | C2 |
| 08/10/2019 | 2664647 | Beef | UK | + | - | - | - | - | - | E | G2 |
| 08/10/2019 | 2664648 | Pork | UK | + | - | - | - | - | - | E | W1 |
| 09/10/2019 | 2664653 | Beef | UK | + | - | - | - | - | - | C | H1 |
| 09/10/2019 | 6489 | Pork | UK | + | - | - | - | - | - | H | C2 |
| 09/10/2019 | 2664639 | Beef | UK | + | - | - | - | - | - | J | Z1 |

+ Growth on agar or positive for *mcr* gene.

- No growth on agar or negative for *mcr* gene.

# 10. Figures

**Figure 1.** Decrease in the percentage of EU beef and pork samples testing positive for AmpC, ESBL and AmpC + ESBL *E. coli* between 2015 and 2017– EU EFSA data.

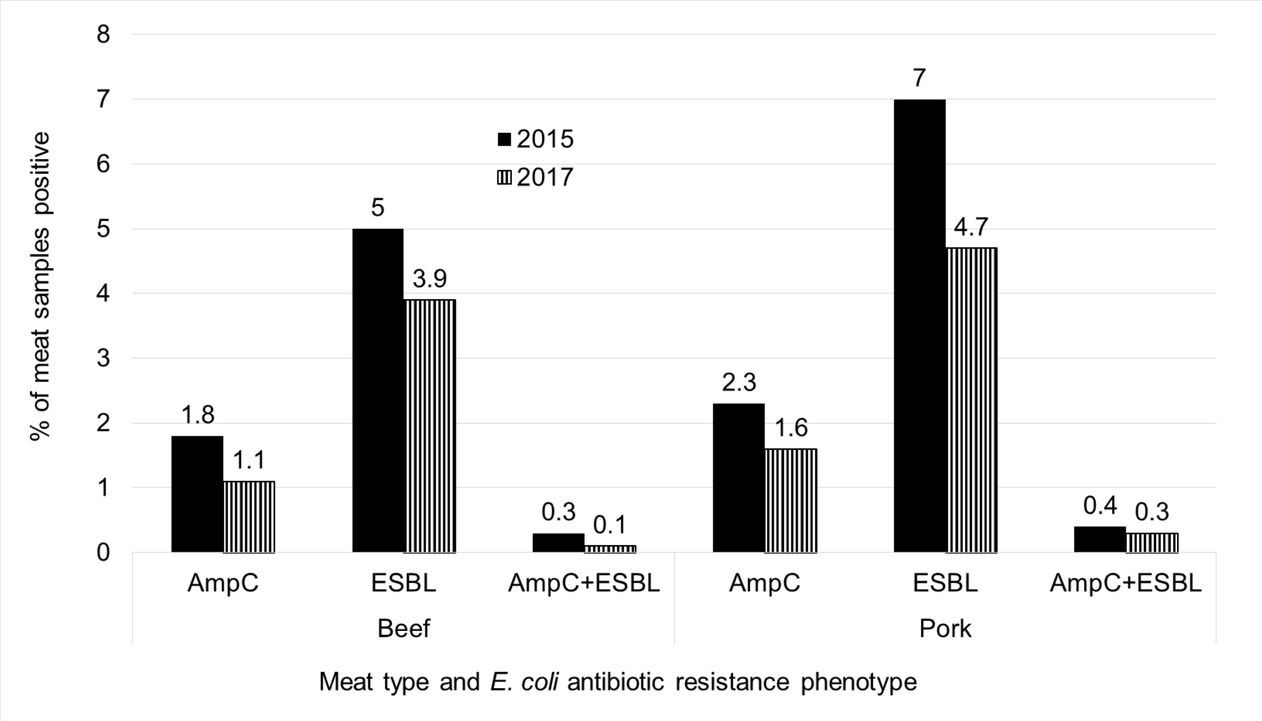



**Figure 2.** Decrease in the maximum country levels (for all countries submitting results) of AmpC-ESBL-producing *E. coli* reported for beef and pork between 2015 and 2017 – EU EFSA data.

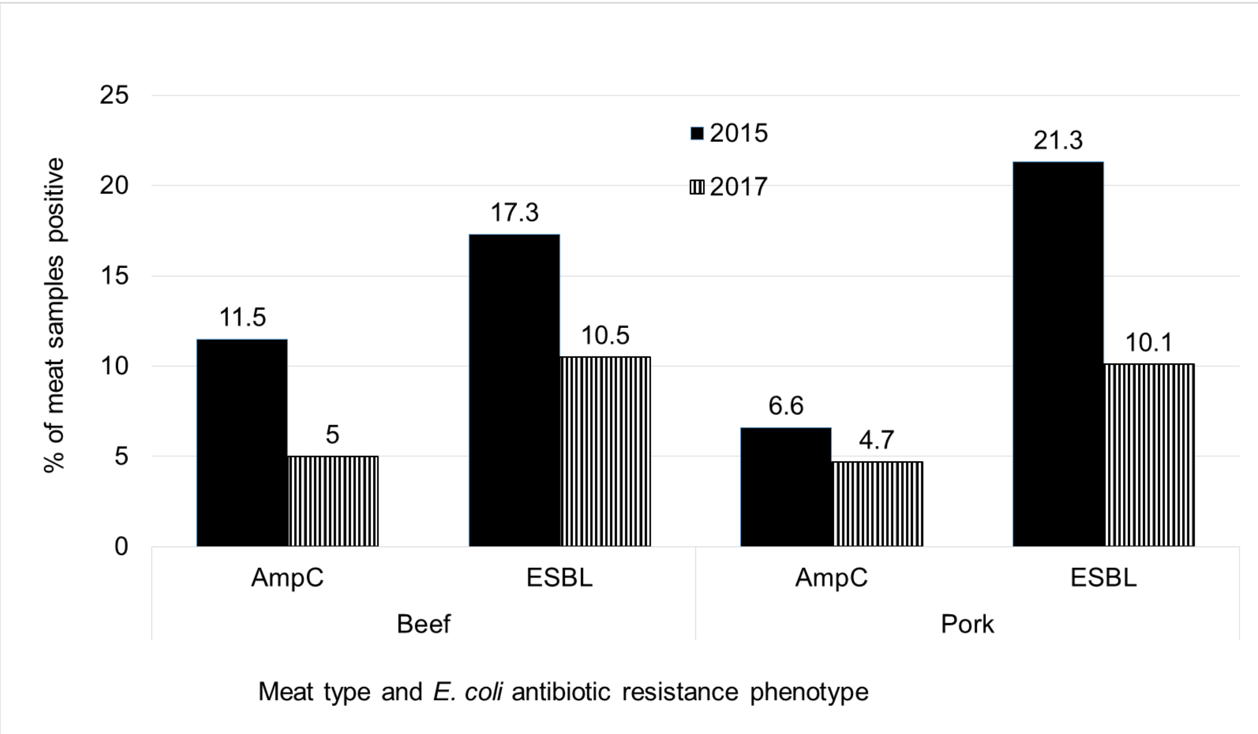
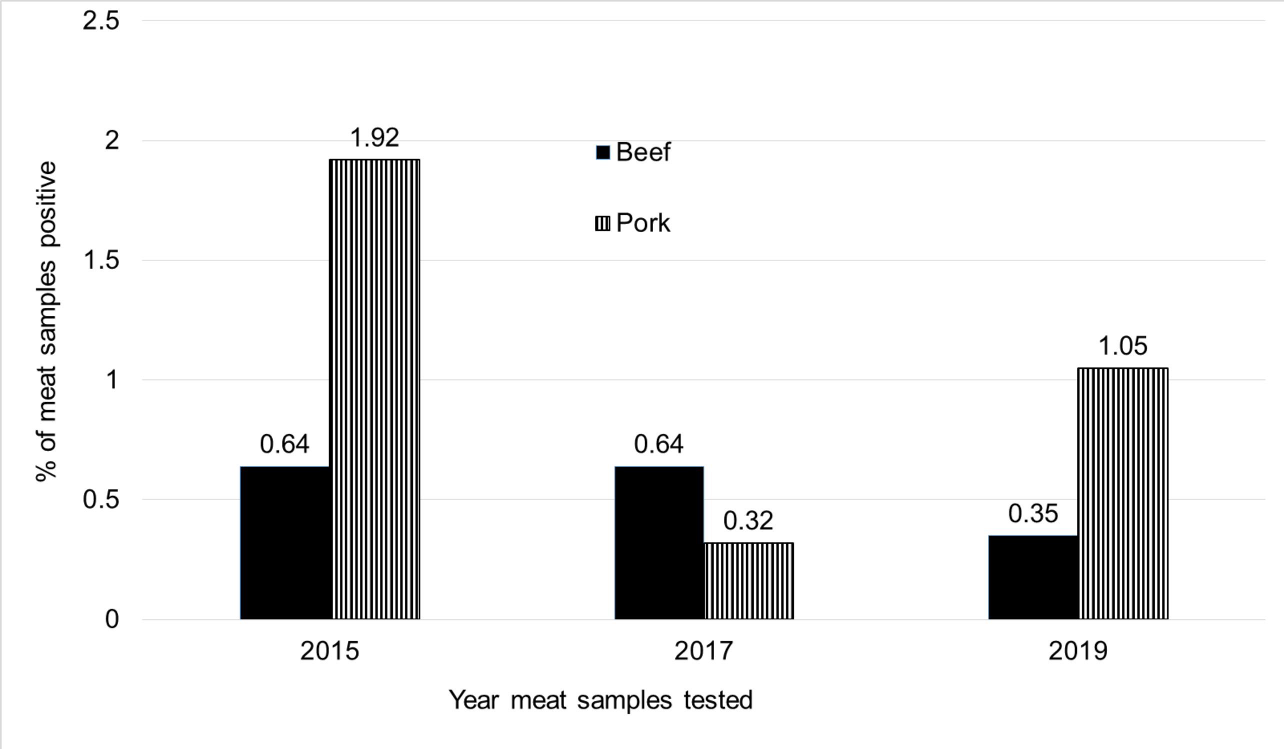


**Figure 3.** Percentages of UK beef and pork samples positive for AmpC-/ESBL-phenotype *E. coli* on MCA-CTX agar from 2015 to 2019



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## 12. Appendix – Discussion from the 2017 report

Previous published studies prior to commissioning of the current EU surveys showed that 20% of minced beef from Austria were positive for mainly CTX-M-1 ESBL-producing *E. coli* [21], whilst another study in Switzerland in 2012 found that none of 104 minced beef and pork samples were positive for ESBL-producing *Enterobacteriaceae*, although in this study 15.3% of the porcine, 13.7% of the bovine, 8.6% of the sheep and 63.4% of the chicken faecal samples yielded ESBL-producers after an enrichment step [22]. Another study in Denmark in 2014 found that 83.8% of broiler meat, 12.5% of pork and 3.7% of beef tested was contaminated with AmpC / ESBL *E. coli* [23]. However, these studies lack a uniform methodology across different countries that is employed in current EU harmonised studies such as reported here.

For 2017 UK beef and pork retail meat samples tested in this study using the EU harmonised method (MCA-CTX), 0.32% (for both meat types) were positive for AmpC phenotype *E. coli* whilst, 0.32% of beef samples only were positive for ESBL phenotype *E. coli*. These results exclude the one extra pork sample positive on CA-ESBL only, since this is an extra test outside the EU harmonised method.

In the EU survey of AMR in bacteria from UK retail meat in 2015 [24], the percentages of beef and pork samples that were positive for ESBL phenotype *E. coli* were 1.0% and 2.1% respectively, and the percentages of beef and pork samples therefore that were positive for AmpC phenotype *E. coli* were 1.0% and 0.4% respectively. As such, between 2015 and 2019, the percentage of retail samples of beef and pork in the UK contaminated with AmpC or ESBL phenotype *E. coli* has remained almost identical.

In a slightly earlier study in which retail beef (n = 159) and pork (n = 79) meat samples were collected and tested in 2013-2014 from 5 different regions in the UK, 1.9% and 2.5% of beef and pork samples respectively, were positive for ESBL-producing *E. coli,* whilst 0.8% of beef samples and 1.3% of pork samples were positive for *E. coli* carrying the AmpC *bla*$_{CIT}$ genes, with *bla*$_{CMY-2}$ the most frequent variant detected by sequencing [18]. This earlier study, whilst suggesting there has been a slight reduction in the numbers of beef and pork contaminated with AmpC or

ESBL phenotype *E. coli* between 2013/14 and 2017, involved a different sampling strategy and different isolation agars, as discussed previously [11].

Results for the 2015 EU monitoring of beef and pork for presumptive ESBL-/AmpC-/carbapenemase-producing *E. coli* have now been published by EFSA [24]. In 2015, EU monitoring was performed on a mandatory basis by 22 member states (MSs) and two non-MSs on meat from pigs, and by 23 MSs and two non-MSs on meat from bovine animals [24]. Results for the UK compared favourably with results from other countries in that presumptive AmpC phenotype *E. coli* in beef in 2015 ranged from 0% in Switzerland to 11.5% in Bulgaria (1% UK), whilst ESBL phenotype *E. coli* in beef ranged from 0% in Switzerland to 17.3% in Bulgaria (1% UK) [24]. For pork, presumptive AmpC phenotype *E. coli* in 2015 ranged from 0% in Switzerland to 6.6% in in the Czech republic (0.4% UK), whilst ESBL phenotype *E. coli* in pork ranged from 0.3% in Sweden to 20.8% in Bulgaria (2.1% UK) [24].

The predominant *E. coli* strain associated with human infections is the pandemic O25-ST131 CTX-M-15-producing clone [15, 16]. Only three isolates from CA-ESBL agar were tested by multiplex PCR for *bla*$_{CTX}$, *bla*$_{OXA}$, *bla*$_{TEM}$ and *bla*$_{SHV}$ genes, of which two isolates (both beef isolates and both from samples also positive on MCA-CTX) were positive for *bla*$_{CTX\text{-}M}$ of sequence type CTX-M 1. As such none of the samples were positive for the human pandemic O25-ST131 CTX-M-15- producing *E. coli* clone. Use of the additional CA-ESBL agar allowed for detection from one sample of an ESBL *E. coli* not isolated from MCA-CTX. As such this beef sample was positive for two different isolates of *E. coli,* one of which was an AmpC and the other an ESBL phenotype.

Whilst a total of three samples out of 624 tested in this study were positive for AmpC or ESBL-phenotype *E. coli* on MCA-CTX agar, none of these isolates were resistant to the last resort antibiotics such as colistin and the three carbapenem antibiotics tested. However, 39 of the beef samples (12.4%) and 46 of the pork samples (14.8%) gave rise to presumptive *E. coli* on MCA-COL agar (colistin resistance), and one of the beef samples was positive for *mcr-1* plasmid mediated colistin resistant *E. coli*, as previously reported. In a recent study, 10,206 isolates of *E. coli* from cattle, chickens and pigs from EU member states were tested for resistance to colistin and for the presence of the plasmid mediated colistin resistance gene *mcr-1* [25]. Of the 10,206 *E. coli* isolates, only 1.4% were resistant to colistin, and 0.7% of isolates were positive for *mcr-1* [25]. Whilst the percentage of beef and pork samples in this study that yielded presumptive *E. coli* that were colistin resistant were much higher than reported from the 10,206 *E. coli* from cattle, chickens and pigs [25], the methodologies were not comparable. Isolates from cattle, chickens and pigs were not stated to be selected with media containing colistin, which will specifically select for colistin resistant *E. coli.* Additionally, isolates from beef and pork in this study were not biochemically confirmed as *E. coli* (beyond being lactose fermenters on MCA-COL agar), unless first confirmed to be *mcr-1* positive. If a single *E. coli* was isolated from each of the meat samples using non-selective media, the percentage of samples that were positive for colistin resistant *E. coli* would have been much lower. The mechanisms of colistin resistance in the *mcr-1* negative isolates selected on MCA-COL agar is likely to be due to chromosomal mutations [26, 27].

It has been suggested, as discussed in a previous EU report [11], that to reduce the occurrence of AmpC-/ESBL-producing *E. coli* in livestock and in retail meat, it might be prudent to avoid use of cephalosporin antibiotics and reduce the use of other antimicrobials to as little as possible, but as much as necessary in livestock; to improve biosecurity to reduce ESBL / AmpC-producing bacterial dissemination; to improve slaughter hygiene and to perform some type of decontamination after slaughter [23].

In pigs a previous study showed that use of ceftiofur and cefquinome exerted a selective pressure for ESBL *E. coli* [28], whilst another study showed reduction of ESBL *E. coli* in pigs following introduction of voluntary restrictions on cephalosporin use [29].

It is also interesting to note that there was a significant drop (odds ratio 0.45 p-value < 0.001) in the percentages of ESBL *E. coli* isolated from chicken meat in 2013/14 (65.4%) [18] compared to the UK EU survey of 2016 (29.7%) [11]. In 2012 the British Poultry council, which represents more than 90% of the UK poultry meat production, banned the use of all cephalosporins in flocks used for poultry meat production [30, 31].

In conclusion, the results of the second year of EU monitoring of retail beef and pork for AmpC and ESBL-phenotype *E. coli* in the UK showed only a low level of < 1% of samples were positive for AmpC or ESBL *E. coli* following examination using sensitive detection methods, and these results are similar to results for these meats in 2015 [24]. With respect to resistance to last resort antibiotics, none of the samples were positive for carbapenem resistant *E. coli.* Some of the samples were positive for colistin resistant presumptive *E. coli* and one of these samples was positive for the *mcr-1* plasmid mediated colistin resistance gene as previously reported [32].