



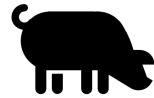
# WG2 Systematic literature review on pre-harvest food safety interventions for pigs

Maria Rodrigues da Costa



Background

Methods



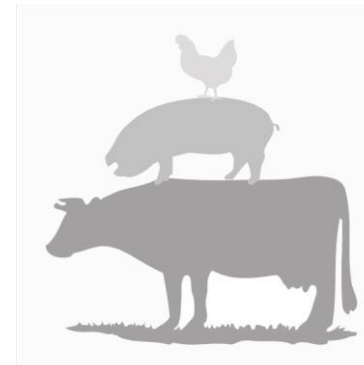
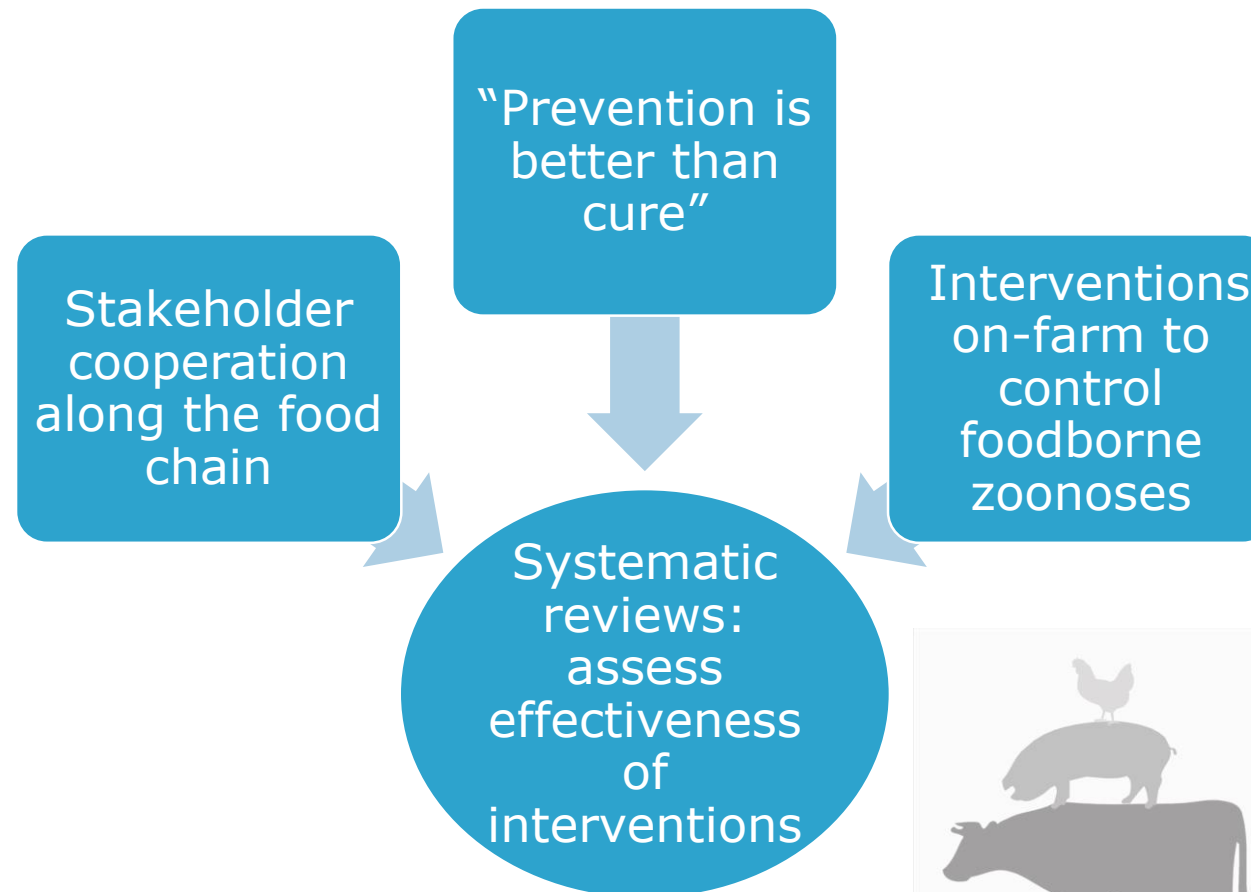
Results/  
Discussion



Results/  
Discussion

Conclusions

RIBMINS main goal "MEAT SAFETY"



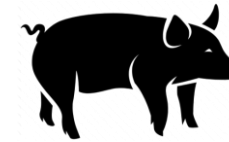
## Identify key pathogens



EFSA Journal 2012;10(6):2741

### SCIENTIFIC OPINION

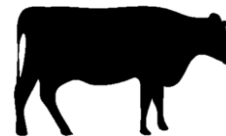
Scientific Opinion on the public health hazards to be covered by inspection of meat (poultry)<sup>1</sup>



EFSA Journal 2011;9(10):2351

### SCIENTIFIC OPINION

Scientific Opinion on the public health hazards to be covered by inspection of meat (swine)<sup>1</sup>

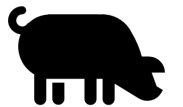


EFSA Journal 2013;11(6):3266

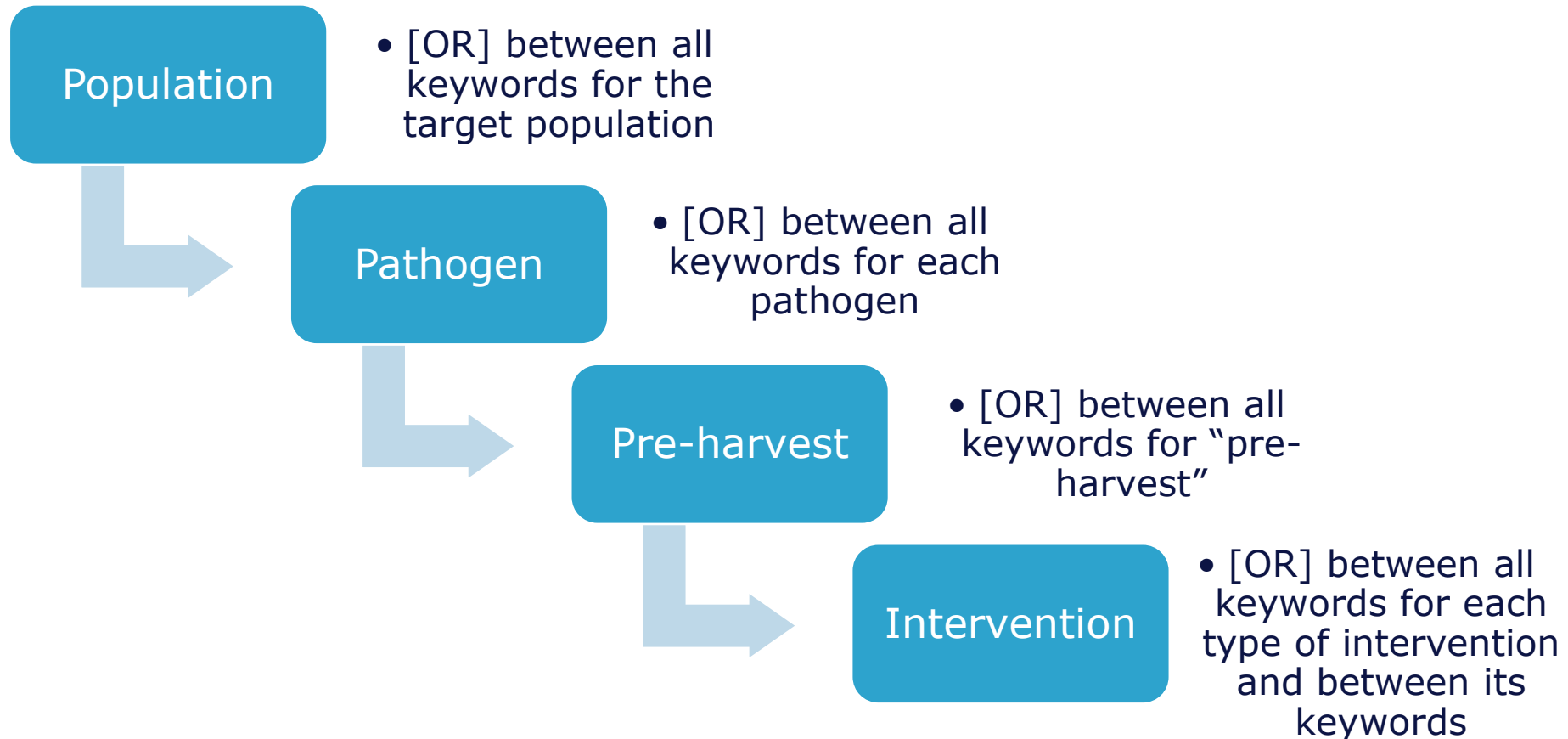
### SCIENTIFIC OPINION

Scientific Opinion on the public health hazards to be covered by inspection of meat (bovine animals)<sup>1</sup>

- Systematic review – PRISMA
  - Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement
  
- Searches were conducted on PubMed® & Web of Science on June 7th 2020
  - Peer-reviewed studies in English
  - Time restrictions: published between 2015 and 2020 (until June 7th)
  - Effectiveness of pre-harvest meat safety interventions to control foodborne pathogens



- Search string structure used for the searches conducted

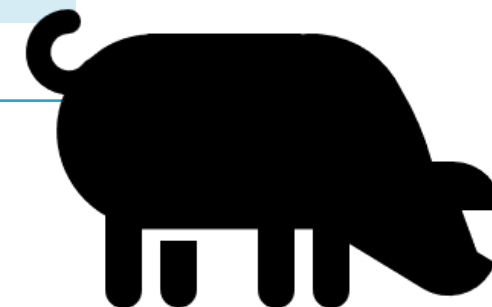


- Eligibility criteria - PICO

PICO	Inclusion Criteria	Exclusion Criteria
Population	Animal species being evaluated: must include (but not limited to) pigs	Does not include actual or theoretical <pathogen> infection/contamination in pigs
	Unit of study [animal, herd, house, barn, farm] and [surfaces, food, water, environment, drinkers, feeder, other animals]	Others
Intervention	Interventions to control/reduce/eradicate <pathogen> in pigs	Studies not mentioning control/reduce/eradicate interventions for <pathogen> in pigs
	Interventions on-farm or during transport (pre-harvest)	Interventions on lairage, at slaughter and post-harvest
	Field/experimental studies	Lab/bench studies
Comparison	Control group present [group subjected to no intervention]	Control group absent
Outcomes	Provides some measure of the efficacy of the intervention	Efficacy of the intervention not measured
Others	Language: English	Other languages
	Peer-reviews	Grey literature

- **Fifteen pathogens identified as public health hazards from pigs**

<i>Clostridium botulinum</i>	<i>Salmonella</i> spp.
<i>Clostridioides difficile</i>	<i>Sarcocystis</i> spp.
<i>Clostridium perfringens</i>	<i>Taenia solium</i>
<i>Campylobacter</i> spp.	<i>Toxoplasma gondii</i>
Hepatitis virus type E	<i>Trichinella spiralis</i>
<i>Listeria monocytogenes</i>	VTEC
MRSA	<i>Yersinia enterocolitica</i>
<i>Mycobacterium avium</i> complex	





## WG2

## Results

Pathogen	Records Identified	Records after Duplicates' Removal	Records Retained after Abstract Screening	Records Retained after Full Text Screening
<i>Clostridium botulinum</i>	3	3	0	0
<i>Clostridioides difficile</i>	8	7	0	0
<i>Clostridium perfringens</i>	43	33	9	5
<i>Campylobacter spp.</i>	156	115	3	2
<i>Hepatitis virus type E</i>	101	77	0	0
<i>Listeria monocytogenes</i>	12	11	0	0
MRSA	194	139	9	1
<i>Mycobacterium avium complex</i>	27	23	3	1
<i>Salmonella spp.</i>	785	555	57	43
<i>Sarcocystis spp.</i>	9	7	0	0
<i>Taenia solium</i>	12	12	0	0
<i>Toxoplasma gondii</i>	101	77	2	0
<i>Trichinella spiralis</i>	63	50	2	0
VTEC	5	5	1	0
<i>Yersinia enterocolitica</i>	87	66	1	0
<b>TOTAL</b>	<b>1606</b>	<b>1180</b>	<b>87</b>	<b>52</b>

- 52 studies retained (1983 to 2020) and analysed

*Salmonella* spp.

*Campylobacter* spp.

MRSA

*Mycobacterium avium*

*Clostridium perfringens*

- For *Salmonella*: 43 studies, comprising 86 trials
  - In-feed and/or water treatments, and vaccination were the most tested interventions and were, overall, successful (72% and 87%)

*Salmonella* spp.

*Campylobacter* spp.

MRSA

*Mycobacterium avium*

*Clostridium perfringens*

- Most *Salmonella* studies were done in commercial farms (n=34 of 43, 79%).
- 8 trials tested the efficacy of antimicrobials to control *Salmonella*. Only 1 had positive results and it was a combined treatment with early off-site weaning.

*Salmonella* spp. (n=43)

*Campylobacter* spp.

MRSA

*Mycobacterium avium*

*Clostridium perfringens*

- Across all trials, the results for *Salmonella* are very encouraging, with 76% (65/86) of the trials assessed reporting positive results.

*Salmonella* spp. (n=43)

*Campylobacter* spp.

MRSA

*Mycobacterium avium*

*Clostridium perfringens*

- 2 studies retained for *Campylobacter* spp. tested the efficacy of probiotics to reduce the colonisation of this pathogen as (competitive exclusion)

*Salmonella* spp.

*Campylobacter* spp.

MRSA

*Mycobacterium avium*

*Clostridium perfringens*

- 5 studies retained for *C. perfringens* assessed the efficacy of vaccinations (n = 4) and probiotics (n = 1).
  - All studies reported positive outcomes for the interventions tested.

*Salmonella* spp.

*Campylobacter* spp.

MRSA

*Mycobacterium avium*

*Clostridium perfringens*

- MRSA: 1 RCT trial to test the efficacy of a thorough cleaning and disinfection protocol for sows and the environment to reduce the prevalence of MRSA in sows and their progeny.
  - Temporary reduction in sows and piglets but not translated into a reduction at weaning or nursery.

*Salmonella* spp.

*Campylobacter* spp.

MRSA

*Mycobacterium avium*

*Clostridium perfringens*



- *Mycobacterium avium* complex: 1 study testing the efficacy of vaccination with two different vaccines (killed “whole cell” vs subunit) in experimentally challenged pigs.
  - Killed vaccine did not prevent disease but attenuated its severity.
  - Subunit vaccine had no effect compared to control

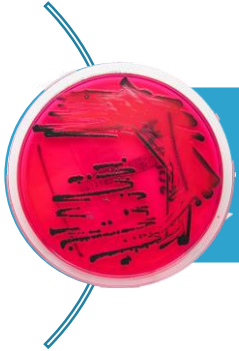
*Salmonella* spp.

*Campylobacter* spp.

MRSA

*Mycobacterium avium*

*Clostridium perfringens*



*Salmonella*: eligibility criteria may have eliminated effective interventions from our study

- At national level, Finland, Norway and Sweden have documented that the successful control of *Salmonella* in cattle, pigs and poultry through pre-harvest interventions is possible
- Heat-treatment of feed, and starting with breeding animals free from *Salmonella* at the top of the breeding pyramid have probably been the most important measures.

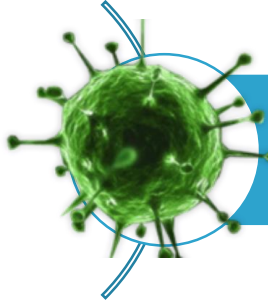


*Campylobacter*: It seems more cost-efficient to control this agent post-harvest



*C. perfringens*: In studies retained, the clinical outcome in pigs seemed to be the main worry, not shedding.

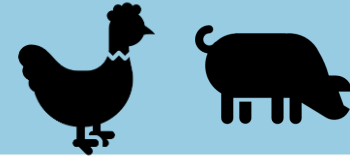
- Low risk, post-harvest interventions seem more appropriate once “risk of disease seems not to be correlated with occurrence in raw meat but rather to improper hygiene and storage”



*MRSA: national control seems to be possible*

- Norway has established a unique control strategy in their pig population, which includes population-wide annual surveillance, in addition to contact tracing upon detection of MRSA in pig farms and farm workers.

- Hepatitis E: new research in recent years, no papers meeting criteria defined. Vaccination could help control.
- *Y. enterocolitica*: one of the most important hazards.
  - Specific pathogen free programs seem to work – though not included in our study
- *T. gondii*: outdoor pigs not included in this study.
  - Control of cat population may be helpful

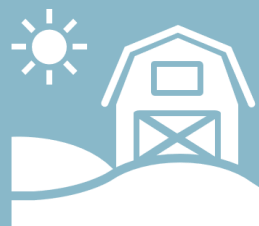


Across broilers and pigs, results were similar:



- Limitations: eligibility criteria might have eliminated effective interventions
- Some pathogens are frequently controlled by post-harvest interventions

- Some foodborne **pathogens** appear to be **best** controlled at a **post-harvest level**.
- Overall, high herd health status coupled with good management and biosecurity **were effective** to control or prevent most foodborne pathogens in pork.
- In spite of not having been included in the review, the SPF herd principle, stamping out and repopulating with disease-free animals, has been reported as a feasible and effective intervention to control foodborne pathogens like *Salmonella*, *Y. enterocolitica* and MRSA.



# WG2 Systematic literature review on pre-harvest food safety interventions for bovine

Maria Rodrigues da Costa





- Eligibility criteria - PICO

PICO	Inclusion Criteria	Exclusion Criteria
Population	Animal species being evaluated: must include (but not limited to) <b>beef cattle</b>	Does not include actual or theoretical <pathogen> infection/contamination in <b>beef cattle</b>
	Unit of study [animal, herd, house, barn, farm] and [surfaces, food, water, environment, drinkers, feeder, other animals]	Others
Intervention	Interventions to control/reduce/eradicate <pathogen> in <b>beef cattle</b>	Studies not mentioning control/reduce/eradicate interventions for <pathogen> in <b>beef cattle</b>
	Interventions on-farm or during transport (pre-harvest)	Interventions on lairage, at slaughter and post-harvest
	Field/experimental studies	Lab/bench studies
Comparison	Control group present [group subjected to no intervention]	Control group absent
Outcomes	Provides some measure of the efficacy of the intervention	Efficacy of the intervention not measured
Others	Language: English	Other languages
	Peer-reviews	Grey literature

- thirteen pathogens identified as public health hazards from cows

*Bacillus anthracis*

Methicillin Resistant

*Staphylococcus Aureus* (MRSA)

*Bacillus cereus*

*Salmonella* spp.

*Campylobacter* spp.

*Sarcocystis hominis*

*Clostridium botulinum*

Verocytotoxigenic *Escherichia coli*  
(VTEC)

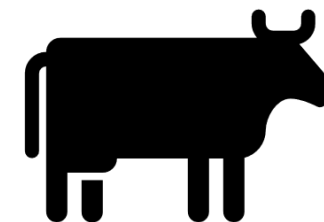
*Clostridium perfringens*

*Taenia saginata*

ESBL-Amp C gene-carrying  
bacteria

*Toxoplasma gondii*

*Listeria monocytogenes*



## WG2

## Results

Pathogens	Records Identified	Records after Duplicates' Removal	Records Retained after Abstract Screening	Records Retained after Full Text Screening
<i>Bacillus anthracis</i>	48	42	3	0
<i>Bacillus cereus</i>	30	30	0	0
<i>Campylobacter</i> spp.	244	211	9	1 <sup>a</sup>
<i>Clostridium botulinum</i>	31	27	5	2
<i>Clostridium perfringens</i>	40	38	3	2
ESBL-Amp C gene-carrying bacteria	107	90	2	1
<i>Listeria monocytogenes</i>	94	84	3	0
Methicillin Resistant <i>Staphylococcus Aureus</i> (MRSA)	108	100	0	0
<i>Salmonella</i> spp.	541	456	43	16 <sup>a</sup>
<i>Sarcocytis hominis</i>	9	8	0	0
VTEC	363	323	32	14 <sup>a</sup>
<i>Taenia saginata</i>	41	37	4	0
<i>Toxoplasma gondii</i>	77	68	0	0
<b>TOTAL</b>	<b>1733</b>	<b>1514</b>	<b>104</b>	<b>36</b>

- 36 studies were retained

*Salmonella* spp.

VTEC

Campylobacter

*Clostridium botulinum*

*Clostridium perfringens*

*ESBL-AmpC*

## Rough overview

*Salmonella* spp.

VTEC

Campylobacter

*Clostridium botulinum**Clostridium perfringens**ESBL-AmpC***Vaccination**

N= 6 studies  
 4x – no effect,  
 1x- increased immunity,  
 1x – partial effect

**Feed additives and treatments**

N= 4  
 1x – oral admin of anti-salmonella  
 bacterium – positive effect  
 2x – probiotics –  
 - 1/ effect not clear  
 - 1/ positive effect  
 1x IgY admin - positive effect

**Antibiotic**

N= 1 – no long term effect

**Biosecurity**

N= 1 - Bird control – *Salmonella* reduction  
 in the environment but not on shedding

**Cleaning and disinfection**

N= 1 - positive effect

**Management**

N= 3  
 1x Sprinklers to alleviate stress -  
 positive effect,  
 2x Milk pasteurisation:  
 -1x positive effect,  
 - 1x no effect

## Rough overview

*Salmonella* spp.

VTEC

Campylobacter

*Clostridium botulinum**Clostridium perfringens**ESBL-AmpC***Vaccination**

N= 4

1x no effect/effect not clear,  
3x positive effect**Feed additives and treatments**

N= 2

2x probiotics –  
- 1x effect not clear,  
- 1x no effect**Combination of measures**

N= 2

1x package of interventions –  
positive effect,  
1x vaccination and probiotic – effects  
not clear**Cleaning and disinfection**

N= 1

1x water disinfection/ treatments – positive  
effect but taste challenges led to reduced  
water consumption**Management**

N= 2 – positive effects

1x water availability  
1x manure compost**Transport and lairage**

N= 3

1x washing trucks – positive effect,  
1x preconditioning – positive effect,  
1x no effect (more power needed),

*Salmonella* spp.

VTEC

Campylobacter

*Clostridium botulinum*

*Clostridium perfringens*

ESBL-AmpC

1x **combined measures** (feed additives and hide spray)

- “Effects of feed-supplementation and hide-spray application of two sources of tannins on enteric and hide bacteria of feedlot cattle”  
(10.1080/03601234.2011.559419)
- No effect seen in decreasing bacterial counts

*Salmonella* spp.

VTEC

Campylobacter

*Clostridium botulinum*

*Clostridium perfringens*

ESBL-AmpC

**2x vaccination:**

- “Neonatal immune response of Brazilian beef cattle to vaccination with *Clostridium botulinum* toxoids types C and D by indirect ELISA”(10.1590/s1678-91992010000300018)
- “Efficacy of *Clostridium botulinum* types C and D toxoid vaccination in Danish cows” (10.1016/j.anaerobe.2013.06.011)
- Increased immunity



*Salmonella* spp.

VTEC

Campylobacter

*Clostridium botulinum*

*Clostridium perfringens*

ESBL-AmpC

1x **Feed additives:**

- “Improvement of intestinal microflora balance and prevention of digestive and respiratory organ diseases in calves by green tea extracts” (10.1016/s0301-6226(00)00233-5)
- Seems to have positive effects

1x **vaccination:**

- “Induction of potential protective immunity against enterotoxemia in calves by single or multiple recombinant *Clostridium perfringens* toxoids” (10.1111/1348-0421.12198)
- Increased immunity

*Salmonella* spp.

VTEC

Campylobacter

*Clostridium botulinum*

*Clostridium perfringens*

*ESBL-AmpC*

1x **feed additive/probiotics:**

- “The effect of *Enterococcus faecium* M74 feed additive on the extended-spectrum beta-lactamases/AmpC-positive *Escherichia coli* faecal counts in pre-weaned dairy calves”  
(10.2754/avb201786040333)
- No effect seen



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Researcher

Maria Costa

- Pessoa, J.C., Rodrigues da Costa, M., Nesbakken, T, Meemken, D. 2021. Assessment of the effectiveness of pre-harvest meat safety interventions to control foodborne pathogens in broilers: a systematic review. Current Clinical Microbiology Reports (2021).

<https://doi.org/10.1007/s40588-021-00161-z>

- Rodrigues da Costa, M., Pessoa, J.C, Meemken, D. Nesbakken, T. 2021. A Systematic Review on the Effectiveness of Pre-Harvest Meat Safety Interventions in Pig Herds to Control Salmonella and Other Foodborne Pathogens. Microorganisms, 9, 1825.

<https://doi.org/10.3390/microorganisms9091825>

### Previous Lecture

Current Clinical Microbiology Reports (2021) 8:21–30  
<https://doi.org/10.1007/s40588-021-00161-z>

BACTERIOLOGY (N BOREL, SECTION EDITOR)



#### Assessment of the Effectiveness of Pre-harvest Meat Safety Interventions to Control Foodborne Pathogens in Broilers: a Systematic Review

Joana Pessoa<sup>1,2</sup> • Maria Rodrigues da Costa<sup>3</sup> • Truls Nesbakken<sup>4</sup> • Diana Meemken<sup>5</sup> • on behalf of the RIBMINS Cost Action

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microorganisms

### This Lecture



Systematic Review

#### A Systematic Review on the Effectiveness of Pre-Harvest Meat Safety Interventions in Pig Herds to Control *Salmonella* and Other Foodborne Pathogens

Maria Rodrigues da Costa<sup>1</sup> , Joana Pessoa<sup>2,3,4</sup>, Diana Meemken<sup>5,\*</sup> and Truls Nesbakken<sup>6</sup>

Thank you for the attention.  
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