

## Guidelines for Fresh Produce Food Safety 2022

**FPSC's revised exclusion periods for use of raw manures or animal grazing – *what growers need to know***

# Takeaways from this presentation

Changed requirements for exclusion periods between application of raw or untreated manure/grazing of animals and the harvest of fresh produce

New requirements – are as follows

**Growing zone  $<20^{\circ}\text{C}$  (monthly mean maximum):**

Exclusion period of 90 or 180 days

**Growing zone  $\geq 20^{\circ}\text{C}$  (monthly mean maximum):**

Exclusion period of 45 or 80 days

# Why are we doing this?

- Frequent incidents involving contamination of fresh produce with enteric pathogens and increasing burden of foodborne illness linked to fresh produce
- Range of contamination sources: soil amendments, raw manure, incursions of wild animals into growing environments, birds, rodents, agricultural water, adjacent land use .....
- Goal is to minimise the likelihood of pathogens contaminating fresh produce – requires a multifaceted approach

**The primacy of ensuring food safety surpasses all other considerations**



# Globally .... *No consistency*

- **UK Food Standards Agency**  
12-month gap between livestock last grazing in the field and harvesting of a ready-to-eat crop
- **USDA**  
Manure incorporated into soil not less than 120 days prior to harvest
- **GlobalGap**  
60 days between application of untreated raw manure of animal origin and harvest
- **CanadaGap**  
Earliest Allowable Harvest Date (EAHD) of 120 days between manure application and harvest



## DRAFT

14.4

Where the harvestable part of the crop is grown in or within 1 metre of the ground surface or is harvested from the ground and the crop may be eaten uncooked, the following shall ~~not be permitted~~ on the growing site within 365 days of harvest of the crop:

- Application of raw manure; or
- Application of un-composted green waste; or
- Livestock stocking.

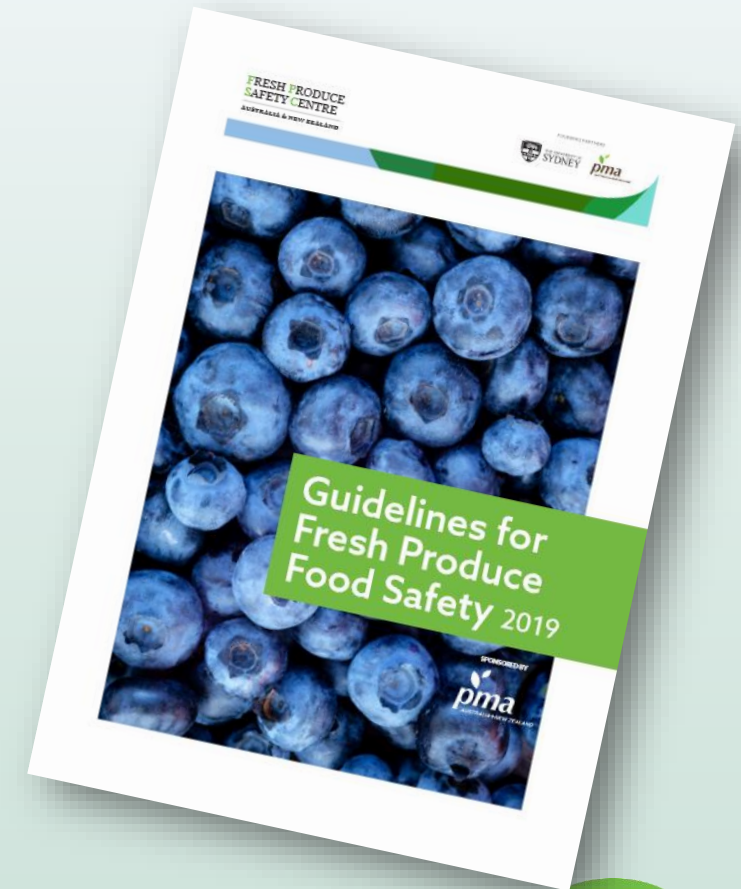
Where raw manure and un-composted green waste is applied to growing sites, these shall be incorporated into the soil immediately after application, and for annual crops, prior to sowing or transplanting.

Storage sites for all raw manure and un-composted green waste shall be off-site or located, constructed and maintained to minimise the risk of contaminating produce. If on-site, storage shall be indicated on a farm map.

Equipment used to apply raw manure and un-composted green waste shall be dedicated for this purpose or thoroughly cleaned after use. Cleaning records shall be kept.

# Our approach .....

- FPSC established **Guidelines Technical Group** in August 2020 to review exclusion periods between application of raw or untreated manure/grazing of animals and harvest
- **Chair:** Dr Sharon Horton [FPSC Board member]
- Nine members [Three academics, six from industry/industry associations]
- Ten meetings [25 August 2020 – 3 March 2022]
- **Scope**  
To review peer-reviewed literature and recommend updated exclusion periods, and update section 6.2 of the Guidelines



# Terms of Reference

1. To examine peer-reviewed and published literature to determine the most appropriate exclusion periods, or range of exclusion periods, between grazing or application of untreated animal manure and crop harvest, for different crop risk categories, under Australian and New Zealand conditions
2. To provide other recommendations/guidelines for the management of the risk of microbial contamination of fresh produce in relation to grazing and the application of untreated manures
3. To prepare a revised section 6.2 of the *Guidelines for Fresh Produce Food Safety*, with appropriate references, to reflect any updated recommendations/guidelines



standards apply to the  
112.54 and § 112.55 ?

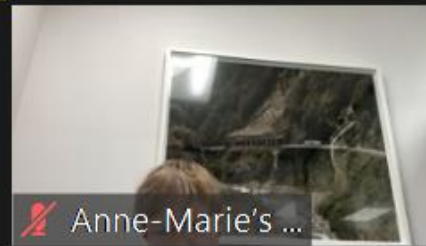
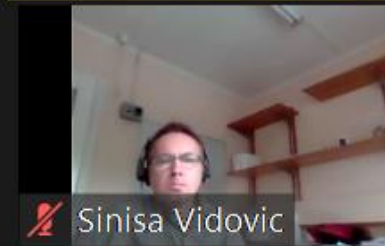
method that is scientifically validated to

can detect **one colony forming unit (CFU) per 5**  
(sampled) analytical portion.

can detect **three most probable numbers (MPN)**  
(being sampled) of total solids.

can detect **0.3 MPN per 1 gram** (or milliliter, if  
liquid is being sampled) of total solids.

**three most probable numbers (MPN) per gram** (if liquid is being



# Current exclusion periods

The 2019 Guidelines recommend exclusion periods between grazing or application of raw or untreated manure and harvest

Table 5. Exclusion period (days) between grazing or application of untreated animal manure and crop harvest\*

|  | Inedible skin or shell       |                               |  | Edible skin         |   |  |
|--|------------------------------|-------------------------------|--|---------------------|---|--|
|  | Always eaten cooked          | May be eaten uncooked         | No pathogen reduction step after harvest | Always eaten cooked | Pathogen reduction step after harvest** | No pathogen reduction step after harvest |
| Harvestable part grown in contact with the soil  | 45<br>e.g. taro              | 45<br>e.g. onion              | 90<br>e.g. rockmelon                     | 45<br>e.g. potato   | 45<br>e.g. carrot                       | 90<br>e.g. lettuce                       |
| Harvestable part grown close to (or picked up from) the ground, some soil contact likely | 45<br>e.g. pumpkin, chestnut | 45<br>e.g. peas, passionfruit | 45<br>e.g. pineapple                     | 45<br>e.g. rhubarb  | 45<br>e.g. capsicum                     | 90<br>e.g. blueberry, parsley            |
| Harvestable part grown above the ground, soil contact unlikely                           | 45<br>e.g. plantain          | 45<br>e.g. banana             | 45<br>e.g. lychee                        | 45<br>e.g. quince   | 45<br>e.g. apple, lemon                 | 45<br>e.g. apricot                       |

\* Note that some standards mandate longer exclusion periods e.g. the Fresh Salad Producers Group (A-NZ) voluntary Standard for Fertilisers and Soil Additives and the Harmonised Australian Retailer Produce Scheme (HARPS).

\*\* Pathogen reduction steps include:

• Significant time between harvest and consumption

• Wash step that can achieve minimum 3 log reduction of human pathogens, water treated to achieve *E. coli* <1cfu/100ml



# The process

## Guidelines Technical Group

- Assembled a comprehensive collection of literature from seven databases – covering pathogens in manure from cattle, poultry, and pigs
- Considered the impact of variables on pathogens: temperatures, soil type, and modes of application
- Found there was an infinite number of combinations, limited domestic data, and challenges in interpreting the data
- Determined minimum, maximum and average exclusion days for <math><10^{\circ}\text{C}</math>, <math>10\text{-}20^{\circ}\text{C}</math>, <math>20\text{-}30^{\circ}\text{C}</math> temperature scenarios, comparing 95<sup>th</sup> percentile and 99<sup>th</sup> percentiles

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General Interest

## Environmental Drivers for Persistence of *Escherichia coli* and *Salmonella* in Manure-Amended Soils: A Meta-Analysis

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### ABSTRACT

Application of organic amendments to agricultural land improves soil quality and provides nutrients essential for plant growth; however, they are also a reservoir for zoonotic pathogens whose presence poses a significant risk to public health. The persistence of bacteria in manure-amended soil, and differences in manure handling practices, are important issues from a food safety perspective. The primary objective of this study was to quantitatively summarize the variations in the rate of decline of *Escherichia coli* and *Salmonella* spp. in manure-amended soil under laboratory and field conditions, and to assess the impact of environmental factors. Available literature data on persistence of *E. coli* and *Salmonella* spp. in manure-amended soil from 42 primary research studies were extracted and statistically analyzed using a mixed-effect regression model. The results indicated that temperature (soil and air combined) was the most prominent factor affecting persistence of both *E. coli* and *Salmonella* spp. under laboratory conditions ( $P < 0.001$ ), and of *E. coli* under field conditions ( $P < 0.05$ ). The time required for a log reduction of *E. coli* under field conditions was significantly higher at low temperature (0 to 10°C) than at high temperature (greater than 20°C) ( $P < 0.05$ ). In addition, application method was identified as a significant factor, with manure incorporation to soil inducing longer survival compared with surface application by approximately 1.2 times. The significant variation observed among primary research studies of bacterial persistence has highlighted that mitigation strategies associated with the use of manures in fresh produce production need to be improved by addressing factors such as climate, soil management, application method, and initial microbial levels. These findings may be used to support guidelines establishing exclusion periods between manure fertilization and the grazing or harvesting of crops, and may be useful for the generation of quantitative microbial risk models for fresh produce.

### HIGHLIGHTS

- A data set of 418 inactivation curves from 42 studies was compiled and statistically analyzed.
- Temperature was the most significant factor affecting decline rates.
- Laboratory trials exhibited longer survival times of *E. coli* compared with field trials.
- No significant difference was observed between median decline rates of *E. coli* and *Salmonella* spp.

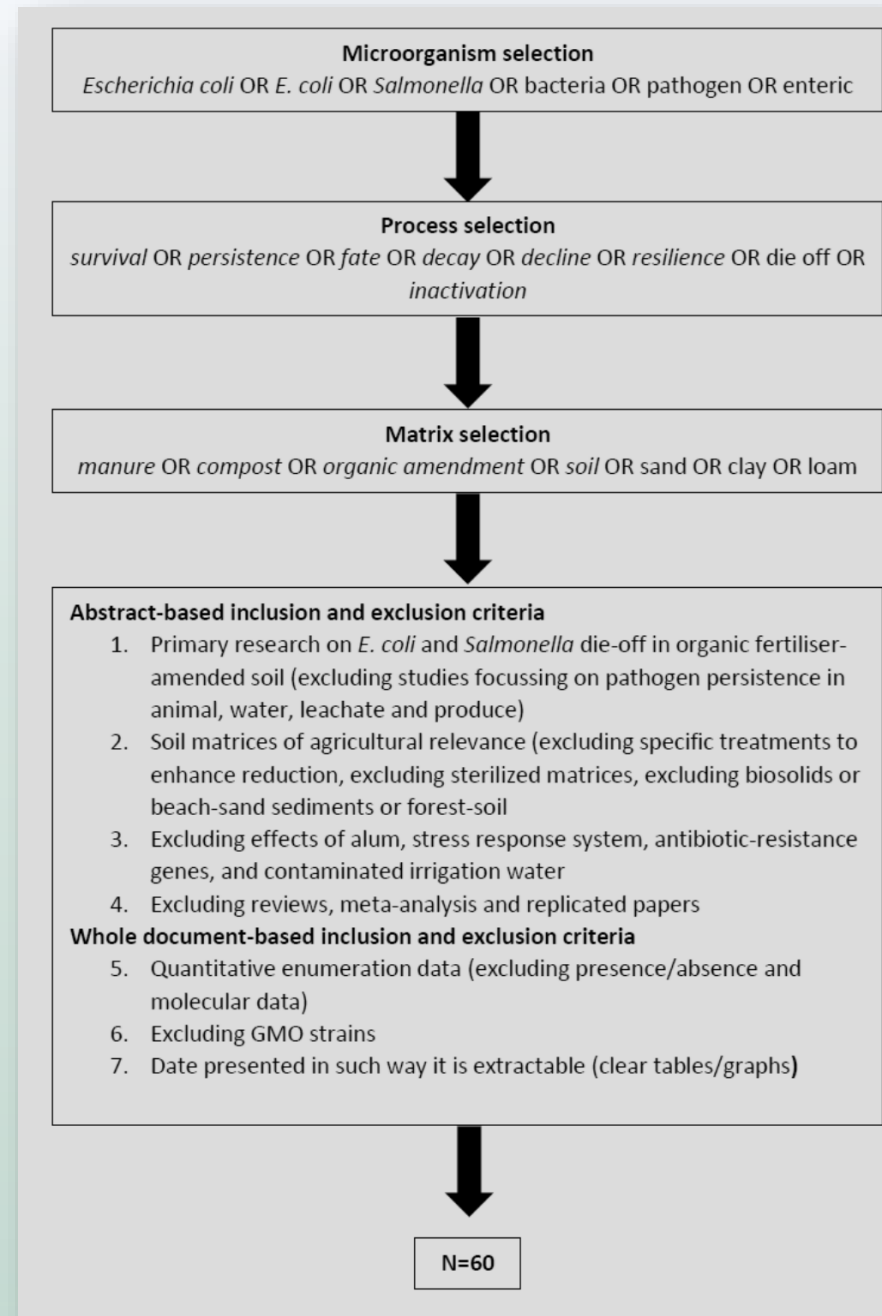
FPSC  
AUSTRALIA &  
NEW ZEALAND

# Considerations

- **Manure types:** poultry and cattle manure were considered the most frequently used manures
- **Temperature:** The lower the temperature the greater the survival of pathogens such as *Salmonella* spp. and *Listeria monocytogenes*
  - Low temperatures slow enzymatic activity and inhibit or stop microbial growth and proliferation, but do not kill bacteria – prolonging their survival
- Other environmental factors such as method of application, relative humidity, soil type were difficult to assess



# Literature review and data evaluation



# Exclusion period at <10 °C

| Type of manure | Microorganism          | Min (Days) | Average (Days) | Max (Days) |
|----------------|------------------------|------------|----------------|------------|
| Broiler        | <i>E. coli</i>         | 33         | 107            | 236        |
|                | <i>Salmonella</i> spp. | 91         | 134            | 173        |
| Feedlot cattle | <i>E. coli</i>         | 36         | 123            | 247        |
|                | <i>Salmonella</i> spp. | 156        | 156            | 156        |
| Piggery        | <i>E. coli</i>         | 192        | 192            | 192        |
|                | <i>Salmonella</i> spp. | -          | -              | -          |

Calculation was based on *upper 99<sup>th</sup> percentile* for manure incorporated into soil

# Exclusion period at 10-20°C

| Type of manure | Microorganism          | Min (Days) | Average (Days) | Max (Days) |
|----------------|------------------------|------------|----------------|------------|
| Broiler        | <i>E. coli</i>         | 19         | 60             | 133        |
|                | <i>Salmonella</i> spp. | 78         | 109            | 142        |
| Feedlot cattle | <i>E. coli</i>         | 20         | 70             | 139        |
|                | <i>Salmonella</i> spp. | 127        | 127            | 127        |
| Piggery        | <i>E. coli</i>         | 98         | 98             | 98         |
|                | <i>Salmonella</i> spp. | -          | -              | -          |

Calculation was based on *upper 99<sup>th</sup> percentile* for manure incorporated into soil

# Exclusion period at 20-30°C

| Type of manure | Microorganism          | Min (Days) | Average (Days) | Max (Days) |
|----------------|------------------------|------------|----------------|------------|
| Broiler        | <i>E. coli</i>         | 5          | 16             | 35         |
|                | <i>Salmonella</i> spp. | 43         | 60             | 78         |
| Feedlot cattle | <i>E. coli</i>         | 6          | 18             | 37         |
|                | <i>Salmonella</i> spp. | 70         | 70             | 70         |
| Piggery        | <i>E. coli</i>         | 29         | 29             | 29         |
|                | <i>Salmonella</i> spp. | -          | -              | -          |

Calculation was based on *upper 99<sup>th</sup> percentile* for manure incorporated into soil

# Stakeholder consultation

- Targeted consultations on recommended changes to exclusion periods between September – October 2021
- Stakeholders including HARPS, Freshcare, and international bodies
- *Salmonella* spp. and broiler manure were used to establish exclusion periods
- Presented three tables covering survival of *Salmonella* spp. based on different temperatures, with 95<sup>th</sup> percentile of confidence:

<10°C

10-20°C

20-30°C

- Feedback recommended:
  - Rationalising the number of tables – recommended only two tables covering growing zones <20°C and ≥20°C
  - More conservative approach to pathogen survival was recommended *i.e.* move from 95<sup>th</sup> to 99<sup>th</sup> percentile

# Changes after consultation

95th

## Desired exclusion period at <10 °C

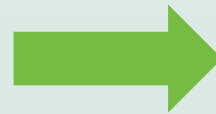
| Type of manure | Microorganism          | Min (Days) | Average (Days) | Max (Days) |
|----------------|------------------------|------------|----------------|------------|
| Broiler        | <i>E. coli</i>         | 16         | 52             | 115        |
|                | <i>Salmonella</i> spp. | 60         | 84             | 109        |
| Feedlot cattle | <i>E. coli</i>         | 18         | 60             | 120        |
|                | <i>Salmonella</i> spp. | 97         | 97             | 97         |
| Piggery        | <i>E. coli</i>         | 93         | 93             | 93         |
|                | <i>Salmonella</i> spp. | -          | -              | -          |

## Desired exclusion period at 10-20 °C

| Type of manure | Microorganism          | Min (Days) | Average (Days) | Max (Days) |
|----------------|------------------------|------------|----------------|------------|
| Broiler        | <i>E. coli</i>         | 12         | 38             | 85         |
|                | <i>Salmonella</i> spp. | 50         | 70             | 90         |
| Feedlot cattle | <i>E. coli</i>         | 13         | 44             | 89         |
|                | <i>Salmonella</i> spp. | 81         | 81             | 81         |
| Piggery        | <i>E. coli</i>         | 69         | 69             | 69         |
|                | <i>Salmonella</i> spp. | -          | -              | -          |

## Desired exclusion period at 20-30 °C

| Type of manure | Microorganism          | Min (Days) | Average (Days) | Max (Days) |
|----------------|------------------------|------------|----------------|------------|
| Broiler        | <i>E. coli</i>         | 4          | 12             | 27         |
|                | <i>Salmonella</i> spp. | 33         | 46             | 60         |
| Feedlot cattle | <i>E. coli</i>         | 4          | 14             | 28         |
|                | <i>Salmonella</i> spp. | 54         | 54             | 54         |
| Piggery        | <i>E. coli</i>         | 22         | 22             | 22         |
|                | <i>Salmonella</i> spp. | -          | -              | -          |



## Desired exclusion period at <10 °C

| Type of manure | Microorganism          | Min (Days) | Average (Days) | Max (Days) |
|----------------|------------------------|------------|----------------|------------|
| Broiler        | <i>E. coli</i>         | 33         | 107            | 236        |
|                | <i>Salmonella</i> spp. | 91         | 134            | 173        |
| Feedlot cattle | <i>E. coli</i>         | 36         | 123            | 247        |
|                | <i>Salmonella</i> spp. | 156        | 156            | 156        |
| Piggery        | <i>E. coli</i>         | 192        | 192            | 192        |
|                | <i>Salmonella</i> spp. | -          | -              | -          |

## Desired exclusion period at 10-20 °C

| Type of manure | Microorganism          | Min (Days) | Average (Days) | Max (Days) |
|----------------|------------------------|------------|----------------|------------|
| Broiler        | <i>E. coli</i>         | 19         | 60             | 133        |
|                | <i>Salmonella</i> spp. | 76         | 109            | 142        |
| Feedlot cattle | <i>E. coli</i>         | 20         | 70             | 139        |
|                | <i>Salmonella</i> spp. | 127        | 127            | 127        |
| Piggery        | <i>E. coli</i>         | 98         | 98             | 98         |
|                | <i>Salmonella</i> spp. | -          | -              | -          |

## Desired exclusion period at 20-30 °C

| Type of manure | Microorganism          | Min (Days) | Average (Days) | Max (Days) |
|----------------|------------------------|------------|----------------|------------|
| Broiler        | <i>E. coli</i>         | 5          | 16             | 35         |
|                | <i>Salmonella</i> spp. | 43         | 60             | 78         |
| Feedlot cattle | <i>E. coli</i>         | 6          | 18             | 37         |
|                | <i>Salmonella</i> spp. | 70         | 70             | 70         |
| Piggery        | <i>E. coli</i>         | 29         | 29             | 29         |
|                | <i>Salmonella</i> spp. | -          | -              | -          |



# Changes after consultation

## Desired exclusion period at <10 °C

| Type of manure | Microorganism          | Min (Days) | Average (Days) | Max (Days) |
|----------------|------------------------|------------|----------------|------------|
| Broiler        | <i>E. coli</i>         | 16         | 52             | 115        |
|                | <i>Salmonella</i> spp. | 60         | 84             | 109        |
| Feedlot cattle | <i>E. coli</i>         | 18         | 60             | 120        |
|                | <i>Salmonella</i> spp. | 97         | 97             | 97         |
| Piggery        | <i>E. coli</i>         | 93         | 93             | 93         |
|                | <i>Salmonella</i> spp. | -          | -              | -          |

## Desired exclusion period at 10-20 °C

| Type of manure | Microorganism          | Min (Days) | Average (Days) | Max (Days) |
|----------------|------------------------|------------|----------------|------------|
| Broiler        | <i>E. coli</i>         | 12         | 38             | 85         |
|                | <i>Salmonella</i> spp. | 50         | 70             | 90         |
| Feedlot cattle | <i>E. coli</i>         | 13         | 44             | 89         |
|                | <i>Salmonella</i> spp. | 81         | 81             | 81         |
| Piggery        | <i>E. coli</i>         | 69         | 69             | 69         |
|                | <i>Salmonella</i> spp. | -          | -              | -          |

## Desired exclusion period at 20-30 °C

| Type of manure | Microorganism          | Min (Days) | Average (Days) | Max (Days) |
|----------------|------------------------|------------|----------------|------------|
| Broiler        | <i>E. coli</i>         | 4          | 12             | 27         |
|                | <i>Salmonella</i> spp. | 33         | 46             | 60         |
| Feedlot cattle | <i>E. coli</i>         | 4          | 14             | 28         |
|                | <i>Salmonella</i> spp. | 54         | 54             | 54         |
| Piggery        | <i>E. coli</i>         | 22         | 22             | 22         |
|                | <i>Salmonella</i> spp. | -          | -              | -          |

## Desired exclusion period at <20 °C

| Type of manure | Microorganism          | Min (Days) | Average (Days) | Max (Days) |
|----------------|------------------------|------------|----------------|------------|
| Broiler        | <i>E. coli</i>         | 33         | 107            | 236        |
|                | <i>Salmonella</i> spp. | 91         | 134            | 173        |
| Feedlot cattle | <i>E. coli</i>         | 36         | 123            | 247        |
|                | <i>Salmonella</i> spp. | 156        | 156            | 156        |
| Piggery        | <i>E. coli</i>         | 192        | 192            | 192        |
|                | <i>Salmonella</i> spp. | -          | -              | -          |

## Desired exclusion period at ≥20 °C

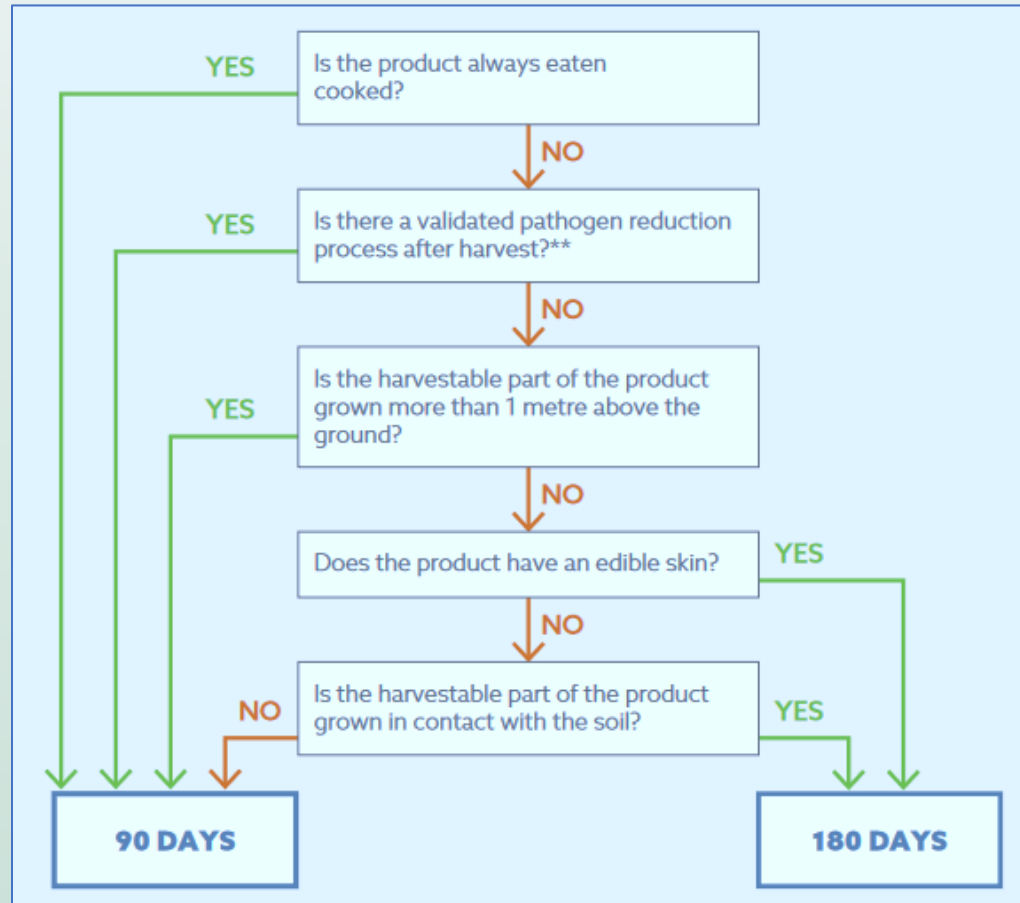
| Type of manure | Microorganism          | Min (Days) | Average (Days) | Max (Days) |
|----------------|------------------------|------------|----------------|------------|
| Broiler        | <i>E. coli</i>         | 5          | 16             | 35         |
|                | <i>Salmonella</i> spp. | 43         | 60             | 78         |
| Feedlot cattle | <i>E. coli</i>         | 6          | 18             | 37         |
|                | <i>Salmonella</i> spp. | 70         | 70             | 70         |
| Piggery        | <i>E. coli</i>         | 29         | 29             | 29         |
|                | <i>Salmonella</i> spp. | -          | -              | -          |

95<sup>th</sup>

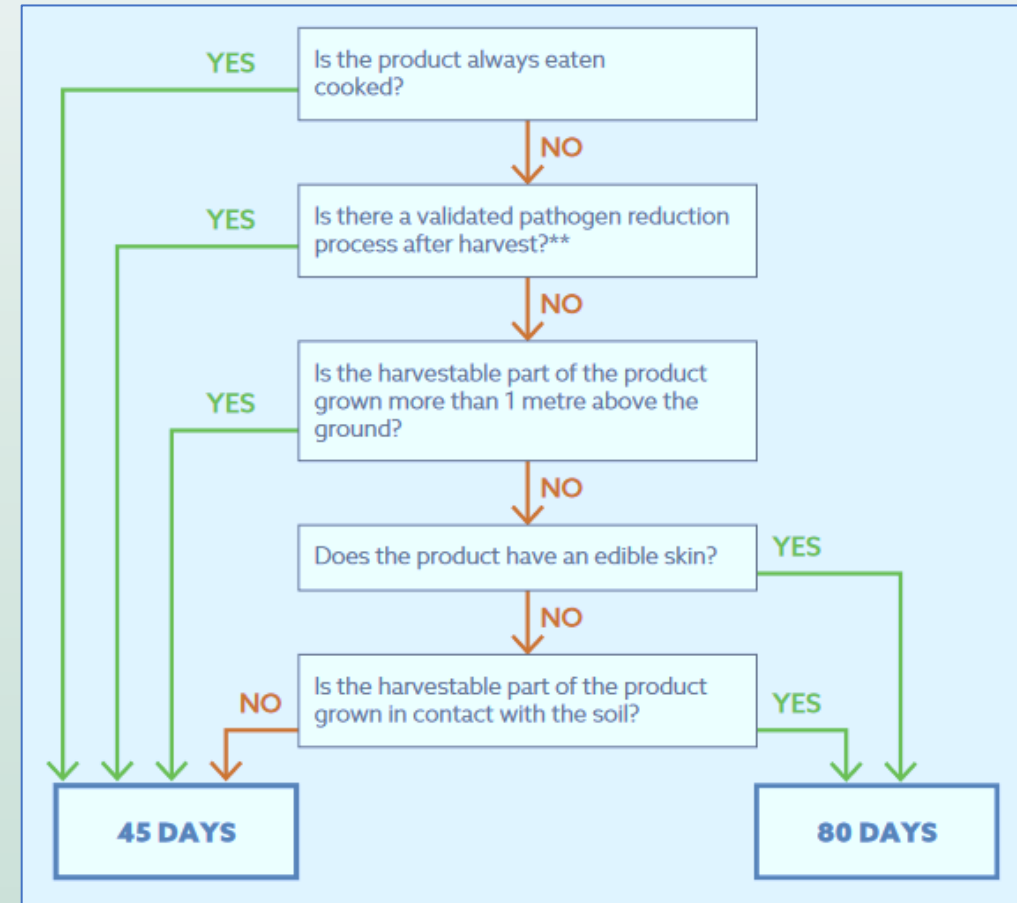
99<sup>th</sup>

# Decision tree rather than tables

Mean maximum temperature <20°C



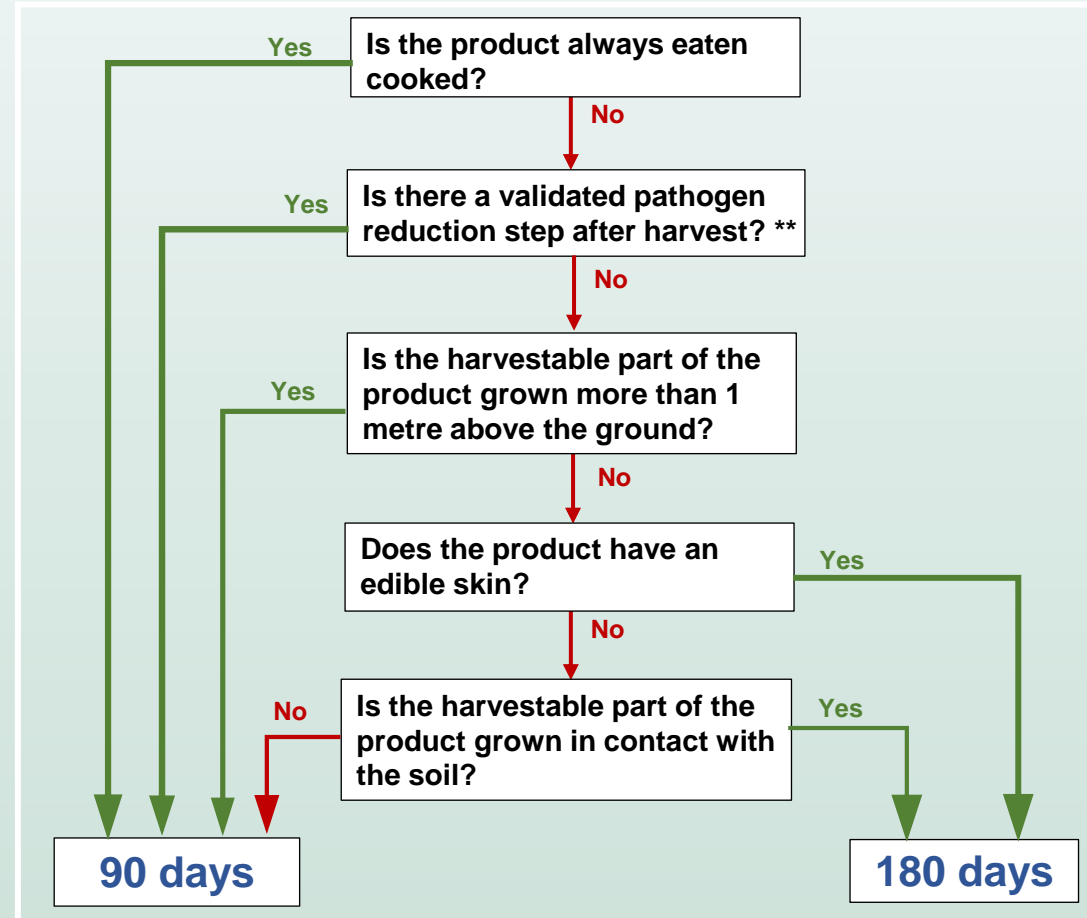
Mean maximum temperature ≥20°C



# Worked example

- Establish monthly mean maximum temperatures from Bureau of Meteorology - <http://www.bom.gov.au/>
- This determines which of the decision trees should be used for your location
- The number of days is how many days between grazing of livestock or application of untreated animal manure and crop harvest (exclusion period)

Mean maximum temperature <20°C



# Temperatures

## Summary statistics for all years

[Information about climate statistics](#)

| Statistic | Jan  | Feb  | Mar  | Apr  | May  | Jun  | Jul  | Aug  | Sep  | Oct  | Nov  | Dec  | Annual |
|-----------|------|------|------|------|------|------|------|------|------|------|------|------|--------|
| Mean      | 30.2 | 29.5 | 28.2 | 25.9 | 23.4 | 20.8 | 20.9 | 22.8 | 25.7 | 27.3 | 28.8 | 29.6 | 26.1   |
| Lowest    | 28.1 | 26.9 | 26.9 | 23.7 | 21.9 | 19.3 | 19.7 | 20.7 | 23.8 | 23.7 | 26.0 | 26.0 | 25.1   |
| 5th %ile  | 28.2 | 27.9 | 27.0 | 24.4 | 22.3 | 19.8 | 19.7 | 21.4 | 23.9 | 24.8 | 26.1 | 27.0 | 25.1   |
| 10th %ile | 28.6 | 27.9 | 27.2 | 24.6 | 22.6 | 19.9 | 19.9 | 21.6 | 24.3 | 25.5 | 26.4 | 27.4 | 25.3   |
| Median    | 30.0 | 29.5 | 28.0 | 26.0 | 23.2 | 20.9 | 20.9 | 22.6 | 25.2 | 27.6 | 29.0 | 29.9 | 26.1   |
| 90th %ile | 31.8 | 31.5 | 29.5 | 27.3 | 24.8 | 21.7 | 21.7 | 24.0 | 27.6 | 28.6 | 30.7 | 32.1 | 26.8   |
| 95th %ile | 32.5 | 31.7 | 29.9 | 27.3 | 25.3 | 21.9 | 22.1 | 24.2 | 28.1 | 28.7 | 31.1 | 32.2 | 26.9   |
| Highest   | 33.4 | 31.8 | 30.3 | 27.3 | 25.9 | 22.1 | 22.5 | 25.8 | 28.7 | 28.9 | 32.4 | 32.7 | 27.6   |

## Lismore

## Summary statistics for all years

[Information about climate statistics](#)

| Statistic | Jan  | Feb  | Mar  | Apr  | May  | Jun  | Jul  | Aug  | Sep  | Oct  | Nov  | Dec  | Annual |
|-----------|------|------|------|------|------|------|------|------|------|------|------|------|--------|
| Mean      | 26.6 | 26.5 | 25.6 | 23.9 | 21.3 | 18.9 | 18.4 | 19.5 | 21.6 | 22.8 | 23.9 | 25.5 | 22.9   |
| Lowest    | 24.6 | 25.1 | 24.5 | 21.9 | 19.8 | 17.8 | 17.4 | 18.3 | 20.1 | 21.5 | 21.8 | 23.6 | 22.2   |
| 5th %ile  | 26.0 | 25.2 | 25.0 | 22.2 | 20.2 | 17.9 | 17.5 | 18.5 | 20.3 | 21.6 | 22.6 | 23.7 | 22.4   |
| 10th %ile | 26.0 | 25.6 | 25.0 | 22.6 | 20.5 | 18.1 | 17.5 | 18.8 | 20.4 | 21.8 | 22.7 | 23.7 | 22.5   |
| Median    | 26.6 | 26.4 | 25.7 | 24.0 | 21.1 | 18.8 | 18.2 | 19.5 | 21.6 | 22.6 | 24.0 | 25.4 | 22.9   |
| 90th %ile | 27.4 | 27.4 | 26.2 | 25.1 | 22.4 | 20.2 | 19.4 | 20.4 | 23.4 | 23.9 | 25.1 | 26.5 | 23.4   |
| 95th %ile | 27.5 | 27.7 | 26.3 | 25.2 | 22.4 | 20.2 | 19.4 | 20.8 | 23.6 | 24.3 | 25.1 | 26.5 | 23.4   |
| Highest   | 27.8 | 27.8 | 26.9 | 25.5 | 23.3 | 20.4 | 19.8 | 21.3 | 23.7 | 25.3 | 25.9 | 28.2 | 23.7   |

## Forster–Tuncurry


## Bairnsdale

## Summary statistics for all years

[Information about climate statistics](#)

| Statistic | Jan  | Feb  | Mar  | Apr  | May  | Jun  | Jul  | Aug  | Sep  | Oct  | Nov  | Dec  | Annual |
|-----------|------|------|------|------|------|------|------|------|------|------|------|------|--------|
| Mean      | 25.9 | 25.5 | 23.9 | 20.8 | 17.6 | 15.0 | 14.6 | 15.7 | 17.8 | 19.9 | 21.9 | 23.8 | 20.3   |
| Lowest    | 22.7 | 22.1 | 21.1 | 17.6 | 15.6 | 12.8 | 12.8 | 12.9 | 15.4 | 17.3 | 19.4 | 20.2 | 19.1   |
| 5th %ile  | 23.0 | 22.7 | 21.7 | 18.7 | 15.7 | 13.7 | 13.4 | 14.3 | 15.8 | 17.7 | 19.6 | 20.9 | 19.2   |
| 10th %ile | 24.3 | 23.5 | 22.4 | 19.0 | 16.4 | 14.1 | 13.6 | 14.6 | 16.3 | 18.4 | 19.9 | 22.2 | 19.5   |
| Median    | 26.0 | 25.4 | 24.1 | 20.9 | 17.8 | 15.1 | 14.5 | 15.7 | 17.7 | 20.0 | 21.8 | 24.0 | 20.3   |
| 90th %ile | 27.7 | 27.4 | 25.7 | 22.4 | 18.8 | 16.1 | 15.8 | 17.0 | 19.4 | 21.5 | 23.9 | 25.7 | 21.1   |
| 95th %ile | 28.3 | 27.7 | 25.9 | 22.9 | 19.1 | 16.5 | 16.0 | 17.3 | 19.6 | 21.8 | 24.3 | 25.8 | 21.3   |
| Highest   | 28.6 | 29.9 | 26.4 | 23.8 | 20.0 | 17.0 | 16.1 | 18.1 | 19.9 | 23.3 | 26.1 | 26.3 | 21.3   |

# Going forward .....

- Release of revised Guidelines 
- Prepare a communications strategy and undertake industry engagement
- Scheme owners continue to review their standards
- Recommendation to undertake further research on the die-off of pathogens in raw manures

