Pork storage and shelf life

Yvette Cottam, Brian H.P. Wilkinson, Karin Weidgraf and Roger W. Purchas

Institute of Food, Nutrition and Human Health, Massey University, New Zealand

Introduction

The shelf life of fresh pork is largely determined by three factors: the number of bacteria that are present on the freshly cut pork surfaces at the time of packaging; the temperature at which the pork is stored; and the type of packaging material and gaseous environment surrounding the pork in the package. If all four factors are optimised then microbial numbers present on the freshly cut surfaces prior to packaging should be at a minimum and their subsequent growth rates should also be at a minimum thus ensuring long shelf life pork.

To achieve storage of > 7 weeks the bacterial load on the eviscerated cooled pork carcasses must be < 2 log cfu cm⁻², as by 8 weeks of vacuum package storage this bacterial load (mainly lactic acid bacteria) is > 6 log cfu cm⁻², the maximum number for acceptance by some consumers (Holley et al., 2004).

Where do the microbes come from?

There are many sources of microbial contamination in the slaughter of pigs and it is important from both a health and a shelf life perspective that the contamination points be identified and controlled. The three major contamination sources are: faecal, pharyngeal and environmental (Borch et al., 1996a). The number and types of bacteria present on the carcass, and hence the cuts, arises as a consequence of both indirect and direct contact with the animal’s skin, trotters, gut contents, faecal material and of course contaminated equipment and table surfaces (Huis in’t Veld et al., 1992). The extent of the microbial transfer between these sources depends on the hygiene and sanitation practices before and during processing and handling, and of course storage and distribution of the finished product (Koutsoumanis and Sofos, 2004). The stages of possible contamination are presented in Figure 1.

The microbial numbers and types present on the freshly slaughtered carcasses is a reflection of the micro-organisms acquired by the animal on the farm, between the farm and the slaughter-house, and on the slaughter-house floor, i.e., equipment and surfaces (Huis in’t Veld et al., 1992).

Whilst risk management programmes, hazard analysis and critical control point (HACCP) programmes (part of a risk management programme) and the sanitation standard operation procedures (SSOP) (also a part of a risk management programme). HACCP programmes have all been instituted by most New Zealand slaughter plants, there is a need for these programmes to be extended from the processing plant back to the farm and from the slaughter-houses to the final customer.
Microflora

There are two types of micro-organisms of interest to the pork industry: those that cause illness (food-poisoning), and those that cause spoilage (Huis in't Veld et al., 1992). Meat and meat products are responsible for a major fraction of all food-borne infections (Huis in't Veld et al., 1992). The main pathogenic microflora of interest to the pig slaughter industry include *Aeromonas hydrophila*, *Campylobacter coli/jejuni*, *Listeria monocytogenes*, *Salmonella* spp., *Staphylococcus aureus* and *Yersinia enterocolitica* (Borch et al., 1996a). *Aeromonas* and *Shewanella* spp. are facultative anaerobes, can grow at −1°C, and are often found in vacuum-packed pork (Holley et al., 2004). *Campylobacter jejuni/coli* is an important cause of enteritis in humans, although they do not grow below 30°C, have a low heat resistance and are sensitive to drying and freezing, so are not a major problem if pork is stored under normal cold storage conditions (Borch et al., 1996a). The pig is the most important source of *Yersinia enterocolitica* infection in humans (Nesbakken et al., 1994).

*Salmonella typhimurium* appears to be the most important serotype in pigs (Huis in't Veld et al., 1992), and Salmonellosis is well recognized as a major health threat to consumers of pork and pork products (Beloeil et al., 2004). An estimated 15% of all salmonellosis cases in The Netherlands were associated with the consumption of pork (Berends et al., 1998a). Both *Salmonella* and Pseudomonads are the predominant spoilage bacteria in pork products (Liu et al., 2006). One study in the Netherlands demonstrated that there was a direct relationship between the prevalence of Salmonella-positive pigs, carcasses and pork, and pork-associated Salmonellosis (Berends et al., 1998a). If this is something that is happening in general then a reduction in the number of positive pigs will lead to a decrease in Salmonellosis in humans In general, *Salmonella typhimurium* does not cause clinical illness in pigs (van der Gaag et al., 2004).

The main spoilage micro-organisms on pork are *Pseudomonas, Lactobacillus, Brochothrix thermosphacta, Clostridium perfringens, Aeromonas putrefaciens (produces hydrogen sulphide) and Enterobacteriacea*. A complete list of genera associated with the contamination of meat/poultry can be seen in a paper by Koutsoumanis and Sofos (2004). The bacterial species that ultimately causes the spoilage of meat is dependent on a number of factors, such as the dominant species at the time of packaging, the pork pH, the storage temperature and the gaseous environment surrounding the meat in the pack.

**Table 1.** Micro-organisms from pork implicated in food-borne disease, their minimal growth temperature and method of eliminating or restricting their growth
<table>
<thead>
<tr>
<th>Organism</th>
<th>Ideal growing conditions</th>
<th>Killed by</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Salmonellae</strong></td>
<td>Intestinal parasites</td>
<td>min 7°C</td>
<td>Inhibited by <strong>CO₂</strong></td>
</tr>
<tr>
<td><strong>Escherichia coli</strong></td>
<td>Intestinal</td>
<td>min 7°C</td>
<td></td>
</tr>
<tr>
<td><strong>Campylobacter jejuni</strong></td>
<td></td>
<td>min 32°C</td>
<td>Cooking</td>
</tr>
<tr>
<td><strong>Yersinia enterocolitica</strong></td>
<td></td>
<td>min –1°C</td>
<td>Multiplies at fridge temperatures</td>
</tr>
<tr>
<td><strong>Listeria monocytogenes</strong></td>
<td>Humans/pig carriers</td>
<td>min 0°C</td>
<td></td>
</tr>
<tr>
<td><strong>Clostridium perfringens</strong></td>
<td></td>
<td>min 12°C</td>
<td></td>
</tr>
<tr>
<td><strong>C. botulinum</strong></td>
<td></td>
<td>min 3°C</td>
<td></td>
</tr>
</tbody>
</table>

(McClure, 2002)
(Sivertsvik et al., 2002)

**Generalised pork production summary.**

Figure 1 presents a summary of a generalised pork production flow diagram showing possible sources of microorganisms (MOs) together with approaches to minimising the number of microorganisms from each source and/or minimising the growth of those microorganisms already present. Some plants may not use some of the operations in their slaughter process. For instance a number of New Zealand plants do not use singeing and if they do it is often just a very light singe.

**Approaches to reduce or minimize microbial numbers on pigs before arrival at plant**

Live animals can be carriers of pathogenic bacteria, with high numbers of bacteria present on the skin, both ‘normal flora’ of the skin and organisms of soil, water and faecal origin (Koutsoumanis and Sofos, 2004). There are many factors influencing the numbers/species of organisms present on the animals, including climate, geographical location, method and distance of transportation and holding conditions at the plant. For example, soil bacteria are more common on animals raised on pasture, whereas enteric origin...
bacteria are more common in animals raised in pens (Koutsoumanis and Sofos, 2004). The number of live animals that carry *Salmonella* spp. is strongly correlated with the number of contaminated carcasses at the end of the slaughter line (Berends et al., 1997), with this cross-contamination estimated to account for 29% of the positive carcasses (Botteldoorn et al., 2003).

If we take *Salmonella* as an indicator organism, it has been found that the spread of this microbial contaminant, and hence other micro-organisms, is very likely to occur during transportation, where animals are in close contact with each other (via body contact) and with floors/surfaces contaminated by other infected animals (Koutsoumanis and Sofos, 2004). Research has failed to establish a relationship between visibly dirty animals and the microbial condition of the carcass, therefore it is thought that the processing is more important than the condition of the skin (Koutsoumanis and Sofos, 2004).

The cleaning and disinfection of lairage pens has been shown to decrease the prevalence of culturable *S. enterica* in these pens, but the ability of this to reduce the prevalence in live pigs was not conclusive (Schmidt et al., 2004). An alternative to the use of holding pens at abattoirs and the associated risk of the spread of *Salmonella enterica* between pigs, is to hold the pigs in the transport trailers until slaughter. This has been shown to decrease the levels of infected animals entering the slaughter plant (Rostagno et al., 2005).

The microbial condition of the live animal is of paramount importance for the microbiology and food safety of the consumer end products in relation to food-borne infections (Huis in't Veld et al., 1992). A reduction in the numbers of *Salmonella* and other micro-organisms in the intestines at pre-harvest can reduce the contamination at later stages (Beloeil et al., 2004). The feeding of coarse-ground grains in comparison to fine-ground grains is known to decrease the proportion of *Salmonella*-positive pigs, as the coarse particles stimulate the microbiota and the production of organic acids such as lactic acid, lowering the
Figure 1. A generalised pork production flow diagram showing possible sources of microorganisms (MOs) together with approaches to minimising the number of MOs from each source and/or minimising the growth of those MOs already present (adapted from Borch et al., (1996a)).
pH in the stomach (Kim et al., 2005). The inclusion of sodium chlorate in pre-slaughter feed suppresses pathogen numbers in the gut (Anderson et al., 2001).

The time between the last meal and slaughter does affect the fullness of the stomach, a full stomach will pose a higher risk of puncture during dressing (Borch et al., 1996a) and the numbers of bacteria released from the stomach/caeca are affected by feed withdrawal. Coliform numbers and E. coli biotype 1 numbers in the stomach were not affected by feed withdrawal (for 15 hours prior to dispatch from the piggery to the abattoir) but the holding time (holding at abattoir for an additional 0-1, 2-3 or 4-5 hours) showed a decrease in the numbers between the 0-1 and 4-5 hours (Nattress and Murray, 2000). Caecal coliforms and E. coli biotype 1 increased as a result of feed withdrawal, and also as a result of holding time up to 4-5 hours. These results show that in the event of the release of stomach or caecal contents onto the carcass, larger numbers of E. coli would be released from the caeca and fewer from the stomachs of those pigs not subject to feed withdrawal (Nattress and Murray, 2000). The prevalence of caecal lacerations was not associated with feed withdrawal time, suggesting that feed withdrawal will not increase contamination of carcasses by increasing caecal lacerations (Morrow et al., 2002). Recommendations of time between last meal and slaughter range from 16 to 24 hours (Murray, 2000).

There is potential for a change in the bacterial flora in the digestive tract due to feed withdrawal, with the concentration of E. coli biotype 1 (an indicator species), for example, increasing by one order of magnitude with 20 hours compared with 5 hours fasting post-slaughter (Nattress and Murray, 2000). This suggests that feed withdrawal may decrease the potential of nicking the GI tract, but if any content does leak out the consequences may be magnified. The information is summarised in Table 2.

<table>
<thead>
<tr>
<th></th>
<th>20h feed withdrawal on farm vs abattoir</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stomach pH</td>
<td>- 12%</td>
</tr>
<tr>
<td>Lactic acid bacteria</td>
<td>- 3.5%</td>
</tr>
<tr>
<td>E.coli</td>
<td>- 8%</td>
</tr>
<tr>
<td>Caecum pH</td>
<td>+ 1%</td>
</tr>
<tr>
<td>Lactic acid bacteria</td>
<td>same</td>
</tr>
<tr>
<td>E.coli</td>
<td>+ 8%</td>
</tr>
</tbody>
</table>

**Table 2.** Effect of 20hrs off feed on microbial numbers in stomach and caecum

(Murray, 2000)

Approaches to reduce or minimize microbial numbers on pigs when they arrive at the meat plant.
The time in lairage has been shown to affect the spread of pathogenic bacteria, with pigs known to lie down after about 1½ hours after arrival at the slaughter plant, therefore increasing the risk of cross-contamination (Warriss, 2003).

Visible contamination of the living animal has little effect on the microbiological condition of the carcass (Gill, 2004), and washing the pigs pre-slaughter has no effect or even increases the microbiological contamination of carcasses (if the pigs are wet). This concurs with the results of Bolton et al., (2002), who found washing the pigs pre-slaughter (power-hosing at 1030 kPa, water 19°C) decreased the number of Salmonella on the skin of pigs, from 27% (on-farm) to 10% (after washing) incidence, although subsequent stunning/bleeding increased the incidence to 50%, so pre-slaughter washing was not considered an effective control measure. However, recent studies with cattle and sheep at New Zealand plants suggests that washing these animals with chlorinated water (100 ppm free chlorine) has been quite effective in reducing subsequent carcass microbial numbers and as a consequence leading to extensions in shelf life (Personal communication, Neil Smith, Silverfern Farms).

**Approaches to reduce or minimize microbial contamination during stunning, bleeding and dehairing.**

The first possible contamination step in the pig slaughter process is sticking, which is a potential source of microbial contamination from contaminated equipment. This is usually not a problem if good manufacturing principles are followed.

The following pig dressing processes that include scalding, dehairing, singeing, polishing are major sources of cross-contamination (Koutsoumanis and Sofos, 2004). Despite the clean appearance of the pig carcass after these processes, these carcasses may be heavily contaminated with bacteria (Gill and Bryant, 1993).

Scalding, the immersion of the carcass in a tank of water (60°C for 8 minutes) results in the destruction of most bacteria on the surface of the skin (Koutsoumanis and Sofos, 2004). However, scalding at temperatures less than 60°C results in little kill of Salmonella and E.coli species (Koutsoumanis and Sofos, 2004). Scalding can also be carried out in a vat of steam (Borch et al., 1996a). A time-temperature combination of 60°C for 1.4 min was required to achieve a 1 log reduction in Salmonella in scald water, which is equivalent to 65°C for 0.18 minutes (Bolton et al., 2003). Gill et al., (1995) found that a temperature of 85°C for 20 seconds reduced the total numbers of bacteria by 2 orders of magnitude, and reduced non-thermoduric spoilage bacteria from 50% to 10%. No further reduction in surviving flora numbers/composition was observed with a higher temperature or a longer time.

Dehairing, the mechanical removal of the hair by rotating drums with scraper blocks which rotate the carcass and remove the hairs, is a source of recontamination by faecal matter
(Borch et al., 1996a). It is well known that the dehairing step has a large potential for cross-contamination of carcasses (Warriner et al., 2002). Dehairing equipment is a likely source of contamination of pork by mesophilic enteric pathogens (Gill and Bryant, 1993), which are removed with the scalding but are re-deposited on carcasses by dehairing equipment. One way to prevent the contamination by dehairing equipment is the use of chemical dehairing (Koutsoumanis and Sofos, 2004).

The greatest reduction of skin bacterial load is achieved by singeing or flaming, with recontamination commonly occurring at the scraping/polishing step (Huis in't Veld et al., 1992). Singeing (800-900°C) or flaming (1000°C) for a total of 10-15 seconds, reduces the microbial count on the skin but is dependant on the temperature/time combination used (Borch et al., 1996a). Reduction in microbial numbers only occurs when the skin is singed/flamed at temperatures that will produce a toasted colour to the skin (Borch et al., 1996a). If singeing and flaming only raise the surface temperature of the carcass, but does not produce a toasted colour, then it fails to reduce or eliminate the bacterial contamination on the surface of the carcass (Yu et al., 1999; Borch et al., 1996a; Gill and Bryant (1992)).

Research has shown that \textit{E.coli} from the scraper/dry polisher became distributed on wet polisher blades, band saws and butchers’ hands, even though the carcasses went through a singing step after being dry-polished (Warriner et al., 2002).

Polishing is carried out by stainless steel scrapers or nylon brushes, and contributes to spreading the microbial population over the surface of the carcass as bacteria may become established on the brushes/scrapers (Borch et al., 1996a). Scraping and polishing have been reported to re-contaminate carcasses (Rivas et al., 2000; Yu et al., 1999; Gill and Bryant, 1993), whereas Gill and Bryant (1992) found bacterial numbers to decrease after polishing. The microbiological condition of polished carcasses can be improved by heating the carcass surface with sheets of water at 85°C (pasteurizing treatment) (Gill and Jones, 1997), although these carcasses are recontaminated during the dressing period (Gill and Jones, 1998).

Berends (1997) estimated that, after singeing, 5-15% of contamination of carcasses with \textit{Salmonella} spp occurred during the polishing step, 55-90% during current evisceration practices and 5-35% from further processing.

The gut contents is well known as a major source of carcass contamination (Bolton et al., 2002). Therefore, skilled, trained operators are very important, as damage to the intestines and contamination of the skin must be avoided (Huis in't Veld et al., 1992).

As a consequence, evisceration is a key step in cross-contamination by Enterobacteriaceae, with significant (P<0.05) increases in carcass counts on post-eviscerated carcasses (Warriner et al., 2002). This concurs with the results found by Rivas et al., (2000). One of the major ways of stopping some of this cross-contamination is by sealing off the rectum with a plastic
bag immediately after it has been freed. The enclosed rectum is then withdrawn from the body thorough the abdominal incision with the intestines attached. A study has shown that the spread of *Y. enterocolitica* O:3/biovar4 to pig carcasses can be considerably reduced by this procedure (Nesbakken et al., 1994).

Decontamination of carcasses can be carried out by ‘safe’ substances such as lactic acid (Berends et al., 1997). However, steam pasteurization cannot be used because it increases the deleterious effects of PSE and results in excessively pale muscles of non-PSE susceptible pigs (Gill and Jones, 1997). However, such decontamination procedures are still not allowed for most species here in New Zealand.

**Approaches to reduce or minimize microbial contamination on carcasses during chilling and retail cut preparation.**

The muscle tissue of healthy pigs is in principle free of micro-organisms (Huis in't Veld et al., 1992). Some species of micro-organism, such as *Campylobacter* spp., are not very hardy, according to Huis in't Veld et al., (1992) who showed, for example, that there is very low survival of these organisms after overnight chilling. The conditions during storage, processing and handling have a more important impact on the types of micro-organisms present on carcasses than the initial density (Koutsoumanis and Sofos, 2004).

The temperature of a carcass increases from 37°C to 40°C immediately post-slaughter, due to metabolic activity taking place in the muscle pre-rigor (Koutsoumanis and Sofos, 2004). The application of an efficient cooling process is extremely important, to decrease the possibility of rapid pathogenic bacterial growth on the warm carcass surface (Koutsoumanis and Sofos, 2004). A temperature of 7°C is accepted as the lower limit below which most pathogenic bacteria do not proliferate, therefore the carcass must be chilled to this temperature before it is sent for further processing (Koutsoumanis and Sofos, 2004). A number of factors influence the efficiency of the cooling process, including chilling capacity, patterns of air flow in the chiller, arrangement and spacing of carcasses (Koutsoumanis and Sofos, 2004). The drying of the skin of the carcass can also affect the microbial population, the drying out causes a decrease in bacterial load, although the loss of carcass weight is economically undesirable (Koutsoumanis and Sofos, 2004). The spraying of chilled water during the first few hours of cooling prevents these weight losses, and can assist in the cooling process as a consequence of evaporative cooling.

Normal carcass chilling procedures are rapid chilling followed by slower chilling. Blast chilling (-30°C to -10°C for 1 to 1.5 hours) to reduce the surface skin temperature as quickly as possible to the air temperature followed by cold room storage (3 to 5°C overnight to 3 days) (Borch et al., 1996a). Under commercial conditions, the exposure of carcasses to a
blast of freezing air before conventional chilling is likely to substantially improve the hygiene
efficiency of the chilling process (Gill and Jones, 1992). However, care must be taken to
ensure that cold-shortening does not occur as this can lead to unacceptably tough pork.

Carcass cooling processes must be well controlled to contain the possibility of rapid
proliferation of both pathogenic and spoilage bacteria on the meat while it remains warm (Gill
and Jones, 1997). Carcasses may be contaminated during the chilling process by contact with
contaminated surfaces/hands, water splashes or from the air, although the main concern
during the cooling process is not new contamination, but the growth/survival of existing
organisms (Koutsoumanis and Sofos, 2004).

The cleaning of equipment plays a role in the spread of bacteria, if equipment is not
effectively cleaned and sanitized, the potential for debris to be left behind in machinery such
as bandsaws, conveyor belts, trolleys or in bins or table tops leads to contamination of
carcasses (Yu et al., 1999). It is known that many bacteria are susceptible to drying, therefore
the cleaning and drying of equipment used in processing is an important step in improving
microbiological safety of pork (Gill and Landers, 2004). Effective cleaning/disinfecting of
workers hands plays an important role in reducing the potential for contamination of carcasses
(Koutsoumanis and Sofos, 2004).

**Approaches to reduce bacterial numbers and/or growth by packaging and/or
storage conditions**

- packaging-types (air, high O2-MA, vacuum, no O2 MA, 100% CO2)
- temperature

Spoilage is generally due to a small fraction of initial microflora, which become dominant
through handling and storage of the products. Pork products which undergo the most handling
and processing are likely to be of the poorest microbiological quality (Duffy et al., 2001).
Storage of meat under chill temperatures inhibits the growth of some pathogenic micro-
organisms, but not others (Sivertsvik et al., 2002). For example, *Listeria monocytogenes* is
able to multiply under chill temperatures, and *Clostridium botulinum* is able to multiply in
anaerobic conditions. Interactions between the different species of microflora are also
important in the overall spoilage of pork products (Liu et al., 2006), for example, lactic acid
bacteria show antagonistic activity on coliforms and *Salmonella*, whereas yeasts were
antimicrobial on lactic acid bacteria.

Before storage, pork has been found to have a flora of around $10^3$ cfu cm$^{-2}$, including a
number of spoilage organisms such as pseudomonads, enterobacteria, *Brochothrix
thermosphactica* (Gill and Jones, 1996). Spoilage of moist fat occurs when the microbial
population is $\geq 10^6$ cm$^{-2}$, whereas muscle spoils when microbes $\geq 10^8$ cm$^{-2}$, therefore bacterial spoilage of fat is likely to precede that of muscle tissue due to fat surfaces being more heavily contaminated initially than muscle surfaces and the lower levels needed (Gill and Jones, 1996).

**Modified Air Packaging**

The development of modified air packaging (MAP), mainly to extend shelf life of products, has resulted in increased shelf life and higher quality, in response to consumer demand (Sivertsvik et al., 2002). MAP involves replacing the air in a package with a fixed gas mixture, the 3 main gases used are oxygen, nitrogen and carbon dioxide, usually in combinations of 2 or 3 (Sivertsvik et al., 2002). These gases have different properties, carbon dioxide inhibits the growth of bacteria and moulds, nitrogen inhibits the oxidation of fats and pack collapse, and oxygen prevents anaerobic growth (Rao and Sachindra, 2002). For products with high levels of unsaturated fats, like pork, with shelf-life limited by microbial growth and oxidative rancidity, a gas mixture of CO$_2$ and N$_2$ is recommended, with complete removal of O$_2$. Many other gases have been tested, for example carbon monoxide, ozone, helium, ethylene oxide, but regulations, safety concerns, reduced sensory quality or economic factors have limited their use. The microflora development of vacuum-packaged pork cuts stored for 8 weeks was related to the pH and also the fat content of the meat, with faster and more extensive microbial growth on cuts of higher pH and fat content (Blixt and Borch, 2002).

The atmosphere in MAP changes with time. The gas composition changes with time owing to the diffusion of gases in and out of the product, the permeation of the gases in/out of the pack (no pack except aluminium foil laminated pouches exclude the diffusion of gases) and the product and microbial metabolism (Church, 1994). Also the effect of the modified atmosphere has different effects on the various types of micro-organisms in the pack, for example *Pseudomonas* and enterobacteriaceae are more inhibited by MAP than lactic acid bacteria (Rao and Sachindra, 2002).

Vacuum and CO$_2$ packaging has been shown many times to reduce or inhibit the survival or growth of pathogens on meat products, for a summary of these see review by Rao and Sachindra (2002). For example, CO$_2$ has an inhibitory effect on Salmonella, and the degree of inhibition is increased as the storage temperature decreases. Lactobacilli replace spoilage organisms in MAP fresh meat as they are less sensitive to CO$_2$ (Rao and Sachindra, 2002).

For retails cuts of meat, if the time between meat cutting and display is short, then simple over-wrapped trays are used (Gill and Jones, 1996). If longer storage is desired, it is necessary to use modified atmospheres such as the addition of N$_2$. After one or two days the
stored pork had a less desirable appearance than fresh product. If longer storage times are required then vacuum or CO₂ storage is best (Gill and Jones, 1996). This same study showed that if chops were stored under either N₂ or CO₂ then their appearance was similar to fresh pork chops after 42 days of storage. Moreover, chops stored under vacuum or CO₂ for 42 days showed no objectionable odours, whereas those stored under N₂ for 28 days or longer, or O₂+CO₂ for 21 days or longer had stale sour odours. The results of the study indicated that the storage time of pork chops under N₂ or O₂+CO₂ was around a week, and was >3 weeks if stored under CO₂ (Gill and Jones, 1996). Other studies have shown that storage lives of ≥ 8 weeks are feasible so long as the hygiene in the cutting room is superb, the pork is packaged in CO₂ packs and the stored packs are held at –1.5°C (Holley et al., 2004).

MAP and VP products are ‘safe’ so long as they are held at correct chill storage temperatures (≤ 4°C) (Rao and Sachindra, 2002), whereas under inadequate storage conditions both Clostridium botulinum and C.perfringens could grow and produce toxins, causing food poisoning.

References
Alban L, Stark KDC. 2005. Where should the effort be put to reduce the Salmonella prevalence in the slaughtered swine carcass effectively? Preventive Veterinary Medicine 68(1):63-79.


Huis in't Veld JHJ, Mulder RWAW, Snijders JMA. Impact of animal husbandry and slaughter technologies on microbial contamination of meat: monitoring and control.; 1992; Clermont-Ferrand, France. p pp 79-100.


Murray AC. Reducing losses from farm gate to packer -a Canadian's perspective; 2000; p 1-13.


