An assessment of guidelines for treatment of meat from a FMD vaccination zone

Per Have, Danish Veterinary Institute, Lindholm, Kalvehave

According to the OIE animal health code a waiting period following the last outbreak of FMD is necessary before a country or zone can regain its status as free from FMD with or without vaccination. The waiting period is primarily meant to allow for disclosure of residual infectivity, if any, by exposure of susceptible species at risk and development of clinical signs or signs of infection, according to the 2002 revision of the OIE FMD animal health code.

Animal products prepared during the waiting period may constitute a risk of transmitting FMD, depending on species, vaccination status and product type, among others. The risk may be linked either to the presence of carriers or recently infected naive animals at risk. Emergency protective vaccination clearly will reduce the risk of encountering recently infected animals, whereas the risk posed by carriers established prior to vaccination would not be significantly altered by vaccination.

Fresh meat derived from carrier animals (cattle and sheep) does not contain infectious virus (Sutmoller, 2001) whereas fresh meat from recently infected (clinically or subclinically) animals may contain significant amounts of virus. In ruminants, maturation to pH<6, deboning and removal of visible lymphatic tissue greatly reduces any viral infectivity and is often used as a risk reducing step when importing beef from countries that are not free from FMD without vaccination. In contrast, maturation to pH<6 is not a reliable feature of pork, hence thermal treatment is normally applied as a risk reducing step rather than maturation and deboning.

The risk presented by fresh meat is tightly associated with the occurrence of recently infected animals at the time of slaughter. The occurrence of such animals is dependent on availability of susceptible animals at risk, i.e. before vaccination or after vaccination until the onset of immunity in vaccinated species and obviously also in species left unvaccinated. It is worth emphasizing here, that the value of a waiting period to demonstrate (clinically or by NS-serology) absence of viral activity also depends on availability of susceptible animals at risk. Conversely, since vaccination eliminates animals from population at risk (also in terms of NS-serology) it follows that monitoring for viral activity and risk management for fresh meat should both focus on non-vaccinated animals if possible.

Heat treatment

Thermal inactivation is widely used to reduce or eliminate microorganisms (bacteria, viruses) in animal products. The effect of heating is always determined by a combination of time and temperature. For practical purposes, the kinetics of inactivation is often assumed to be first-order but this is not always the case. Quite often the survivor curve shows a biphasic shape which may be approximated by describing a linear decay of two discrete populations, i.e. a sensitive and a more resistant fraction within a given population of organisms. The degree of biphasic behaviour may be temperature dependent.

The decimal reduction time $D_T$ at a given temperature $T$ denotes the time needed to reduce the viable population by 90%. A semi-log plot of D-values against temperature often yields a linear relationship, from which a $z$-value may be calculated. The $z$-value is defined as the number of degrees temperature required to change D by one log unit, that is the change in temperature needed...
to raise or lower the death rate by a factor ten. The z-value is normally considered to be constant for a given strain of microorganism in a given product.

In practice, heat treatment includes a heating phase and cooling phase. To account for the combined effect during heating and cooling, the temperature/time relationship data can be used to calculate lethal rates over the entire process and integrating into a cumulated lethal effect, expressed relative to a standard treatment at a chosen reference temperature \( \sum 10^{(T-Tr)/z} \cdot \Delta t \) where T is the temperature during the time interval \( \Delta t \) and \( T_r \) is the reference temperature e.g. 70°C).

The heat resistance of FMDV in meat products has been investigated in a number of studies. Thus Blackwell et al. (1988) found that FMDV in infected lymph node survived a thermal processing time of 1.45 hr reaching a final core temperature of 71.2°C. However, the period above 70°C was appreciably less than 30 min. FMDV did not survive 79.4°C reached after 2 hr. Garcia-Vidal et al. (1988) found that processing at 75°C for 20 min or 80°C for 15 min eliminated FMDV. In a more recent study (Masana et al., 1995) it was found that FMDV survived processing at 75°C for 2 hr but not for 4 or 5.75 hr. Although these studies used an overall similar approach, minor technical differences in conjunction with absence of kinetic data (rate of inactivation) makes it difficult to make a proper comparison, especially because estimates of D and z values have not been made. Below are the results of Garcia-Vidal et al. plotted into positive or negative relative to lines corresponding to treatment of 70°C for 1 h or 30 min, respectively, and assuming a z-value of \( \approx 14 \), which has been found to be a reasonable approximation for a number of viruses (unpublished data).

**Control measures in the new EU directive**

If protective vaccination is applied, a surveillance area around the vaccination zone must be defined, where intensified surveillance can take place (Article 52-2). However, there is no indication how such a surveillance should be performed.

The waiting period until regaining freedom from FMD when applying protective vaccination is divided into 3 phases according to overall perceived risk:

- **Article 54**: Measures applicable in the vaccination zone during the period from the beginning of emergency vaccination until at least 30 days have elapsed following the completion of such vaccination (Phase 1)
- **Article 55**: Measures applicable in the vaccination zone during the period (not earlier than 30 days) from (the date of completion of) emergency vaccination until the survey and the classification of holdings are completed (Phase 2)
• **Article 58**: Measures applicable in the vaccination zone after the completion of the survey and the classification of holdings until the foot-and-mouth disease and infection free status is recovered (Phase 3)

The following treatments are prescribed for meat and milk, respectively, for each of the 3 phases.

<table>
<thead>
<tr>
<th></th>
<th><strong>Cattle</strong></th>
<th><strong>Sheep</strong></th>
<th><strong>Milk</strong></th>
<th><strong>Pork</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phase I</strong></td>
<td>+vacc heat treatment¹</td>
<td>heat treatment¹</td>
<td>UHT or HTST</td>
<td>heat treatment¹</td>
</tr>
<tr>
<td></td>
<td>-vacc n.a.</td>
<td>not allowed</td>
<td>n.a.</td>
<td>not allowed</td>
</tr>
<tr>
<td><strong>Phase II</strong></td>
<td>+vacc deboning</td>
<td>deboning</td>
<td>UHT or HTST</td>
<td>heat treatment¹</td>
</tr>
<tr>
<td></td>
<td>-vacc n.a.</td>
<td>? (e.g. sheep)</td>
<td>n.a.</td>
<td>?</td>
</tr>
<tr>
<td><strong>Phase III</strong></td>
<td>+vacc deboning</td>
<td>deboning</td>
<td>UHT or HTST</td>
<td>heat treatment¹</td>
</tr>
<tr>
<td></td>
<td>-vacc none</td>
<td>none</td>
<td>n.a.</td>
<td>none</td>
</tr>
</tbody>
</table>

¹A number of options are available, as specified in Council Directive 2002/99/EC of 16 December 2002 laying down the animal health rules governing the production, processing, distribution and introduction of products of animal origin for human consumption

² can only be placed on national market until 3 months after last outbreak; later rules to be decided by committee procedure

In phase I and II only meat from vaccinated animals can be marketed, reflecting a relative lower risk of vaccinated animals to non-vaccinated animals. In phase II the requirement of heat treatment of beef is replaced by maturation and deboning, reflecting a less stringent effect of deboning compared to heat treatment. In phase III the requirement for treatment of meat from vaccinated animals is maintained, whereas meat from non-vaccinated animals can be marketed without treatment. The latter is a dramatic change from phase II and can hardly be justified by relative risk assessment of meat from vaccinated vs. non-vaccinated animals. Likewise, the particular restriction on marketing of pork to the national market from vaccinated animals is not in line with the fact that, should any viral activity remain, it would mainly constitute a risk to non-vaccinated animal (pigs not being carriers).

The heat treatments referred to in Council Directive 2002/99/EC prescribe the following options:

- (a) **Heat treatment in a hermetically sealed container with an F0 value of 3.00 or more**
- (b) **Heat treatment at a minimum temperature of 70 °C, which must be reached throughout the meat**
- (c) **Heat treatment at a minimum temperature of 80 °C, which must be reached throughout the meat**
- (d) **Heat treatment in a hermetically sealed container to at least 60 °C for a minimum of 4 hours, during which time the core temperature must be at least 70 °C for 30 minutes**
- (i) **Heat treatment ensuring a core temperature of at least 65 °C is reached for the time necessary to achieve a pasteurisation value (pv) equal to or more than 40.**

**Discussion**
The lethal effect of option b and c will depend on the length of heating and cooling period and it is therefore not possible to make a direct comparison and assessment of each option. If, as mentioned above, a lethal effect corresponding to 70°C for 1 hour is used as a guideline, option d can be shown (by lethal rate integration) to correspond to 70°C for approx. 70 min. Option a corresponds to 121°C for 3 min and exceeds by far 70°C for 1 hour.

In conclusion, the issue of safeguarding meat from FMDV needs particular consideration of what must be treated, i.e. an assessment of the relative risk of occurrence and quantity of FMDV in meat from vaccinated and non-vaccinated animals, respectively as well as how such meat should be treated. The current requirements for the heat treatment of meat from FMDV vaccinated animals, although based on empirical data, can be considered to provide a high degree of safety when applied to low-level contaminated products such as meat from vaccinated animals.

Until specific estimates of death rates and heat stability of FMDV become available it will difficult to set up more specific guidelines in terms of quantitative risk reduction of FMDV in meat. Such guidelines should also take into account the relative risk of occurrence and quantity of FMDV in meat from vaccinated and non-vaccinated animals, respectively.

References
Garcia-Vidal, W et al., J. Food Science, 1988, 53(6), 1650.
Masana, MO et al., J. Food Protection, 1995, 58(2), 165.