High-Frequency Heating

FOOD SAFETY TECHNOLOGY SUMMARY	
Status	Currently available
Location	Post-packaging
Intervention type	Exposure to radiant energy
Treatment time	Few seconds to several minutes
Regulations	No specific restrictions as long as used within the permitted frequency range. Widely used for cooked products
Effectiveness	No consensus in the literature
Likely cost	Not known although this technology used in other industries is expensive due to the protective shielding necessary
Value for money	Difficult to ascertain
Plant or process changes	Protective shielding to avoid radiation exposure will need space allocation. However, if used as a thawing process, may be able to reduce holding areas or better utilise space
Environmental impact	Utilises energy
OH&S	Radiant energy leaks must be prevented and controlled
Advantages	Can be used on packaged product Radiofrequency heating is more uniform and more precise control of the process Microwave heating can reduce thawing time from hours to minutes
Disadvantages or limitations	Can cause product discolouration

High-Frequency Heating

High-frequency heating (i.e., radiofrequency, microwave and infra-red heating) is a thermal process, which could be used to eliminate microorganisms. It has received notable attention from the meat industry, and has shown great potential to be used as an alternative to conventional steam and hot water treatments for meat processing. This is because these conventional treatments are conductive heating methods. They typically rely on the heat conduction from the exterior to the interior of the meat products. This, in turn, requires longer treatment time, and leads to much more severe treatment of the outer meat surface, which causes undesirable changes in meat quality. By contrast, high-frequency heating uses electromagnetic energy to heat the products. This provides more rapid and uniform heat distribution and therefore minimise quality reduction of the products.

Radiofrequency or dielectric heating

The US Federal Communication Commission (FCC) has designated the frequencies of radiofrequency heating for industrial use. These include 13.56, 27.12 and 40.68 MHz. Radiofrequency heating could be distinguished from other high-frequency heating by its wavelength. The wavelength at the radiofrequency-designated heating frequencies is about 22 to 360 times as great as those at the other designated heating frequencies. This higher wavelength also allows greater penetration depth in a product. Therefore, radiofrequency heating is more suitable for treatment of large-diameter products, such as meat products

Guo *et al.* (2006) reported that radiofrequency heating was as effective as conventional method in decontaminating meat products. The study evaluated and compared the efficacies of radiofrequency heating (at 1.5 kW and 27.12 MHz) and hot water cooking in inactivating *E. coli* in ground beef. The beef samples were heated using both methods until the centre reached 72°C. The results revealed that the radiofrequency heated the beef samples uniformly and faster (~4.25 minutes) than hot water treatment (~150.33 minutes). However, both methods reduced similar numbers of *E. coli*.

The quality of heated products by radiofrequency heating has also been investigated. Laycock *et al.* (2003) studied the effects of radiofrequency heating on the colour, water holding capacity, and texture of three different types of meat products (i.e., ground, comminute, and muscle). It was found that the eating quality of some meat products was adversely affected, especially the texture. Furthermore, Mckenna *et al.* (2006) compared the quality and heating time of meat products after radiofrequency heating to that of steam heating. The results revealed that products heated by radiofrequency heating had harder consistency than those heated by steam treatment.

Microwave heating

Microwave relies on the same heating principle as radiofrequency heating but it uses higher frequencies. The permitted frequency bands for microwave are 433, 915, 2,450 and 5,800 MHz, as specified by the US FCC. It has also been reported that microwave penetration is greater at 915 MHz than at 2,450 MHz. Therefore, microwave at 915 MHz is more suitable for heating thick masses of materials such as red meats (Yarmand and Homayouni, 2011).

Microwave has previously been studied for its effectiveness in destroying bacteria and extending the shelf life of meat products (Aziz *et al.*, 2002). It was found that bacterial counts were reduced by 1-2 log cfu/g in beef samples after exposure to microwave for 20-30 seconds. These samples appeared to extend their shelf life by at least one more week during storage at 5°C.

Microbial inactivation by microwave is traditionally thought to be due to its thermal effect. However, several reports have suggested that non-thermal microwave (at frequencies above the standard 2,450 MHz) could lead to the destruction of microorganisms (Banik *et al*., 2003; Pakhomov *et al*., 2001; Shamis *et al.,* 2008). Of particular note was that Shamis *et al.* (2008) have developed a 'cold' microwave treatment for decontaminating raw meats. A single exposure of meat samples to high frequency microwave radiation (18 GHz at 16 Watt for 52 seconds) was tested and appeared to cause inactivation of *E. coli* and *Staphylococcus aureus* (decontamination rate of at least 60%) without the sample's internal temperatures exceeding 45°C. Furthermore, it was demonstrated that repeated exposure to the high frequency microwave was more effective (decontamination rate of at least 95% for both organisms) in decontaminating raw meat compared to single exposure.

Infra-red heating

Infra-red pasteuriser manufactured by Unitherm Food Systems, Inc. is approved by USDA FSIS. Its application is recognised for post-process, pre-package surface pasteurisation on ready-to-eat products such as roast beef and corned beef. Previous published research using this technology indicated that 1.25 to 3.5-log reductions of *L. monocytogenes* were achieved with treatment times of 60 to 120 seconds for various ready-to-eat meat products (Gande and Muriana, 2003).

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