Radio Frequency (RF) Thawing Irregular Shape Frozen Beef — a Computational Study

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Abstract

Imported beef often comes in halves or quarters of frozen bodies, which are irregular. Radio frequency (RF) heating can reduce processing time and minimize nutritional damage when applied in meat thawing. Because of its large penetration depth and high heating rate, RF thawing has a great potential for rapid thawing and heating uniformity improvement. The purpose of this study was to explore the internal temperature distribution of the irregular beef during RF thawing, and then to determine the influence of thickness, surface area, shape on the uniformity of the thawing of beef. COMSOL Multiphysisc® software was used to simulate the thawing process, by entering the physical properties of frozen beef samples including dielectric properties, thermal characteristics change with temperature to the software. Then the internal temperature change and distribution was simulated. After the simulation process was completed, we can obtain the temperature uniformity indexes for beef in different shapes, volumes and thickness. The reference beef size is 17.2*12.0*3.8 cm3. RF thawing of three different thickness of beef (1.8cm, 3.8cm, 5.8cm); three different surface areas with constant thickness of 3.8 cm (original, 2 times, 4 times); three different shapes of beef (rectangle, trapezoid, step shape) were simulated. Beef thawing were simulated at a 27.12 MHz frequency RF system from -13℃ to 4℃. After 6000s RF thawing under a voltage of 1375 V, the thawing rate and temperature uniformity of beef with different thickness, different surface areas, different shapes were compared. Temperature rise of 1.8cm beef is the highest among all thickness and decrease as thickness increases. Accordingly, the temperature uniformity index (UI) increases from 0.0023950, 0.0025876, 0.0026159.When expanding the surface areas of beef, the original size beef is the first to reach -4℃ with the lowest UI, then comes the 2 times and 4 times surface area.. When thawing different shapes of beef, the step shape has the highest heating rate, then the trapezoid second and the rectangle is the last. The UI of rectangle, step shape, trapezoid are 0.0023950, 0.0023023, and 0.0021753, respectively. The simulation results show that the internal temperature distribution changed significantly with geometrical factors. When the other conditions are constant, the temperature of smaller size beef rises faster. Also, when the surface areas increased, the uniformity decreased.

Reference

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Frarag et. al. Dielectric and thermophysical properties of different beef meat blends over a temperature range of -18 to +10 ℃. Meat Science. 79, 740-747 (2008)
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Figures used in the abstract

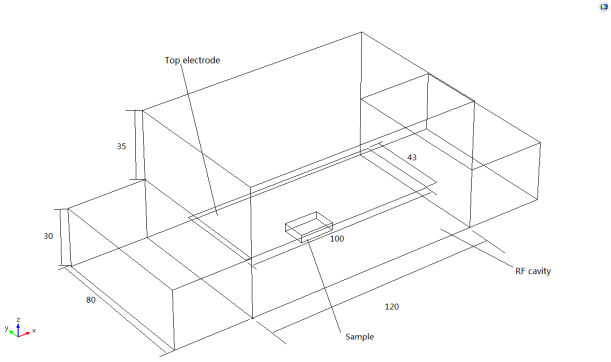

Figure 1: RF system heating cavity model

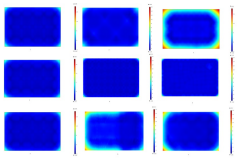

Figure 2: Temperature distribution of cross section

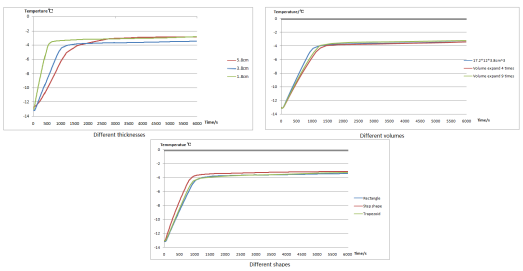

Figure 3: Temperature curves of different thicknesses, volumes, shapes

1	2	3
0.0023950	0.0025876	0.0026159
1	4	5
0.0023950	0.0052197	0.011754
1	6	7
0.0023950	0.0023023	0.0021753

Figure 4: The temperature uniformity index