

An appraisal of the freezing capabilities of tunnel and spiral belt freezers using liquid nitrogen sprays

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Abstract

A parametric analysis, comparing the heat transfer and operating characteristics of a tunnel and a spiral belt freezer, has been carried out using liquid nitrogen sprays under typical commercial freezing conditions. Experimental data were obtained for a controlled spray pressure of 2.4 bar, and two selected pizza sizes (128 and 180 mm diameter) were used based on a freezing capacity of 500 pizzas per hour. The freezing time of the two pizza samples was between 4.1 and 4.4 min in the spiral belt and tunnel freezers, respectively, and appeared to vary directly with sample mass. The average heat transfer coefficients in the precooling section were 28 and 35 $\text{W m}^{-2} \text{K}^{-1}$ in the tunnel and spiral belt freezers, respectively. These values were about $\frac{1}{6}$ and $\frac{1}{5}$ of the overall heat transfer coefficients in the freezing section, and $\frac{1}{16}$ and $\frac{1}{15}$ of the average heat transfer coefficients of individual droplets, respectively, while maintaining freezer temperature between -140 and -150 °C during freezing. Drip losses were low (0.55 to 0.6%) in the two freezers, and microbial destruction was in the order of six-fold. The mean sensory scores for textural feel of the frozenthawed samples were not significantly different ($P > 0.05$), but panelists detected significant differences ($P < 0.05$) among samples on visual appearance.