Impact of Emissive Power of Electric Infrared Emitters on Tomato Peeling Performance

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Abstract

This study investigated the effect of emissive power of electric infrared emitters on tomato heating rate, tomato peeling performance and final product quality. Four types of electric emitters, including ceramic full trough element (CFTE), pillared quartz element (PQE), quartz tungsten medium (QTM) and quartz halogen medium (QHM), were tested based on their ability to produce higher emissive power. The peeling performance of electric emitters was compared with that of catalytic infrared emitters (CIR). The high emissive power of these emitters increased the heating rate of tomato, resulting in achieving better tomato peeling performance and product quality. Electric emitters achieved an acceptable tomato peeling performance and product quality in less than 20 seconds of heating time. PQE achieved the acceptable peeling performance in 10 seconds. However, tomato experienced skin burn with longer heating time under these emitters, which needs to be controlled.

Background

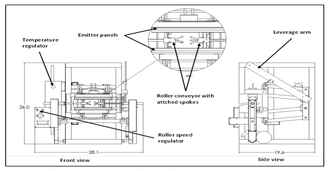
Emissive power of an IR emitter is one of the most important factors to determine its suitability for a specific application. The spectral characteristics (distribution of radiant energy over wavelength spectrum) are related to emissive power of emitter, which influence the heat transfer efficiency. Ideally, spectral characteristics of emitter match to the absorption characteristics of the objects to be heated in order to maximize the absorption of IR energy and achieve optimal heating efficiency. Electric emitters can produce a wide range of temperature (up to as high as 2500°C), resulting in generation of a wide range of emissive power and wavelength spectrum, which may be suitable for different applications in food processing, including peeling. In contrast, CIR emitters usually attain lower temperature and emissive power which is preferred in food drying applications because lower emissive power is suitable for controlling the drying rate. However, peeling is a different unit operation which requires a rapid heating with relatively higher IR intensity than drying. A high emissive power will increase the heating rate of tomato, resulting in achieving better tomato peeling performance and product quality. Therefore, a comprehensive study is important to understand the effect of emissive power of electric emitters on tomato peeling performance.

Objective

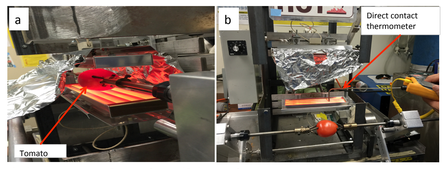
To compare tomato peeling performance and product quality under maximum emissive power of different electric emitters.

Materials and Methods

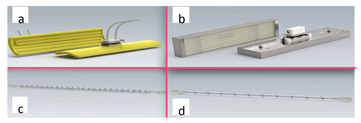
Tomato cultivar: Hz 6410 (Diameter – 50-53 mm)
Electric IR emitters: CFTE, PQE, QTM and QHM (1000 W, 240 V; WECO International Inc., Clio, Michigan, USA)
Residence times: 10, 15, 20 and 25s (3 replicates)
Rotation speed: 5 rpm (Constant)
Distance between emitters: 70 mm (Constant)
Experimental Design: Split plot



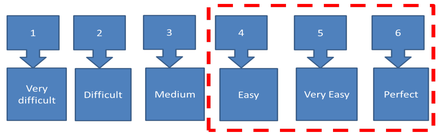
Schematic of IR heating system



(a) Tomato heating (b) Emitter temp measurement



Emitters: (a) CFTE (b) PQE (c) QTM (d) QHM



Peeling easiness scale

Raw tomatoes

Peeled tomatoes

Results and Discussion

Results revealed that the emissive power significantly affected the peeling performance and product quality. The emissive power of electric emitters CFTE, PQE, QHM and QTM were found to be 938, 1137, 1083 and 878 W, respectively (Figure 6), which were significantly higher than that of previously tested CIR emitter based on energy intensity. All the electric emitters tested in this study achieved acceptable tomato peeling performance in significantly lower residence time (≤20 seconds) compared to previously tested CIR emitters which required 51 seconds to achieve similar peeling performance. PQE and QTM achieved acceptable peeling performance in residence times ≤ 20 seconds. Among all, PQE had the highest emissive power and achieved the acceptable peeling performance (Figures 1-4) in shortest residence time (only 10 seconds). Tomatoes experienced skin burn at residence time >25 seconds. All the IR emitters tested in this study emitted a peak wavelength in medium wavelength emission spectrum (2-4 µm) (Figure 5).

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Results and Discussion (continued)

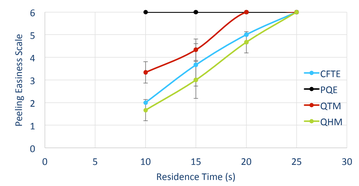

Fig 1. Tomato peeling easiness

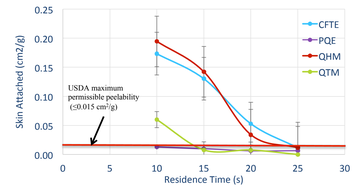

Fig 2. Tomato peelability

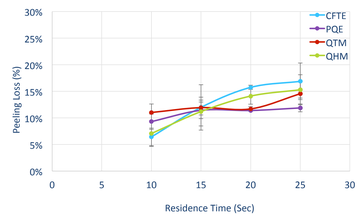

Fig 3. Tomato peeling loss

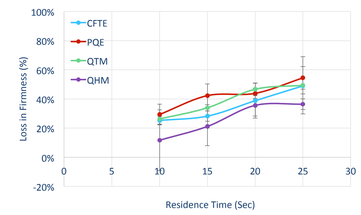

Fig 4. Tomato firmness loss

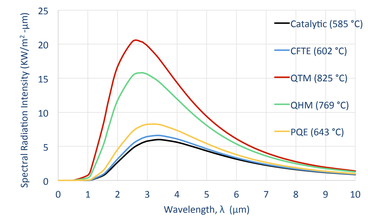

Fig 5. Spectral characteristics of IR emitters

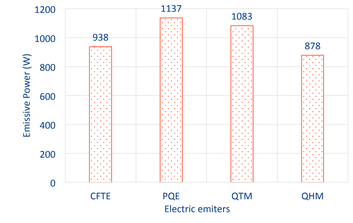

Fig 6. Emissive power of emitters

Conclusions

Electric IR emitters with high emissive power significantly reduced residence time to achieve acceptable tomato peeling performance and product quality. The unique feature of electric emitters with high emissive power can make them suitable for a broad range of food processing applications, including peeling process.

Acknowledgments

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