

Dehydration of Wheat Medium by Radio Frequency - Hot Air Drying

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Outline

- Introduction**
- Objectives**
- Materials and methods**
- Results and discussion**
- Conclusions**

Introduction

Solid-state fermentation medium

- ❑ Grain contains carbon and nitrogen sources as a solid-state medium for microbial growth
- ❑ Medium → sterilization → inoculum → fermentation → sterilization → drying → ground → capsules



Dehydration methods of fermented products

Freeze-drying:

Low temperature drying processes

Maintain the functional components in products

Too long drying time

Expensive operation cost

Conventional hot air drying:

Convenient and cheaper drying process

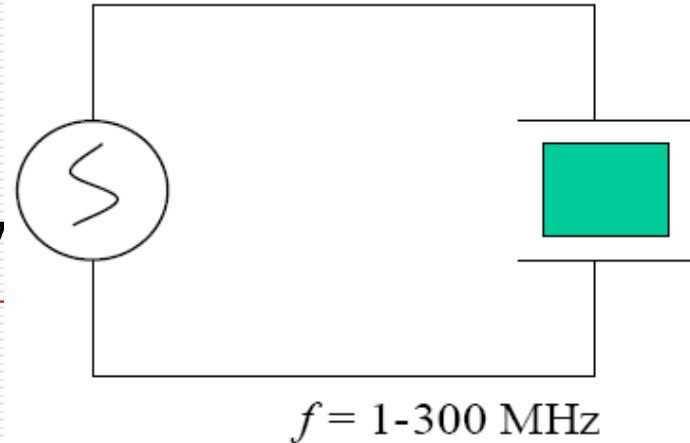
Large heat transfer resistance in the fermented products

Long drying time

Radio frequency-hot air drying:

Solve the slowest step in the downstream processing

Radio frequency (RF) energy



- ❑ The thermal energy is converted by the rotational responses of polarized molecules and migration of charged ions in a parallel pair of electrode plates. (Zhang et al., 2006)

$$Q = 2\pi f \epsilon_0 \epsilon'' E^2$$

- ❑ To provide more uniform and faster heating in food products than conventional methods. (Zhao et al., 2000; Piyasena et al., 2003; Marra et al., 2008)

- ❑ RF has larger penetration depth than microwave.

$$d_p = 4.47 \times 10^7 / (f \sqrt{\epsilon' \tan \delta})$$

RF applications in food industries

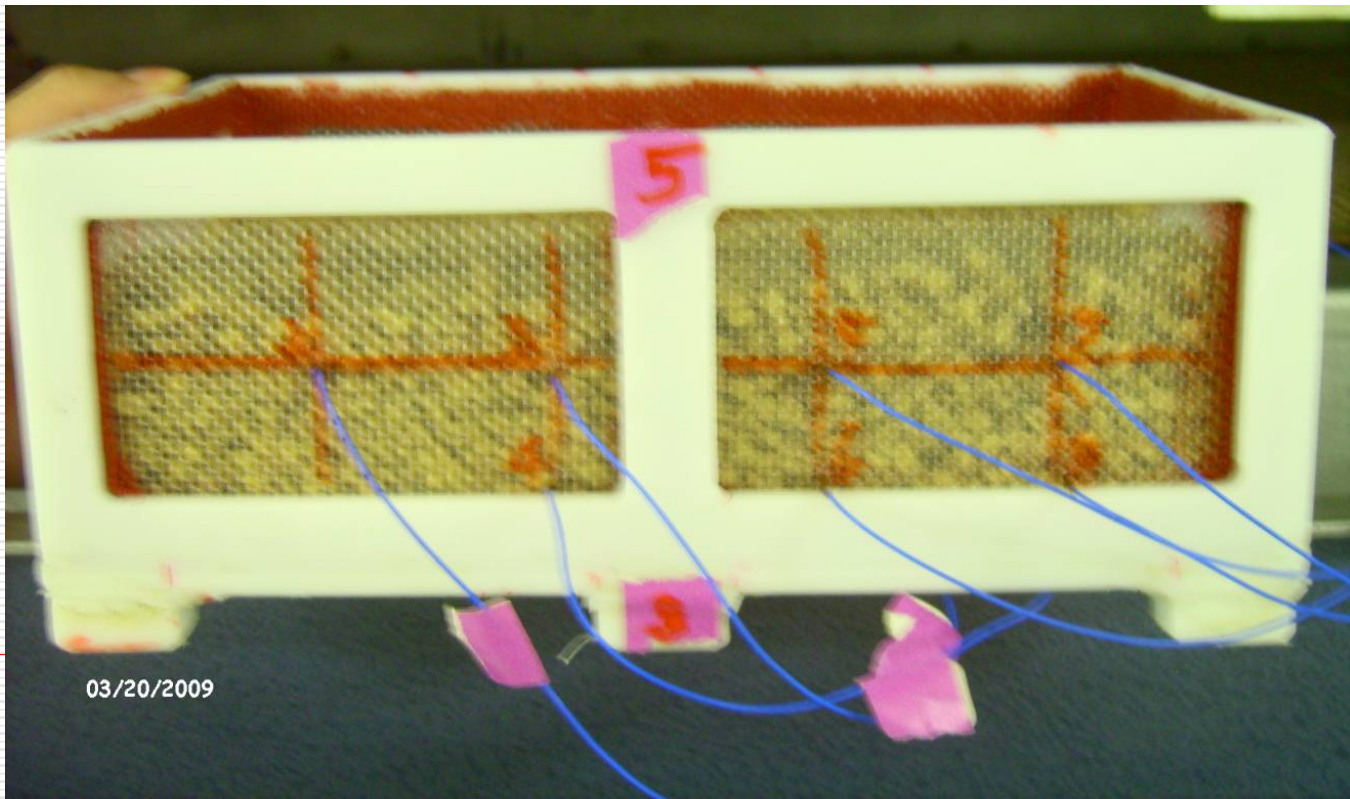
- Cooking of meat and bread**
- Dehydration and blanching of vegetables**
- Defrosting of frozen products**
- Pasteurization**
- Post-bake drying of cookies and snacks**
- Disinfestations of fruits and nuts**

Objectives

- To rapidly dehydrate wheat medium by combining RF with hot air drying.**
- To determine RF-hot air drying operation parameters.**
- To compare color between RF-hot air dried and conventional hot air dried wheat media.**

Materials

- **Wheat media with 20~50% moisture content (w.b.) was placed in a rectangular plastic container (25 cm x 15 cm x 9 cm) and the bulk density was about 760 kg/m³.**

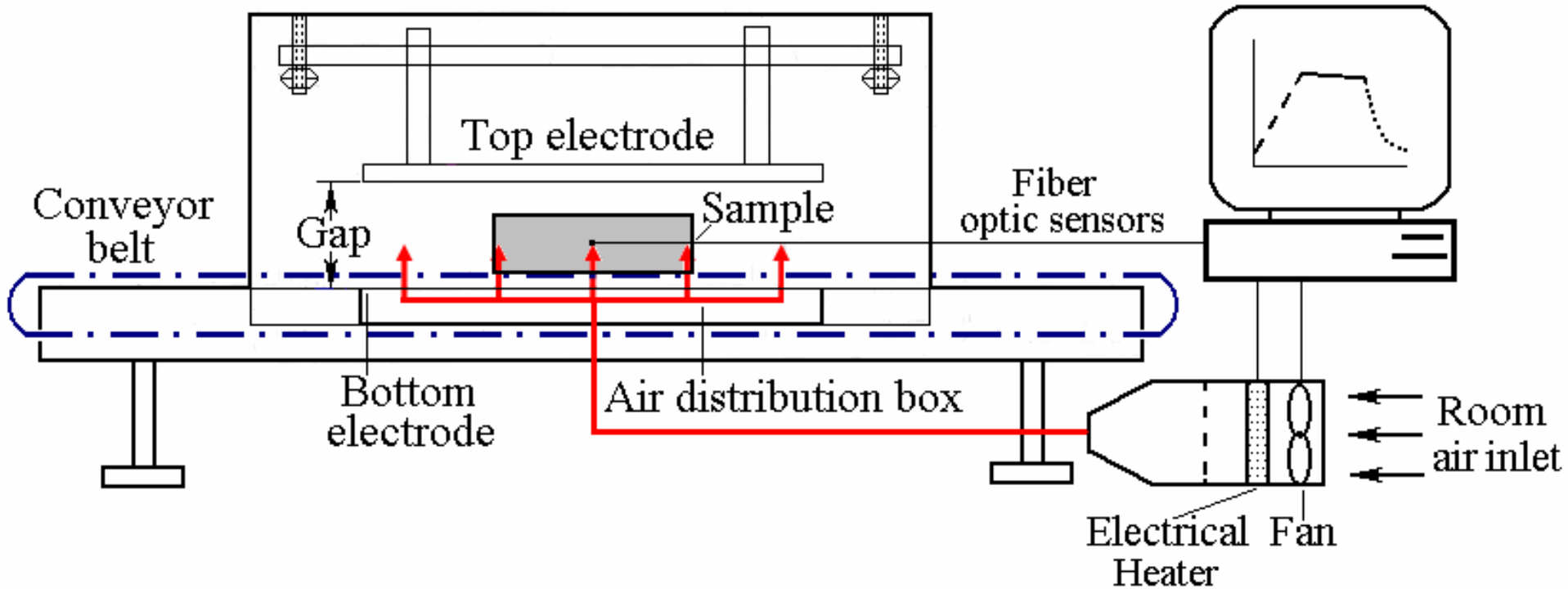


Front view of RF-hot air drier



02/18/2009

6 kW, 27.12 MHz RF-hot air drying system

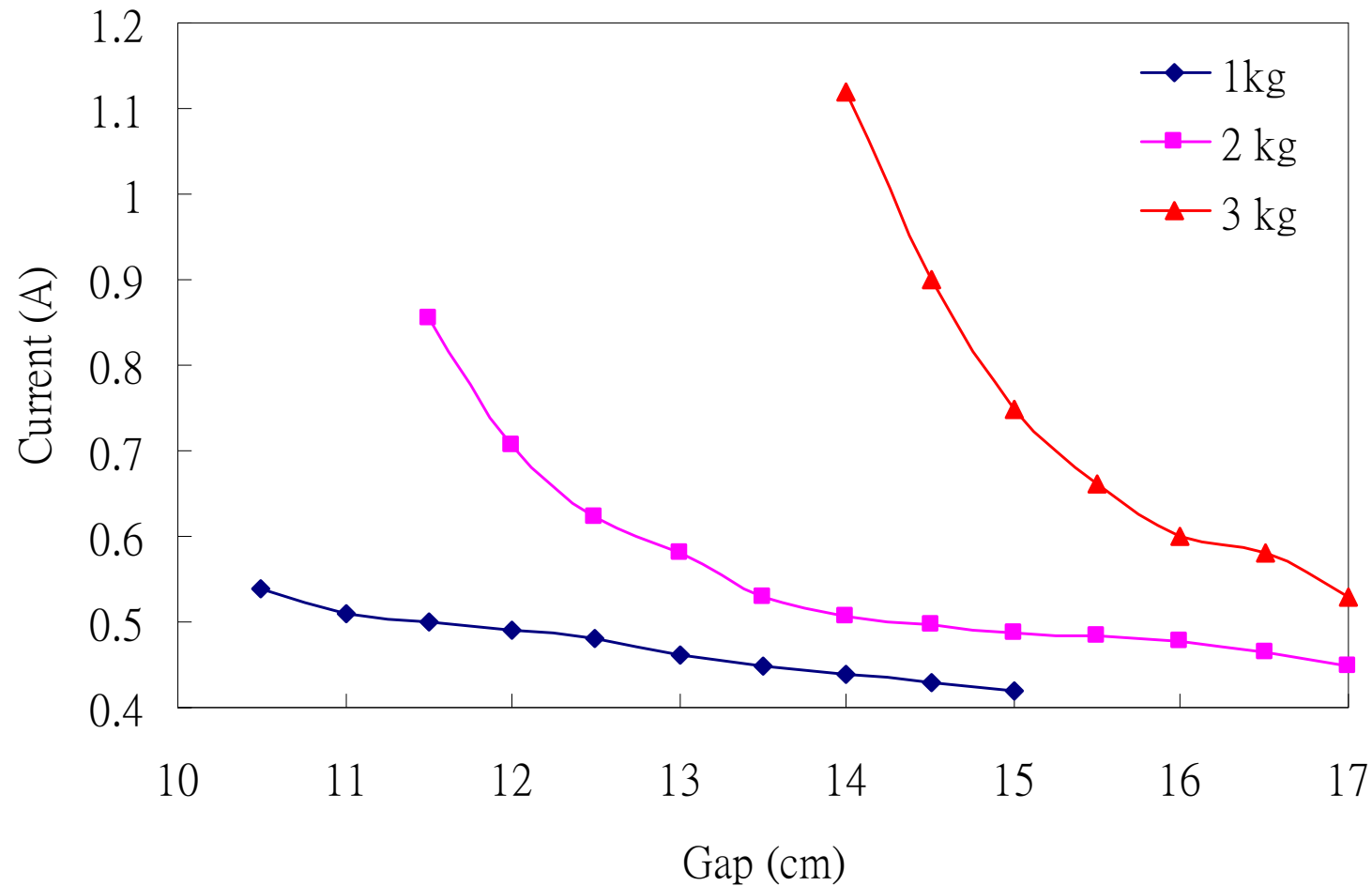


Methods

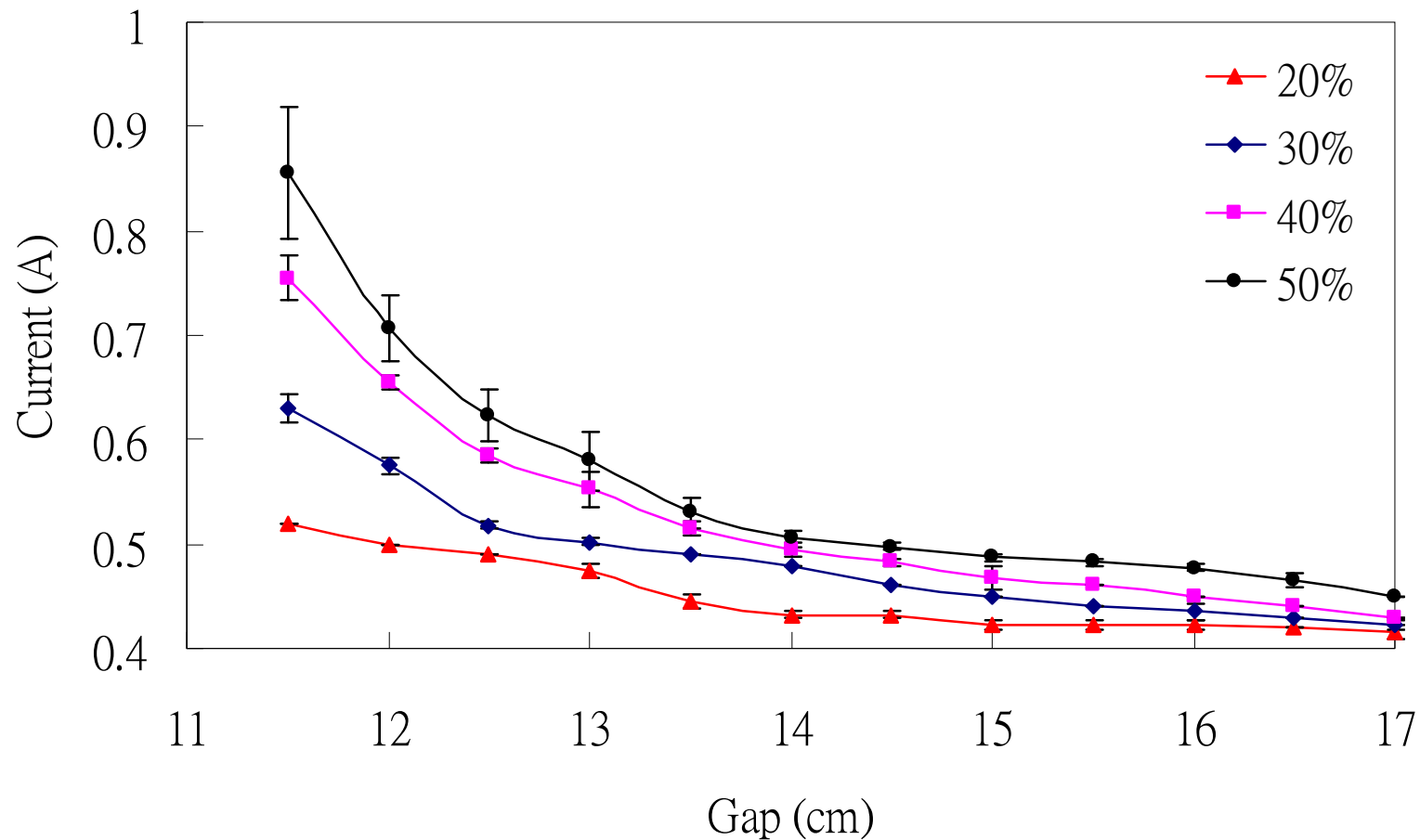
- Seven fiber optical temperature sensors (UMI, FISO Technologies Inc.) were inserted from the front side of the container 5 cm into the wheat medium at different positions.
- After heating, the surface temperatures were measured with a digital infrared camera (Thermal CAM TM SC-3000).
Temperature uniformity index (α) = SD/ AVG
- The color (L^* , a^* , b^*) of dried wheat medium was measured by a colorimeter (Model CM-2002, Minolta Corp.) as a quality index.

Results and discussion

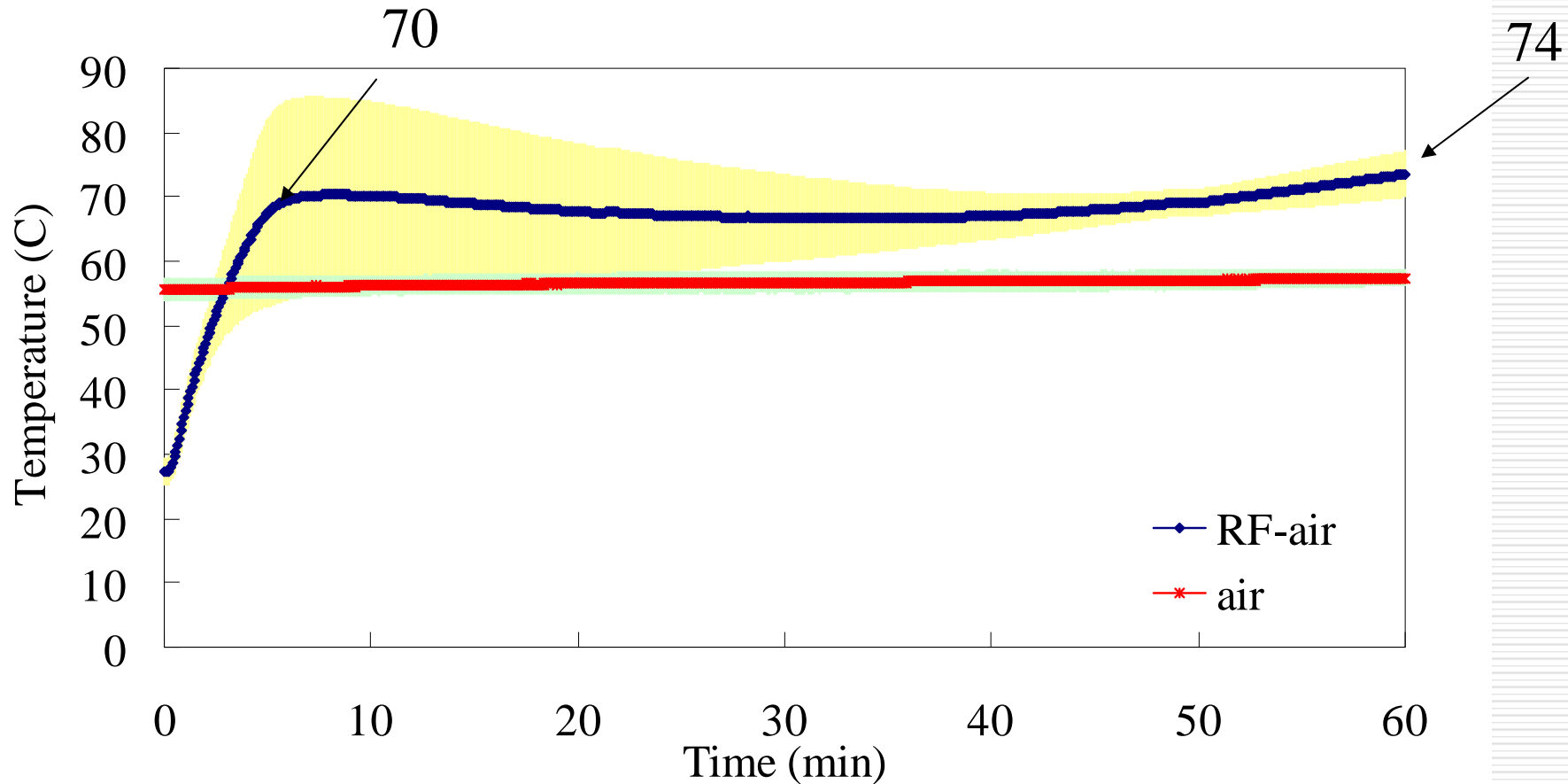
Effect of sample loading on RF current at different gap in a RF-hot air dryer



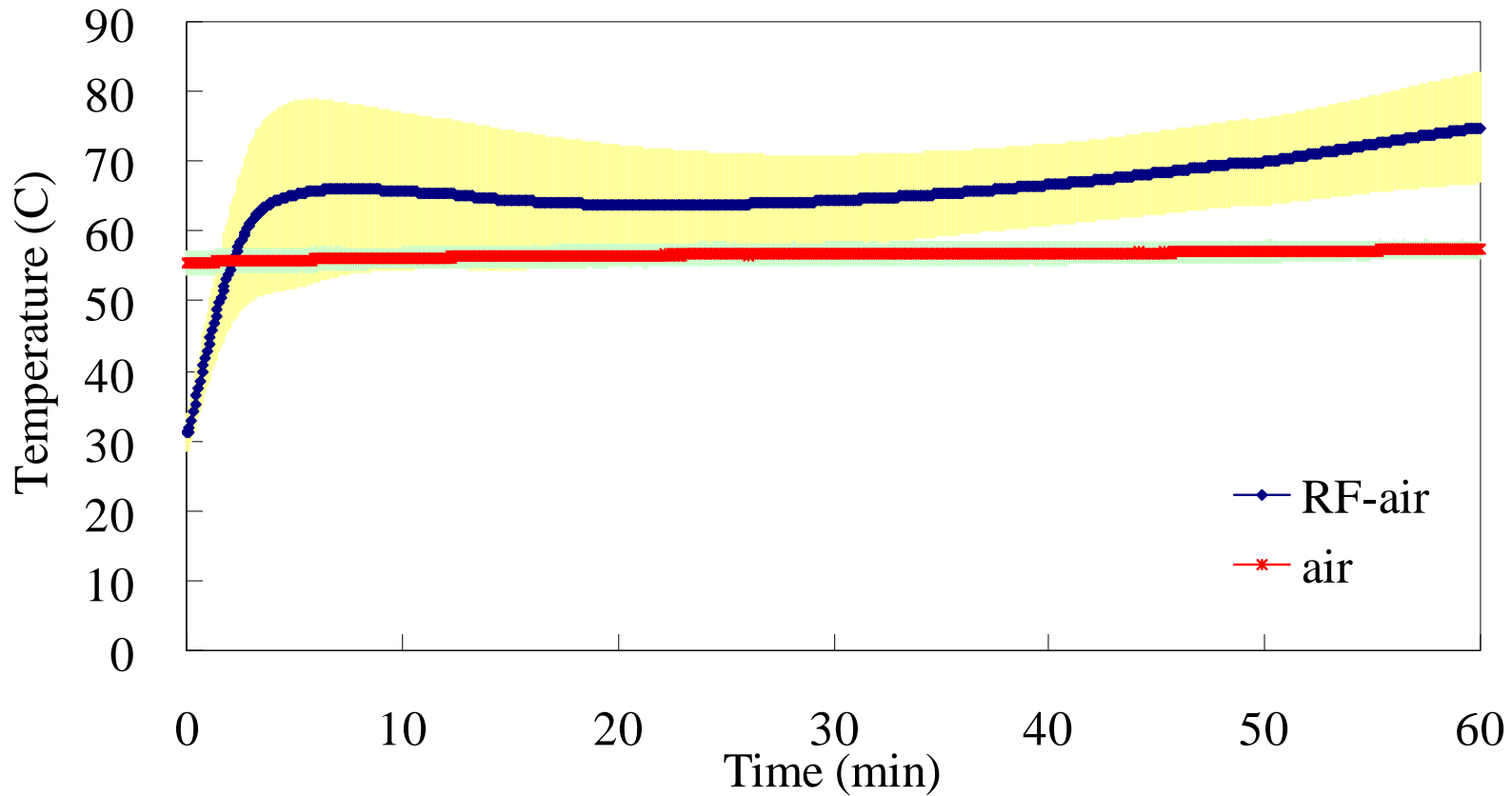
Effect of moisture contents of wheat media on RF current at different gap in a RF-hot air dryer



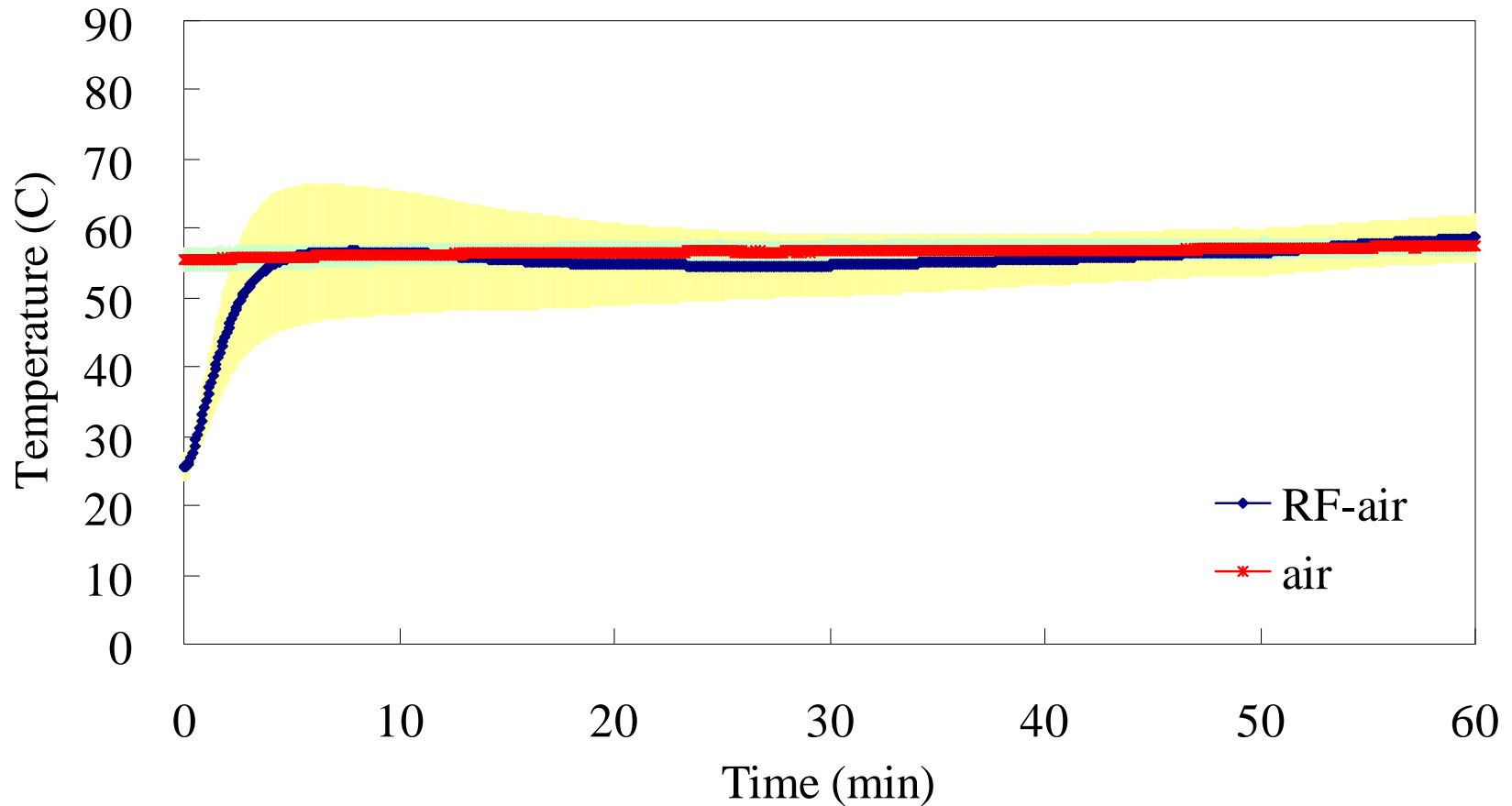
Sample temperature history for 11.5 cm gap in RF-hot air drying of 2 kg 50% wheat medium



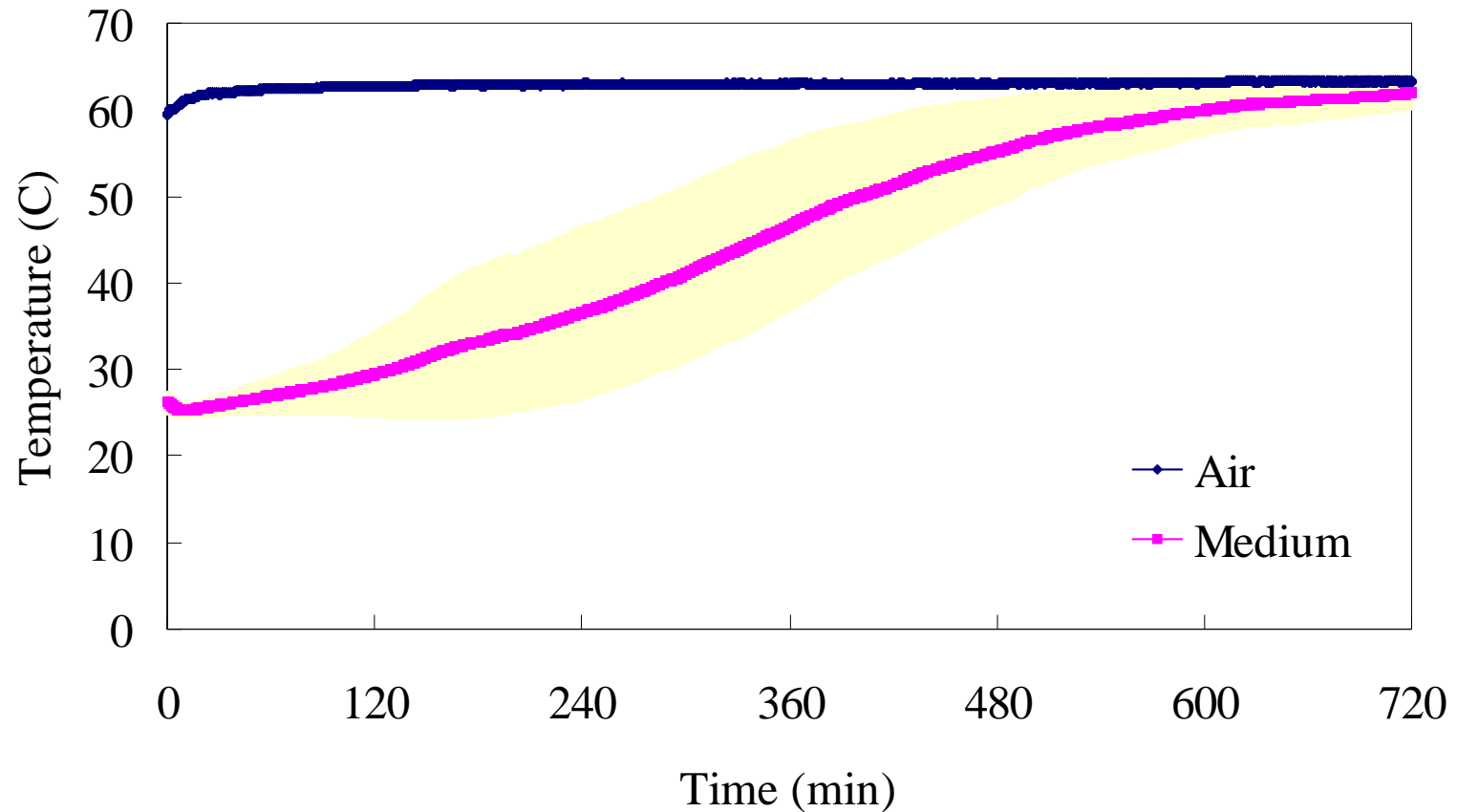
Sample temperature history with 12 cm gap in RF-hot air drying of 2 kg 50% wheat medium



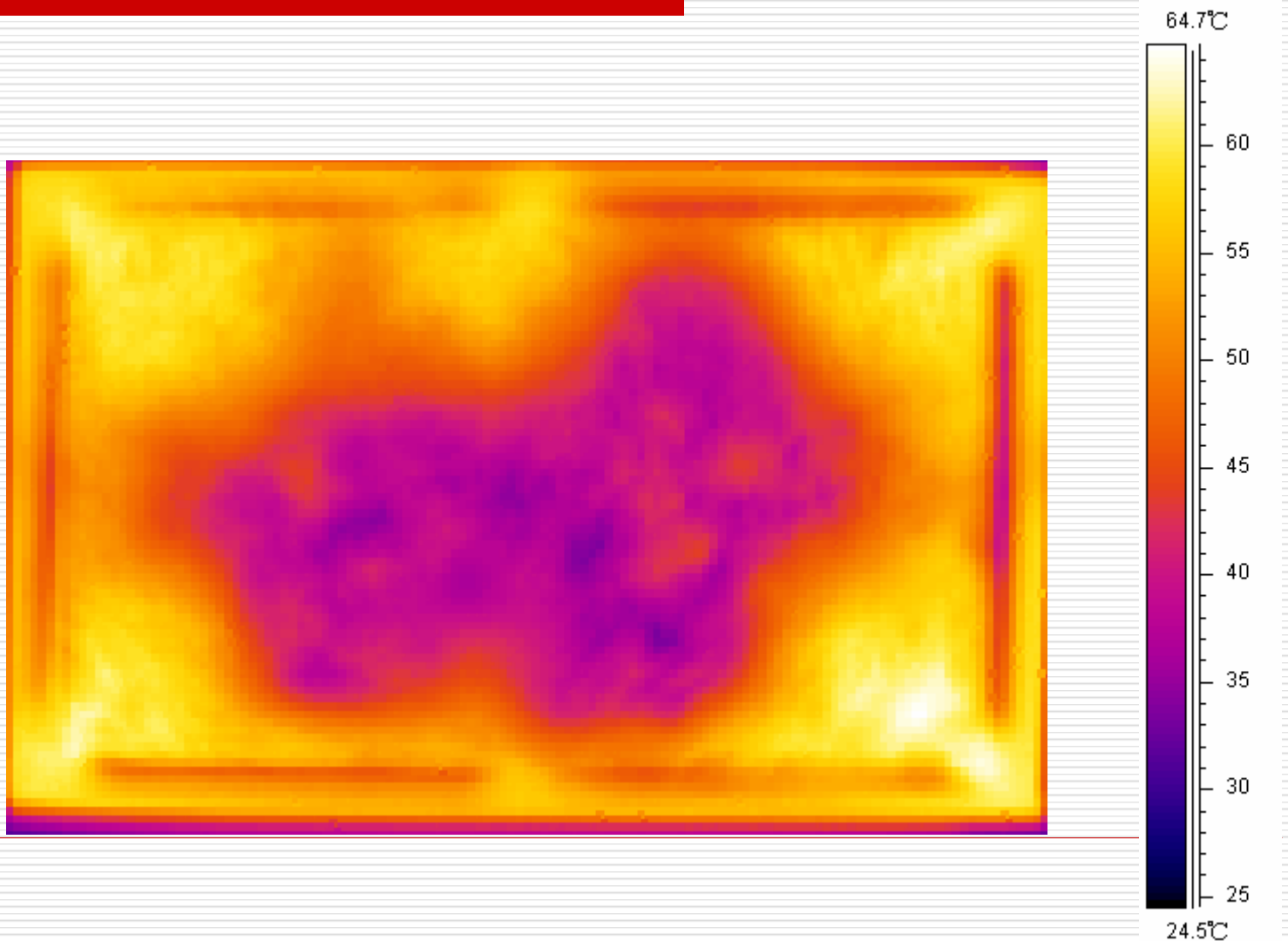
Sample temperature history for 12.5 cm gap in RF-hot air drying of 2 kg 50% wheat medium



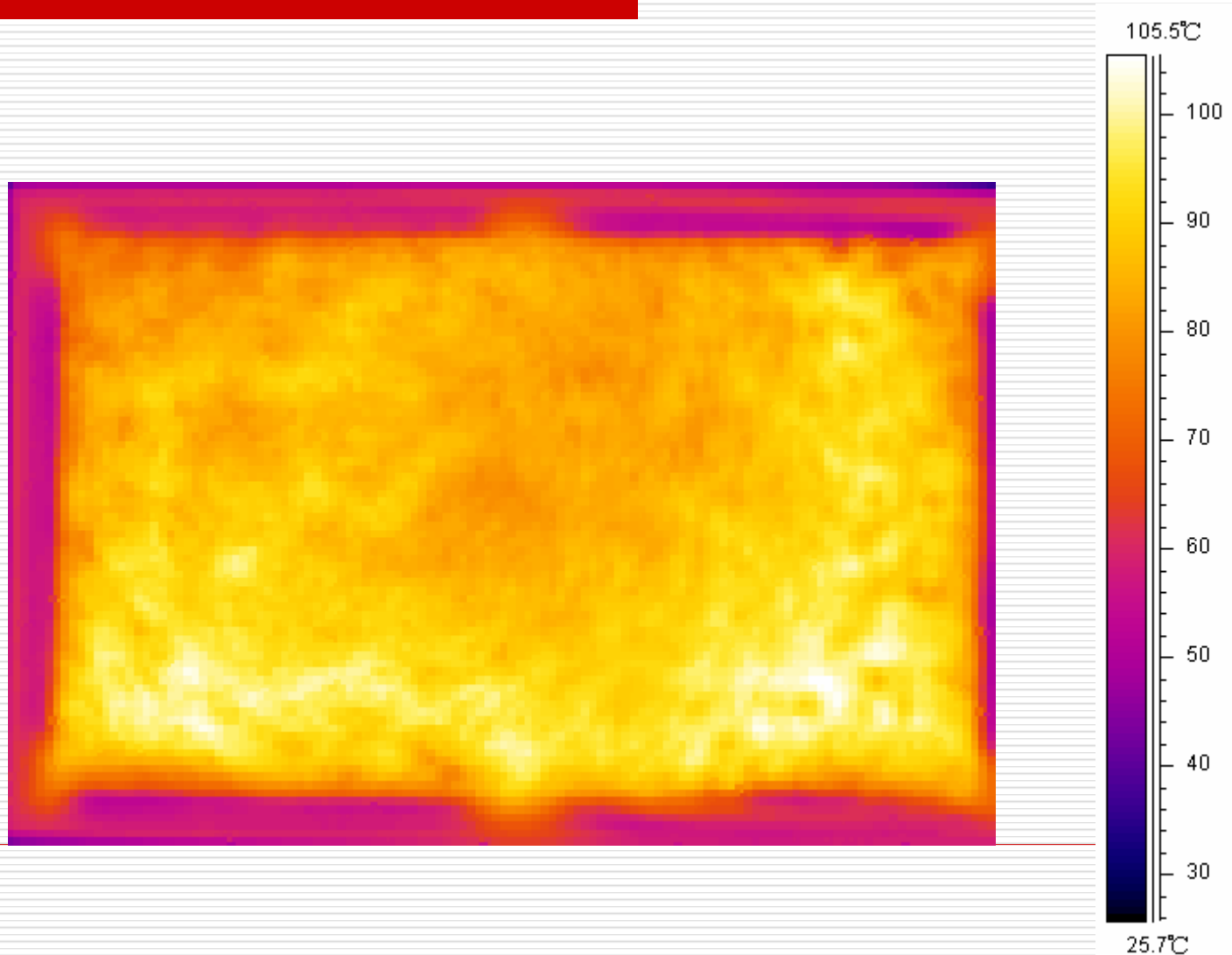
Temperature profiles of hot air drying 2 kg 50% wheat medium



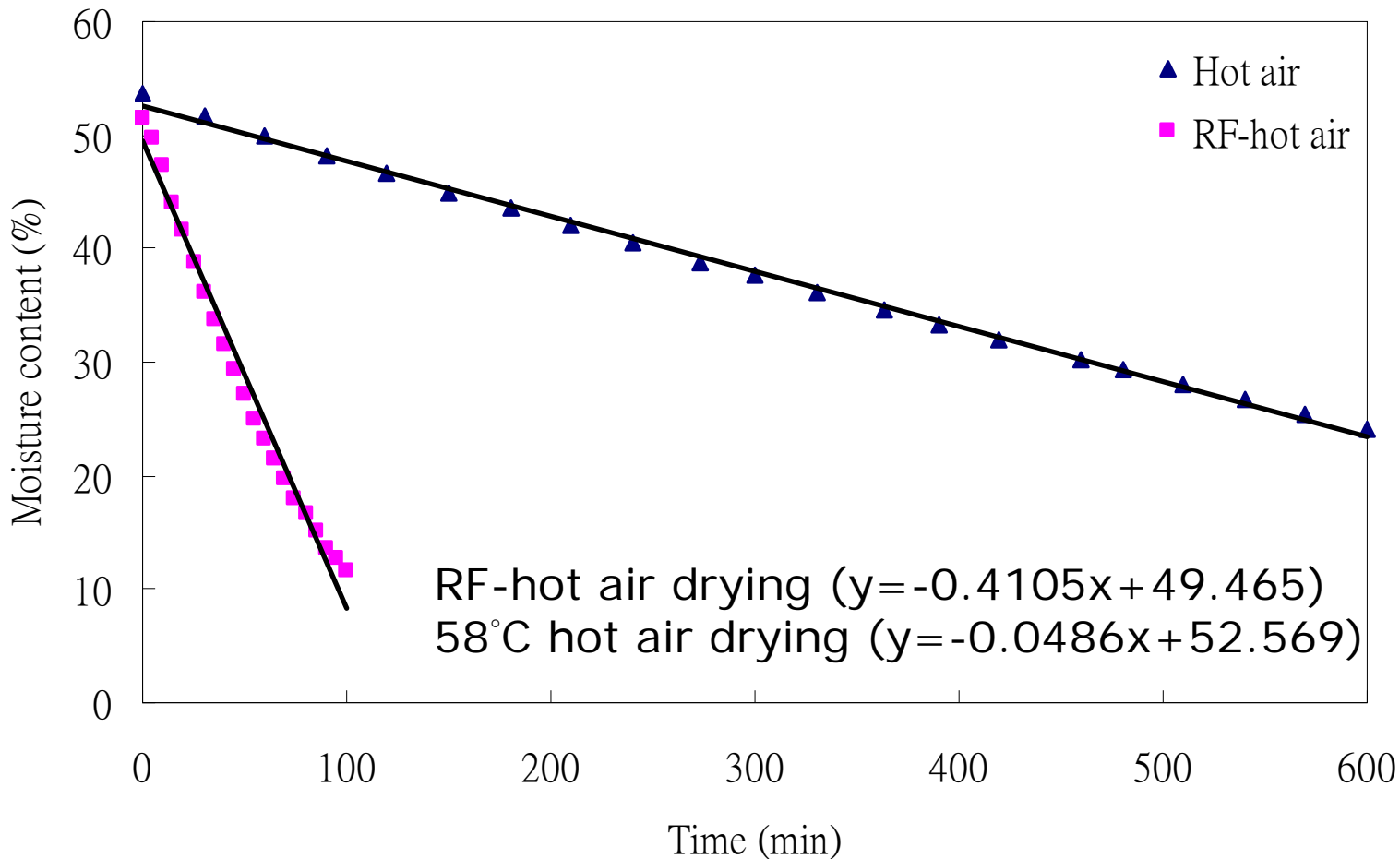
Surface temperature of wheat medium after 12 hr hot air drying



Surface temperature of wheat medium after RF-hot air drying (90 min)



The drying curves of 2 kg 50% wheat medium in RF-hot air drying with 12.5 cm electrode gap and hot air drying at 58°C



Color of final wheat media by different drying treatments

Treatment	MC (%)	A _w	L*	a*	b*
Hot air drying 12 hr	5.3±1.11	0.60±0.02	44.42±1.53	7.13±0.24	22.80±0.65
RFHA 90 min	5.38±0.19	0.33±0.03	43.33±1.04	7.39±0.54	22.68±1.41

Conclusions

- The RF energy overcame heat resistance in wheat medium experienced in hot air drying and significantly increase drying rate.**
- The RF-hot air drying with a suitable electrode gap resulted in relatively uniform temperature distribution and removal of the required amount of water from wheat medium.**
- The colors of the final wheat media after both RF-hot air drying and hot air drying were not significantly different.**
- The RF-hot air drying may serve as a potential drying method for fermented wheat media with short drying time and acceptable quality of the final product.**