The New Storage Technology: Effect of Far Infrared Ray (FIR) Ceramic Sheet Package on Storage Quality of Pork Loin

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ABSTRACT : A total of 30 pork loin sections were utilized to evaluate the effects of FIR ceramic sheet in PE and vacuum package on preserving the quality of chilled pork stored at 4 and 0°C. Based on meat color, results indicated that pork loin packaged in ceramic sheet and control treatment showed that the samples of the control treatment tended to darken gradually in comparison with the samples at 0 day, but FIR treatment had few changes. Among the total plate counts of sliced loin in PE and loin in vacuum package under different storage times at 4 and 0°C, results showed that FIR ceramic sheet package treatment had lower total plate counts and significant differences ($p<0.05$). In VBN value, both treatments tended to rise high with the increasing of storage time, but the FIR treatment was significantly lower ($p<0.05$) than the control treatment. Its results had a corresponding relationship with the total plate counts. Regarding the drip loss of sliced loin in PE and loin in vacuum package, it showed that FIR ceramic sheet package treatment had lower drip loss and significant differences ($p<0.01$). These results showed that the use of FIR ceramic sheet package, including PE and vacuum package, is an effective method of maintaining the quality of meat. ***(Asian-Aust. J. Anim. Sci. 2003. Vol 16, No. 11 : 1695-1700)***

Key Words : FIR, Ceramic, Package, Storage, Quality, Pork, Loin

INTRODUCTION

Electromagnetic wave has several kinds of frequency and energy. According to the wavelength it could be divided into the cosmic ray, r, x, ultraviolet ray, visible light, infrared ray, microwave and electric wave. The range of the infrared ray is from the wavelength 0.76 μm to 1,000 μm (Robinson, 1973). In the sunlight, 80% is infrared ray, 13% visible light, and the rest of the 7% ultraviolet ray and electromagnetic wave farther up than ultraviolet ray in frequency (Egawa, 1990). Infrared ray and visible light are classified as "light of growth", but ultraviolet ray is classified as "light of destruction" (Sasaki, 1987). On the basis of the wavelength, the infrared ray could be divided into near infrared ray (0.78-2.0 μm), middle infrared ray (2~4-5.6 μm), and far infrared ray (FIR) (4-5.6~15 μm) (Omori, 1994).

The composition of FIR radiator includes ceramic, metal oxide and, glass etc., (Iita, 1988) the material of radiator must closely be black body emissivity, including ceramic material and metal oxide (ex. ZrO_2, TiO_2 and MnO_2 etc.) (Sasaki, 1987). Food and organic material at wavelength of 3-5 μm have the biggest absorption wave (Fujii et al., 1983). According to the reports of Shimizu (1987a), Sawai et al. (1994a), Sawai et al. (1994b) and Sawai and Shimizu (1995), measured by the Bactometer Model 64, bacteria, such as *Staphylococcus, E. coli, Coliform Salmonella* and *B. subtilis* ATCC6633 etc., were found to have the effects of bacteriostatic and bacteriostasis after the addition of FIR ceramic powder.

In Ishi's experiments (1990), food items, such as vegetables, fish, meat etc., were put into the air-cycled cold freeze at -10°C for two days. The moisture of food evaporated, and it caused drip loss of 5-7%. When the thin films of FIR ceramic sheet were placed at the cold freeze of a blowing export, under the same term, drip loss could be reduced by half. The reason was that when storage was at low temperature, and the moisture in food, especially free water, would evaporate. However, the water molecule in gas was an incomplete mono-molecule. One part would be shown in conjunction and be combined with hydrogen in the FIR ceramic sheet. And it would be cut and form free radical that was combined with food cell to form binding water that was not easy to be evaporated (Shimizu, 1987b). Therefore, the moisture at surface did not evaporate easily, and it had the protective effect on the original color (Sasaki, 1987).

In exporting port, part meat that is chilled and frozen is generally preferred, as the price of the frozen meat is low. At the same time, this lead to the price competition in some countries. Therefore, in the last few years, the business has mainly targeted developing of chill-storage pork for exporting. When the meat was sold in part meat condition and stored at a long time, it would easily change the appearance and have too much drip loss. At the same time, the plate count is too high, and it would become slimy. On the other hand, when the meat was sold in sliced condition

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in supermarkets, it also had the same weakness. Therefore, in order to improve the quality and the level of the chilled meat and increase the competence for export and the quality of supermarket business, we aimed at making use of FIR ceramic sheet treatment of packing method.

The purpose of this study was to compare the effects of FIR treatment (ceramic sheet package, including PE and vacuum conditions) on the storage quality of pork loin. The pH value, L, a, b, values, total bacterial counts, VBN value, drip loss were measured at 0 to 7 days in PE package, 0 to 42 days in vacuum package during the storage period at 4 and 0°C.

MATERIALS AND METHODS

Sample preparation

Fifteen samples of market weight (about 100 kg) crossbred barrows loins (postmortem 3 h) were purchased from a local meat market. One group of the loin sections were sliced into 0.5 cm thickness and the samples were the loins (10 pieces) that were held separately in polystyrene foam trays. Then they were wrapped over with a PE sheet package (control lots) and ceramic PE sheet package (adding FIR ceramic powder in PE). Both were allocated to storage intervals (0, 1, 2, 5, 7 days) at 4°C. The other group of the loins (8 kg) was packed in the vacuum package (NY/PE/EVA:15/30/30 M:1 by Sun Ying Co., Taiwan). A vacuum was developed in each pouch with 14136 kg/sq meter (20 psi) and heat sealed with vacuum packer (Multivac A 300/2, Germany). Then they were also wrapped over with a PE sheet package (control lots) and ceramic PE sheet package (adding FIR ceramic powder in PE). Both were subjected to different storage intervals (0, 7, 14, 28, 35, 42 days) at 0°C.

FIR ceramic sheet preparation

Ceramic sheet contents :

a: PE (polyethylene): 95%, b: Ceramic powder: 5%

Process :

Kaolin ground and metal oxide
(include TiO_2, ZrO_2, SiO_2, MgO and Al_2O_3 etc.)
↓
Mixing
↓
Sun drying for 7 days
↓
Heating at 1,500°C (15 h)
↓
Cooling
↓
Crushing
↓
Ceramic powder
↓
95% PE particle and 5%ceramic powder mixing by plastic extruder machine
↓
Ceramic sheet
(40 cm×60 cm×0.065 mm in width, length, and thickness)

Measurement of pH value

The pH value was measured after homogenization of 5 g of muscle in 20 ml of distilled water by means of an electric pH meter with glass electrode (Micro-computer: model 6200, Jenco Elect. LTD) (Ockerman, 1974).

Color measurement

Instrumental color determinations were made on without and with ceramic treatment samples. And the treatments through the packing material on the meat surface were exposed to light during storage on the same days as color evaluation. L,a,b, values were determined as described by Smith and Brekke (1975) by using a hunter L,a,b, spectrocolormeter (Micro Color DATA-STATION, DR LANGE, Germany). The spectrocolormeter was set using standard plate with values of "L"=92.4, "a" = -0.7, and "b" = -0.9. The Hunter "L" values indicated the degree of lightness or brightness; the Hunter "a" measured redness (positive) or greenness (negative); and the Hunter "b" value was a measurement of yellowness (positive) or Blueness (negative). During measurement, readings were taken from six different areas on loin slice surface (PE package) and loin surface (vacuum package) and the mean results were expressed as L, a and b values, respectively. Vacuum package samples were opened in 4°C refrigerator for 15 min. The PE package samples were measured immediately after opening.

Microbial analysis

Samples were prepared by removing randomly chosen 10 g samples from each chip and loin using aseptic techniques.

Samples were placed in sterile bags pummeled for 1 min in a stomacher (model 400). Each dilution was plated on plate count agar (Difco.); plates were incubated at 36±1°C for 48 h. (FDA, 1986)

VBN values (volatile basic nitrogen analysis)

Samples were prepared by removing randomly chosen 2.5 g samples and determined as described by CNS (1982), using Conway's dish (Sibata, 6031-02).

Drip loss measurement

Packages containing the sample and the drip were weighed following storage for the appropriate interval. The packages were then opened and the samples were removed

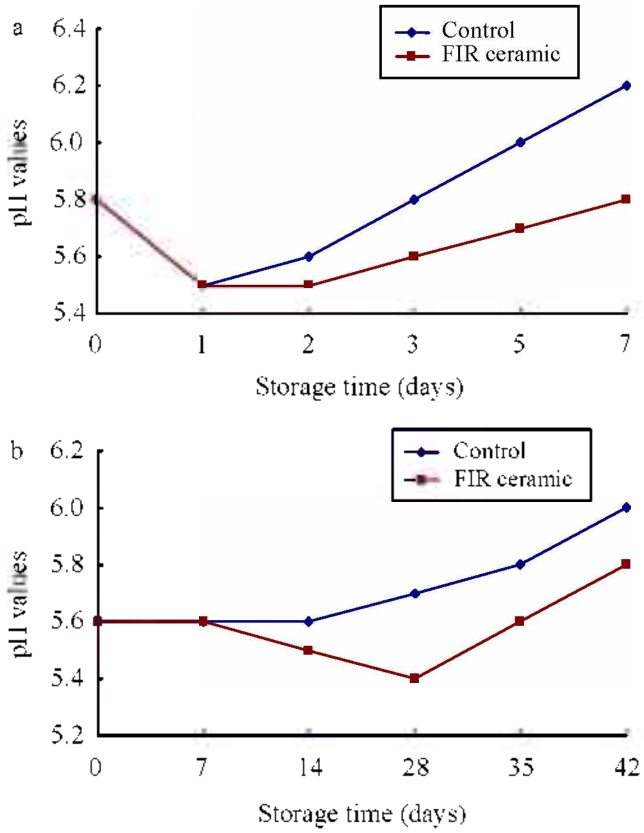

Figure 1. Effect of FIR treatment on pH values of PE and vacuum package pork sliced loin and loin during storage time. a: PE package stored at 4°C, b: Vacuum package then wrapped with PE sheet package stored at 0°C.

and weighed. The drip loss of the loins was calculated by the following formula: (Honikel, 1987)

$$\text{Drip loss \%} = \frac{\text{Weight of loin before storage (gm)} - \text{Weight of loin after storage (gm)}}{\text{Weight of loin before storage (gm)}} \times 100\%$$

Statistical analysis

Data were analyzed statistically using the General Linear Model Procedure of the SAS. Institute (SAS., 1985). The significance of treatment effects was solved using the Student's T-test (Pur and Mullen. 1980).

RESULT AND DISCUSSION

The pH value

The pH value of sliced loin with FIR ceramic sheet packaged in PE and the control treatment under different storage time at 4°C was shown in Figure 1(a). Both treatments tended to rise higher with the increasing of storage time. There were no significant differences between the FIR and the control treatments in 0 to 3 day storage time. But from 5th day onwards, the control treatment tended to get higher rapidly, and had significant differences ($p<0.05$)

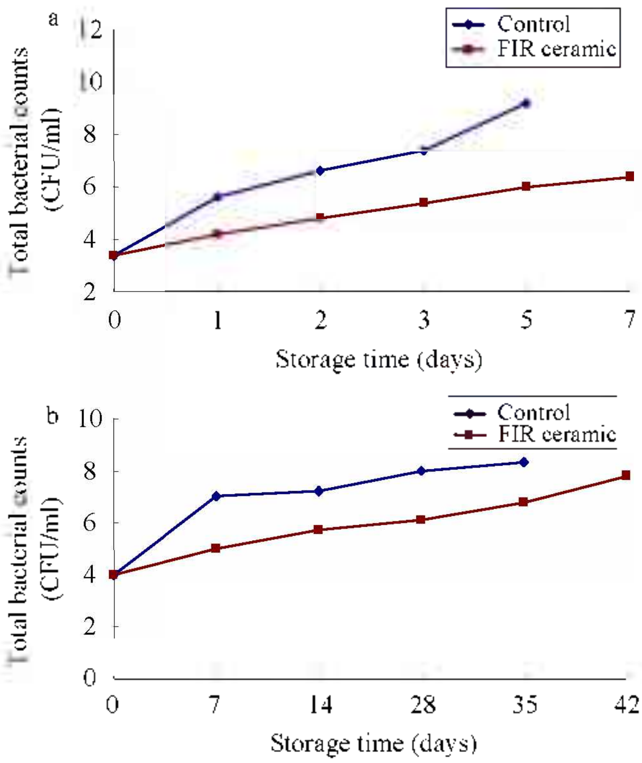

Figure 2. Effect of FIR treatment on total bacterial counts of PE and vacuum package pork sliced loin and loin during storage time. a: PE package stored at 4°C, b: Vacuum package then wrapped with PE sheet package stored at 0°C.

with the FIR treatment. The significant effects were to have an increased pH from the 5th to the 7th day. This increase may lead to greater total plate count and VBN values of control treatments. Figure 1(b) showed the effects on pH value of loin with FIR ceramic sheet packaged in vacuum and the control treatment under different storage time at 0°C. There were no significant differences ($p<0.05$) between the FIR and the control treatments.

Total plate count

The effects on total plate count of sliced loin with FIR ceramic sheet packaged in PE and the control treatments under different storage time at 4°C were shown in Figure 2(a). There were significant differences ($p<0.05$) between the FIR and the control treatments. When stored for 7 days. the total plate count of FIR ceramic sheet package was 7.6×10^{6}. However. when the control treatment was in storage until the 3rd day. the total plate count had already been 3.1×10^{6}. until the 5th day to the spoiled level. Figure 2(b) showed the effects on total plate count of loin with FIR ceramic sheet packaged in vacuum and the control treatment under different storage time at 0°C. When stored until the 7th day, the control treatment had significant differences ($p<0.05$) with the FIR treatment. When stored

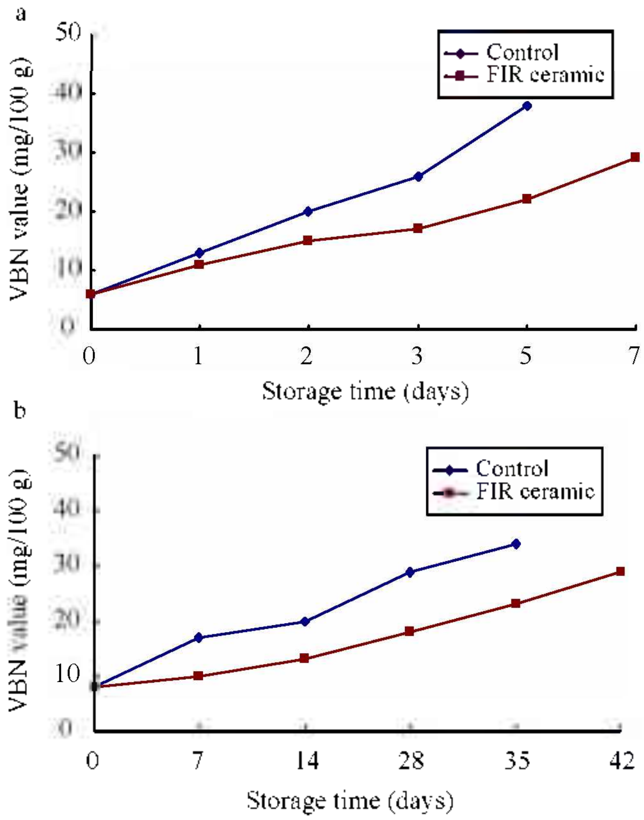

Figure 3. Effect of FIR treatment on VBN values of PE and vacuum package pork sliced loin and loin during storage time.
a: PE package stored at 4°C, b: Vacuum package then wrapped with PE sheet package stored at 0°C.

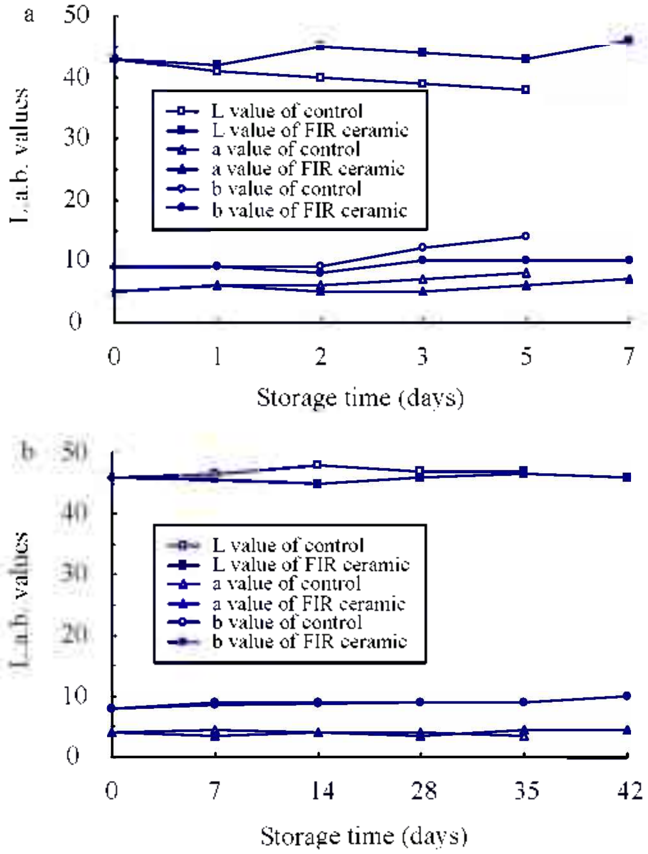

Figure 4. Effect of FIR treatment on L.a.b. values of PE and vacuum package pork sliced loin and loin during storage time.
a: PE package stored at 4°C
b: Vacuum package then wrapped with PE sheet package stored at 0°C.

until the 28th day, the control treatment had already been 5.6×10^7 and had off-odor. However, when stored until 35th day, the FIR treatment reached to 3.6×10^6, to the 42nd day 6.7×10^7. It had already reached the spoiled level, but it had no off-odor.

FIR ceramic sheet packaged in PE and vacuum package were found to be an effective method for extending the shelf life of pork loin. Results showed that FIR ceramic sheet packaged in PE of sliced pork loin at 4°C had a shelf life of more than 7 days (Figure 2(a)). On the other hand, results showed that FIR ceramic sheet packaged in vacuum of pork loin at 0°C had a shelf life of more than 35 days (Figure 2(b)). According to Ayres (1960), the spoilage of meat was normally caused by the growth of *Psendomonas* that cause a putrefied smell upon spoilage. Omori (1994) found that the unheated sterilizing effect might result from the vibration caused by the wavelength from FIR action and the bacteria tissue. This affected the denature of protein and the change of nucleic acid of the bacteria itself to have the effect of inhibiting bacteria spoilage. But it was only limited to the low-temperature sterilizing effect on food surface (Nishizawa, 1986). Shimizu (1987a) and Hashimoto et al. (1991) found that FIR ceramic effect on inhibiting bacteria spoilage was focused on food surface and had better sterilizing effect on *coliforms* and *staphylococcus aureus*. Besides, Sawai and Shimizu (1995) found that adding the FIR ceramic powder had effects of bacteriostatic and bacteriostasis.

VBN value

The effects on VBN value of sliced loin with FIR ceramic sheet packaged in PE and the control treatment under different storage time at 4°C were shown in Figure 3(a). Both treatments tended to rise higher with the increasing of storage time. However, there were significant differences ($p<0.05$) between the FIR and the control treatment when stored until the 2nd day. When stored until the 3rd day, VBN value of the control had already reached 25 mg/100 g, but the FIR treatment had reached 17.1 mg/100 g. Figure 3(b) showed the effects on VBN value of loin with FIR ceramic sheet packaged in vacuum and the control treatment under different storage time at 0°C. Both treatments tended to rise higher with the increasing of storage time, but the FIR treatment was significantly lower

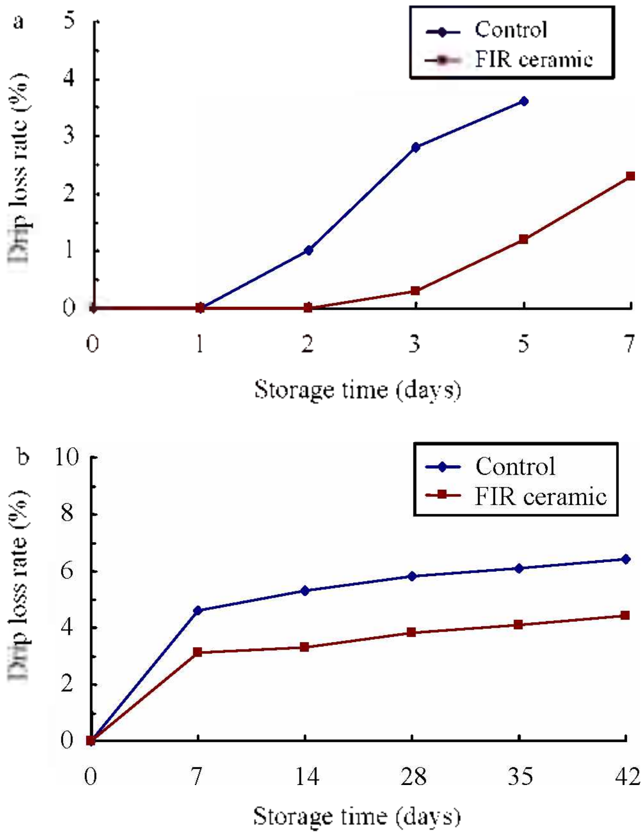

Figure 5. Effect of FIR treatment on drip loss rate of PE and vacuum package pork sliced loin and loin during storage time.
a: PE package stored at 4°C, b: Vacuum package then wrapped with PE sheet package stored at 0°C.

($p<0.05$) than the control treatment. Its results showed a corresponding relationship with the total plate counts.

L, a and b values

The effects on L.a.b. value of sliced loin with FIR ceramic sheet packaged in PE and the control treatment under different storage time at 4°C were shown in Figure 4(a). During storage, the samples of the control treatment tended to become dark-red gradually in comparison with the sample at 0 day, but the FIR treatment had few changes. Figure 4(b) showed the effects on L.a.b. value of loin with FIR ceramic sheet packaged in vacuum and the control treatment under different storage time at 0°C. After opening the package for 15 min, and measuring the changes of meat color, it was found that the FIR treatment and control treatment had no significant difference ($p>0.05$). In Sasaki's experiment (1987), it was found that in ceramic treatment of food, the moisture of meat surface did not evaporate easily and it had a protective effect on the original color.

Drip loss

The effects on drip loss of sliced loin with FIR ceramic sheet packaged in PE and the control treatment under different storage time at 4°C were shown in Figure 5(a). The FIR treatment began to have drip when stored until the 3rd day. However, the control treatment was the same when stored until the 2nd day. Besides, the drip loss of both treatments had significant differences ($p<0.01$) during different storage time. Figure 5(b) showed the effects on weight loss of loin with FIR ceramic sheet packaged in vacuum and the control treatment under different storage time at 0°C. The FIR treatment was significantly lower ($p<0.01$) than the control. And with the increasing of storage time, the differences became more significant.

Drip loss was 0% after packaging and prior to storage in both packaging treatments; and from 1 to 3.75% (from 2 to 5 days of storage) in without-ceramic treatment and from 0 to 2% (from 2 to 7 days storage) in with-ceramic treatment in PE package; and from 4.0 to 8.5% (from 7 to 42 days storage) in without-ceramic treatment; and from 4.0 to 6.5% (from 7 to 35 days of storage) in with-ceramic treatment in vacuum package. Without-ceramic treatment packaged pork loins sustained greater drip loss than with ceramic treatment packaged in PE or vacuum. According to Ishi's (1990) experiment, it was found that when food was stored in low temperature, the moisture of food, especially the free water, would evaporate. However, the water molecule in gas was completely a mono-molecule. One part would show conjunction to be combined with hydrogen in FIR ceramic sheet. And it would be cut and form free radical that was combined with food cell. Then the combination would likely form binding water that was not easy to be evaporated.

CONCLUSIONS

Based on pH values, total plate count, VBN and L.a.b. value, pork sliced loin in PE package with FIR ceramic sheet had a shelf life of about 7 days at 4°C. And pork loin in vacuum package with FIR ceramic sheet had a shelf life of nearly 42 days at 0°C. However, in control treatment, pork sliced loin in PE package had a shelf life of 3 days at 4°C. And pork loin in vacuum package had a shelf life of 14 days at 0°C. These results showed that the use of FIR ceramic sheet package, including PE and vacuum package, was an effective method of maintaining the quality of meat.

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