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# Effect of ohmic heating on colour and texture of chicken frankfurter

J Lim-im<sup>1</sup>, C Kulketwong<sup>1</sup>, N Suwanpayak<sup>2</sup> and D Thungsotanon<sup>1</sup>

<sup>1</sup> Department of Engineering, King Mongkut's Institute of Technology Ladkrabang, Prince of Chumphon, Chumphon, 86160, Thailand

<sup>2</sup> Department of General Science, King Mongkut's Institute of Technology Ladkrabang, Prince of Chumphon, Chumphon, 86160, Thailand

E-mail: dithaporn.th@kmitl.ac.th

**Abstract.** Ohmic method is a heating technique using the electrical current directly through the food. In this study, the commercial chicken frankfurters were heated by an alternating current in a voltage range of 45-55 V and compared the qualities in term of colour, texture, moisture content and water activity with the non-heating. The voltage gradient was conversely correlated with the heating duration. The high voltage gradient could raise the target temperature in a short time but it provided the less shear force of specimen tenderness. On the other hand, every voltage insignificantly influenced the sausage moisture content. The large amount of the water activity was significant decreased at the voltage gradient of 50 V and the hardness and the shearing level of the sample of this intensity were similar to the non-heating sausage. The specimens with ohmic heating seemed homogeneous colour with naked eye whereas the measured values were slightly different.

## 1. Introduction

Ohmic heating is one of the electromagnetic methods [1] but differs from the other since the electrodes direct contacts with the food [2]. When the electrical current flows through the food, is like a resistor, the heat is uniform and rapidly generate in the food [3-8] inducing the nutrient and structure of food which are still retained [1, 9]. The ohmic heating is applied in the several applications i.e., cooking, blanching, pasteurization, extraction and thawing [9-10].

From above-mentioned, the structure and nutritional properties of the ohmically cooked food is less deteriorated because of the steady thermal. A wide range of studies is regarded in terms of texture and colour as Bozkurt and Icier [11] cooked the ground beef by the ohmic method and reported that the product was more homogeneous colour than the conventional method and the voltage gradient unaffected the firmness and the toughness of the ground beef. Zell *et al.* [5, 12-13] described that the colour of the ohmically heated beef muscle and turkey meat were lighter than cooking with the conventional method and the tenderness of beef depended on the heating duration time. Moreover, the ohmic method was used in the beef thawing and found that the voltage gradient affected the texture properties [7].

In the case of the processed meat, Shirsat *et al.* [3] analysed the texture of the pork frankfurter and reported that the ohmically heated frankfurter was less elasticity than the steam method but the hardness and chewiness were better. The high voltage gradient from the ohmic method could reduce the water holding capacity and no difference in the structure of the meat emulsion batter [14]. The



texture of the pork Bologna sausage after ohmic treatment was softer than the smoke house process [15].

Most aforementioned literatures studied in the effect of ohmic heating on the whole meat or the processed pork product. On the other hand, there is a few amount of the processed chicken research. So, this study aims to develop the ohmic system for heating the chicken frankfurter and compare the parameters of colour, texture, moisture content and water activity between ohmically heated product and the non-heating.

## **2. Materials and methods**

### *2.1. Sample preparation*

The footlong chicken frankfurters (CPF Food and Beverage, Thailand) that were purchased from the convenience store were chilled in the refrigerator at 4°C for 24 h. Each sample with a diameter of 20 mm was equivalent cut into 100 mm and thawed at the temperature room (25°C) for 1 h before testing.

### *2.2. Ohmic heating system and procedures*

The laboratory scale system consisted of the cell, the heating unit and the data acquisition. The cylindrical cell was made from the ultra-high molecular weight polyethylene with an inner diameter of 22 mm, a 14.5 mm wall thickness and a total length of 150 mm. Upper of the casing had the three small holes for inserting the thermocouples. Two electrodes, the stainless steel 304, were parallel housed between a 100 mm gap of a sausage chamber and the two ends of the caps.

The system diagram as shown in figure 1, the electrical voltage from the power supply was altered by the variable transformer and measured with the voltmeter before directing to the sausage within the ohmic cell. Electric current and heating temperature in the chamber were detected with the current meter and the thermocouples. Analog signals of the input voltage, output current, and temperature were simultaneous transmitted for recording and processing to the data acquisition, consisted of NI USB-6001 (National Instrument, Malaysia) and LabVIEW 2014 software.

The ohmic cell was boiled in the 100°C of water for 10 min and dried by the hot air before the experiment. The 100 mm of frankfurter was filled in the cell chamber, sandwiched with the two electrodes and pierced the three thermocouples (type K and PT 100) into the sample. The voltage gradient varied from 45-55 VAC and immediately stopped when the inner product temperature reached 70°C.

### *2.3. Quality analysis*

The 100 mm length of chicken frankfurters with ohmic heating (OH) and non-heating were equal divided into 3 pieces to estimate the quality as follows:

*2.3.1. Colour measurement.* The lightness ( $L^*$ ), red-green ( $a^*$ ) and yellow-blue ( $b^*$ ) values of the inner circular section and the outer surface of sausage samples were measured by the CIELAB colour space with the CR-400 Chroma meter (Konica Minolta, Japan) that was calibrated with the internal light (D65) before examining the product colour.

*2.3.2. Texture measurement.* The compression and shearing analysis were achieved by the texture analyzer (Lloyd Instrument model TAPlus, Amatek, UK). The ball probe with the speed of 20 mm/min was perpendicular compressed into the center of the circular area of the specimens. For the Warner-Bratzler shear testing, the sausages were alike placed as the tooth-food contact direction and the forces were examined at the crosshead speed of 20 mm/min.

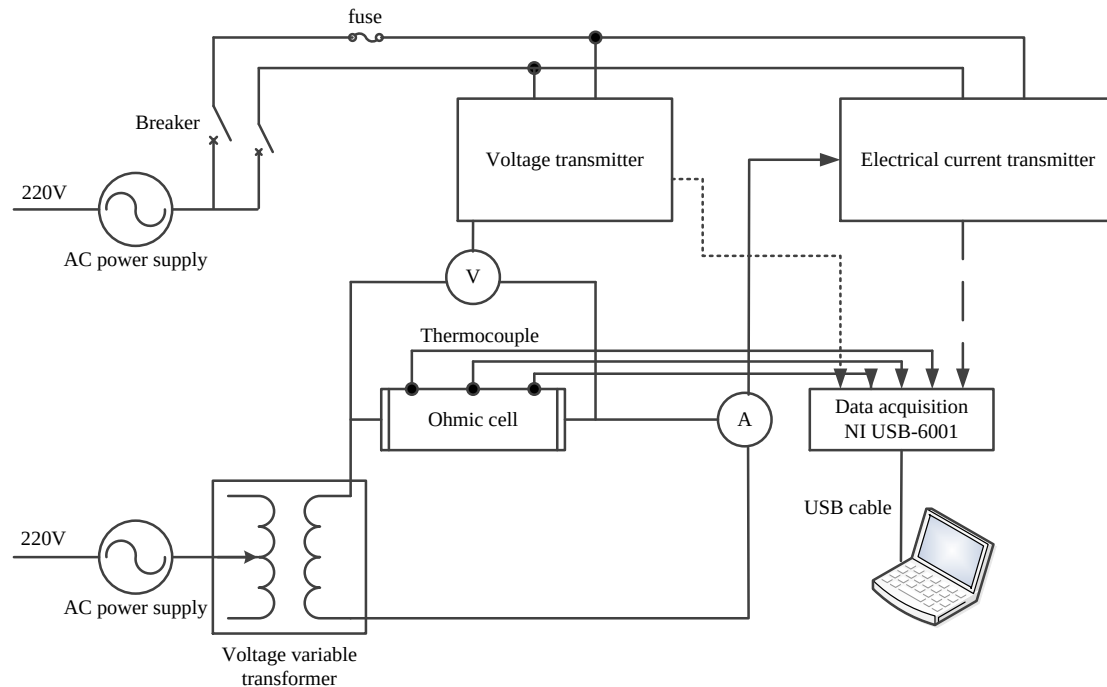


**Figure 1.** Schematic of the ohmic heating system.

**2.3.3. Moisture content and water activity measurement.** The samples were minced, packed in a small plate and put in Lab Master aw Neo (Novasina, Switzerland) to determine the water activity ( $a_w$ ) values. Whilst, the final moisture content was estimated by drying the residual specimens with hot air at 105°C in the universal oven UN 55 (Memmert, Germany) for 24 h.

#### 2.4. Data analysis

The analysis of variance (ANOVA) was performed by SPSS software. The post hoc test were compared using Bonferroni correction to assess the different quality samples between non-heating and ohmic heating.

### 3. Results and discussion

The frankfurters after treatments were compared with the non-heating specimen and found that the  $L^*$  and  $b^*$  scales of the inner section in table 1 were significant differences ( $p < 0.05$ ). The ohmic cooking caused the darker than non-heating, the  $L^*$  values in the sausages varied from 72.859-74.375. The  $b^*$  parameter of the low voltage got the specimen nearer yellow tone. Whereas, the  $a^*$  factor was no significant difference ( $p \geq 0.05$ ) and the red scale showed in the range of 6.824-7.577. The total colour difference ( $\Delta E^*$ ) of the specimens when compared with the non-heating was found that the greatest and lowest value were found in the voltage of 45 V and 50 V, respectively, but the  $\Delta E^*$  values of all ohmic samples were statistically insignificant ( $p \geq 0.05$ ).

On the other hand, the  $L^*$  and  $b^*$  parameters of the external surface of the sausage indicated that no significant differences ( $p \geq 0.05$ ) between heating and non-heating, although the  $a^*$  factor was significant. The red shade of the sample at the voltage of 50 V was brighter than another. The  $\Delta E^*$  that compared with the non-heating showed that the largest value occurred at the voltage of 50 V whereas the values were not statistically significant ( $p \geq 0.05$ ) between the different voltage gradient. Moreover, the naked eye observation appeared that the experimental product had a uniform shade as the results of the ground beef and the turkey meat after ohmic cooking [11-13].

**Table 1.** The colour scales of the footlong frankfurters.

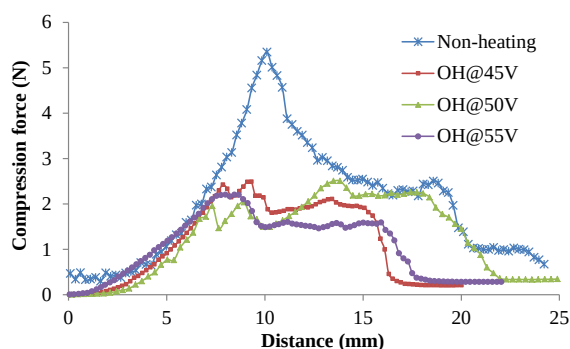
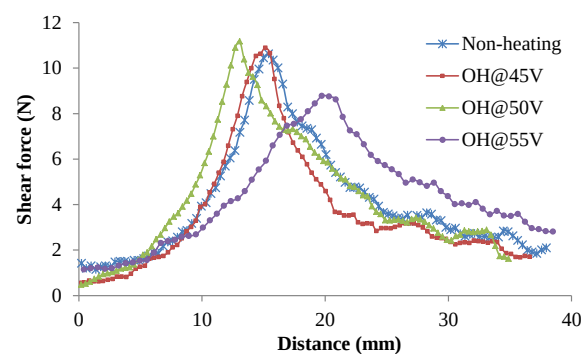
| Sections      | Variables    | Conditions                   |                              |                              |                              |
|---------------|--------------|------------------------------|------------------------------|------------------------------|------------------------------|
|               |              | Non-heating                  | Ohmic heating                |                              |                              |
|               |              |                              | 45 V                         | 50 V                         | 55 V                         |
| Inner surface | L*           | 74.375 <sup>b</sup> (0.436)  | 72.859 <sup>a</sup> (0.149)  | 74.234 <sup>ab</sup> (0.536) | 73.990 <sup>ab</sup> (0.754) |
|               | a*           | 7.399 <sup>ns</sup> (0.130)  | 7.577 <sup>ns</sup> (0.428)  | 6.824 <sup>ns</sup> (0.356)  | 6.954 <sup>ns</sup> (0.115)  |
|               | b*           | 26.419 <sup>a</sup> (0.548)  | 28.650 <sup>b</sup> (0.916)  | 28.029 <sup>ab</sup> (0.126) | 28.032 <sup>ab</sup> (0.381) |
|               | $\Delta E^*$ | -                            | 2.945 <sup>ns</sup> (0.655)  | 1.965 <sup>ns</sup> (1.499)  | 1.998 <sup>ns</sup> (0.407)  |
| Outer surface | L*           | 69.897 <sup>ns</sup> (0.312) | 68.912 <sup>ns</sup> (0.726) | 70.540 <sup>ns</sup> (1.482) | 69.158 <sup>ns</sup> (0.515) |
|               | a*           | 10.557 <sup>b</sup> (0.116)  | 11.143 <sup>b</sup> (0.536)  | 9.426 <sup>a</sup> (0.552)   | 10.668 <sup>b</sup> (0.191)  |
|               | b*           | 40.108 <sup>ns</sup> (0.375) | 40.627 <sup>ns</sup> (1.415) | 39.933 <sup>ns</sup> (1.402) | 41.711 <sup>ns</sup> (0.181) |
|               | $\Delta E^*$ | -                            | 1.649 <sup>ns</sup> (1.503)  | 2.286 <sup>ns</sup> (1.182)  | 1.819 <sup>ns</sup> (0.656)  |

<sup>a,b</sup> Means in the same row with difference superscript letters are different at a 95% significance level.

<sup>ns</sup> is no significant difference.

The texture analysis, compression, in figure 2 was no statistically significant differences ( $p \geq 0.05$ ), although the frankfurters had cooked. The high voltage gradient led the heated sausages to be more softness and the small compression force. The softness or hardness of the processed meat depended on the amount of water, but the ohmic method unaffected the overall moisture content of specimens. However, the hardness related the changing of the internal cell and ingredients of the product [3].

The Warner-Bratzler shear force applied to the ohmic and non-heating specimens as shown in figure 3 described the level of tenderness and was statistically different ( $p < 0.05$ ). For this experiment, it was found that the tenderness of the sample at the voltage of 50 V was rather than that of original one, whereas the short time at the 55 V of the ohmic system had the lowest shear strength. These results differed from the fresh meat that the increasing treatment time influenced the tenderness and softness of whole beef and reduced the shearing [5, 12].

**Figure 2.** The compression forces between ohmic heating and non-heating.**Figure 3.** The Warner-Bratzler shear forces at the different heating condition.

During testing, the voltage gradient was inverse to the heating time. From figure 4, the statistically significant differences ( $p < 0.05$ ) were obtained in the water activity ( $a_w$ ) between the non-heating and ohmic heating (OH). The lowest  $a_w$  showed at the voltage of 50 V, whereas the 55 V of OH was closer to the non-heating than the 45 V. Additionally, the water activity was not only free water in the food, but also affected the microorganisms, product quality and shelf life. If the  $a_w$  reduced suitably, the sausages would preserve for a long time.

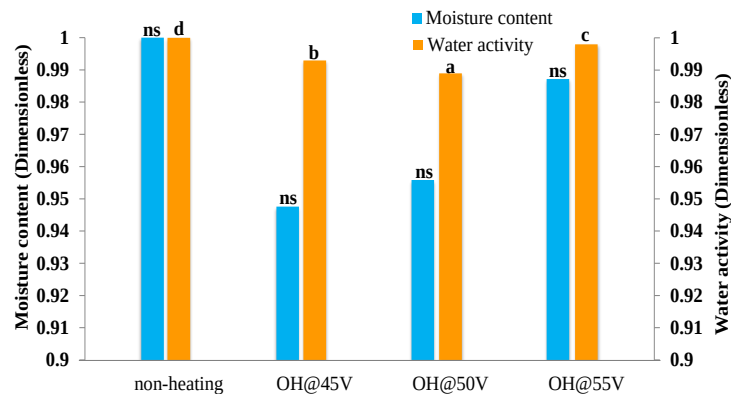


**Figure 4.** The water activity values and moisture content of the sausages.

Although, the water activity and water content were the food safety factors but both of them was not similar meanings. The moisture content was a total amount of water including to the water activity and important parameter for texture analysis. The water quantity in the frankfurters was shown no significant ( $p \geq 0.05$ ) as figure 4. The dimensionless scales were compared and obtained that the large voltage gradient could decrease a few water in the sample due to the short time. In addition to the moisture content in the fresh meat cell was unchanged by the ohmic heating [7].

#### 4. Conclusion

The voltage gradient was inversely related to the heating duration time. The colour of ohmic specimen was observed uniform shade. The results of texture analysis, especially, the shearing was shown the lowest force at the highest voltage gradient but the compression or the softness factor was insignificant differences in every treatment. Ohmic method unaffected the moisture content but the intermediate voltage gradient could reduce a lot of water activity that was the importance of preservation. In order to determine the product shelf life, the future study will present the effect of the electrical conductivity and the microbial counting.

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