Effect of dried tomato waste powder on pH, water holding capacity, and water activity of Frankfurter made from Thai native beef

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The aim of the study was to evaluate the effect of dried tomato waste powder (TWP) on pH, water holding capacity, and water activity of Frankfurter sausage made from Thai native beef during storage. Frankfurters were made with six levels of TWP at 0%, 1%, 2%, 3%, 4%, and 5% of dry TWP in 6x3 Factorial Experiments in Completely Randomized Design. All parameters were performed at day 1, 7, and 14 of storage. The result was found that dried TWP addition decreased pH and a_w, but increased %WHC of Frankfurters. The pH decreased (Linear, p<0.01) significantly during 14 days of storage. Water activity was significant at 0% compared to the treatments contained TWP on day 14. The %WHC did not differ during 14 days of storage, but found higher of %WHC in Frankfurters contained TWP than the control. Storage time affected significantly on pH value at day 1 and day 14, but %WHC and a_w was not significant. Addition of 2% dried TWP improved water holding capacity of Frankfurter sausage made from Thai native beef.

Keywords: Frankfurter sausage, dried tomato waste powder, storage time, WHC

INTRODUCTION

There is an increased demand for functional, healthy, and convenient processed meats. Color is the first impression to consumers’ acceptability of meat products. Synthetic additives such as nitrite found widely in most processed meats chiefly for providing color attraction and antimicrobial function. However, the awareness of consumers about long term effect of nitrite addition in processed meats becomes expansion. Therefore, the natural colorants as preferred by consumers due to its healthy advantages become a good substitution of nitrite. Moreover, addition of synthetic additives response to health problems such as allergic and hypersensitive (Osterlie and Lerfall, 2005). Gould (1992) revealed that tomatoes (over 80%) were consumed in variety processed forms such as sauce, ketchup, and tomato juice. Tapiero et al., (2004) recently reported that tomatoes and processed tomatoes provided an abundant health benefits. Tapiero et al., (2004), Goula and Adamopoulos (2005) stated
that lycopene content and other carotenoid compounds were found abundantly in tomatoes and processed tomatoes. A few studies have been revealed regarding the use of tomato peel and pulp powder or lycopene in meat and processed meats made from variety of meats (Parsi et al., 2014; Kaur et al., 2015; Joseph et al., 2014) who found decreasing in pH value and increasing the percentage of water holding capacity during storage. However, the effects of tomato waste (seed, pulp, peel) powder (TWP) in sausage made from Thai native beef have not yet been studied. Therefore, the objective of this study was to investigate the effectiveness of dried TWP supplement on pH, water holding capacity, and water activity of frankfurter sausage made from Thai native beef during chilled storage for 14 days.

**MATERIALS AND METHODS**

The fresh mixture of TWP was obtained from Rosa Company in Nongkai province. The TWP was dried in the oven at a temperature about 50 to 55°C for 8 hours. The dried TWP was ground with grinder machine (DMF-20A, China) and continuously passed to sieve machine (Model S49-600, China) in 80 mesh size to obtain the final powder. The fresh meat of Thai native beef was purchased from local abattoir in Khon Kaen province. The meat was cooled in ice during transportation and immediately kept in chilling room at 4°C for 24 h before processing.

**Frankfurter sausage preparation**

The Frankfurter sausage formulation was adapted from Department of Livestock Development (2003). The sausages were prepared according to 6x3 Factorial Experiments in Completely Randomized Design with dried TWP addition at 0%, 1%, 2%, 3%, 4% and 5% of total mixture, respectively. The sausages were stored (4°C) and analyzed for qualities at day 1, 7 and 14 of storage.

**pH Analysis**

The pH of Frankfurter sausage was determined on day 1, 7 and 14 with three replications by using method described by Eyiler and Oztan (2011) with some modification.

**Water Holding Capacity (WHC)**

The WHC determination was slightly modified from Jin et al., (2008) as described by Kim et al., (2011). The percent WHC was calculated using following formula:

\[
\text{WHC} = \frac{\text{sample before heating} - \text{sample after heating and centrifuged}}{\text{Total water content in sample}} \times 100
\]

**Water activity (a_w)**

The water activity analysis was determined followed AOAC (1995) method using water activity meter (chilled mirror dew point).

**Statistical Analysis**

Data of pH, water holding capacity and water activity was analyzed according to Factorial Experiment in Completely Randomized Design procedure using Statistical Analysis System (SAS) program. Different means of treatments was analyzed using orthogonal polynomials procedure.

**RESULTS AND DISCUSSION**

**Effect of TWP on pH of Frankfurter sausage during storage**

The effect of TWP on pH of Frankfurter sausage at day 1, 7 and 14 was presented in Table 1. Non-significant (p>0.05) interaction between levels of TWP and storage time was found. The pH of sausage was not different (p>0.05) at day 1, 7 and 14 when different levels of dried TWP were added. At day 1, significant differences (p<0.05) on pH were found at 0%, 1% and 5% of TWP. At day 7, 0% and 5% were found significantly (p<0.05), and significant differences (p<0.05) at 0%, 1% and 5% on day 14. Increasing levels of TWP decreased significantly (Linear, p<0.01) on pH values on day 1, 7 and 14 of storage. The result was similar to Kim et al., (2011) in low fat pork sausage, Modzelewska- capitula (2012) in meatloaf, Calvo et al., (2007) in dry fermented sausage, Hayes et al., (2013) in pork luncheon rolls and Salem (2013) in beef sausage, Wimontham and Rojanakorn (2016) added gac aril powder contained lycopene incorporated nitrite in Vienna sausage reduced pH values. Uearreeloet and Konsue (2016) used gac aril powder and sodium nitrite combination decreased pH of Frankfurter sausages, in which the pH ranged from 5.15 to 6.24 was lower than the present study. Decreasing of pH in Frankfurters with dried TWP was due to the addition high amount of dried TWP and lower pH of tomato powder. The changing in pH values of sausages contained tomato product had been reported by Eyiler and Oztan (2011), Candogan (2002) and Deda et al., (2007).The pH was significant at day 1 and 14 of storage (Table 4).
Table 1: pH value of Frankfurter sausage made from Thai native beef at day 1, 7 and 14

<table>
<thead>
<tr>
<th>Dried TWP (%)</th>
<th>Storage time (days)</th>
<th>Inter$^1$</th>
<th>Orthogonal polynomials$^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>0</td>
<td>6.43a</td>
<td>6.40a</td>
<td>6.35a</td>
</tr>
<tr>
<td>1</td>
<td>6.39a</td>
<td>6.35</td>
<td>6.30a</td>
</tr>
<tr>
<td>2</td>
<td>6.33</td>
<td>6.29</td>
<td>6.24</td>
</tr>
<tr>
<td>3</td>
<td>6.29</td>
<td>6.27</td>
<td>6.21</td>
</tr>
<tr>
<td>4</td>
<td>6.28</td>
<td>6.25</td>
<td>6.21</td>
</tr>
<tr>
<td>5</td>
<td>6.21b</td>
<td>6.18b</td>
<td>6.07b</td>
</tr>
<tr>
<td>P-Value</td>
<td>0.11</td>
<td>0.11</td>
<td>0.06</td>
</tr>
</tbody>
</table>

Means with different superscript within column shown significant difference (p<0.05)

$^1$Interaction effect between dried TWP levels and storage time, Inter = Interaction

$^2$means orthogonal polynomials analysis of dried TWP level; Lin, Qua, Cub, Quar and Quin mean Linear, Quadratic, Cubic, Quartic and Quintic

ns means non-significant

** means highly significant (p<0.01)

Increasing storage time increased the acidity of sausage. The result was similar with Calvo et al., (2007) who found reduction in pH of sausage contained tomato product during storage.

The reason of decreasing on pH value of sausage contained tomato product had been explained by Candogan (2002).

Effect of TWP on %WHC of Frankfurter sausage during storage

The effect of TWP on water holding capacity at day 1, 7 and 14 was shown in Table 2. The interaction of TWP levels and storage time was not significant (p>0.05). Non-significant difference (p>0.05) on %WHC was found when TWP was added. At day 1, the percentage of WHC was slightly changed from 94.14% to 96.72%. At day 7, %WHC was 93.85% to 96.75%, and 86.86% to 95.52% on day 14. The result was in agreement with Kim et al., (2011) used tomato powder in low fat Frankfurter sausage which found slightly increasing in WHC values when TWP was added; however, the present study found higher than 15-18% compared to the result of Kim et al., (2011). The %WHC of sausages was slightly increased compared to control, this could be due to ADF content in TWP, which helped to prevent water releasing out of product. Knoblich et al., (2005) reported that acid detergent fiber (ADF) 299.4 g/kg was found in peel and 537.9 g/kg in seed of tomato on dry basis. Pectin and inulin had function in improving the water retention in a product that could help the product to hold more water (Kmiecik and Lisiewska, 2000), who found 2.16 g/kg of pectin in peel of tomato. Different sources of fiber had been used to improve the %WHC of product (Gerardo et al., 2015; Cengiz and Gokoglu, 2007; Lopez-Lopez et al., 2009). The reduction of %WHC on 14 days might be due to the chemical breakdown through a complex reactions in the product. Water holding capacity means the ability of preventing water being released out of products, small amount of releasing water changes greatly on %WHC (Hermansson, 1986).

Effect of TWP on water activity of Frankfurter sausage during storage

The effect of dried TWP on water activity (aw) of Frankfurter sausages at day 1, 7 and 14 was shown in Table 3. Non-significant interaction (p>0.05) between TWP levels and storage time was found. The water activity was not significant (p>0.05) difference when added TWP compared to the control. At day 14, significant differences (p<0.05) between sausage contained TWP and control were found; however, there was not significant among sausage containing TWP. The aw was range from 0.97 to 0.98, which was still a normal range of fresh sausage (Luca et al., 2004). The TWP concentration and other ingredients like isolated soy protein (ISP) in the formulation could act on the reduction of free water in the product that made lower in water activity (Sureshkumar et al., 2006). Moreover, insoluble fiber had been reported in reducing the moisture and free water in the sample that made the water activity got lower (Van der Hoeven-Hangoor et al., 2014).
Table 2 Water holding capacity (%) of Frankfurter sausage made from Thai native beef

<table>
<thead>
<tr>
<th>Dried TWP (%)</th>
<th>Storage time (days)</th>
<th>Inter¹</th>
<th>Orthogonal polynomials²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>0</td>
<td>94.14</td>
<td>93.85</td>
<td>86.86</td>
</tr>
<tr>
<td>1</td>
<td>95.24</td>
<td>96.75</td>
<td>94.27</td>
</tr>
<tr>
<td>2</td>
<td>95.13</td>
<td>95.02</td>
<td>94.04</td>
</tr>
<tr>
<td>3</td>
<td>95.44</td>
<td>95.72</td>
<td>93.49</td>
</tr>
<tr>
<td>4</td>
<td>96.72</td>
<td>94.02</td>
<td>95.52</td>
</tr>
<tr>
<td>5</td>
<td>93.34</td>
<td>92.86</td>
<td>93.62</td>
</tr>
<tr>
<td>P-Value</td>
<td>0.45</td>
<td>0.93</td>
<td>0.27</td>
</tr>
</tbody>
</table>

Means with different superscript within column shown significant (p<0.05)
¹ Interaction effect of dried TWP levels and storage time, Inter.= Interaction
² Orthogonal polynomials analysis of dried TWP levels; Lin, Qua, Cub, Quar and Quin mean Linear, Quadratic, Cubic, Quartic and Quintic
ns means non-significant

Table 3 Water activity (aₜ) of Frankfurter sausage made from Thai native beef

<table>
<thead>
<tr>
<th>Dried TWP (%)</th>
<th>Storage time (days)</th>
<th>Inter¹</th>
<th>Orthogonal polynomials²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>0</td>
<td>0.9806</td>
<td>0.9783</td>
<td>0.9783²</td>
</tr>
<tr>
<td>1</td>
<td>0.9785</td>
<td>0.9730</td>
<td>0.9749</td>
</tr>
<tr>
<td>2</td>
<td>0.9727</td>
<td>0.9731</td>
<td>0.9738</td>
</tr>
<tr>
<td>3</td>
<td>0.9711</td>
<td>0.9724</td>
<td>0.9733</td>
</tr>
<tr>
<td>4</td>
<td>0.9719</td>
<td>0.9735</td>
<td>0.9743</td>
</tr>
<tr>
<td>5</td>
<td>0.9714</td>
<td>0.9744</td>
<td>0.9737</td>
</tr>
<tr>
<td>P-Value</td>
<td>0.64</td>
<td>0.73</td>
<td>0.06</td>
</tr>
</tbody>
</table>

Means with different superscript within column shown significant p<0.05
¹ Interaction effect between dried TWP levels and storage time, Inter= Interaction
Orthogonal polynomials analysis of dried TWP levels; Lin, Qua, Cub, Quar and Quin mean Linear, Quadratic, Cubic, Quartic and Quintic
ns means non-significant

Table 4 Storage time effect on pH, WHC and aₜ of Frankfurter sausages

<table>
<thead>
<tr>
<th>Quality attributes</th>
<th>Storage time (days)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>6.32²</td>
<td>6.29</td>
<td>6.23ᵇ</td>
</tr>
<tr>
<td>WHC (%)</td>
<td>95.00</td>
<td>94.70</td>
</tr>
<tr>
<td>aₜ</td>
<td>0.9727</td>
<td>0.9741</td>
</tr>
</tbody>
</table>

Means with different superscript within row shown significant (p<0.05)
WHC means Water Holding Capacity, aₜ means Water Activity

CONCLUSION

The addition of dried TWP decreased pH value, aₜ, and increased %WHC of Frankfurters. The pH values decreased (Linear, p<0.01) significantly as increased levels of TWP. The %WHC and aₜ were not significant with TWP addition. The %WHC was found higher in Frankfurters contained dried TWP than control group. The storage time influenced significantly on pH, but WHC and aₜ were not significant during storage. Therefore, addition of dried TWP as natural ingredient improved water holding capacity of Frankfurter sausages from Thai native beef. This may improve eating quality of the product.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

ACKNOWLEDGEMENT

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AUTHOR CONTRIBUTIONS
SS wrote and reviewed the manuscript. SU and AC read and approved the final version.

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Frankfurter from Thai native beef contains dried TWP
enriched with n-3