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EFFECT OF DRY SALTING ON THE COLOR OF SARDINE

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Abstract
Salting is known as one of the oldest methods used to preserve foods and traditionally divided into dry salting and brine salting practices. Dry salting technique is one of the most widely used salting techniques. This technique is based on the application of sodium chloride directly to the foodstuff. Dry salting of fish has been in use since antiquity to extend the shelf life of fish. In the modern world, dry salted fish is still a popular food. However, the color of dry salted fish changes over time. This study aims to reveal these color changes of dry salted sardines. Color parameters L *, a *, b *, Chroma and Whiteness values were measured during raw, after brine and after dry salting of the fish samples. According to results, the L * value increased significantly after brining and decreased slightly after dry salting. It was observed that dry salting altered L * value of the sardine samples. However, the most dramatic differences were observed in the brine, and dry salting stages a * and b * values. According to this, while fresh sardines a * value was 6.19 ± 0.46, it decreased to -4.66 ± 0.10 after brine. After dry salt, a * value was determined as -5.26 ± 0.06. b * value was found to be -0.07 ± 0.62 for fresh sardines. However, this value decreased to -7.70 ± 0.26 after the brine, and a statistically significant difference was found. At the end of dry salting, b* value of sardines increased to 0.07 ± 0.35. The reason for this increase is the yellowing of the fish. According to the color scheme (NBS) determined by the Inter-Society Color Council, sardine fish were classified as grayish purple. However, after brine, the color of the sardine fish was classified as pale purple. After dry salting, the color category was determined as 'greenish gray.' According to these data, the salting stages significantly change the color of sardine fish. In later studies, it is recommended to examine consumer preferences using different salting rates and temperatures.

Key words: Color, dry salting, brine salting, sardine.

INTRODUCTION
Fish consumption has been in the human diet for at least 380 000 years (Arason et al. 2013; Toussaint-Samat 2009). However, fish should be consumed quickly because it deteriorates rapidly. The most effective method found in the earliest times is undoubtedly to extend the shelf life by salting. This method, which is still in use today, is based on the removal of water from fish muscle. Meat has a wonderful flavor and texture during complex reactions, including proteases and lipases, during the salting process (Hall 2011). Salt affects not only flavor and texture but also color. Its effect on color is yellowish with pure NaCl, while white with magnesium and calcium content (Hall 2011). There are four type of salting; dry, pickle, brine and injection (Arason et al. 2013).

Dry salting has been known as kench salting and the salted products accepted as heavily salted products because they come into direct contact with the salt and too much salt passes through the osmosis to the meat. (Arason et al. 2013; Oehlenschlager 2014). They have also lower water activity, which avoid microbial growth (Pittia and Antonello 2015). However, this halophilic environment is suitable for Halobacterium spp., which is responsible 'pink dots’ on the salted fish products (Hall 2011). Brine salting generally using for pickling and also for first step of smoking (Alcíçek and Atar 2010).

Color determination of food products is important step for consumer acceptance. There are instrumental methods for color analyze. In recent years, computer based image processing techniques have been used successfully for color analysis of seafood (Alcíçek and Balaban 2015a, 2015b; Balaban et al. 2014; Balaban and Alcíçek 2015; Kim et al. 2014; Kong et al. 2015). It is based on the analysis of digital images with special software and reliable digital data is obtained (Yagiz et al. 2009).

The aim of this study was to determine the color parameters of sardines salted with brining and then dry salting.
MATERIALS AND METHODS

Fresh sardine (Sardina pilchardus) samples were bought from a local fish market (Canakkale, Turkey) and transferred immediately in a Styrofoam box with ice. The whole fish samples washed with tap water and put in a brine solution (8%, 1:1 w/v) for 4 hours at 4°C. The brined samples were drained and put into dry salt (1:1 v/v) for dry salting process during 20 days at 4°C. The samples washed with tap water after the process and dried with paper towel. The color analysis of the samples was performed at each step (raw, after brining and after salting) with computer based image analysis which explained by Alçiçek and Balaban (2012). The statistical analysis was performed by SPSS v23 (IBM, NY, US). The One-Way ANOVA was used to determine the difference of the processes. The Tukey multiple range test was used as post-hoc test at $p<0.05$.

RESULTS AND DISCUSSION

Table 1 shows the color parameters of the sardine samples.

<table>
<thead>
<tr>
<th>Color parameters</th>
<th>Process steps</th>
<th>Mean</th>
<th>Std. Error</th>
<th>*Post-Hoc test</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>$L^*$</td>
<td>Raw</td>
<td>56.60</td>
<td>0.46</td>
<td>a</td>
<td>53.63</td>
<td>59.27</td>
</tr>
<tr>
<td></td>
<td>After brining</td>
<td>60.06</td>
<td>0.86</td>
<td>b</td>
<td>55.40</td>
<td>64.71</td>
</tr>
<tr>
<td></td>
<td>After dry brining</td>
<td>58.99</td>
<td>0.84</td>
<td>b</td>
<td>53.58</td>
<td>64.36</td>
</tr>
<tr>
<td>$a^*$</td>
<td>Raw</td>
<td>6.19</td>
<td>0.46</td>
<td>a</td>
<td>3.62</td>
<td>8.04</td>
</tr>
<tr>
<td></td>
<td>After brining</td>
<td>-4.66</td>
<td>0.10</td>
<td>b</td>
<td>-5.14</td>
<td>-3.84</td>
</tr>
<tr>
<td></td>
<td>After dry brining</td>
<td>-5.26</td>
<td>0.06</td>
<td>b</td>
<td>-5.53</td>
<td>-4.71</td>
</tr>
<tr>
<td>$b^*$</td>
<td>Raw</td>
<td>-0.07</td>
<td>0.62</td>
<td>a</td>
<td>-4.10</td>
<td>3.89</td>
</tr>
<tr>
<td></td>
<td>After brining</td>
<td>-7.70</td>
<td>0.26</td>
<td>b</td>
<td>-10.01</td>
<td>-6.58</td>
</tr>
<tr>
<td></td>
<td>After dry brining</td>
<td>0.07</td>
<td>0.35</td>
<td>b</td>
<td>-3.24</td>
<td>2.26</td>
</tr>
<tr>
<td>Chroma</td>
<td>Raw</td>
<td>10.12</td>
<td>0.22</td>
<td>a</td>
<td>9.00</td>
<td>11.63</td>
</tr>
<tr>
<td></td>
<td>After brining</td>
<td>10.35</td>
<td>0.20</td>
<td>a</td>
<td>9.48</td>
<td>12.21</td>
</tr>
<tr>
<td></td>
<td>After dry brining</td>
<td>10.61</td>
<td>0.17</td>
<td>a</td>
<td>9.60</td>
<td>12.01</td>
</tr>
<tr>
<td>Whiteness</td>
<td>Raw</td>
<td>55.17</td>
<td>0.47</td>
<td>a</td>
<td>52.32</td>
<td>57.93</td>
</tr>
<tr>
<td></td>
<td>After brining</td>
<td>58.48</td>
<td>0.78</td>
<td>b</td>
<td>54.09</td>
<td>62.80</td>
</tr>
<tr>
<td></td>
<td>After dry brining</td>
<td>57.22</td>
<td>0.78</td>
<td>b</td>
<td>52.18</td>
<td>62.38</td>
</tr>
</tbody>
</table>

*The different letters show the difference between process steps in the same color parameter

The $L^*$ value of the raw material of the sardine (initial) was 56.60±0.46. This value increased after brining and this increase was statistically significant ($p<0.05$). This result showed that brining process highly effective on the brightness of the sardine samples due to magnesium and calcium content of the salt (Hall 2011). Same increased levels were observed by the other researchers (Alçiçek and Balaban 2015a). After dry brining the $L^*$ value of the samples slightly decreased (Figure 1). However, this decrease did not show any statistically significance ($p>0.05$). Same trend was observed in Whiteness parameter (Figure 5). The $a^*$ and $b^*$ values of the samples dramatically decreased after brine salting step. This difference was found statistically significant ($p<0.05$). However, there were no significant difference between the salting $a^*$ and $b^*$ values of the brine salting and dry ($p>0.05$) (Figure 2 and 3). These results showed that
brining and dry salting have a strong effect on the redness and yellowness of the sardine samples. The Chroma value of the samples did not show any significance during process steps \( (p > 0.05) \) which is not expected (Figure 4).

Figure 1: The \( L^* \) value of the sardine samples changes during process steps

Figure 2: The \( a^* \) value of the sardine samples changes during process steps

Figure 3: The \( b^* \) value of the sardine samples changes during process steps
According to the color scheme (NBS) determined by the Inter-Society Color Council, sardine fish were classified as grayish purple. However, after brine, the color of the sardine fish was classified as pale purple. After dry salting, the color category was determined as 'greenish gray.' According to these data, the salting stages significantly change the color of sardine fish. In later studies, it is recommended to examine consumer preferences using different salting rates and temperatures.

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