Antioxidant Activity of Onion and Garlic Juices in Stored Cooked Ground Lamb

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ABSTRACT

The effects of onion juice on several characteristics of cooked ground lamb were investigated. Onion juice was a more effective antioxidant than garlic juice in reducing development of rancidity in meat. TBA values for onion-treated samples were lower (P<0.05) after storage when the distillation method of TBA measurement was used. The extraction method may be a less sensitive test for rancidity. Taste panelists were able to discriminate between the onion-treated samples and the control, but onion samples were not preferred (P>.05). Mean hedonic scores were higher (P<0.05) for the onion-treated samples, indicating a more acceptable flavor after storage.

Interest in development of oxidative rancidity in meat products has increased in recent years due to the current trend of using precooked meats in both institutional and home meal preparation (5,13). Oxidative rancidity has been reported to result in a detectable warmed-over flavor in stored cooked meat (11). Rancidity and warmed-over flavor have been interpreted to denote the same characteristic (2).

As malonaldehyde, whose formation is associated with development of rancidity in meat, is a potential carcinogen (10), controlling oxidative rancidity would be of interest for both health and flavor control reasons.

Many plant tissues contain compounds possessing antioxidant activity (4,12), such as flavonoids and ascorbic acid. Younathan et al. (16) recently reported that beef treated with onion juice or textured vegetable protein, and stored for 3 d at 4°C showed a slower rate of oxidation than control beef.

The purpose of this study was to measure the effect of onion juice on several consumer quality characteristics, and to compare two methods of measuring thiobarbituric acid (TBA) values as an index of oxidative rancidity. The effect of onion juice on color changes in raw lamb was investigated because of the reported relationships among color changes, TBA values and metmyoglobin formation (6,8).

MATERIALS AND METHODS

Preparation of samples

In preliminary experiments conducted at the American University of Beirut (AUB), the effects of garlic and onion juices on the TBA (thiobarbituric acid) values of cooked lamb after frozen or refrigerated storage, were assessed. Fresh ground lamb with the following composition: 15.3% protein, 24.0% fat, 60.2% water, was purchased locally and divided into three portions to prepare three samples: a control sample, a garlic-treated sample and an onion-treated sample. One portion was mixed with NaCl (1% by weight) and distilled water (20% by weight) and designated as control. The second portion or onion sample was mixed with NaCl (1% by weight) and freshly extracted onion juice (20% by weight), and the garlic sample was prepared by mixing the meat with NaCl (1%) and garlic juice (4.8%) and distilled water (15.2%). Forty-gram lamb patties were formed and baked in a conventional gas oven at 176°C for 15 min. The cooked patties were then stored in sterile 18 oz. polyethylene plastic bags (Whirl-Pak). All samples were protected from light and were held either at 5°C for 3 or 7 d or at -20°C for 15 or 30 d. Proximate analysis and Thiobarbituric Acid tests were determined on these samples as described later. The experiment was repeated three times, and two analyses were done on each sample.

In subsequent experiments conducted at the Pennsylvania State University (PSU), the effect of onion juice on the TBA values, color difference and sensory characteristics of cooked lamb were evaluated. The experiment was repeated twice and two analyses were done on each sample. Ground (twice, 0.32-cm holes diameter template) frozen lamb meat (22% fat) obtained at the PSU Meat Laboratories was used. The meat was thawed for 48 h at 5°C, then divided into three samples. It was then mixed for 2 min at medium speed (Kitchen Aid, Model K5A, Hobart Man. Co., Troy, OH) with NaCl (1%) and freshly prepared yellow onion juice (20%) or NaCl (1%) and distilled water (20%). Onion juice was prepared by finely

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chopping the whole onion in a Waring Blender and extracting the juice through cheesecloth. One hundred-gram samples of lamb were first tempered to 2°C ± 1°C, then formed into patties of 2.54-cm thickness using a 5.08-cm stainless steel cylinder. The patties were baked in a convection oven at 176°C for 25 min and removed from the oven at an internal temperature of 86°C. The cooled lamb patties were then vacuum packaged and protected from light and stored at either 5°C for 3 or 7 d or at −20°C for 15 or 30 d.

**Thiobarbituric acid test (TBA)**

TBA values were determined by the distillation method outlined by Tarladgis et al. (14), and by a modified extraction method (15). The extraction reagent consisted of 20% trichloroacetic acid (TCA), 0.1% propyl gallate and 0.1% ethylenediamine tetraacetic acid (EDTA) dissolved in 2 M phosphoric acid. Ten grams of sample were mixed with 25 ml of the extraction solution and 25 ml of distilled water for 2 min. The liquid was then centrifuged at 3000 rpm at 10°C for 15 min to obtain a clear extract. The 0.02 TBA solution was added and the optical density of the onion samples were measured at 538 nm against a blank containing 4.83 ml of extraction solution, 5 ml of TBA reagent and 0.17 ml of onion juice to correct for the reaction of the onion juice with the TBA reagent.

**Cooked yield**

The percent cooked yield was determined by weighing the patties before and after cooking.

**Color**

Color difference was measured with a Gardner XL-10 color difference meter. The instrument was standardized with a pale pink tile with the following values: L (reflectance) = 67.4; a (redness) = +18.4; b (yellowness) = +9.1.

**Proximate analysis**

Association of Official Analytical Chemists (AOAC) procedures were used to determine moisture (100°C convection oven), fat (petroleum ether extractables) and protein (micro-Kjeldahl).

**Sensory evaluation**

Sensory evaluation was carried out by a 12-member trained panel which consisted of judges with previous experience in sensory evaluation. Orientation sessions were conducted to familiarize the judges with lamb meat flavor and the procedure of evaluation. Differences among treatments were determined using a directional triangle test (7). Flavor acceptability was measured using a 9-point hedonic (7) testing (1 = dislike extremely to 9 = like extremely) and magnitude estimation (9). The latter method allows panelists to assign numbers to sensory stimuli without restriction so that the ratio of the numerical assignment reflects ratios of sensory perception. Taste panel tests were repeated twice. The total number of panelists varied from 21 on days 0 and 30 to 24 on storage day 7.

**Statistical analysis**

An analysis of variance was used to test the data. When differences were found, Duncan’s Multiple Range Test was used (3).

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**RESULTS AND DISCUSSION**

**Effect of onion and garlic juices on TBA values**

With the initial experiments, addition of onion and garlic juices reduced development of oxidative rancidity (P<0.05) in cooked ground lamb, as measured by the TBA test (Table 1). Onion juice was more effective than garlic in lowering the TBA values of the meat samples. The antioxidant effect of both juices was detected after either refrigerated or frozen storage, with the average TBA value for the control higher than either the onion or garlic samples on the first day of mixing.

Subsequent experiments at the Pennsylvania State University showed the same trend whether the extraction or the distillation TBA methods were used (Table 2). In either instance control samples had consistently higher TBA values than the onion-treated samples. Using the distillation method, treatment and control were different (P<0.05) as early as after 3 d of refrigerated storage and after 30 d of frozen storage. With the extraction method significant treatment-control differences (P<0.05) were noted after 7 d of refrigerated storage. No significant differences were found during frozen storage. This may indicate that the extraction method is less sensitive than the distillation method for measuring rancidity.

**Effect of treatments on percent cooked yield**

There was no detectable differences between the percent cooked yield of the onion-treated samples and the control samples (71.4% and 72.5%, respectively). Moisture retention of the two treatments was similar to that of lamb meat with no water or onion juice added but containing the 1% NaCl. The percent yield of the latter sample was 72.5%, and was not different from the ones obtained with the two treatments. Addition of 20% onion juice does not affect the percent cooked yield of the meat.

**Effect of onion juice on color of raw lamb**

Addition of onion juice resulted in a significant decrease of both L and a values (P<0.05) as compared to the control sample with water added (Table 3). The greyish color obtained in lamb meat with onion juice was similar to the color changes that occur in ground meat samples with a high percentage of metmyoglobin formation. A color difference between the control and onion treatments was not detectable in the samples after cooking.

**Sensory evaluation**

Triangle test results indicated that the panelists were able to identify the sample containing onion juice (Table 4) but did not indicate any significant preference for either the onion-treated samples or control. Magnitude estimates for onion flavor intensity (Table 5) were higher for the onion-treated samples (P<0.05), but panelists were not able to show any significant differences in level of rancidity between treatment and control. There was a trend toward higher magnitude estimates for level of ran-
ONION AND GARLIC JUICES ADDED TO LAMB

413

TABLE 1. Mean distillation TBA values of cooked ground lamb with added onion and garlic juice and held at 5°C or -20°C (AUB study).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Refrigerated storage (5°C) days</th>
<th>Frozen storage (-20°C) days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Onion</td>
<td>1.96 b</td>
<td>3.16 b</td>
</tr>
<tr>
<td>Garlic</td>
<td>2.56 c</td>
<td>5.24 c</td>
</tr>
<tr>
<td>Control</td>
<td>2.90 d</td>
<td>6.74 d</td>
</tr>
</tbody>
</table>

*Each mean value is the average of 6 determinations. Mean values in the same column with different letters are different (P<0.05).

TABLE 2. Mean TBA values of cooked ground lamb with and without onion juice (PSU study).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Refrigerated storage (5°C), days</th>
<th>Frozen storage (-20°C), days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Onion</td>
<td>1.63</td>
<td>2.50 b</td>
</tr>
<tr>
<td>Control</td>
<td>2.25</td>
<td>4.32 c</td>
</tr>
</tbody>
</table>

*Each mean is the average value of four determinations. For each method, mean values in the same column with different letters are different (P<0.05).

TABLE 3. Mean color difference values of raw lamb meat with and without onion juice.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>L</th>
<th>a</th>
<th>b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onion</td>
<td>45.95 c</td>
<td>5.45 c</td>
<td>7.38 d</td>
</tr>
<tr>
<td>Control</td>
<td>48.75 d</td>
<td>15.08 d</td>
<td>8.95 d</td>
</tr>
</tbody>
</table>

*L = lightness to darkness
a = redness to greeness
b = yellowness to blueness

*Mean values in the same column with different letters are different (P<0.05).

TABLE 4. Triangle test results indicating the number of correct identification of the pair and the corresponding preference.

<table>
<thead>
<tr>
<th>Days of storage</th>
<th>Control versus onion*</th>
<th>Preference for onionb</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>12/21*</td>
<td>7/12</td>
</tr>
<tr>
<td>7</td>
<td>17/24***</td>
<td>10/17</td>
</tr>
<tr>
<td>30</td>
<td>12/21*</td>
<td>6/12</td>
</tr>
</tbody>
</table>

*Ratio indicates the number of correct identifications over the number of total determinations. One asterisk indicates significance at the 5% level. Three asterisks indicate significance at the 0.1% level.

b = Not significant at the 5% level.

TABLE 5. Ratios of magnitude estimation for level of rancidity and onion flavor intensity of cooked lamb meat.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Refrigerated storage (5°C), days</th>
<th>Frozen storage (-20°C), days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Onion</td>
<td>0.79 c</td>
<td>0.78 c</td>
</tr>
<tr>
<td>Control</td>
<td>1.00 c</td>
<td>1.00 c</td>
</tr>
<tr>
<td>Onion</td>
<td>1.00 c</td>
<td>0.73 c</td>
</tr>
<tr>
<td>Control</td>
<td>0.38 d</td>
<td>0.41 d</td>
</tr>
</tbody>
</table>

*aRatios in the same column with different letters are significantly different.

bNumbers increase with an increase in detectable rancidity or onion flavor intensity. Responses were compared to a pivot point reflecting a panelist’s numerical assignment for a product of this type.

rancidity in control samples; however, the difference was not significant.

Mean hedonic scores of the cooked meat were higher (indicating a more acceptable flavor) for the onion-treated samples after 7 d of storage at 5°C and 30 d of storage at 0°C (Table 6). The level of onion juice was relatively high and may have masked the "warmed-over" flavor.

Addition of onion resulted in a more desirable product, which corresponded to lower TBA values with either refrigerated or frozen storage. Though all samples showed...
TABLE 6. Mean hedonic scores* of cooked lamb meat during storage.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Refrigerated storage (5°C), days</th>
<th>Frozen storage (-20°C), days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Onion</td>
<td>5.62</td>
<td>5.67 b</td>
</tr>
<tr>
<td>Control</td>
<td>4.95</td>
<td>3.96 c</td>
</tr>
</tbody>
</table>

*Mean scores in the same column with different letters are different (P<0.05). A value of 9 = like extremely; 8 = like very much; 7 = like moderately; 6 = like slightly; 5 = neither like or dislike; 4 = dislike slightly; 3 = dislike moderately; 2 = dislike very much; 1 = dislike extremely. Each mean is the average value of 21 scores for storage days 0 and 30, and 24 scores for storage days 7.

an increase in rancidity with storage time, the control sample had the highest TBA value after 7 d of storage at 5°C (Table 2), and the lowest hedonic score of 3.96. Although addition of onion juice resulted in a more desirable product, the findings do not imply that this was solely due to lower TBA values.

REFERENCES