The Sensory Properties, Color, Microbial, Lipid Oxidation, and Residual Nitrite of Se’i Marinated with Lime and Roselle Calyces Extracts

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ABSTRACT

Meat deterioration can occur because of lipid oxidation and bacteria that could affect meat quality. It has been recognized that fruits of lime (Citrus aurantifolia) and roselle (Hibiscus sabdariffa) calyces contain bioactive compounds that have a capability to prevent oxidation and bacterial growth. The objective of this research was to investigate the effect of lime and roselle calyces extracts on se’i (Rotenese smoked beef) quality. Completely randomized design (CRD) with 2x4 factorial pattern was used in this study. The first factor (E) was source of extracts i.e., lime extract (E1) and roselle extract (E2). The second factor (L) was level of the extract consisted of 4 levels i.e., control (without extract/L0); L1 = 1%; L2 = 2%; and L3 = 3% (v/v). Each treatment consisted of 3 replications. Sensory properties measured were aroma, taste, and tenderness. Other variables measured were color, total plate count (TPC), thiobarbituric acid reactive substances (TBARS), and residual nitrite. The taste and tenderness of se’i were affected (P<0.05) by combination of the extract and the level of the extract. Results showed that there were significant interactions (P<0.05) between the kind of extracts and the level of extract on L (lightness), a (redness), and b (yellowness) values, TPC, TBARS, and residual nitrite values. The level of 3% of lime extract as well as 3% of roselle calyces extracts improved score of taste and tenderness, reduced a values, decreased TPC, TBARS, and residual nitrite values. Marinating in 3% of roselle calyces extract decreased the b value but marinating in 3% of lime increased the b value of se’i. It is concluded that marinating 3% of roselle or 3% of lime gives the best effect on taste, tenderness, TPC, and TBARS values of se’i.

Keywords: roselle, lime, se’i, residual nitrite, sensory properties

ABSTRAK

Kerusakan pada daging disebabkan oleh terjadinya oksidasi lemak dan juga karena bakteri yang mempengaruhi kualitas daging. Telah dilaporkan bahwa dalam buah jeruk nipis dan kelopak bunga rosela terdapat komponen-komponen biooaktif yang mempunyai kemampuan menekan laju oksidasi lemak dan pertumbuhan bakteri. Tujuan penelitian ini adalah untuk menguji pengaruh ekstrak jeruk nipis dan ekstrak kelopak bunga rosela pada kualitas daging se’i. Rancangan yang digunakan dalam penelitian ini adalah rancangan acak lengkap 2 x 4 dengan pola faktorial. Faktor pertama adalah jenis ekstrak yang terdiri atas dua level, yaitu ekstrak jeruk nipis dan ekstrak kelopak bunga rosela. Faktor kedua adalah level pemberian yang terdiri atas 4 level, yaitu 0% (kontrol), 1%, 2%, 3% (v/v). Setiap perlakuan terdiri atas 3 ulangan. Peubah yang diukur adalah aroma, rasa, keempukan, warna, total plate count (TPC), thiobarbituric acid reactive substances (TBARS), dan residu nitrit. Hasil penelitian menunjukkan bahwa terdapat pengaruh interaksi antara jenis ekstrak dan level pemberian ekstrak pada rasa, keempukan, nilai L (lightness), a (redness), and b (yellowness), TPC, TBARS, dan residu nitrit se’i. Level pemberian ekstrak jeruk nipis 3% atau ekstrak rosela 3% memberikan hasil tertinggi pada skor rasa dan keempukan, nilai terendah pada nilai a, TPC, TBARS, dan residu nitrit se’i. Level pemberian 3% ekstrak kelopak bunga rosela menurunkan nilai b, tetapi level pemberian 3% ekstrak jeruk nipis meningkatkan nilai b. Dapat disimpulkan bahwa penggunaan ekstrak jeruk nipis atau ekstrak kelopak bunga rosela dengan level 3% pada daging se’i memberikan pengaruh terbaik pada rasa, keempukan, TPC, dan TBARS.

Kata kunci: rosela, jeruk nipis, se’i, residu nitrit, sifat sensori

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INTRODUCTION

Generally, lipid in meat consists of triglycerides, phospholipids, cholesterol, and fat-soluble vitamins. Fatty acids in triglycerides consisted of both saturated and unsaturated fatty acids. When beef meat is stored, the double bond of unsaturated fatty acids changes to short chain fatty acids, aldehydes, or ketones causing rancidity (Santos-Fandila et al., 2014). The process of lipid oxidation occur both in cooked and uncooked meats (El-Alim et al., 1999). Thus, in meat processing, antioxidant is usually added in order to reduce the rate of lipid oxidation (Shah et al., 2014).

Meat deterioration can occur because of bacteria. Meat is a nutrient–rich medium that offers ideal conditions for bacterial growth. The bacteria release their metabolites on meat surface during storage time causing organoleptic change (Dainty et al., 1985). Thus, the use of antibacterial agent is necessary in meat processing.

Antioxidant and synthetic antimicrobial such as butylated hydroxyl toluene (BHT) and nitrate have been used in meat industry for many years (Fernandez-Lopez et al., 2005). However, nowadays consumers are more concern about the negative impact of using synthetic additives on their health dealing with risk of toxicity and carcinogenicity (Ardabili et al., 2010). Thus, using natural additives such as plants to substitute the synthetic additive has notably increased (Sebranek et al., 2005; Ghafar et al., 2010). Such plants are lime (Kumari et al., 2013; Boshtam et al., 2011; Fernandez-Lopez et al., 2005) and roselle (Mahadevan et al., 2009; Karabacak & Bozkurt, 2008; Bozkurt & Belibagl, 2009).

Lime fruit contains flavonoids and vitamin C. Lime could decrease rancidity as many as 50% in beef meatballs (Fernandez-Lopez et al., 2005), reduced the number of total bacteria and residual nitrite of se‘i (Malelak et al., 2015) and also could effectively tenderize beef and goat meats (Iqbal et al., 2016). These studies showed the beneficial function of lime in meat industry including antioxidant and antibacterial activities.

The effectiveness of roselle in reducing lipid oxidation (TBARS value) in sucuk (a vegetarian dry-fermented sausage) has been reported by Karabacak & Bozkurt (2008) and in kavurma (Tukey’s traditional meat product) (Bozkurt & Belibagl, 2009). Moreover, addition of rosetta in Sucuk can enhance the color, flavor, and texture of sucuk (Karabacak & Bozkurt, 2008). The addition of 1.5%-6% of dried rosette calyces in broiler diets reduced bacterial number both in fresh and cooked chicken meats (Onibi & Osho, 2007).

Se‘i (Rotenesse smoked meat) is usually made from beef, sliced into rope-shape, spiced with salt and saltpeter, then it is smoked. Saltpeter has a function as a preservative particularly against Clostridium botulinum and give a red color to the product. In spite of these benefits, sometimes, addition of high amount of saltpeter in meat product can increase the level of nitrite residue in meat products. It was reported that high level of nitrite residue could bring the potential risk of childhood leukemia, brain tumors, and colon-rectal cancer (Demeyer et al., 2008). It was reported that citrus fruits juice containing organic acids had an ability to reduce the concentration of residual nitrite in cured meat products (Viuda-Martos et al., 2009). Organic acids are also found in rosette calyces such as: citric acid, ascorbic acid, maleic acid, malic acid, oxalic acid, and tartaric acid (Mahadevan et al., 2009). Addition of rosette or lime extract in other meat products such as se‘i, could also affect their characteristics. The objectives of this experiment were to investigate the effect of lime and roselle calyces extract on the aroma, taste, tenderness, color, total plate count (TPC), thiobarbituric acid reactive substances (TBARS), and residual nitrite of se‘i.

MATERIALS AND METHODS

Materials

The amount of 18 kg of beef meat obtained from butt and rump of Bali cattle cows were purchased from meat shop in Kupang, West Timor. Fresh roselle calyces and lime fruits were obtained from Oefafi Village, Kupang District. Calyces of roselle were dried in hot air oven at 60°C for 3 d with 10.83% dry matter weight. The dried calyces were milled using laboratory hammer mill to obtain dry powder (1 mm mesh). To obtain 1%, 2%, and 3% (w/v) of roselle extract, each of 1, 2, and 3 g of the powder were poured into 350 mL volumetric glass and then distilled water were added up to 100 mL. The mixture was then shaken using an orbital shaker (Unimax 1010, Heidolph, Germany) for 2 h at room temperature, then filtered through a filter paper (Whatman no.4) (Mohd-Esa et al., 2010). The extract was stored at 4°C for 2 d.

The limes were hammered and then sliced around from the top to the bottom and then squeezed to obtain the extract. The lime extract was put in jar glass and then distilled water was added up to 100 mL then the mixture was mixed thoroughly. The mixture was boiled in hot plate at 60°C for 1 h and then filtered with Whatman (No.41) filter paper (Karabacak & Bozkurt, 2008) with a modification. To obtain 1%, 2%, and 3% (v/v) of the lime extract, each of 1, 2, and 3 mL of the extract were poured into 350 mL volumetric glass and then distilled water was added to reach the volume of 100 mL. Then the mixture was heated at 45°C in a stirring hot plate for 30 min then filtered with Whatman (No.41) filter paper and stored at 4°C for 2 d.

The calyces were dried in an oven at temperature of 60°C for 3 d, and blended with Philips blender to obtain the mass. To obtain 1%, 2%, and 3% (v/v) of roselle extract, the amount of 1, 2, and 3 g of roselle mass were poured into volumetric glass and distilled water was added up to 100 mL, stirred at 60°C for 5 min and filtered with Whatman (No.41) (Karabacak & Bozkurt, 2008) with a modification.

Experimental Design

Completely randomized design (CRD) with 2x4 factorial arrangement was used in this study. The first factor (E) was source of extracts consisted of 2 levels i.e., the lime extract (E.) and the rosette extract (E.). The second factor (L) was the level of the extract consisted of 4
levels i.e., control (without extract/ L_0); L_1 = 1%; L_2 = 2%; and L_3 = 3%. Each treatment consisted of 3 replications.

**Se'i Processing**

Beef sample of 8500 g weight was trimmed off connective tissue and fat then sliced in rope-shape (talolak) and then 2550 mg (300 mg/kg) salt peter and 160 g salt were added and mixed well manually. Then, the beef was divided into 3 groups. The first group was control (without treatment). The second group was beef treated with the lime extract at doses of 1%, 2%, and 3% of the extract (v/v). The third group was beef treated with the roselle extract at doses of 1%, 2%, and 3% (v/v). Each group was well mixed and marinated for ±12 h.

After marinating, the slices of beef were managed in frame then smoked using *Schleichera oleosa* wood and all meat surfaces were covered with *Schleichera oleosa* leaves while smoking. After smoking, se’i was placed and packed into a transparent 0.05 mm polyethylene plastic. The packaged sample was coded according to each treatment. The samples were then stored in a refrigerator at 4°C before being analyzed.

**Sensory Evaluation**

Two training sessions were conducted for twenty-five panelists from Animal Science Faculty students in order to familiarize them with the characteristics of se’i to be evaluated. To examine the aroma, 30 g of samples were sliced, put into small glass jars, and allowed to stand for several hours. One minute after opening the jars, the panelists immediately examined the aroma. The aroma characteristics were evaluated using 1-5 points category scale where one was odorless and 5 was very strong se’i aroma. For each replication from the treatments, the aroma was measured twice.

The taste and tenderness characteristics of the treated se’i were evaluated using a 1 to 9 scale (9= extremely like; 1= extremely dislike) and tenderness characteristics (9= extremely tender; 1= extremely tough). Each panelist had two pieces of se’i (± 2 mm thick x 2 cm length) for each of 3 replicates of each treatment. The samples were put in the white plate that had been labeled with three digit random numbers then the plates were offered randomly to the panelists. An average of the three measurements was used to calculate means score for each of treatment for the taste and tenderness of se’i sample.

**Color Determination**

Color determinations of se’i sample were applied in three measurements to calculate average scores for L, a, and b values. Color values were described as coordinates (lightness (L, black-white (darkness-lightness)), redness (a, ± red-green), and yellowness (b, ± yellow-blue). The color values were measured using Minolta colorimetry equipment (CR-200; Minolta Co), Osaka-Japan.

**Microbial Analyses**

Ten grams finely chopped of se’i from each treatment were homogenized with 100 mL of sterile 0.1% peptone water containing 0.85% NaCl and 1% Tween 80 as emulsifier at temperatures of 40-45°C for 2 min in a Stomacher 400 Lab Blender. Ten mL of the preceeding dilution were mixed with 0.1% sterile peptone water. Total plate count were enumerated in standard plate count agar (Oxoid agar) after incubation at 35°C for 48 h ±2 h, then all colonies on plates were counted (Harrigan & Mc Cance, 1976).

**Determination of Thiobarbituric Acid Reactive Substances (TBARS) Values**

Ten grams of minced se’i was homogenized with 100 mL distilled water for 2 min. The homogenized sample was added some drops of 4 M HCl slowly until the mixture reached the pH of 1.5. Then the mixture was warmed and distilled (5 mL), then distilled solution was collected in conical flask. A blank was prepared with the same protocol using 100 mL distilled water without sample (Mohd-Esa et al., 2010). The thiobarbituric acid reactive substances (TBARS) values were expressed as mg malonaldehyde/kg sample.

**Residual Nitrite Analysis**

Residual nitrite level of se’i was determined as mg NaNO₂/kg meat by a spectrophotomet method at 540 nm as described in AOAC (1995). For each treatment, measurements were made twice. Five grams of se’i were minced and transferred into a 250-mL beaker glass. Forty milliliter of water was added and the solution was heated to 80°C for 15 min then transferred into a 250-mL volumetric flask. Hot water was added to bring the final volume of about 200 mL then the solution was transferred to steam bath for 2 h then the solution was shaken occasionally. The solution was cooled to room temperature. Water was added to reach the final volume of 250 mL. The solution was filtered and centrifuged to make it clear. A 2.5 mL of sulphanilamide solution was added to aliquot containing 5-50 ug NaNO₂ in 50 mL volume flask and the solution was mixed. Five minutes later, a 2.5 mL NED reagent was added, mixed, and diluted to a final volume of 100 mL mixed and let color develop in 15 min. A 5-mL portion of the solution was transferred to photometer cell to measure absorbance at 540 nm against blank consisted of 45 mL water, 2.5 mL of sulphanilamide reagent, and 2.5 mL of NED reagent. The concentration of nitrite was determined by comparing with standard curve with a straight line up to 1 ppm NaNO₂ in a final solution. Standard curve was made by adding 10, 20, 30, and 40 mL of nitrite working solution to 50 mL volume of flasks. A 2.5 mL of sulphanilamide reagent was added and after 5 min a 2.5 mL of NED reagent was added.
Organic Acids Analysis

Ascorbic acid was determined by UV-Visible Spectrophotometry (Mussa & Sharara, 2014). Oxalic acid, malic acid, citric acid and succinic acid was determined by high performance liquid chromatography (HPLC) (Ergonul & Nergiz, 2010). Tartaric acid was determined by high performance liquid chromatography (HPLC) (Kowalski & Wittrig, 2017).

Statistical Analysis

The data of aroma, taste, and tenderness were analyzed using non-parametric Kruskal-Wallis test. The Mann-Whitney test was used to differentiate among the means (significance P<0.05; highly significance was P<0.01). Values of L, a, and b; TPC, TBARS, and residual nitrite data were calculated with analysis of variance (ANOVA) Duncan test was used to determine the differences among means (significantly different was P<0.05) (SPSS, 20).

RESULTS

The aroma, taste, and tenderness of se‘i marinated with roselle and lime extracts are presented in Table 1. The color analyses of se‘i marinated with roselle and lime extracts are presented in Table 2. There was a significant interaction effect (P<0.05) between the type of extract and the level of extracts on lightness (L), redness (a), and yellowness (b) values of se‘i. The lowest lightness values were found in se‘i samples treated with 1% of lime and 3% of roselle extracts. The highest lightness (L*) values were found in se‘i samples treated with 1%-2% of roselle and 2% of lime extracts.

The addition of roselle and lime extracts decreased the redness (a) values of se‘i. The highest redness value was found in control se‘i (P<0.05), and se‘i treated with 1% roselle extract had the lowest redness values (Table 2). The addition of 1% of roselle extract kept yellowness (b) values at the lowest level and the highest yellowness (b) values was found in se‘i added with 3% of lime extract (P<0.05) (Table 2). The number of total bacteria or total plate count (TPC) (log cfu/g), thiobarbituric acid (TBARS) value (mg malonaldehyde /kg), and nitrite residual (mg/kg) values of se‘i marinated with roselle and lime extract are presented in Table 3. There was a significant interaction effect between the type of extract and concentration of extract on total plate count (TPC) (P<0.05). The type and the concentrations of the extracts had significant interaction effects on TBARS parameter. In addition, the type and the concentration of extract had interaction effects (P<0.05) on nitrite residual of se‘i.

DISCUSSION

Sensory Evaluation

The result about aroma found in this experiment contradicted with those reports by Malelak et al. (2015) that aroma of se‘i was affected by lime extract. This difference could be due to the lower level of the extract used in this experiment than that used in Malelak et al. (2015). Bozkurt & Belibagl (2008) reported that ad-
dition of roselle increased the aroma score of kavurma and sucuk (Karabacak & Bozkurt, 2008). This difference could be due to the number and types of ingredients used in sucuk processing that were the mixture of black paper, cumin, and also starter culture while in se‘i processing only used salt and saltpeter.

Se‘i added with 3% of roselle extract or 3% of lime extract had increased score taste. Karabacak & Bozkurt (2008) reported that the use of roselle increased flavor and tenderness of sucuk. Malelak et al. (2015) also explained that supplementation of lime extract increased taste score of se‘i.

The samples added with 3% of lime had increased tenderness (P<0.05) compared to the other four treatments and control. It was reported that citric acid was more effective as a tenderising agent for beef and goat meats compared to the other organic acids (Iqbal et al., 2016). Citric acid was also reported to increase the tenderness of chicken breast (Kim et al., 2015).

Iqbal et al. (2016) suggested that acids could weaken the meat structure to improve proteolysis. Proteolysis breaks off peptide bonds of amino acids in meat proteins such as collagen that results in increasing tenderness (Marino et al., 2013). However, the use of citric acid did not enhance the tenderness of culled cow meat (Klinhom et al., 2015). The result of this experiment showed that although citric acid content in lime was lower than in roselle, addition of 2% of lime did not increase the se‘i tenderness. Thus, other factors might be involved in affecting the tenderness of se‘i.

**Color Determination**

The L values found in the present experiment were in agreement with those reported by Bozkurt & Belibagl (2009) that addition of roselle increased lightness value of kavurma. However, Bozkurt & Belibagl (2009) found that roselle did not affect L value of sucuk. Se‘i treated with 1%-2% of roselle extract and 2% of lime increased lightness (L) values.

It was reported that lightness values were influenced by antioxidant compounds (Fernandez-Lopez et al., 2005). Anthocyanins and organic acids in roselle had the ability as an antioxidant (Bozkurt & Belibagl, 2009). Antioxidant compounds could retard metmyoglobin (MMb) formation that eventually decreased the lightness values (Fernandez-Lopez et al., 2005). For this reason, addition of 1%-2% of roselle extract increased the lightness (L) of se‘i samples (P<0.05), however the lightness of the se‘i was decrease when the level of rosella extract increased to 3%. The increased level of the extract used in the se‘i processing will increase the total concentration of antioxidant.

When 1% of lime extract was added, the lightness values decreased (P<0.05). The extract could weaken the meat structure/myofibrils (Iqbal et al., 2016) so the water would be released from the structure and when the se‘i was smoked the water would loss so the lightness values of the se‘i would decrease. The lightness values increased by adding 2% of extract then decreased again at the level of three percent. The decrease in L values with the addition of 3% of the lime extract was due to the increased total antioxidant content in the extract. The decreased L values were caused by the decrease in lightness and increase in a dark color formation due to the browning reactions (Bayram & Bozkurt, 2007). However, if the L values were above 50, the meat was brighter than darker (Patrascu et al., 2013).

Addition of citric acid in chicken breasts reduced redness (a) values due to denaturation of myoglobin (sarcoplasmic heme protein) (Kim et al., 2015). The lowest a values of se‘i treated with 1% of roselle extract in this experiment indicated that denaturation of myoglobin was occured due to the presence of citric acid and the organic acids in roselle as well as in lime extracts. Similar result was reported that the addition of roselle decreased the a value of sucuk (Bozkurt & Belibagl, 2009). It was interested that the addition of 2%-3% roselle extract increased the a values and this phenomenon was also observed in the addition of 1% and 3% of lime extract but the values were still lower than the control. It seems that the role of citric acid or other organic acids in influencing the a values was affected during smoking. It was reported that denaturation of protein increased when the internal temperature of meat during processing increased which caused the decrease in myoglobin content (Sen et al., 2014). However, if the meat was processed with a low temperature during a
longer duration of cooking condition (< 65°C) the meat would be more reddish since the process of myoglobin denaturation was low (Sanchez Del Pulgar et al., 2012). Other possibility that affected this phenomenon was the heating during smoking that might prevent the binding of citric acid to iron of heme in myoglobin. The prevention of iron binding with citric acid will increase the availability of heme to bind oxygen resulting in the increase in a values of se’i. However, further experiment is needed to support this argument.

The result about the yellowness (b) values of se’i found in this experiment was similar to that reported by Bozkurt & Belibagl (2009) that the addition of roselle could reduce yellowness values of kavurma. The decrease in yellowness values suggested that the color of se’i turned to blue rather than yellow. In this experiment addition of 1% and 3% of rosette extract and 1% and 2% of lime extract reduced the yellowness (b) values of se’i, but the value increased when the level of lime extract addition was increased to 3%.

Microbial Population

All treatments caused the decrease in total plate count (TPC) number, except in the addition of 1% of roselle extract. The lowest TPC numbers was found in se’i treated with 3% of lime (0.48 log cfu) and the highest was found in control and se’i treated with 1% of roselle extract i.e., 1.62 and 1.61 log cfu, respectively. TPC of se’i marinated in lime extract was lower than those marinated in roselle extract. The lower TPC in se’i marinated in lime extract could be due to the higher antibacterial content in lime extract than in roselle extract. TPC number in this experiment was lower than that was reported by Malelak et al. (2015). However, all se’i samples in all treatment and control in this experiment had number of bacteria lower than 1x10⁵ cfu. Maximum bacterial contamination permitted in smoked meat was 1x10⁶ cfu (5 log cfu/g) (SNL.7388:2009).

Roselle and lime extracts contain organic acids (Table 4) such as citric acid that has an antibacterial activity (Hussain et al., 2015). The differences in the amount of organic acids content in these two extracts (Table 4) used in this experiment could explain the differences in their effects on the reducing of TPC in se’i.

Thiobarbituric Acid Reactive Substances (TBARS) Values

All treatments used in this experiment reduced the thiobarbituric acid (TBARS) values of se’i. The increase in the levels of either roselle or lime extract used in this experiment decreased the TBARS values of se’i. These results recommended that these two extracts inhibited lipid oxidation and the lime extract had a higher antioxidant activity than roselle extract. Fernandez-Lopez et al (2005) also reported that lime extract showed an antioxidant activity in beef meat ball. Roselle showed an antioxidant activity in sucuk (Karabacak & Bozkurt, 2008) and kavurma (Bozkurt & Belibagl, 2009).

Nitrite Residual Analysis

All treatments reduced the nitrite residual value and the lowest value was found in se’i marinated in 2% roselle extract and 1% and 2% lime extracts. These results were similar to those reported by Malelak et al. (2015) that application of lime in the se’i production decreased nitrite residual values. However, the nitrite residual amount in this experiment was lower than that reported by Malelak et al. (2015). This difference was due to the amount of nitrate (saltpeter) used in this experiment was 300 mg/kg of meat that was lower than nitrate used in Malelak et al. (2015) that was 500 mg/kg of meat. The level of nitrite addition that is permitted in meat processing products is 500 mg/kg (National Agency for Drug and Food Control, 2013). Thus, the ranges of nitrate used and the residual nitrite level in this experiment were in the ranges allowed by the government rule.

The reduced nitrite residual levels in the se’i processed in this experiment were related to the bioactive content of roselle and lime extracts. Viuda-Martos et al (2009) stated that the use of citrus co-product (orange dietary fiber) could reduce nitrite residual in dry-cured sausage and bologna sausage dry sausage meat product due to the presence of bioactive compounds such as organic acids and polyphenols. Kilic & Oztan (2013) reported that the use of organic acids (ascorbic acid) reduced nitrite residual in smoked fish. Although the ascorbic acid in roselle calyces was higher than in lime (Table 4), the nitrite residual level in se’i treated with lime was lower than in se’i treated with roselle calyces. The results of observation showed that the contents of other organic acids, except ascorbic acid, in lime extract was higher than those in roselle calyces extract (Table 4). The differences in the amount of organic acids compounds in the two extracts resulted in the differences in the nitrite residual content in se’i samples (Table 3).

The reduction of the nitrite residual levels could be an acceptable alternative to reduce the intake of nitrite in processed meats to avoid consumers from negative effect of health.

Table 4. Organic acids contents in roselle and lime extracts

<table>
<thead>
<tr>
<th>Kind of extract</th>
<th>Ascorbic acid (mg/100g)</th>
<th>Citric acid (%)</th>
<th>Tartaric acid (%)</th>
<th>Malic acid (%)</th>
<th>Oxalic acid (%)</th>
<th>Succinic acid (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roselle</td>
<td>106</td>
<td>2.025</td>
<td>2.167</td>
<td>1.657</td>
<td>1.890</td>
<td>1.761</td>
</tr>
<tr>
<td>Lime</td>
<td>12</td>
<td>4.391</td>
<td>4.744</td>
<td>7.307</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

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CONCLUSION

The addition of 3% of roselle calyces extract and 3% of lime extract increased the score of taste and tenderness, but decreased the a values, TPC, TBARS, and nitrite residual value. The marination of se’i in 3% of roselle calyces extract decreased the b value but marination in 3% of lime extract increased the b value of se’i. Marination of se’i in 3% of roselle extract or 3% of lime extract gave the best effect on taste, tenderness, TPC, and TBARS values of se’i.

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