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Effect of addition of different citrus juice on the quality of se'i made from the meat of cull Bali cows with different body condition scores

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ABSTRACT

Various attempts are required to improve the quality of se'i as a traditional beef processed product from The Province of East Nusa Tenggara, Indonesia, since the raw beef commonly used is from thin cull Bali cows. Using raw beef from fatter cows may improve the quality of se'i, but the addition of organic acids such as different citric juices may also improve the quality of se'i. This research aimed to evaluate the quality of *se'i* processed from beef of cull Bali cows with different body condition scores (BCS) and added citrus juice (CJ) during marination to improve aroma, reduce lipid oxidation and bacterial contamination. A completely randomized design (CRD) with a 3 x 3 factorial arrangement was assigned in this study. The first factor was the BCS of the cull cow i.e., BCS2, BCS3, and BCS4. The second factor was citrus juice, i.e. no citrus juice as control (NC), Lime juice (LJ), and Kaffir lime juice (KLJ). Results showed that the addition of KLJ improved the aroma and acceptability of se'i, but the addition of LJ failed to improve those parameters in BCS 2. In all BCS, the addition of lime or kaffir lime juice reduced the pH, residual nitrite, lipid oxidation, and the total plate count (TPC). However, in BCS 4 only KLJ reduced the pH but it did not reduce the residual nitrite. In conclusion, the addition of KLJ was more effective to improve the sensory value of se'i, particularly when it was made from thin cull Bali cows (BCS 2). Meanwhile, to improve the shelf-life and the food safety of se'i as indicated by the ability to reduce the residual nitrite and thiobarbituric acid-reactive substances (TBARS) in *Se'I,* the addition of LJ proven to be more effective than KLJ. To produce the highest quality of se'i, it is suggested to process beef from fat cull Bali cows (BCS 4) with the addition of lime juice for best sensory quality or with the addition of lime juice for longer shelf-life and minimum bacterial contamination.

Keywords: *Cull cow meat, Body condition score, Se'i, Citrus juice*

INTRODUCTION

Besides the quality of raw meat used to produce se'i, the use of food additives has been reported to improve the quality of se'i. Malelak *et al*. (2015; 2017) reported that the addition of lime juice increased the sensory value of *se'i.* Moreover, adding lime juice to the meat of cull cow increased the shelf-life of se'i by inhibiting the rate of lipid oxidation (Malelak *et al*., 2017), and reducing the total bacteria in *se'i* (Malelak *et al*., 2015). The positive effect of lime addition to processed meat is due to its high content of bioactive substances. Limes (*Citrus aurantifolia*) and also are usually used as food additives since it contains many bioactive substances such as polyphenols, flavanols, flavonoids, tannins, and ascorbic acid (Lubinska-Szczygieł *et al*., 2018) and citric acid (Penniston *et al*., 2008). Polyphenols, ascorbic acid and citric acid were correlated to antioxidant activity (Ayala-Zavala *et al*., 2011; Dhavesia, 2017; Lubinska-Szczygieł *et al*., 2018). Whereas, flavonoids were able to inhibit the growth of bacteria and fungi (Ortuno et al., 2006) and also have antioxidant activity (Fernandez-Lopez *et al*., 2007). Adding citrus juice also reduces the residual nitrite levels in meat products by preventing the formation of carcinogenic n-nitrosamines (Viuda-Martos *et al*., 2009).

Kaffir lime (*Citrus hystrix*) is also commonly used as a food additive in processed foods of Timor, East Nusa Tenggara Province, Indonesia. Compared to lime, kaffir lime fruits contain higher organic acids and terpene compounds (Lubinska-Szczygieł *et al*., 2018). As a result, adding the juice to meat during marination may produce a more intensive aroma and taste of se'i. To our knowledge, there is extremely limited information on the use of kaffir lime juice as compared to lime juice as additives in *se'i* production particularly when se'i is made from the meat of cull Bali cows differing in their BCS. Thus, this study aimed to investigate the effect of adding lime or kaffir lime juice during marination on the quality of se'i made from cull cow meat with different body condition scores (BCS).

MATERIALS AND METHODS

The meat was obtained from the *Biceps femoris* muscle of cull Bali cows that were slaughtered with a body condition score of 2, 3, and 4 respectively. The meat was taken from BCS 2 was not contain subcutaneous fat whereas, meat taken from BCS 3 contained ± 1 cm subcutaneous fat and taken from BCS 4 contained ± 3 cm subcutaneous fat. The beef was purchased from Oeba slaughterhouse, Kupang, West Nusa Tenggara. Citrus fruits, i.e. lime (*Citrus aurantifolia*) and kaffir lime (*Citrus hystrix*) were purchased from a traditional market in Kupang, East Nusa Tenggara.

Preparation of Citrus Juice

Citrus fruits were washed with clean water then drained with a clean cloth. The fruits were beaten until soft, sliced, and squeezed. The collected juice was then filtered and transferred into a glass bottle and stored in a refrigerator at 4ºC before being used.

Treatments and Processing Procedure of *Se'i*

The experiment was conducted following a completely randomized design with 3 x 3 factorial arrangement. The first factor was the source of meat from cull Bali cows with different body condition scores (BCS) i.e., BCS 2, 3, and 4, and the second factor was citrus juice (CJ) i.e., no citrus juices as control (NC), lime juice (LJ), and kaffir lime juice (KLJ).

A total of 24 kg of meat consisted of 8 kg of meat from cull Bali cows with BCS 2, 3, and 4 respectively were purchased from the butcher house. The meat was trimmed off the excessive connective tissue and subcutaneous fat before being sliced into a *rope shape*. In *se'i* processing the excessive fat should be trimmed since it is the characteristic se'i that only lean meat is used and no visible fat is allowed. The meat was then weighed to determine the amount of salt, saltpeter, and citrus juice to be added. For each kg of beef, 2% of salt and 300 mg of saltpeter (KNO_3) were added and thoroughly mixed manually. Meat from each BCS was then divided into three parts to be treated with no citrus as control (NC) or with 3% (v/v) of Lime juice (LJ) and 3% (v/v) Kaffir lime juice (KLJ). The treated meat was then marinated for ± 12 h. After being marinated the meat was set on the frame then smoked in a drum smoker. The wood of Kusambi (*Schleichera oleosa*) was used as fuel and its leaf was used to cover the meat during **being smoked** which lasted for about 45-60 minutes until well done.

Sensory Evaluation

The sensory quality (aroma, taste, tenderness, and overall acceptability) of *se'i* was examined by 15 well-trained students from the Faculty of Animal Science, The University of Nusa Cendana, Indonesia. Each panelist was given a worksheet and two encoded samples of *se'i* for each treatment. The panelists were asked to evaluate the sensory quality by using a hedonic scale (5= like very much; 4= like; 3= like slightly; 2= dislike; 1= dislike very much). The panelists were asked to clean their palates between samples with water.

Determination of pH

pH value was measured by using a digital pH meter (Hanna HI 99163, HANNA Instruments, and the USA) at ambient temperature. A sample of 10 g of *se'i* was minced using an electric mincer and then homogenized with 10 ml of distilled water for 30 seconds. For each sample, the reading was conducted 3 times.

Residual Nitrite Analysis

The residual nitrite level was determined as mg $NaNO_2$/kg of meat by the spectrophotometer method at a wavelength of 540 nm (AOAC, 1995). For each treatment, measurements were made in duplicate. A 5 g sample of *se'i* was minced for 5 minutes and transferred into a 250-mL beaker. Forty-milliliter water was heated to 80°C for 15 min and then transferred into a 250-ml volumetric flask. Hot water was further added to bring the volume to about 200 mL. It was then transferred into the flask to a steam bath for 2 h shaking occasionally. After 2 hours, the solution was cooled to room temperature. Water was added to produce a 250 mL solution. The solution was later filtered and centrifuged. As much as 2.5 mL of sulphanilamide solution was then added to an aliquot containing 5-50 ug NaNO2 in a 50 mL vol flask and mixed. A 2.5 mL NED reagent was added to the solution 5 min later, and mixed. The mixture was then kept for about 15 min to let color develop. A 5-mL portion of the solution was then transferred to the cell photometer and the determination was done using the absorbance at 540 nm against a blank of 45 mL water, 2.5 mL of sulphanilamide reagent, and 2.5 mL of NED reagent. The concentration of nitrite was determined by comparison with the standard curve of a straight line up to 1 ppm $NaNO_2$ in the final solution. A standard curve was made by adding 10, 20, 30, 40 mL of nitrite working solution to 50 mL vol flasks. As much as 2.5 mL of sulphanilamide reagent was added and after 5 min 2.5 mL of NED reagent was added.

Lipid Oxidation

The level of lipid oxidation in meat products was measured by the concentration of thiobarbituric acid reactive substance (TBARS). A 0.4 g sample was weighed into a 30 mL screw-capped pyrex tube (PYREX, Tewksbury, MA, USA). Two to three drops of antioxidant solution (A: 0.3 g butylated hydroxyl anisole + 5.4 g propylene glycol, B: 0.3 g butylated hydroxyl toluene + 4.0 g tween 20), 3 mL of thiobarbituric acid (TBA) solution, and 17 mL TCA-HCl (trichloroacetic acid + 0.6 N HCl) solution were added. The mixture was vortexed for 10 minutes and then incubated at 100 °C of boiling water in a water bath for 30 minutes for color development. The sample was then cooled in cold water for 10 minutes and 5 mL of the supernatant solution was transferred into 10 mL glass tubes. Two mL of chloroform was added and then centrifuged for 15 minutes at 2,000 × g. The absorbance of the supernatant solution was determined at 532 nm against a blank sample containing all reagents to subtract the sample. Each treatment was measured 3 times. TBA (mg malonaldehyde / kg sample) = [(absorbance sample - absorbance blank) × 46] / [sample weight (g) × 5] (Lim *et al*., 2014).

Total Bacteria / Total Plate Count (TPC)

Analysis of the total bacteria count was conducted following the procedure of Harrigan and McCance (1976). Ten grams of sample from each treatment after being cut into small pieces using a sterilized scissor and tweezer was put in 90 mL of sterile peptone water (0.1%), homogenized using a stomacher, then diluted. The diluted solution was then implanted on Plate Count Agar (PCA, Oxoid, UK). The Petri dishes were then incubated at 37°C for 24 hours. The number of colonies that grew was counted using a colony counter.

Data Analysis

Sensory data were analyzed using the Kruskal-Wallis test and followed by the Mann-Whitney test to determine the differences between treatments using Proc. NPARWAY of SPSS 20. The pH value, the residual nitrite value, the fat oxidation value, and the total bacterial value were analyzed using Proc. ANOVA, followed by the Least square means test (Proc.

LSMean) to see the differences between treatment combinations when the interaction was found significant (SAS 9.1.3 portable).

RESULTS AND DISCUSSION

Sensory Quality

The average scores for aroma, taste, tenderness, and overall acceptability of *se'i* made from beef cull cow with BCS 2, 3 and 4 and added with lime or kaffir lime juice were presented in Table 1. The result from the present experiment showed that the aroma of se'i was higher when it was made from cull Bali cows with BCS 2 compared to those made from BCS 3 and 4. Conversely, the acceptability of se'i was highest for the one made from the beef of cull Bali cows having BCS 4. Meanwhile, the taste and tenderness of se'i were comparable regardless of the different BCS of cows. The decline of aroma for se'i made from BCS 3 and BCS 4 compared to BCS 2 was unexpected since the fat content of the raw meat increased with increasing BCS (Table 2). Fat plays an important role in flavor (taste and aroma) and off-flavor development in raw as well as processed meat (Awan *et al*., 2014; Souza and Bragagnolo, 2014; Kosowska *et al*., 2017). When the lipid melts during heating, it produces flavors (Arshad *et al*., 2018). However, the most dominant factor affecting the flavor of cooked beef is the content of phospholipids as compared to triacylglycerol (Kosowska *et al*., 2017). Phospholipids contain more unsaturated fatty acids mainly linolenic and arachidic acids. Those unsaturated fatty acids particularly arachidic acids produce a very intense flavor when it is oxidized (Blank *et al*., 2001). Hence, it is possible that the increase of fat content in cows having higher BCS might be due to the increase of triacylglycerol rather than phospholipids.

Results also showed that the addition of lime juice significantly improved (P<0.05) the aroma of se'i only when it was made from the meat of cull cows with BCS 3 and 4 but failed to improve the aroma of se'i that was made from cull cows with BCS 2. Meanwhile, the addition of kaffir lime juice improved the aroma of se'i more than that added with lime juice for se'i made from all BCS, indicating that kaffir lime juice is a more effective food additive to improve the aroma of se'i regardless of the quality of raw meat used to produce se'i.

Both citric juices comparably enhanced (P<0.05) the taste and tenderness of se'i in all BCS. Meanwhile, KLJ was found superior over LJ in improving the acceptability of se'i. In general, the result showed that the highest average sensory scores were shown in *se'i* made from BCS4 and given Kaffir lime juice compared to the other treatments (P<0.05).

The superiority of kaffir lime juice in improving the aroma and taste as well the acceptability of se'i particularly when it was made from thin cows (BCS 2) may be related to the higher content of organic acids (ascorbate acid, citrate acid, tartaric acid, and malic acid) in kaffir lime compared those contained in lime (Table 3). Kang *et al.* (2007) reported that the addition of organic acids (citric, malic, and lactic) during marination improved the attribute flavor of food.

Table 1. The Averages Scores ± standard deviation of Aromas, Taste, Tenderness and Overall Acceptability of *Se'i* Processed from Beef Cull Cow with BCS 2, 3 and 4 and Added Lime or Kaffir Lime Juice

Body Condition Score	Citrus Juice	Aroma	Taste	Tenderness	Overall acceptability
2	NC	$3.72{\pm}0.17^{b}$	$3.11{\pm}0.16^{a}$	$3.12{\pm}0.69^{a}$	$3.75{\pm}0.19^{a}$
	LJ	$3.60{\pm}0.12^{b}$	$4.17{\pm}0.61^{c}$	$3.72{\pm}0.69^{c}$	$3.22{\pm}0.11^{a}$
	KLJ	$4.44{\pm}0.59^{c}$	$3.94{\pm}0.94^{b}$	$3.84{\pm}0.10^{c}$	$4.18{\pm}0.93^{b}$
3	NC	$3.48{\pm}0.11^{a}$	$3.25{\pm}0.21^{a}$	$3.84{\pm}0.86^{a}$	$3.84{\pm}0.06^{a}$
	LJ	$4.33{\pm}0.60^{c}$	$3.79{\pm}0.85^{b}$	$3.12{\pm}0.69^{a}$	$4.02{\pm}0.06^{b}$
	KLJ	$4.49{\pm}0.80^{cd}$	$3.89{\pm}0.73^{b}$	$3.38{\pm}0.93^{b}$	$4.54{\pm}0.02^{c}$
4	NC	$3.33{\pm}0.26^{a}$	$3.17{\pm}0.06^{a}$	$3.12{\pm}0.69^{a}$	$4.12{\pm}0.26^{b}$
	LJ	$4.58{\pm}0.47^{d}$	$4.04{\pm}0.83^{c}$	$3.67{\pm}0.73^{c}$	$4.27{\pm}0.05^{b}$
	KLJ	$4.76{\pm}0.29^{e}$	$4.01{\pm}0.92^{c}$	$3.81{\pm}0.10^{c}$	$4.58{\pm}0.10^{c}$

^{a,b} means in the same column with different superscript differ significantly (P<0.05).

Table 2. Water. Protein and Lipid Content in Raw Meat of Cull Cow with Different Body Condition Score (BCS)

BCS	Water (%)	Protein (%)	Fat (%)
2	62.25±0.03	28.62±0.74	6.42±0.17
3	65.36±0.09	25.59±0.08	7.05±0.03
4	67.12±0.12	21.03±0.007	8.96±0.02

Table 3. Organic Acids Content in Lime and Kaffir Lime

Citrus juice	Ascorbic acid (mg/100g)	The citric acid (%)	Tartaric acid (%)	Malic acid (%)
Lime	12	4.391	4.744	7.307
Kaffir lime	47	5.208	7.087	10.579

pH Value

Results of the present experiment showed that adding lime or kaffir lime juice reduced (P<0.01) the pH of *se'i* which was processed from the meat of cull Bali cows having BCS 2 and 3, whereas in se'i made from meat from fat cull cows (BCS4), pH was only significantly reduced when it was added with kaffir lime juice (Table 4). The pH decline with the addition of citrus juice occurred mainly due to the fact that lime and kaffir lime contained several organic acids as shown in Table 3. The result of the present experiment is consistent with previous results which showed that the addition of citrus juice significantly reduced the pH of meat processed products (Hong *et al*., 2016). In this case, the higher the organic acid content in citrus juice the higher the pH decline as observed in the present experiment. In this case, in kaffir lime added se'i pH was significantly higher than that in lime -added se'i.

The failure of the addition of lime to reduce pH in *se'i* made from BCS 4 was unexpected. and may have been resulted from the highest water content in the raw meat produced from cull cows having BCS 4 (67.12%) (Table 2). High water content could reduce the concentration of organic acids in lime juice when added to the meat. It was indicated that citrus juice can lower the pH but the effects depend on BCS which is related to water content in the raw meat.

Residual Nitrite

Residual nitrite is the amount of nitrite present after manufacturing (Cassens. 1997). In meat processing, nitrite can be converted to nitrosamine which has been identified as a potentially carcinogenic substance (Bedale *et al*., 2016). Thus, the residual nitrite in meat products should be controlled. The limits for residual nitrite permitted in meat products ranges from 40 to 100 ppm (Bao-jin *et al*., 2007), but in Indonesia, the limit is 30 ppm (Indonesian Food and Drugs Board, 2013). As shown in Table 4, the residual nitrite was slightly higher than the limit especially in se'i that was made from the meat of cull cow with BCS 2 and 3 with no addition of citric juice.

Nitrite loss during the manufacturing process depends on the pH of the products and also the addition of ascorbic acid (EFSA, 2003). As the pH value increases, the residual nitrite concentration also increases (Ahn and Maurer, 1989). The addition of ascorbic acid decreased residual nitrite in pork luncheon rolls (Hayes *et al*., 2013) and also in meat emulsions (Choi *et al*., 2017). When the residual nitrite decreases the nitrosamine formation also decreases (Giese, 1994). Hence. it was hypothesized in this experiment that adding citric juice could reduce the concentration of residual nitrite in se'i. As shown in Table 4, this is particularly true with the addition of lime. The addition of lime juice during the processing of se'i consistently reduced (P<0.001) the residual nitrite concentration in se'i made of meat from cull Bali cows with different BCS. On the other hand. the addition of kaffir lime juice reduced the residual nitrite of *se'i* made of meat from cull cows with BCS 2 and 3 (P<0.01) but failed to reduce the level of residual nitrite in BCS 4 (Table 4). From this study, it is indicated that lime juice is more effective in reducing the concentration of residual nitrite in *se'i* compared to kaffir lime juice. Previous results indeed showed that the addition of lime juice during the processing of se'i (Malelak et al., 2015; 2017) and cured beef (Ermawati *et al*., 2014) reduced the content of residual nitrite. However, the superiority of lime juice over kaffir lime juice is somewhat difficult to explain as the content of organics acids is higher in kaffir lime than in lime juice. Moreover. kaffir lime juice is a more pH depressant than lime juice in se'i.

Thiobarbituric Acid Reactive Substances Values

Lipid oxidation is one of the main factors that deteriorate meat quality and produce an undesirable flavor. The degree of lipid oxidation is determined by the concentration of thiobarbituric acid-reactive substances (TBARS) in meat and processed meat product (Arguelo *et al*., 2016). The amount of TBARS in meat or meat-processed products is commonly expressed as milligrams of malondialdehyde per kilogram of meat (Papastergiadis *et al.,* 2012). The concentration of TBARS as an indication of lipid oxidation in *se'i* processed from cull cow beef with BCS 2, 3, and 4 and given lime or kaffir lime juice are presented in Table 4. The result of the present experiment showed that the lowest TBARS concentration was 0.37 mg MDA/kg (BCS2LJ), and the highest was 0.84 (BCS4NC) mg MDA/kg. Bouyanfif *et al.* (2019) stated that food products with TBARS values < 0.576 mg MDA/kg are classified as fresh, and those with TBARS values between 0.65 mg and 1.44 mg MDA/kg DW are classified as rancid but they are still acceptable. Meanwhile, those with TBARS values 1.5 mg MDA/kg are classified as rancid and unacceptable for consumption. The TBARS values in this experiment ranged from 0.37 to 0.84 mg MDA/kg and therefore they were still acceptable.

Results of the present experiment indicated that adding both lime and kaffir lime juice reduced (P<0.01) TBARS concentration in s*e'i*. In this case, lime juice was more effective to inhibit lipid oxidation compared to kaffir lime juice in all BCS. The superiority of lime juice over kaffir lime juice in reducing TBARS in se'i appears to be unrelated to their organic ac-

Table 4. The Averages Value of pH. Residual Nitrite. TBA. TPC of *Se'i* Processed from Beef of Cull Cow with BCS 2. 3 and 4 and Added with Lime or Kaffir Lime Juice during Marination

Body Condition Score	Citrus Juice	pH	Residual Nitrite (mg/kg)	Lipid Oxidation (mg MDA/ kg)	Total Plate Count (log cfu/g)
2	NC	6.56^{c}	36.76^{f}	0.70^{de}	2.63^{e}
	LJ	6.36^{b}	21.27^{b}	0.37^{a}	1.55^{b}
	KLJ	6.28^{a}	25.30^{c}	0.58^{c}	1.58^{bc}
3	NC	6.58^{c}	32.95^{e}	0.74^{e}	3.72^{f}
	LJ	6.38^{b}	17.93^{a}	0.44^{a}	1.62^{c}
	KLJ	6.24^{a}	28.23^{d}	0.66^{d}	1.48^{a}
4	NC	6.58^{c}	29.74^{d}	0.84^{f}	5.35^{g}
	LJ	6.52^{c}	20.53^{b}	0.51^{b}	1.68^{d}
	KLJ	6.35^{b}	28.03^{d}	0.75^{e}	1.52^{ab}
SEM		0.023	0.767	0.023	0.018
P-values					
BCS		0.001	0.034	<0.001	<0.001
Citrus Juice		<0.001	<0.001	<0.001	<0.001
BCS x Citrus Juice		0.001	<0.001	0.009	<0.001

[a.b] means in the same column with different superscript differ significantly (P<0.01)
SEM = standard error means; P= probability. NC: non citrus/ control. LJ= lime juice. KLJ= Kaffir lime juice). MDA= malonaldehyde)

id content in the juice. The content of organic acids was higher in kaffir lime juice compared to that in lime juice (Table 3). The result of this study, therefore, demonstrated that lipid oxidation was also influenced by other components apart from organic acids. Citrus fruits are commonly rich in bioactive components such as vitamins A, C, and E, minerals, flavonoids, coumarins, limonoids, carotenoids, pectins (Zhou. 2012), and also many bioactive terpenes (Limonene, Citral, terpinene-4-ol) (Spadaro *et al*., 2012). Flavonoids are known as natural antioxidants and it inhibits lipid oxidation (Boshtam *et al*., 2011) and flavonoids content in kaffir lime juice was higher than in lime juice (Lubinska-Szczygieł *et al.* 2018). Similarly, vitamin E can protect cell membranes from oxidation damage (Dasgupta and Klein, 2014). Lemonade and citral concentration in lime was higher than in Kaffir lime (Lubinska-Szczygieł *et al.,* 2018). It is likely that in this experiment other antioxidants, i.e. terpenes (limonene and citral) in the citrus juice had a greater role in reducing fat oxidation in addition to organic acids, flavonoids, and/or vitamin E, and probably the content of those components in lime was higher than that in kaffir lime.

Total Plate count

The total plate count (TPC) of *se'i* processed from the beef of cull cow differing in their body condition score and given lime or kaffir lime juice were presented in Table 4. TPC observed in the present experiment varied between 3.199 x 10^1 and 5.248 x 10^3 CFU. This range of TPC appears still below the maximum limit set by NSAI. The maximum limit for bacterial contamination in smoked meat is $1x10^5$ CFU (5 logs CFU/g) (NSAI, 2009). The number of bacteria up to $1x10^7$ CFU usually smells off-odor or smells "cheesy" or "buttery" and if it reaches $1x10^9$ CFU "off-odor" already smells rancidity (Jay, 2000).

Nevertheless, the result showed that adding lime or kaffir lime juice significantly reduced TPC in *se'i* made of meat from cull Bali cows with different body condition scores. In this case, kaffir lime juice was more effective in reducing the TPC of *se'i* compared to lime juice (P<0.01). This can be attributed to the higher content of organic acid in kaffir lime compared to that in lime juice. Organic acids such as citric acid (Sekar, 2013; Hussain *et al*., 2015) and ascorbic acid (Benoy *et al*., 2016) are known as potent antimicrobial substances. Citric acid has been proven effective in inhibiting the growth of *Staphylococcus aureus* and *Escherichia coli* (Sekar, 2013; Al-Dalali *et al*., 2019). Citric acid can diffuse into the cell membrane and the form of the undissociated acid can reduce the concentration of acid ions in the microbial cytoplasm. Once in the microbial cytoplasm, weak acids can dissociate so that ions (H +) are released thereby the cytoplasmic pH will increase. Adding citrus juice which contains several organic acids will cause acid build-up in the cytoplasm. This will inhibit the release of H^+ and the transport of other substrates into the cytoplasm so that metabolism is inhibited. As a result, the microorganism development is inhibited (Vasseur *et al.,* 1999). The antimicrobial effect of ascorbic acid/vitamin C also may be exerted through the disruption of the microbial membrane since vitamin C can combine with microbial cell walls (Benoy *et al*., 2016).

CONCLUSION

This experiment concluded that the sensory values, i.e. aroma, taste, and acceptability are improved better with the addition of kaffir lime juice compared to lime juice especially when the raw meat is of lower quality, i.e., produced from thin cull Bali cows (BCS 2). However, fat oxidation and the total plate count are reduced better with the addition of lime juice compared to kaffir lime juice in all BCS, hence to improve shelf-life and food safety of se'i using citrus juice is considered to be more effective than kaffir lime juice. The best quality of se'i can be produced from raw meat taken from fat cull cows (BCS 4) and added with kaffir lime juice for best sensory properties and lime juice for longer (shelf-life and minimum bacterial contamination.

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