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Sensory-related Attributes of Raw and Cooked Meat of Culled Saanen Goat Marinated in Ginger and Pineapple Juices

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ABSTRACT

The effects of ginger and pineapple juices on pH, color (L*, a*, b*), thiobarbituric acid reactive substances (TBARS), sensory intensity, and sensory preference of culled goat meat were determined. Completely randomized design (CRD) and randomized completely block design (RCBD) were applied for physicochemical attributes and sensory profiles, respectively. In raw condition, the pH of ginger-marinated sample was higher than that of pineapple-marinated sample. The increased trend in pH was found in the ginger-marinated and control-marinated samples, while the decreased trend was found in pineapple-marinated sample. A better redness stability of ginger-marinated sample was observed during the storage. Both plant juices had significant effects on controlling the malonaldehyde (MDA) formation. Ginger-marinated sample exhibited a brighter red color, less gamey odor, stronger marinated odor, and higher preference. In cooked samples, increasing pH but still with similar trend as in all raw samples was recorded. L* and b* of all samples were decreased on the fifth day of storage, while a* of ginger-treated sample was immensely elevated. Marinated juices were significant on retarding MDA formation along with less browning color and gamey aroma intensities. Reddish-brown color and stronger marinated odor resulted in high preferences on ginger-marinated sample. Less brown color in pineapple-marinated sample contributes to lower color and overall acceptances. In conclusion, ginger juice had a significant effect on covering the gamey flavor and showed positive effect on other sensory-supported attributes.

Keywords: ginger juice; pineapple juice; marinades; meat color; sensory attributes

INTRODUCTION

Gamey odor is one of the main problems usually causing less preferences in some domesticated-animal meat. The term of gamey odor is associated with the odor of wildly free-living animals which is termed as game animals such as deer, feral buffalo, springbok, impala, etc. In some domesticated animals, this odor could still be easily detected on animal hair. To some degrees, severe gamey odor is even still also be found after cooking that further affects the taste and flavor of meat products. Due to its importance, this specific lexicon was used by some researchers to specify its intensity on domesticated meat such as beef (Maughan *et al*., 2012; Tansawat *et al*., 2013; O'Quinn *et al*., 2016) and culled beef (Stelzleni & Johnson 2008) whether in term of odor (raw meat) or aroma, taste, and flavor (cooked meat).

Goat is considered as a well-adapted small ruminant and being an important meat source in developing countries (Webb, 2014) and might be classified as a secondary ruminant class consumed worldwide. Although being a significant small ruminant for small scale Asian farmers or Moslem consumers, the preference is limited due to its strong gamey odor, taste, or flavor. As reported by Rødbotten *et al.* (2004), a great intensity of gamey odor in a raw goat meat was also slightly higher than that of hare meat, while similar trend was also found in the flavor of cooked meat. Even, less public preference on its smell and taste also increased with the older age of the goat (Ivanović *et al*., 2016).

Ginger (*Zingiber officinale*) and pineapple (*Ananas comocus*) are two important plants easily found in Asian wet market. Ginger is an essential root spices generally used to prepare curry in Southeast Asian kitchen, while pineapple is an optional ingredient that could be used to prepare barbeque. Besides the good tenderizing properties, attractive specific odor of those plants was considered. Since those plants are popular ingredients in Asian cooking, the application of such plants for marinade might relevant for the consumers. Ginger is characterized by its minty, lemon-like, and woody aroma (Pang *et al*., 2017), while fruity, apple-like, sweet, and caramel-like odor are significant in pineapple fruit (Zheng *et al*., 2012).

Marinating is one among various methods applied in meat and poultry meat processing. In Thailand practice, poultry meat are common meat type easily found with various marinade applications and thus various poultry meat marinade researches were also reported (Wongwiwat *et al*., 2010; Komoltri & Pakdeechanuan, 2012; U-chupaj *et al*., 2017; Kaewthong & Wattanachant, 2017; Saelin *et al*., 2017). In a modern butchery, meat could be found in the form of cube dimension as a ready-to-cook style sold in a supermarket. In Thailand, various cube meats marinated in local Thai mixed ingredients has been entering the modern butchery with a refrigerated temperature controller.

It is important to find a suitable odorant to cover or minimize the off-odor resulted from the gamey odor in the meat of Saanen-crossbred goat. The aromatic characteristics of ginger and pineapple were hypothesized to contribute to cover gamey odor/flavor and oxidation-related odor both raw and cooked meat of Saanen-crossbred goat. Therefore, the evaluation of ginger and pineapple used in the form of marinade juices in goat meat could be controlled with the same manner such butchery market as widely applied in poultry meat. The objective of this research was to determine the effect of ginger and pineapple juices on pH, color, TBA, sensory intensity, and sensory preference of raw meat of Saanen-crossbred goat during a refrigerated storage. Similar determination for cooked meat obtained from such treated meat as ready-to-eat meat was also conducted.

MATERIALS AND METHODS

Materials

Shoulder cut of 7-year-old culled Saanen-crossbred goat was obtained from frozen carcass after thawing. *M. supraspinatus* and *M. infraspinatus* were selected as the samples. The meat was cut into a 2 x 2 x 1.5 cm^3 dimension, placed in food container (square microwave container, polypropylene, aro®, Thailand), and stored in a refrigerator before marinated treatments (control, ginger marinated, and pineapple marinated). The fresh ginger and pineapple were bought from wet market in Songkhla Province, Thailand. Those plants were blended using a blender (Panasonic, Malaysia). Pure water extracts from those blended paste were filtered using white cotton and cooled in a refrigerator before being used. Twenty five percent (w/w) of each pure marinating agent was applied on meat for 30 min in refrigerated temperature. After that, marinated samples were moved from marinade juices, transferred into empty meat trays, and stored in a refrigerator. The samples were taken on days 1, 3, and 5 of storage for chemical and sensory analyses. Each sample was grilled using an electrical griller HSG-305 (Hanabishi, Thailand) for 7 min representing a cooked sample, while raw samples were directly analyzed.

Methods

pH. Blended meat was mixed with deionized water in the ratio of 1:5 and homogenized using a homogenizer (WiggenHauser®, Germany). A digital pH meter (WiggenHauser®, Germany) was used for pH measurement. Calibrating procedure was conducted using calibration solution at pH 7 and 4 before sample reading, respectively (Wattanachant, 2004).

Color. A Hunterlab colorimeter (Hunterlab ColorFlex, Virginia) was used to measure the lightness (L*), redness (a*), and yellowness (b*) colors of meat surfaces. Standardization of color instrument was conveyed using a black glass and a white standard tile before sample reading (Putra *et al*., 2017).

Thiobarbituric acid reactive substances (TBARS). Malonaldehyde (MDA) substance was measured using distillation method and analyzed by TBA reagent as adapted from Tarladgis *et al.* (1960). Minced meat (10 g) was homogenized with deionized water (50 mL) using a homogenizer for 1 min in 250 mL beaker glass. Then, the homogenate was transferred into a 500 mL Erlenmeyer flask. The remaining homogenate was washed using deionized water and transferred into such Erlenmeyer flask to the amount of 47.5 mL. Subsequently, 2.5 mL of 4 N HCl was added to the mixture and then shaken properly. Ten drops of antifoaming was dropped into the Erlenmeyer before distillation sequence was applied. The sample was heated at 380°C and distilled solution was collected using 50 mL Erlenmeyer flask. After that, 5 mL of distilled solution was mixed with 5 mL of TBA reagent, and the mixture was transferred to stopper tube and homogenated properly using a stirrer. Such TBA reagent used was prepared from the dilution of 0.02 M TBA in 10 mL of deionized water and 90 mL of glacial acetic acid. The tube was heated at 98-100°C in a water bath for 35 min. After cooling using running tap water, the solution reading was conducted at 538 nm using a spectrophotometer. Standard curve of 1,1,3,3-tetramethoxypropane were used to express TBARS in mg MDA equivalent/kg sample.

Sensory evaluation. Sensory evaluation was conducted by adapting the general guidelines explained by Meilgaard *et al.* (2016). A total of 15 semi-trained panels were used to score their sensory preferences and sensory intensities on samples provided. The samples were served to the panels using three digit numbers. The sensory intensity was determined using 9-point-scale to develop a specific lexicon of its detectable characteristics. The sensory preference was conveyed using 9-point-scale (1= dislike extremely, 9= like extremely) for color, odor/aroma, and overall acceptance for both raw and cooked samples.

Statistical analysis. Research was carried out using a completely randomized design (CRD) for physicochemical attributes and randomized completely block design (RCBD) for sensory profiles. Statistical analysis was conducted using SPSS program. One-way ANOVA was conveyed for comparing means determination. Post hoc multiple comparisons was analyzed using Duncan at a significant level of 0.05.

RESULTS

Raw Meat

The pHs of ginger and pineapple juices used were 6.64 and 3.74, respectively. The pH, color (L*, a*, b*), and TBARS of raw meat of culled Saanen-crossbred goat masked with some marinating agents during refrigerated storage are presented in Figure 1. Non-marinated samples exhibited significantly higher pH than that of marinated-samples with ginger and pineapple (P<0.05). During storage, the increasing pH of non-marinated and ginger-marinated samples was observed (P<0.05). In contrast, the decreasing pH of pineapple-marinated samples during storage was recorded (P<0.05).

The lightness of samples from non-marinated and ginger-marinated samples were comparable on the first day of storage period, but higher than that of pineapple-marinated sample. During storage, the lightness of ginger-marinated and pineapple-marinated samples were more significant than non-marinated sample (P<0.05). The increasing trend of lightness was also found in non-marinated samples on the third day of storage (P<0.05), however, it was stable until the fifth day of storage. The redness of non-marinated sample was higher than that of ginger-marinated and pineapple-marinated samples on the first day of storage (P<0.05). The redness of non-marinated sample was far decreased on the third and fifth days (P<0.05). The yellowness of pineapple-marinated sample was lower than that of non-marinated and ginger-marinated samples on the first day of storage. A gradual increase in the yellowness was found in ginger-marinated and pineapple-marinated samples by the longer days of storage, while the increasing of yellowness in non-marinated sample was recorded on the fifth day of storage.

Ginger-marinated samples exhibited lower TBARS compared to the others on the first day of storage (P<0.05). On the third day, TBARS of all samples increased meaningfully. Moreover, non-marinated samples revealed higher TBARS compared to the others (P<0.05). On the fifth day, the decreasing of TBARS

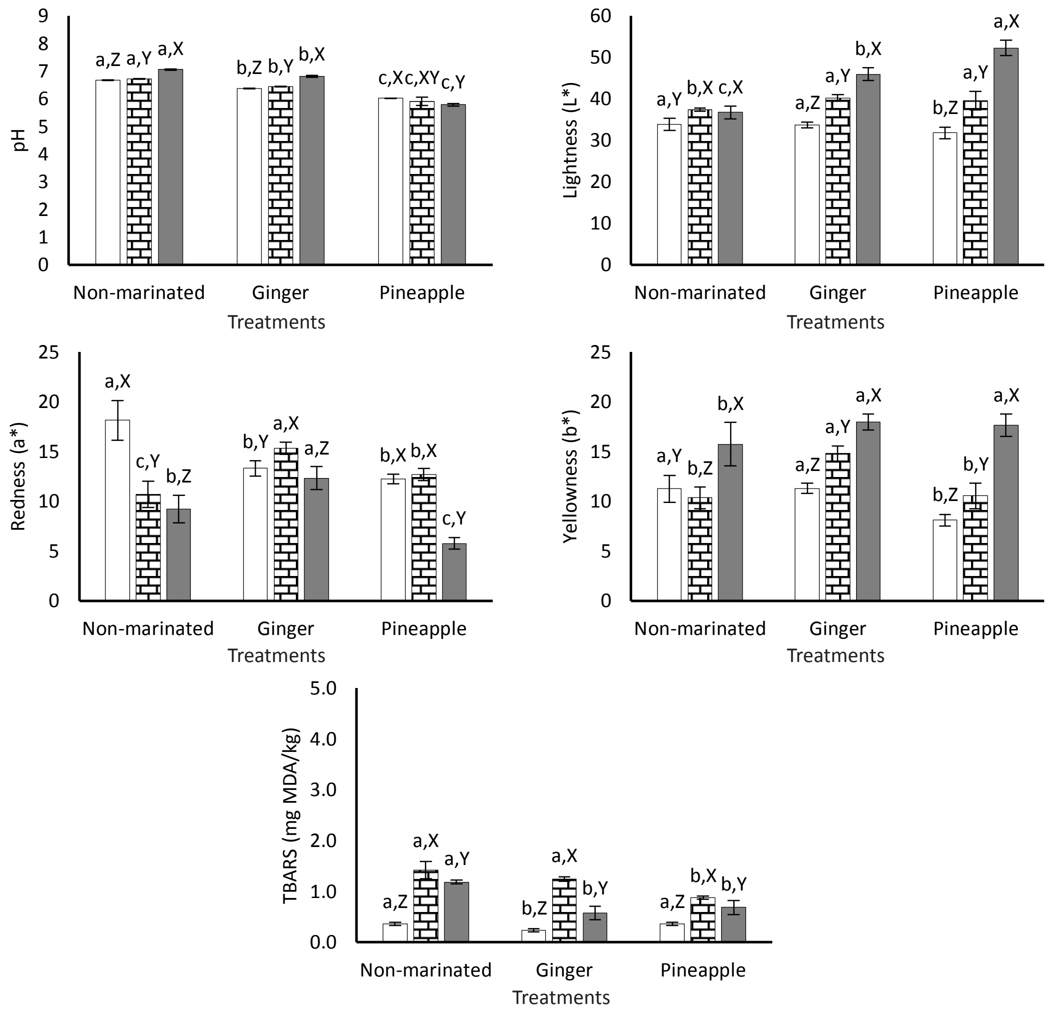

Figure 1. pH, lightness (L*), redness (a*), yellowness (b*), and TBARS (mg MDA/kg) of raw culled Saanen crossbred goat meat masked with some marinating agents during refrigerated storage (□ Day 1 ⊞ Day 3 ■ Day 5). [abc]Means (±SD) within various marinating agents with different lower cases differ significantly (P<0.05); [XYZ]Means (±SD) within various storage periods with different upper cases differ significantly (P<0.05).

Table 1. Sensory attributes of raw culled Saanen crossbred goat meat masked with some marinating agents during refrigerated storage

Sensory evaluation	Storage day	Treatments		
		Non-marinated	Ginger	Pineapple
Sensory intensity				
Redness intensity	Day 1	7.20±1.57^{a,X}	5.07±1.33^{b,X}	5.80±1.82^{b,X}
	Day 3	6.80±1.08^{a,X}	4.60±1.80^{b,X}	6.67±1.35^{a,X}
	Day 5	5.93±2.34^{a,X}	5.07±1.75^{a,X}	6.53±1.88^{a,X}
Wholeness odor intensity	Day 1	5.60±1.88^{a,X}	6.07±1.98^{a,X}	6.27±1.94^{a,X}
	Day 3	4.60±2.20^{a,X}	5.00±2.78^{a,X}	5.47±1.73^{a,X}
	Day 5	5.60±1.99^{a,X}	5.60±2.50^{a,X}	5.20±1.78^{a,X}
Gamey odor intensity	Day 1	5.33±2.02^{a,X}	4.00±2.20^{a,X}	5.13±2.39^{a,X}
	Day 3	6.00±2.14^{a,X}	2.73±2.02^{b,X}	5.00±2.42^{a,X}
	Day 5	4.93±3.22^{a,X}	4.13±3.09^{a,X}	4.93±2.43^{a,X}
Marinade odor intensity	Day 1	2.13±1.19^{c,X}	6.80±2.04^{a,X}	4.13±2.03^{b,X}
	Day 3	1.60±0.74^{c,XY}	7.60±0.99^{a,X}	5.53±1.81^{b,X}
	Day 5	1.27±0.59^{c,Y}	7.87±1.25^{a,X}	5.47±2.67^{b,X}
Sensory preference				
Color acceptance	Day 1	7.47±1.06^{a,X}	5.33±1.68^{b,Y}	5.80±1.57^{b,Y}
	Day 3	6.40±1.30^{a,Y}	7.20±1.32^{a,X}	4.60±1.59^{b,Y}
	Day 5	4.13±2.00^{b,Z}	7.67±1.29^{a,X}	4.40±1.64^{b,Y}
Smell acceptance	Day 1	5.20±2.14^{a,X}	6.40±1.88^{a,Y}	5.13±2.10^{a,X}
	Day 3	5.40±1.72^{b,X}	7.67±0.98^{a,X}	4.87±1.51^{b,X}
	Day 5	4.33±1.95^{b,X}	7.27±1.39^{a,XY}	4.73±1.58^{b,X}
Overall acceptance	Day 1	6.33±1.72^{a,X}	6.80±1.42^{a,Y}	5.00±1.31^{b,X}
	Day 3	6.20±1.57^{b,X}	7.67±0.90^{a,X}	4.73±1.22^{c,X}
	Day 5	5.20±1.74^{b,X}	7.60±1.06^{a,XY}	4.53±1.36^{b,X}

Note: ^{abc}Means (±SD) within various marinating agents with different lower cases differ significantly (P<0.05); ^{XY}Means (±SD) within various storage periods with different upper cases differ significantly (P<0.05).
Redness color - redness representing freshness of sample (1= pale red extremely, 9= dark red extremely), wholeness odor - intensity of sum of all odors (1= undetectable extremely, 9= detectable extremely), gamey odor - odor representing wild animal (1= undetectable extremely, 9= detectable extremely), marinade odor - odor representing marinated agent used (1= undetectable extremely, 9= detectable extremely).

in all samples were observed (*P*<0.05). However, the marinated samples still showed lower TBARS compared to the non-marinated samples. Moreover, the decreasing trend of TBARS on the fifth day was observed in all treatments.

The sensory intensity and sensory preference of raw meat of culled Saanen-crossbred goat masked with some marinating agents during the refrigerated storage are presented in Table 1. In sensory intensity, gamey odor intensity in ginger-treated samples was lower than that of the others (*P*<0.05). At the same time, pineapple-marinated samples exhibited a comparable result to the non-marinated sample. The intensity of marinade odor in ginger-marinated sample was significantly higher than that of pineapple-marinated sample (*P*<0.05). Moreover, the increasing trends of intensities of odors in both marinades on the third and fifth days of storage were observed.

In sensory preference, non-marinated samples revealed a higher color preference on the first day of storage compared to the others (*P*<0.05). The decreasing color acceptances in non-marinated and pineapple-marinated samples during storage were observed, while the color preference on ginger-marinated sample was increased (*P*<0.05). At the same time, smell acceptance of panels on ginger-marinated sample was higher than the others. The comparable results between non-marinated and pineapple-marinated samples were observed. These similar results represented the inability of pineapple-juice odor to cover the gamey odor during all storage periods. Overall acceptance of non-marinated and ginger-marinated samples on the first day were comparable, but higher than that of pineapple-marinated sample (*P*<0.05). Overall acceptance of non-marinated and pineapple marinated samples was decreased with the longer storage period.

Cooked Meat

Variables of pH, color (L*, a*, b*), and TBARS of grilled meat of culled Saanen-crossbred goat masked with some marinating agents during refrigerated storage are presented in Figure 2. Pineapple-marinated samples exhibited a lower pH compared to the ginger-marinated and non-marinated samples on the first day of storage. Furthermore, increasing pH on the fifth day was observed in all samples.

The lightness of ginger-marinated and pineapple-marinated samples were higher than that of non-marinated sample during all storage days (*P*<0.05). The redness intensities of non-marinated and ginger-marinated samples on the first day of storage were higher than that

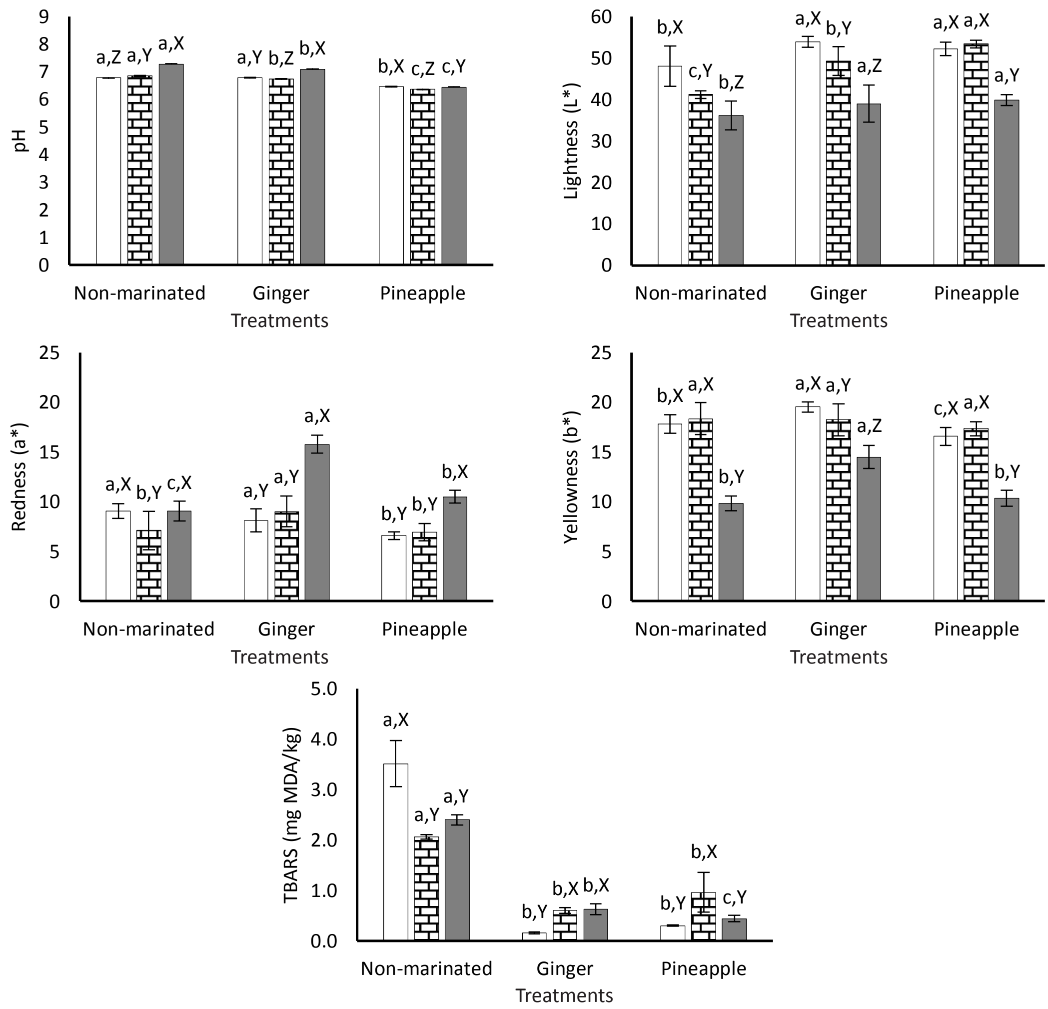

Figure 2. pH, lightness (L*), redness (a*), yellowness (b*), and TBARS (mg MDA/kg) of cooked culled Saanen crossbred goat meat masked with some marinating agents during refrigerated storage (□ Day 1 ⊞ Day 3 ■ Day 5). [abc]Means (±SD) within various marinating agents with different lower cases differ significantly (P<0.05); [XYZ]Means (±SD) within various storage periods with different upper cases differ significantly (P<0.05).

of pineapple-marinated samples. Increases in the redness intensities on the fifth day in both ginger-marinated and pineapple-marinated samples were observed. At the same time, the yellowness intensities of all samples were stable during the third day of storage, while the decreasing result in yellowness intensity was observed on the fifth day of storage.

Non-marinated samples exhibited significant higher TBARS compared to the others (*P*<0.05). The decreasing TBARS in non-marinated samples after the first day of storage was observed. In contrast, the increasing TBARS on the third day of storage period was also observed.

Sensory intensity and sensory preference of grilled meat of culled Saanen-crossbred goat masked with some marinating agents during the refrigerated storage are presented in Table 2. The sensory intensity and brownness intensity of ginger-marinated and pineapple-marinated samples were lower than those of non-marinated samples (*P*<0.05). The wholeness aroma intensities of all samples were similar and comparable until the third day of storage. However, marinated samples exhibited the decreasing intensities. Gamey aroma of ginger-marinated and pineapple-marinated samples on the first day was lower than that of the others. Moreover, the non-significant results between ginger-marinated and pineapple-marinated samples were observed. Comparable results of all treatments within storage period were recorded. Marinade aroma of ginger on the first day was significantly higher than that of pineapple. On the third and fifth days of storage, the intensities were not much different (*P*<0.05). This occurrence could support the result of gamey aroma intensity obtained in ginger-marinated and pineapple-marinated samples.

In sensory preference, color acceptance of non-marinated sample was higher than that of the other on the first day of storage period. The ginger-marinated samples exhibited the increasing color acceptances during storage, while the non-marinated and pineapple-marinated samples were decreased. Smell acceptance of ginger-marinated samples was higher than that of other in all storage days. At the same time, smell acceptance between non-marinated and pineapple-marinated samples was comparable. Overall acceptance of ginger-

Table 2. Sensory attributes of cooked culled Saanen crossbred goat meat masked with some marinating agents during refrigerated storage

Sensory evaluation	Storage day	Treatments		
		Non-marinated	Ginger	Pineapple
Sensory intensity				
Brownness intensity	Day 1	6.80±1.42^{a,X}	4.80±1.26^{b,X}	4.47±2.13^{b,X}
	Day 3	7.53±1.06^{a,X}	5.73±1.44^{b,X}	4.80±2.31^{b,X}
	Day 5	6.67±2.35^{a,X}	4.87±1.13^{b,X}	3.80±2.51^{b,X}
Wholeness aroma intensity	Day 1	5.40±1.88^{a,X}	5.73±1.75^{a,X}	4.60±1.80^{a,X}
	Day 3	5.53±2.10^{a,X}	5.53±2.10^{a,X}	5.00±1.96^{a,X}
	Day 5	6.80±1.47^{a,X}	5.27±2.49^{b,X}	5.00±1.81^{b,X}
Gamey aroma intensity	Day 1	6.00±2.20^{a,X}	4.20±2.14^{b,X}	4.93±1.79^{ab,X}
	Day 3	5.20±2.37^{a,X}	3.87±2.13^{b,X}	4.13±2.33^{b,X}
	Day 5	4.87±2.67^{a,X}	3.73±2.09^{a,X}	4.07±2.15^{a,X}
Marinade aroma intensity	Day 1	2.53±1.96^{c,X}	5.73±1.75^{a,X}	3.93±1.79^{b,X}
	Day 3	2.20±1.52^{b,X}	5.93±1.67^{a,X}	5.07±2.46^{a,X}
	Day 5	2.00±1.46^{b,X}	4.27±2.69^{a,X}	4.47±2.61^{a,X}
Sensory preference				
Color acceptance	Day 1	7.13±0.99^{a,X}	5.67±1.50^{b,Y}	5.07±1.94^{b,X}
	Day 3	6.27±1.83^{a,XY}	6.40±1.40^{a,XY}	4.67±1.80^{b,X}
	Day 5	5.80±1.61^{a,Y}	6.87±1.60^{a,X}	4.33±1.95^{b,X}
Smell acceptance	Day 1	4.93±1.44^{b,X}	6.40±1.40^{a,X}	6.13±2.23^{ab,X}
	Day 3	5.33±1.72^{b,X}	7.20±1.26^{a,X}	4.87±1.73^{b,XY}
	Day 5	3.53±1.55^{b,Y}	7.27±1.28^{a,X}	3.53±1.36^{b,Y}
Overall acceptance	Day 1	5.86±1.75^{a,X}	6.33±1.50^{a,X}	5.20±1.93^{a,X}
	Day 3	5.93±1.53^{b,X}	7.13±1.25^{a,X}	3.67±1.63^{c,Y}
	Day 5	5.40±2.03^{b,X}	7.13±0.92^{a,X}	2.53±0.99^{c,Z}

Note: ^{abc}Means (±SD) within various marinating agents with different lower cases differ significantly (P<0.05); ^{XY}Means (±SD) within various storage periods with different upper cases differ significantly (P<0.05).
Color - Brownness/whiteness representing color of cooked sample (1= light white extremely, dark brown extremely), wholeness aroma - intensity of sum of all aroma (1= undetectable extremely, 9= detectable extremely), gamey aroma - aroma representing wild animal (similar with goat skin odor) (1= undetectable extremely, 9= detectable extremely), marinade aroma - aroma representing marinated agent used (1= undetectable extremely, 9= detectable extremely).

marinated sample was higher than that of the others. Ginger-marinated sample exhibited a higher overall acceptance after the first day of storage. The acceptance level of non-marinated sample was not much changed, while the grilled sample from pineapple-marinated sample exhibited a decreasing overall acceptance during the storage.

DISCUSSION

Raw Meat

Organic acids of pineapple are responsible for the lowest pH values in the pineapple-marinated samples. Pongjanta *et al.* (2011) noted that citric acid is the predominant fraction among various organic acids in pineapple. The others were acetic acid, malic acid, ascorbic, tartaric, oxalic, and sacinic. Lu *et al*. (2014) also highlighted citric, malic, and quinic acids as the major organic acids in various pineapple genotypes. The formation of ammonia and amine during the degradation of protein (Ikonić *et al*., 2013) might be responsible for the increasing pH of the non-marinated and ginger-marinated samples. Such samples had near neutral pH and thus potentially had greater microbial growth and microbial-metabolism products. Moreover, even though microbial metabolism also developed, the decreasing pH by a longer storage time might be associated with the predominant effect of high sugar content of pineapple. The transformation of sugar into lactate resulted in a gradual more acidic condition.

The phenomenon of lower redness in ginger-marinated and pineapple-marinated samples on the first day is due to a covered effect of yellow pigment of ginger juice sample as well as the coagulation of myofibril protein in an acidic pineapple juice. The non-significant substance to prevent the acceleration of transformation of red pigment myoglobin from ferric to ferrous form is responsible for the significant decreasing phenomenon in the non-marinated samples on the third and fifth days of storage. Oxidation caused a transformation of myoglobin state from Fe^{++} (ferrous) to Fe^{+++} (ferric) and thus resulted in a brown meat color formation (Suman & Joseph, 2013). Moreover, the redness of ginger-marinated samples might be associated with their high abilities to transform ferric to ferrous state. This condition was in line with the results of FRAP (Ferric Reducing Ability of Plasma) assay determination reported by Halvorsen *et al.* (2002) which observed a higher ability of ginger (3.76 mmol/100g) to reduce ferric ion to ferrous ion compared to pineapple (1.04 mmol/100g). Moreover, a higher ferric-to-ferrous ion reduction was exhibited in ginger processed with stir fry (Li *et al.*, 2016) that was quite identic with the grilled process in the present study. Furthermore, the yellow color of ginger juice is responsible for the high yellowness color in ginger-marinated samples.

Among various compounds in gingerols and shogaols as substantial compounds in ginger, [6]–gingerol and [6]–shogaol had better antioxidant strengths (Guo *et al.*, 2014). Citric acid as the common organic acid in pineapple plays an important role as a metal chelator and thus inhibits lipid oxidation in meat. The significant role of citric acid on retarding TBA formation was also reported by Kim *et al*. (2015). The decreased TBARS in all samples on the fifth day of storage might be due to the crosslinking of the malonaldehyde with free amino acids resulting in a Schiff base - a sequence of the maillard browning reaction.

A strong ginger odor successfully results a positive covered effect on the ginger-marinated samples. Monoterpenes and sesquiterpenes are the two major odorants found in ginger (Pang *et al.*, 2017). Hexanoic acid methyl ester and ocatanoic acid methyl ester are two foremost odorants identified in pineapple (Liu *el al*., 2011). The elevation of odor intensity of ginger-marinated and pineapple-marinated samples on the third and fifth days might be due to the loss of drip by a longer storage period. Then, the remaining aromatic compounds were absorbed by fat and the meat protein was smelled stronger.

The elevation of the color in ginger-marinated samples by a longer storage time might be associated with the lighter color as was obtained in color instrumental analysis. Therefore, samples marinated in ginger juice visually look cherry redder than the others. The smell and color might significantly cause a higher overall acceptance of ginger-marinated samples than the others.

Cooked Sample

The existence of some organic acids after cooking caused an acidic pH on the pineapple-marinated samples on the first day of storage. The accumulation of microbial metabolic compounds might be responsible for the elevation of pH on the last day of storage. Besides, the formation of degraded compounds from lipid oxidation and Maillard reaction induced by heat during grilling will generate the increasing effect.

Cooking process resulted the increasing of meat lightness (Sen *et al*., 2014) due to the denaturation of meat protein. The colors of juices significantly interfere with the original lightness of marinated samples. The decrease in lightness intensity during storage in all samples were recorded. This decrease might be associated with a darker browning formation by a longer storage time as the crosslinking of malonaldehyde with the free amino group. Likewise, a severe transformation of a yellow color into a brown color is responsible for the decreased intensity of yellowness on the last day of storage.

Free radical scavenging activity and chelating ability might be responsible for antioxidant effect of ginger (Yeh *et al*., 2014) as well as the role of citric acid in ginger as a chelator as was explained earlier. To some degrees, MDA formation in this study as the occurrence of oxidation might be transformed into a conjugated Schiff base. In a deeper explanation, the interaction of MDA with amino acid is responsible for Schiff base formation (Frankel, 2012).

The acidic effect of pineapple juice caused the denaturation of myofibril protein. This condition changes the color of sample into a less browned color after cooking. At the same time, the higher browning formation in a non-marinated sample might be associated with the normal denaturation of globin protein induced by heat during heating. Dull brown color in cooked meat is associated with the formation of denatured globin hemi-chrome due to the denaturation of globin in metmyoglobin (Suman & Joseph, 2014).

The loss of some marinated juices on the fifth day of storage might be a significant cause of the decreased remaining juices aroma after cooking. Moreover, the effect of strong ginger aroma could cover such unattractive gamey odor. Since grilling could remove some of water content and changed flavor compounds, the occurrence might relevant with the study of raw and drying gingers as reported by Bartley & Jacobs (2000). The authors found the decrease in gingerol, increase in terpene hydrocarbons, and the conversion of monoterpene alcohol into acetates. Furthermore, geraniol (18.47%), zingiberene (13.44%), zingerone (7.49), and 6-shogaol (6.30%) were more dominant in the fresh ginger. Moreover, drying process resulted in the changes of some volatile compounds that are dominated by zingiberene (24.58%), (E,E)-a-Farnesene (14.19%), β-Sesquiphellandrene (7.64%), and β-Phellandrene (4.68%).

The higher color preference on the non-marinated sample is due to its normal browning effect. At the same time, pineapple-marinated samples seem to be lighter brown. Higher redness formation particularly on the fifth day caused higher color acceptance of ginger-marinated sample during storage.

Stronger lemon-like odor in ginger-marinated sample caused higher acceptance of ginger-marinated sample during storage. This specific odor could cover gamey odor and off-odor formation resulted from microbial metabolism. Guerrero-Legarreta (2014) noted that bacteria play significant contribution to proteolysis and lipolysis in meat, while endogenous proteases and lipases might just resulted a lesser effect. Furthermore, the approved antimicrobial effects of ginger (Gonçalves*et al*., 2014) and pineapple (Ali *et al*., 2015) could retard the microbial growth. Thus, less protein and lipid degradation might occur due to the less formation of microbial proteases and lipases.

CONCLUSION

Meat treated with ginger juice typically perform closer pH to a raw sample and had intense red color, lower gamey odor, and intense marinated odor compared to sample treated with pineapple juice. Those marinated juices were significant for their oxidant stability and had higher and stable acceptance during storage. Ginger juice is considered as a potential marinated agent to minimize the gamey odor/flavor and lipid oxidation formation on refrigerated meat of Saanen-crossbred goat.

CONFLICT OF INTEREST

Authors declare that there is no conflict of interest in relation to this article.

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