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# Combined Effect of Garlic Juice and Sa-Tay Marinade on Quality Changes of Oyster Meat during Chilled Storage

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## ABSTRACT

Traditionally, meat has been marinated to improve yield, flavor, tenderness, and may increase product shelf life. Sa-tay is a popular dish in Thai restaurant. Physical, chemical, microbiological and sensory qualities after the oyster meat treated with garlic 0, 2 ml of garlic juice then marinated with Sa-tay condiment (8%, wt/wt) were monitored during chilled storage, 4˚C ± 2˚C. pH and glycogen content of all treatments decreased while TVB, lactic acid content, ammonia content and K-value increased as storage time. A TBARS, rancidity indicator, of the control was higher compared with other treatments. Mesophilic and lactic acid bacteria of all treatments particularly the oyster treated with the juice increased as storage time increased. However, psychrophilic bacteria, coliforms, fecal coliforms, *Escherichia coli*, *Staphylococcus aureus*, *Salmonella* spp. and *Vibrio* spp. were low throughout the storage. Consumer acceptability scores of all treatments were higher than borderline (>5) at the end of the storage, 12 days.

**Keywords:** Oyster Meat; Garlic Juice; Sa-Tay; Marinated

## 1. Introduction

Oyster is one of the delicious, nutritious and may be the most expensive bivalve mollusks [1]. It is often eaten raw or lightly cooked, which leads to high risk to have direct implications for disease transmission since bivalve mollusks are filter-feeders that obtain food from the environment by filtering seawater through their gills [2,3]. The pathogenic bacteria, biological toxins and harmful chemicals which accumulate in the oyster are the results of limits of consumers' safety. In addition, oyster is perishable product therefore qualities and economic losses are normally found and necessary to have a proper manage.

Marinating is a process which meat is soaked in marinade-ingredients prior to further process [4]. Marinade is a seasoned solution that serves as substances for meat to be soaked. It is commonly used to increase meat yield, improve meat flavor, tenderness and juiciness by increasing water holding capacity, lower cooking losses, resulted to extend the shelf life of meat [5]. Marinating can be performed through soaking, injection, or tumbling [6]. Generally, garlic is often used as a seasoning agent in marinated meat because of its possessed antibacterial activity leading to lower bacterial count [7]. Nurwantoro *et al.*, [8] addressed that counts of *E. coli*, *Salmonella*, *Staphylococcus*, *Streptococcus*, *Klebsiella*, *Proteus*, *Bacillus*, *Clostridium*, and *Heliobacter pylory* were reduced when treated with garlic. And allicin is a majority active compound responsible for antibacterial action and typical smell of crushed garlic [9]. Pěrez-Giraldo *et al.*, [10] reported that allicin with concentration of 4 mg/ml could inhibit the formation of biofilms (bacterial capsules) nearly 50% cultures of *S. epidermidis* incubated 24 hours.

Sa-tay is a popular ordered dish for all age people in Thai restaurant or even street food shop due to its good smell, creamy, mild taste and extractive color as yellow or brow-yellow. Generally, the ingredients consist of turmeric rhizome, galangal rhizome and garlic bulb. However, the difference of ingredients in term of variety and quantity used in the recipe from home to home or region to region can be found [11]. Since some ingredients used in the Sa-tay have been reported that may contain antimicrobial, antioxidant and medicinal value [12] then the objective of this study was to determine the effect of garlic juice and Sa-tay marinade on physical, che-

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mical and microbiological qualities and sensorial score of oyster meat during chilled storage.

## 2. Materials and Methods

### 2.1. Garlic Juice Preparation

The fresh garlic washed with tap water was blended with blender in a Philips HR-2068 blender (Thailand) before brought to blend with sterilized distilled water at a ratio of 1:3 (garlic:water) until it turn to be slurry.

### 2.2. Sa-Tay Marinade Preparation

The Sa-tay marinade included of brand curry powder 50%, garlic 25% and galangal 25%. The fresh garlic and galangal was blended with blender in a Philips HR-2068 blender (Thailand) before brought to blend with the curry powder and marinade with oyster meat for 30 min.

### 2.3. Oyster Preparation

The oyster meat was washed with tap water before divided into four groups as control sample and oyster meat treated with garlic juice 2 ml, garlic 2 ml + Sa-tay marinated 8% and Sa-tay marinated 8%, respectively. The marinated and un-marinated samples were subjected to analyze for physical, chemical and microbiological quailties and sensorial acceptability during chilled storage.

### 2.4. Physical Analysis

#### 2.4.1. pH

Samples were blended with sterilized distilled water at a ratio of 1:5 (sample:water) and allowed to stand for 2 min before measuring their pH measured with a pH meter (Mettler 350, Singapore).

#### 2.4.2. Color Value

Color of the marinated oyster meat was measured using a color meter (Hunter lab Universal Software). The color was expressed in L*, a*, and b* values, where L means degree of lightness of the samples and ranges from 0 - 100, a means redness to greenness (+ is red, − is green) and b means yellowness to blueness (+ is yellow, − is blue).

### 2.5. Chemical Analysis

#### 2.5.1. Acidity

The method used to determine % lactic acid was based on Simsek *et al*., [13]. Five grams of oyster meat sample was blended and homogenized with 50 ml of distilled water. Then, 5 drops of 1% phenolphthalein were added and mixed. The samples were titrated with 0.1 M NaOH. The formula to calculate % lactic acid (LA) was as followed:

$$\%\ \text{Lactic Acid}\ (\text{LA}) = \frac{\text{Molarity of NaOH} \times \text{molecular mass of LA} \times 100}{\text{Weight of the sample}\ (\text{g})}$$

where,

Molarity of NaOH = 0.1

Molecular mass of LA = 90.08

#### 2.5.2. Determination of K-Value Using Ion Exchange Chromatography

K-value was determined using anion-exchange column chromatography [14]. A ground sample (1 g) was subjected to a serial extraction using 10% PCA and 5% PCA. The final extract (2 ml) was adjusted to pH 9.4 using 0.5 N $NH_3$ (aq). The prepared extract (pH 9.4) was loaded onto an anion-exchange column (1 × 10 $cm^2$) containing Resin-AG (R) 1-$X^4$, 400 meshes Cl-form. The column was rinsed using deionised water (20 ml). The elution was performed using 45 ml of solution A (0.001 N HCl). The eluate was collected, and the volume was made up to 50 ml using solution A. Thereafter, the column was eluted with 45 ml of solution B (0.01 N HCl containing 0.6 M NaCl). The resulting eluate was made up to 50 ml using solution B. Both eluates were read at 250 nm using the corresponding eluent (solution A or B) as the blank. K-value was calculated as follows:

$$\text{K} - \text{value}\ (\%) = \frac{\text{A}}{\text{A} + \text{B}} \times 100$$

where A is $A_{250}$ of eluate A representing the amount of inosine (HxR) and hypoxanthine (Hx), and B is $A_{250}$ of eluate B representing the amount of ATP, ADP, AMP, and IMP.

#### 2.5.3. Total Volatile Base (TVB)

Total volatile base (TVB) contents in the oyster meat were determined using the Conway micro-diffusion method as described by Conway and Byrne [15]. The sample, 2 g was mixed with 8 ml of 4% tricloroacetic acid (TCA) then homogenized at 6500 rpm for 1 min. The homogenate was filtered through Whatman No. 41 filter paper and the filtrate was used for analyses. Sample extract (1 ml) was placed in the outer ring. The inner ring solution (1% boric acid containing the Conway indicator) was then pipette into the inner ring. To initiate the reaction, $K_2CO_3$ (1 ml) was mixed with sample extract. The Conway unit was closed and incubated at room temperature for 90 min. The inner ring solution was then titrated with 0.02 N HCl until the green color turned to pink. TVB were released after addition of saturated and diffused into the boric acid solution. The titration of solution was performed and the amount of TVB was calculated.

 

#### 2.5.4. Thiobarbituric Acid Reactive Substances (TBARS) Value

Ten-gram sample of oyster meat was blended with 50 ml distilled water for 2 min then transferred to a distillation tube. The cup used for blending was washed with an additional 47.5 ml of distilled water. This was added to a distillation tube containing 2.5 ml 4 N HCl and a few drops of antifoam agent. Five-ml of 0.02 M 2-thiobarbituric acid in 90% glacial acetic acid (called a TBA reagent) was added to a vial containing 5 ml of distillate and mixed well. The vials were capped and heated in boiling water for 30 minutes and cooled to room temperature. The absorbance was measured at 352 nm using a spectrophotometer [16].

#### 2.5.5. Determination of Ammonia Content

Ammonia content was determined as described by Parris and Foglia [17]. Sample powder (10 g) was placed in a 600 ml round bottom flask containing 200 ml of distilled water; 10 g carbonate-free MgO and a few drops of antifoam. The mixture was distilled and the distillate 100 ml was collected in an erlenmeyer flask containing 20 ml of 0.1 N HCl. Collected distillate was titrated using 0.05 N NaOH and methyl red was used as an indicator. Ammonia content was calculated and expressed as mg/g sample.

#### 2.5.6. Determination of Glycogen

Sample (50 mg) was boiled with 400 µl of 33% KOH for 20 min. After cooling 700 µl of 96% ethanol was added. The mixture was placed in an ice bath to allow the complete precipitation (~2 h). Thereafter, the mixture was centrifuged at 7500 ×g for 20 min and the supernatant was discarded. One ml of distilled water was added to the pellet, followed by sonication. Subsequently, 100 µl of sample solution was incubated at 90˚C in 2 ml of anthrone reagent (38 ml of concentrated sulphuric acid was added to 15 ml of distilled water and 0.075 g of anthrone) for 20 min in dark and the absorbance was read at 620 nm. Glycogen concentration was calculated from standard curve using glycogen from oyster (II) as standard [18].

### 2.6. Bacteriological Analysis

Total viable count, psychotrophic count, *S. aureus*, *Salmonella* spp., *E. coli*, *Vibrio cholera*, *V. parahaemolyticus* and *V. vulnificus* were determined as procedure of BAM [19,20]. Lactic acid bacteria were determined as procedure of De Man [21].

### 2.7. Sensory Evaluation

All treatments were baked with casserole electricity (House worth HW-1707S, China) at 180˚C for 5 minutes until the core temperature of the meat sample ranged of 80˚C ± 2˚C. The cooked samples were brought to serve to thirty panelists comprising post-graduate students and technicians from the Department of Food Technology, Prince of Songkla University. The panelists were asked to evaluate the attribute preferences as appearance color, flavor, taste, texture and overall of each sample using a nine-point hedonic scale, from "1-dislike extremely" to "9 like extremely"

### 2.8. Statistical Analyses

Data were subjected to Analysis of Variance (ANOVA) and mean comparison was performed using the Duncan's New Multiple Range Test (DMRT). Statistical analyses were carried out using the SPSS statistical software version 6 (SPSS, Inc., Chicago, IL).

## 3. Results and Discussion

### 3.1. Physical Qualities

#### 3.1.1. Change in pH Value

pH is a function of conversion of glycogen to lactic acid, acid and the degradation of muscle components e.g. proteins and nucleotides to amine compound, base, during storage meat. The initial pH value of the control samples was 6.57 and decreased to 5.6 during storage. Similar pH trends were found in the oyster meat treated with garlic 2 ml, garlic 2 ml + Sa-tay marinated 8% and Sa-tay marinated 8% which ranged from 5.54 to 6.54, 5.69 to 6.65 and from 5.78 to 6.69, respectively (**Figure 1**). This result was in agreement with the finding of Balasundari *et al.*, [22] who reported that pH of Pacific oysters (*Crassostrea gigas*) decreased from 6.30 to 5.89 during storage at 5˚C for 18 days. A decrease of pH in oyster meat might be due to the relative high level of glycogen in the meat and the fact that the spoilage of mollusk shellfish was partly fermentative as reported by Cao *et al.* [23]. However, it was found that oyster meat marinated with Sa-tay marinated 8% (without injected with garlic juice) seemed to have higher pH value but not significant difference compared with other treatments. Hunter and Linden; Pottinger [24,25] also addressed the decreasing of pH as a

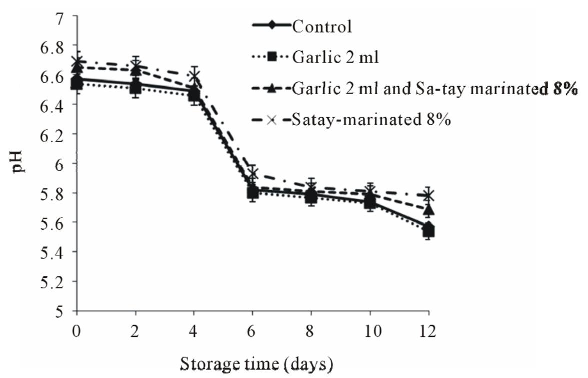


**Figure 1. Effect of garlic juice and Sa-tay marinade on pH values of oyster meat during storage at 4˚C.**

 

basis for determining microbial quality in oysters: pH 6.2 - 5.9 good, pH 5.8 "off", pH 5.7 - 5.5 musty, pH 5.2 and below sour or putrid. Therefore, pH of all treatments in this present studied around 5.5 - 5.8 could be classified as fair.

### 3.1.2. Color

Three color parameters, lightness (L*), redness (a*) and yellowness (b*), were showed in **Figure** 2. L* of all treatments decreased with increased storage time and the lowest values of L* was found in the meat treated with garlic juice (**Figure 2(a)**). This may be due to an increase binding reaction of myoglobin and myofibrillar protein in muscle structure led to the decreased lightness [26]. Moreover, as the pH drop the myoglobin began to unfold, while the myofibrillar proteins were accumulating like charges causing repulsion in the myofibrillar proteins allowed light to be absorbed easily giving the appearance of dark color meat [27-31]. Many researchers reported that negative color attributes have been observed using lactic acid in marinades, turning the meat a dark gray or gray-brown color [32,33]. In addition, there were some fluctuation in the redness, a* value during chilled storage (**Figure 2(b)**) except the oyster meat treated with garlic juice that tended to decreased as storage time increased. This may due to greenish or blue-green color of garlic juice containing organosulfur compound reacted with amino acid in garlic and/or oyster meat [34].

There were 2 trends of b* value changes during storage as a decrease group and constancy group as shown in **Figure 2(c)**. The yellowness of marinated oyster meat was a function of Sa-tay condiment containing turmeric rhizome powder [35].

## 3.2. Chemical Qualities

### 3.2.1. Lactic Acid Content

Initial of lactic acid content was about 0.03% - 0.17% (**Figure 3**) and these values also correlated significantly to pH change during chilled storage (**Figure 1**). It meant that an increase of lactic content caused a decrease of pH. Moreover, lactic acid content in the oyster meat treated with garlic juice was highest may be explained that besides the combined effect of glycolysis pathway and fermentation of lactic acid bacteria [36], garlic juice may also play a role to enhance lactic acid bacterial growth as it's containing prebiotic compound [37,38]. On the other hand, oyster meat marinated with the Sa-tay had lower lactic acid content compared with un-marinated sample. This may be due to anti-lactic bacteria property and/or dehydrated condition when the oyster meat marinated with Sa-tay paste.

### 3.2.2. K-Value

Initial K-value of all treatments was around 11.53% - 15.38%. As storage time increased K-value increased (**Figure 4**). However, the oyster meat treated with garlic 2 ml had the higher K-value at the end of storage, 12 days. Pacheco-Aguilar *et al.*, [39] reported that final K-value of shrimp meat was 50.7% after storage in ice for 15 days. Lakshmanan *et al.*, [40] reported K-value of fishes vary with species, with threadfin bream having K-value of 35% as limit of acceptability [41] while Catla have a acceptability limit when K-value of 55% was ob-

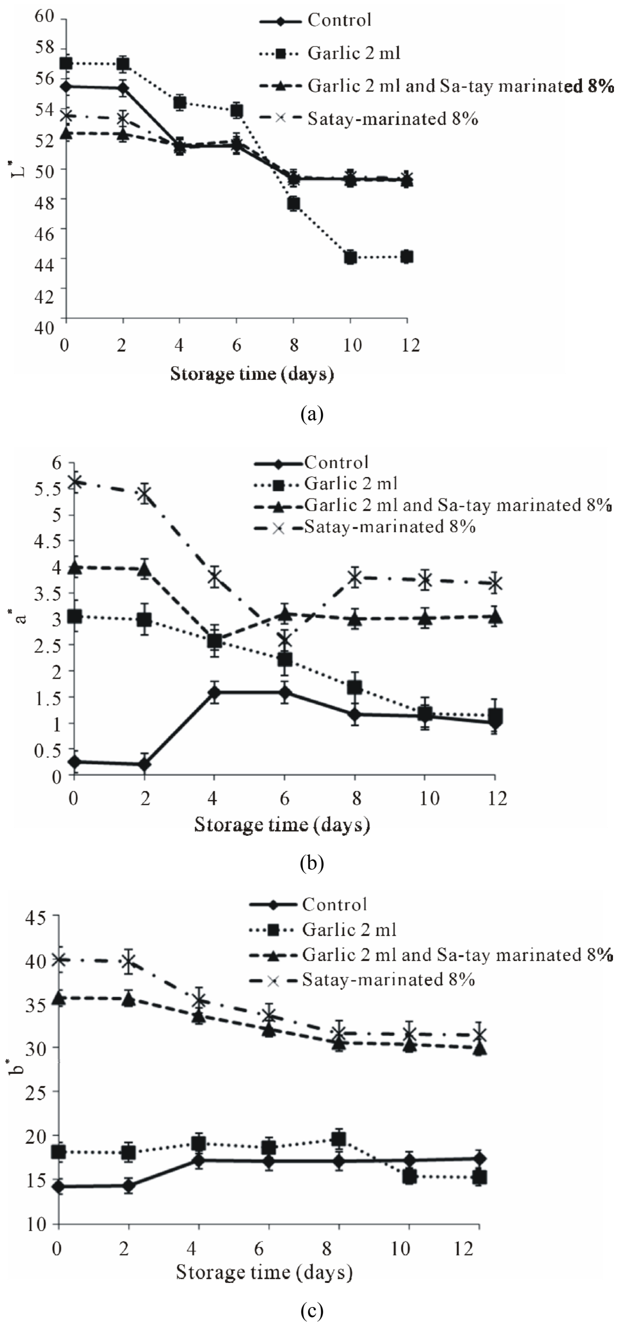


**Figure 2. Effect of garlic juice and Sa-tay marinade on color L*, a* and b* values of oyster meat during storage at 4˚C. (a): L*value, (b): a* value, (c): b*value.**

 

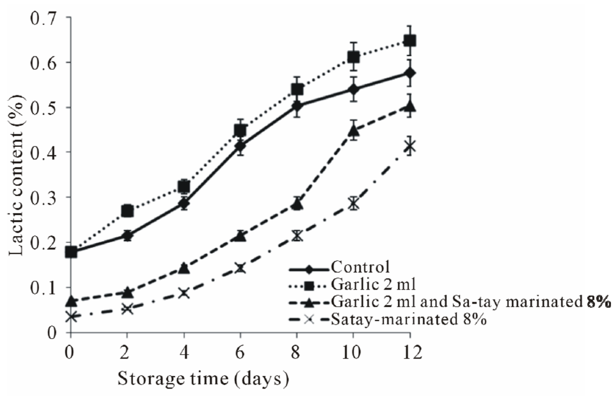


**Figure 3. Effect of garlic juice and Sa-tay marinade on lactic acid content in oyster meat during storage at 4˚C.**

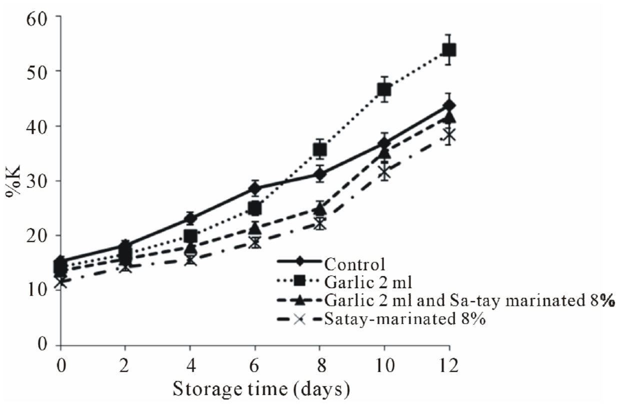


**Figure 4. Effect of garlic juice and Sa-tay marinade on K value in oyster meat during storage at 4˚C.**

tained. Lakshmanan *et al.*, [40] reported a K-value of 53% for *Labeo rohita* as limit of acceptability, while for *Scophthalmus maximus* a K-value of 75% - 85% was considered as the limit of acceptability [42]. K-value of 20% is generally regarded as the optimum freshness limit of shrimp, while 60% is considered as the rejection point [43]. Therefore, based on K-value of 60% it was found that oyster-injected with the garlic juice 2 ml had shorter shelf-life compared with other treatments. The faster nucleotide degradation of oyster-injected with the juice determined by K-value may cause by activity of lactic acid bacteria.

### 3.2.3. Total Volatile Base Nitrogen Value

TVB, which comprised the volatile amines (mainly dimethylamine, trimethylamine and ammonia) of all treatments increased as increased storage time as shown in **Figure 5** even it was lower 30 mg N/100 g which was considered to be unfit for human consumption [44-46]. Such a lower level, ≤20 mg/100 g, in the oyster meat may be due to high content of glycogen that undergoes general acidication as fermention of lactic acid. However, TVB value was highest in the oyster meat injected with garlic juice and marinated with Sa-tay may be due to fault positive reaction in the Conway method used. This experiment agreed with [47] who first reported that TVB of nugget salmon with added pepper-garlic was higher than control sample due to sulfur compound (basic compound) derived from garlic reacted with boric acid led to higher volume of HCl. And it was proved that the garlic juice had high TVB value meant it contained volatile base compound (data not showed) when determined by Conway assay. Therefore, TVB value may not a good indicator for quality determining of marinated food or food containing garlic or volatile base stuff.

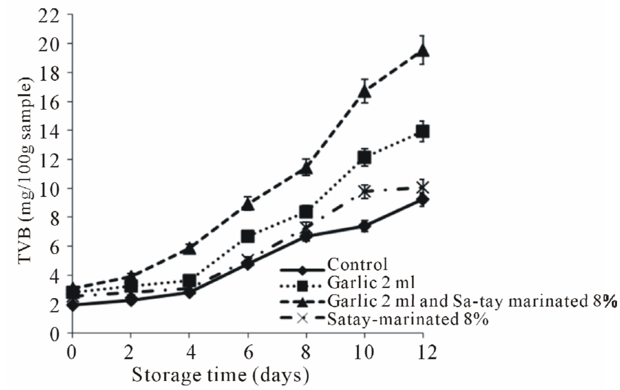


**Figure 5. Effect of garlic juice and Sa-tay marinade on total volatile base nitrogen (TVB) values in oyster meat during storage at 4˚C.**

### 3.2.4. TBARS Values

The TBARS values indicate the content of secondary lipid oxidation products, mainly aldehydes (or carbonyls), which contribute to off-flavors in oxidized meat and meat product [47]. The effect of the garlic juice and Sa-tay marinade on the lipid oxidation evaluated as TBARS values of oyster meat refrigerated for 12 days was shown in **Figure 6**. The TBARS values increased in all treatments over time particularly in the control sample. However, the TBARS values of oyster treated with garlic juice and Sa-tay marinade were lower than control sample ($p < 0.05$). This may be due to antioxidant property of sulfur compounds derived garlic [47,48] and curcuminoid derived from turmeric rhizome [49].

### 3.2.5. Ammonia Content

Ammonia contents of oyster meat with during refrigerated storage were depicted in **Figure 7**. Ammonia content of all samples increased, particularly in the oyster meat injected with garlic juice when storage time increased. An increase was noticeable during 8 - 12 days of storage. Paarup *et al.*, [50] reported that increasing of ammonia contents of squids was also found at day 16 of storage. Ammonia is derived from both enzymatic (en-

 

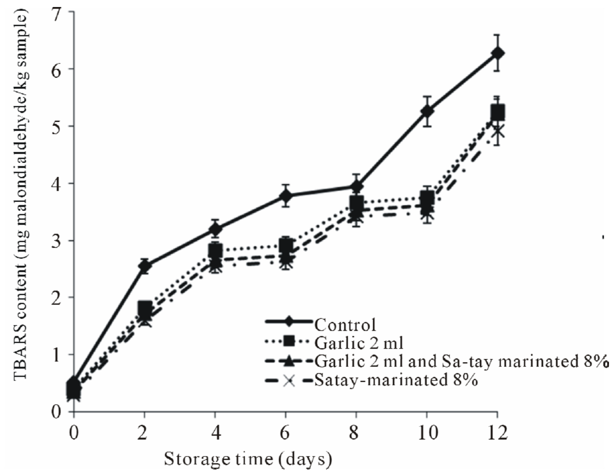


**Figure 6. Effect of garlic juice and Sa-tay marinade on 2-thiobarbitulic acid reactive substances (TBARS) values in oyster meat during storage at 4˚C.**

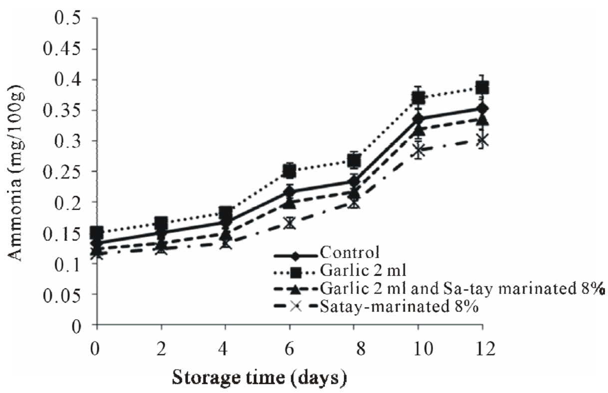


**Figure 7. Effect of garlic juice and Sa-tay marinade on ammonia values in oyster meat during storage at 4˚C.**

dogenous and exogenous enzyme) determination of free amino acids or from decomposition of nucleic bases [51]. Since the distillation method was used in this present study for ammonia determination, the cleavage of amino groups in the proteins at high temperature and alkaline pH might occur. Moreover, all volatile amines might be co-distilled with ammonia, possibly leading to the over-estimated ammonia content.

### 3.2.6. Glycogen Content

Glycogen has served as the indicator of the reproduction-cycle, as glycogen is the energy source of oyster during the proliferation of sex cells [52]. The content of glycogen varies remarkably during the reproduction-cycle. For instance, oysters cultured in Cork Harbour, Ireland, begin to store glycogen in winter, reaching the maximum in spring and decreasing to the minimum at the end of the reproductive cycle in summer or autumn [53]. The initial glycogen content of all treatment was around 6.39 - 6.49 mg/100 g dw and gradually decreased in the first four days then sharply declined afterward (**Figure 8**).

Comparing pH, lactic acid content, K-value and glycogen content meant that injecting garlic juice into to the oyster meat seemed to accelerate the spoilage which was not expectation of using garlic juice as antibacterial agent.

## 3.3. Microbiological Quality

Mesophilic and lactic acid bacteria of all treatment was around 1.04 ± 0.02 - 2.75 ± 0.04 log cfu/g, and 1.07 ± 0.03 - 1.72 ± 0.04 log cfu/g, respectively and gradually increased as increased storage time (**Table 1**). However, it was found that the oyster meat injected with garlic juice without Sa-tay marinating was highest in the both bacterial count. It confirmed that garlic juice played a key role for lactic acid bacterial growth. However, psychrophilic, coliforms, fecal coliforms, *E. coli*, *S. aureus*, *Salmonella* spp. and *Vibrio* spp. were low throughout the storage as showed in **Table 1**.

## 3.4. Sensory Quality

The sensorial scores of the treatment such as appearance, color, texture, flavor and overall during storage were shown in **Table 2**. It was found that all sensory attributes of all oysters slightly decreased but still higher than 5 which was considered as off stage. Surprising, even garlic juice seemed to cause faster spoilage determined by physical (pH), chemical (TVB, ammonia, K-value), microbiological aspects (TVC, lactic acid bacteria counts), there was no negative result on consumer acceptability particularly when using Sa-tay as a marinade agent brought higher sensorial scores compared with un-marinated.

# 4. Conclusion

According to the results of this study, it was found that treated oyster meat with garlic juice pronounced more TVB, ammonia content and increased K-value, TVC,

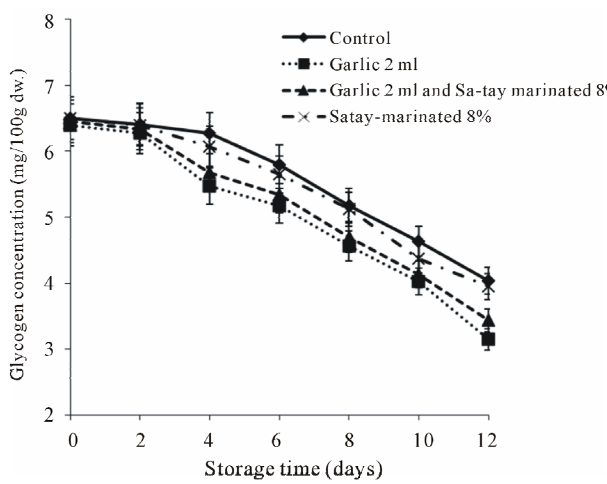


**Figure 8. Effect of garlic juice and Sa-tay marinade on glycogen content in oyster meat during storage at 4˚C.**

**Table 1. Effect of garlic juice and Sa-tay marinade 8% on microorganism values in oyster meat during storage at 4˚C.**

| Bacterial type | Treatment | Storage time (days) | | | |
|---|---|---|---|---|---|
| | | 0 | 4 | 8 | 12 |
| Mesophile (log10 cfu/g) | Control | $1.43 \pm 0.03^{b,D}$ | $2.74 \pm 0.02^{b,C}$ | $4.78 \pm 0.03^{b,B}$ | $5.49 \pm 0.02^{b,A}$ |
| | Garlic 2 ml | $2.75 \pm 0.04^{a,D}$ | $3.36 \pm 0.01^{a,C}$ | $5.62 \pm 0.02^{a,B}$ | $6.20 \pm 0.02^{a,A}$ |
| | Garlic 2 ml and Sa-tay marinade 8% | $2.91 \pm 0.02^{a,D}$ | $2.48 \pm 0.01^{b,C}$ | $4.18 \pm 0.04^{b,B}$ | $5.02 \pm 0.03^{b,A}$ |
| | Sa-tay marinade 8% | $1.04 \pm 0.02^{b,D}$ | $2.31 \pm 0.03^{b,C}$ | $3.59 \pm 0.03^{c,B}$ | $4.35 \pm 0.02^{c,A}$ |
| Psychrophile (log10 cfu/g) | Control | ND | ND | ND | ND |
| | Garlic 2 ml | ND | ND | ND | ND |
| | Garlic 2 ml and Sa-tay marinade 8% | ND | ND | ND | ND |
| | Sa-tay marinade 8% | ND | ND | ND | ND |
| Coliforms (MPN/g) | Control | 10 | 10 | 350 | 540 |
| | Garlic 2 ml | 14 | 21 | 350 | 540 |
| | Garlic 2 ml and Sa-tay marinade 8% | 21 | 21 | 350 | 540 |
| | Sa-tay marinade 8% | 10 | 14 | 350 | 350 |
| Fecal coliforms (MPN/g) | Control | <1.8 | <1.8 | <1.8 | <1.8 |
| | Garlic 2 ml | <1.8 | <1.8 | <1.8 | <1.8 |
| | Garlic 2 ml and Sa-tay marinade 8% | <1.8 | <1.8 | <1.8 | <1.8 |
| | Sa-tay marinade 8% | <1.8 | <1.8 | <1.8 | <1.8 |
| *E. coli* (MPN/g) | Control | <1.8 | <1.8 | <1.8 | <1.8 |
| | Garlic 2 ml | <1.8 | <1.8 | <1.8 | <1.8 |
| | Garlic 2 ml and Sa-tay marinade 8% | <1.8 | <1.8 | <1.8 | <1.8 |
| | Sa-tay marinade 8% | <1.8 | <1.8 | <1.8 | <1.8 |
| *Salmonella* spp. | Control | ND | ND | ND | ND |
| | Garlic 2 ml | ND | ND | ND | ND |
| | Garlic 2 ml and Sa-tay marinade 8% | ND | ND | ND | ND |
| | Sa-tay marinade 8% | ND | ND | ND | ND |
| *S. aureus* (MPN/g) | Control | ND | ND | ND | ND |
| | Garlic 2 ml | ND | ND | ND | ND |
| | Garlic 2 ml and Sa-tay marinade 8% | ND | ND | ND | ND |
| | Sa-tay marinade 8% | ND | ND | ND | ND |
| *V. parahaemolyticus* (MPN/g) | Control | <3.0 | <3.0 | <3.0 | <3.0 |
| | Garlic 2 ml | <3.0 | <3.0 | <3.0 | <3.0 |
| | Garlic 2 ml and Sa-tay marinade 8% | <3.0 | <3.0 | <3.0 | <3.0 |

 

**Continued**

| | | | | | |
|---|---|---|---|---|---|
| | Sa-tay marinade 8% | <3.0 | <3.0 | <3.0 | <3.0 |
| *V. cholerae* (MPN/g) | Control | <3.0 | <3.0 | <3.0 | <3.0 |
| | Garlic 2 ml | <3.0 | <3.0 | <3.0 | <3.0 |
| | Garlic 2 ml and Sa-tay marinade 8% | <3.0 | <3.0 | <3.0 | <3.0 |
| | Sa-tay marinade 8% | <3.0 | <3.0 | <3.0 | <3.0 |
| *V. vulnificus* (MPN/g) | Control | <3.0 | <3.0 | <3.0 | <3.0 |
| | Garlic 2 ml | <3.0 | <3.0 | <3.0 | <3.0 |
| | Garlic 2 ml and Sa-tay marinade 8% | <3.0 | <3.0 | <3.0 | <3.0 |
| | Sa-tay marinade 8% | <3.0 | <3.0 | <3.0 | <3.0 |
| *Lactic acid bacteria* (log10 cfu/g) | Control | 1.68 ± 0.02$^{a,C}$ | 2.74 ± 0.03$^{a,B}$ | 3.42 ± 0.02$^{a,A}$ | 3.48 ± 0.06$^{b,A}$ |
| | Garlic 2 ml | 1.72 ± 0.04$^{a,D}$ | 2.83 ± 0.04$^{a,C}$ | 3.59 ± 0.04$^{a,B}$ | 4.13 ± 0.04$^{a,A}$ |
| | Garlic 2 ml and Sa-tay marinade 8% | 1.12 ± 0.04$^{a,B}$ | 1.52 ± 0.02$^{b,B}$ | 2.37 ± 0.02$^{b,A}$ | 2.97 ± 0.03$^{c,A}$ |
| | Sa-tay marinade 8% | 1.07 ± 0.03$^{a,B}$ | 1.32 ± 0.04$^{b,B}$ | 1.64 ± 0.04$^{c,B}$ | 2.21 ± 0.03$^{d,A}$ |

ND = not detected, $^{a-d}$Means within columns with difference letter are significantly different at $p < 0.05$; $^{A-D}$Means within rows with a difference letter are significantly different at $p < 0.05$.

**Table 2. Effect of garlic juice and Sa-tay marinade 8% on consumer acceptability in oyster meat during storage at 4˚C.**

| Treatment | Storage time (days) | Attribute | | | | | |
|---|---|---|---|---|---|---|---|
| | | Appearance | Color | Flavor | Taste | Texture | Overall |
| Control | 0 | 6.70 ± 0.18$^{abc}$ | 6.46 ± 0.23$^{abcde}$ | 6.03 ± 0.27$^{acdef}$ | 5.30 ± 0.27$^{e}$ | 6.26 ± 0.17$^{defg}$ | 6.06 ± 0.21$^{cdef}$ |
| Garlic 2 ml | | 6.43 ± 0.22$^{abc}$ | 6.13 ± 0.23$^{cde}$ | 5.63 ± 0.27$^{f}$ | 5.86 ± 0.32$^{cde}$ | 6.36 ± 0.21$^{cdef}$ | 5.80 ± 0.25$^{ef}$ |
| Garlic 2 ml and Sa-tay marinade 8% | | 6.93 ± 0.17$^{a}$ | 6.93 ± 0.15$^{ab}$ | 7.33 ± 0.19$^{a}$ | 7.08 ± 0.19$^{a}$ | 7.40 ± 0.16$^{a}$ | 7.23 ± 0.17$^{a}$ |
| Sa-tay marinade 8% | | 7.10 ± 0.16$^{a}$ | 7.00 ± 0.18$^{a}$ | 7.20 ± 0.18$^{a}$ | 6.03 ± 0.30$^{bcde}$ | 7.03 ± 0.17$^{abc}$ | 6.75 ± 0.18$^{abc}$ |
| Control | 4 | 6.46 ± 0.18$^{abc}$ | 6.33 ± 0.20$^{abcde}$ | 5.83 ± 0.27$^{def}$ | 5.56 ± 0.31$^{cde}$ | 5.90 ± 0.23$^{fgh}$ | 5.93 ± 0.29$^{def}$ |
| Garlic 2 ml | | 6.03 ± 0.23$^{cd}$ | 5.96 ± 0.23$^{de}$ | 6.20 ± 0.28$^{bcdef}$ | 5.83 ± 0.27$^{cde}$ | 5.73 ± 0.27$^{fgh}$ | 5.96 ± 0.23$^{def}$ |
| Garlic 2 ml and Sa-tay marinade 8% | | 6.86 ± 0.22$^{ab}$ | 6.76 ± 0.21$^{abc}$ | 7.26 ± 0.19$^{a}$ | 7.03 ± 0.18$^{a}$ | 7.20 ± 0.19$^{ab}$ | 7.18 ± 0.15$^{a}$ |
| Sa-tay marinade 8% | | 6.70 ± 0.24$^{abc}$ | 6.93 ± 0.19$^{ab}$ | 6.56 ± 0.19$^{abcde}$ | 6.43 ± 0.23$^{abc}$ | 6.90 ± 0.20$^{abcd}$ | 6.53 ± 0.23$^{abcd}$ |
| Control | 8 | 6.46 ± 0.26$^{abc}$ | 6.23 ± 0.29$^{bcde}$ | 5.86 ± 0.33$^{def}$ | 5.53 ± 0.26$^{cde}$ | 5.86 ± 0.32$^{fgh}$ | 5.80 ± 0.23$^{ef}$ |
| Garlic 2 ml | | 6.20 ± 0.23$^{bcd}$ | 6.00 ± 0.24$^{de}$ | 6.60 ± 0.29$^{bcdef}$ | 5.46 ± 0.29$^{de}$ | 5.60 ± 0.26$^{gh}$ | 5.96 ± 0.22$^{def}$ |
| Garlic 2 ml and Sa-tay marinade 8% | | 6.76 ± 0.19$^{abc}$ | 6.73 ± 0.22$^{abc}$ | 6.86 ± 0.20$^{ab}$ | 6.36 ± 0.25$^{abcd}$ | 6.83 ± 0.22$^{abcde}$ | 7.03 ± 0.19$^{ab}$ |
| Sa-tay marinade 8% | | 6.70 ± 0.20$^{abc}$ | 6.80 ± 0.20$^{abc}$ | 6.33 ± 0.27$^{bcdef}$ | 5.80 ± 0.31$^{cde}$ | 6.63 ± 0.22$^{bcde}$ | 6.36 ± 0.24$^{bcde}$ |
| Control | 12 | 6.06 ± 0.21$^{cd}$ | 5.76 ± 0.26$^{e}$ | 5.76 ± 0.28$^{ef}$ | 5.43 ± 0.28$^{e}$ | 5.40 ± 0.25$^{h}$ | 5.50 ± 0.24$^{f}$ |
| Garlic 2 ml | | 5.73 ± 0.27$^{d}$ | 5.96 ± 0.23$^{de}$ | 6.03 ± 0.23$^{cdef}$ | 5.46 ± 0.28$^{de}$ | 5.53 ± 0.31$^{gh}$ | 5.70 ± 0.20$^{ef}$ |
| Garlic 2 ml and Sa-tay marinade 8% | | 6.73 ± 0.24$^{abc}$ | 6.73 ± 0.15$^{abc}$ | 6.63 ± 0.22$^{abcd}$ | 6.83 ± 0.25$^{ab}$ | 6.66 ± 0.19$^{abcde}$ | 7.03 ± 0.19$^{ab}$ |
| Sa-tay marinade 8% | | 6.60 ± 0.22$^{abc}$ | 6.63 ± 0.25$^{abcd}$ | 6.76 ± 0.25$^{abc}$ | 5.66 ± 0.30$^{cde}$ | 6.10 ± 0.22$^{efgh}$ | 6.23 ± 0.24$^{cde}$ |

Remark: Mean ± SD from 30 panelists; $^{a-f}$Means within columns with a difference letter are significantly different at $p < 0.05$.

 

lactic acid bacteria. However, garlic juice did not have a negative effect on consumer acceptability whether with or without Sa-tay marinade. Moreover, using Sa-tay as a marinade agent brought higher sensorial scores compared with un-marinated. Therefore, it was clearly showed that marinade Sa-tay can be used for new value added product and as natural preservative agent. However, negative results of using garlic juice as activated K-value and TVC count as well as type of lactic acid bacteria would be further investigated.

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