Marination technology using kandis acid (*Garcinia xanthochymus*) biomass to improve the physical quality of culled chicken meat

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Abstract. Kandis acid (*Garcinia xanthochymus*) is a fruit usually dried with a sour taste and used as a spice in Indonesian cuisine. Aside from being a flavoring and enhancer of flavor images in dishes, kandis acid is also thought to be able to preserve fish. This study aimed to examine the effectiveness of kandis acid in improving the quality of culled chicken meat. This study used a completely randomized design with 4 treatments and 4 replications. The treatment was marination of culled chicken meat in kandis acid solution consisting of 4 different concentrations, i.e., 0% or without kandis acid as a control (P0), 50 g kandis acid + 500 mL distilled water (P1), 50 g kandis acid + 750 mL distilled water (P2), and 50 grams kandis acid + 1,000 mL distilled water (P3). The results revealed that the physical quality of the culled chicken meat was affected by the kandis acid marination especially in the meat pH, which was relatively similar to the drip loss, cooking loss, and tenderness of meat. It is recommended that marination using kandis acid with a concentration of 50 g in 750 mL distilled water can effectively maintain the quality of culled chicken meat.

1. Introduction
Culled chicken meat is meat produced by laying hens that are no longer productive. Culled chicken is a type of meat that is quite difficult to process due to tough and rancid flavor [1] [2]. Some consumers are not able to accept it, so increasing physical quality is the appropriate solution [3]. Chicken meat is also a source of animal protein that is easily damaged so that its quality needs to be maintained against the shelf life before further processing. Several methods to improve physical quality to extend certain shelf life have been carried out such as adding preservatives, but their use is feared to be detrimental to health. Kandis acid is a fruit with a sour taste that is often used as a spice in Indonesian cuisine. Kandis acid is very effective as a food flavoring such as meat and fish. Marinating sour fish in culled chicken meat having a rough texture, tough and less liked is a good solution to extend the shelf life.

Kandis acid contains organic acids such as phenolic acids [4], ascorbic acid some organic and phenolic acids [5]. The addition of acid to meat causes denaturation of proteins so that it breaks the polypeptide bonds and changes the composition of proteins to soften the meat. Kandis acid fruit
extract also has an anti-bacterial activity to Salmonella spp. [6]. Kandis acid fruit is also known to have antioxidant activity [7]. Kandis acid also has phenolic compounds, alkaloids and saponins, tannins, alkaloids, phenolics [8], and flavonoids [9]. The presence of these compounds also acts as antioxidants, which is in line with the study by Rudiansah [10] reported that kandis acid can inhibit spoilage bacteria in tilapia. Besides containing anti-microbial, kandis acid also contains citric acid, so that kandis acid has the potential as a culling chicken meat tenderizer. Marination is a method of processing foodstuffs that aims to preserve and flavor, retain juicily and increase meat tenderness and improve texture. In this study, marination using acidic substances was examined to improve the tenderness of meat because it has the effect of cutting meat fibers and inhibiting spoilage microbes in food.

2. Materials and Methods

2.1 Equipment and Materials

The materials used in this research were 1 kg of kandis acid, distilled water, 2.5 kg of laying hens in the chest. The equipment used in this study were pH meters, penetrometers, beaker glass, a waterbath, an analytical scale, knives, measuring cups, pans, plastics, plastic ropes, hanging racks, stoves, and stationery. Dried kandis acid was then mashed, filtered, and boiled for 30 minutes. The culled chicken was taken on the chest then marinated in the kandis acid extract for 15 minutes [11].

The meat pH value was measured by a portable pH meter [12]. Meat pH was measured after the meat was marinated for 15 minutes using kandis acid with different concentrations. Cooking loss analysis was performed by weighing the meat sample as weight before cooking then boiled in 80 L of water then heated to 70 °C for 60 minutes, then cooled for 30 minutes and weighed [13]. Cooking loss was calculated using the formula:

\[
\text{Cooking loss (\%)} = \frac{\text{meat's weight before being boiled}}{\text{meat's weight after being boiled}} \times 100\% \quad (1)
\]

Drip loss was determined using Bag methods [14]. Drip loss was measured by weighing the meat and then hung in a plastic bag and put at 4 °C for 48 h. Plastic was used to collect liquid meat that was dripping. Hanged meat was conditioned to not touch the plastic bag [15]. Drip loss was calculated using the following formula:

\[
\text{Drip Loss (\%)} = \frac{\text{meat's weight before being hung}}{\text{meat's weight after being hung}} \times 100\% \quad (2)
\]

The tenderness was measured using a Penetrometer [16]. Marinated meat samples were tested using a penetrometer. The study was conducted from January 2019 to March 2020 in the Laboratory of Food Sciences, Faculty of Agriculture, Universitas Sumatera Utara.

2.2 Research Methods

This study used a completely randomized design with 4 treatments and 4 replications. Treatments were marination of culled chicken meat in different kandis acid concentrations, which consisted of 4 levels as follows.

P0 = (0%) or without kandis acid as a control
P1 = 50 g kandis acid + 1000 mL distilled water
P2 = 50 g kandis acid + 750 mL distilled water
P3 = 50 g kandis acid + 500 mL distilled water

Each treatment was marinated in kandis acid concentration for 30 minutes then allowed to stand for 48 h. After settling for 48 h at room temperature, parameter measurements were performed. The parameters in this study were the pH value of meat, cooking loss, drip loss, and tenderness or texture.
of meat. Data was analyzed using analysis of variance so that the effect of the treatment could be determined [17], if the effect of the treatment was significantly different at 0.05% and 0.01% followed by the LSD test or the Least Significant Difference test to find out the best concentration of marinated kandis acid.

3. Results
The physical quality of culled laying hens’ meat after marination using kandis acid is presented in Table 1.

Table 1. Physical quality of culled laying hens’ meat after marination using kandis acid

| Variable                      | P0      | P1      | P2      | P3      |
|-------------------------------|---------|---------|---------|---------|
| Meat pH value                 | 5.20±0.28<sup>a</sup> | 5.73±0.06<sup>b</sup> | 5.78±0.05<sup>b</sup> | 5.60±0.27<sup>b</sup> |
| Drip loss [%]                 | 3.63±0.94 | 3.34±0.46 | 3.22±0.91 | 3.90±0.68 |
| Cooking loss [%]              | 31.16±2.02 | 27.71±2.09 | 23.25±2.07 | 29.72±1.95 |
| Texture/Tenderness [g/mm/s]   | 32.50±8.66 | 39.50±1.29 | 38.25±7.50 | 40.50±3.32 |

Note: Means with different superscript reveal a significant difference (P<0.01)

3.1 Meat pH value
Analysis of pH is an indicator of the degree of acidity used to express the acidity or alkalinity of an ingredient and solution [18]. Based on Table 1 and Figure 1, the pH value of culled laying hens after marination using kandis acid showed a very significant difference (p<0.01) in the applied treatments.

Figure 1. Meat pH in 48-h storage after marination using kandis acid.

The control showed a significantly lower pH (5.20) compared to the marination of kandis acid of 5.73 (P1), 5.73 (P2), and 5.60 (P3), respectively. The pH values of the three marination treatments were not significantly different (p>0.05). This is in agreement with research conducted by Patriani and Wahyuni [19] that marination using kandis acid extract of 5% to 15% reduces the acidity from 5.76 to 5.60. The higher percentage of kandis acid extracts generated lower pH value or increase acidity. In the P0 treatment, the pH value was lower than marination treatments. It is apparently that after cutting the culled chicken meat, the pH would decrease as a result of the glycogen alteration through the process of glycolysis in an aerobic condition, then hydrogen ions which are freed during the glycolysis process cannot bind to oxygen, resulting in ion accumulation in muscle. Hydrogen ions are used to convert pyruvic acid to lactic acid, which will eventually accumulate lactic acid in the meat. Lactic acid accumulation causes an increase in the acidity of the meat resulting in a decrease in the quality of the meat. According to Patriani et al. [20], the pH value of meat without treatment at room temperature can decrease from 5.82 at a shelf life of 12 h, 5.41 at 24 h, and 5.33 at 36 h. The longer the shelf life, the lower the pH value, so that the acidity of the meat is higher.
Kandis acid contains organic acids, i.e., ascorbic acid and citric acid as anti-microbial substances so that it can reduce the pH value and increase the acidity. The organic compounds of citric acid and ascorbic acid in kandis acid is included in the category of weak acid, but it has the potential to suppress the rate of microbial growth. In this study, the pH value of the treatment is included in the normal category. Soeparno [21] stated that the pH value in meat is normally between 5.4 to 5.8. The weak acid group in kandis acid can reduce the pH value, but with the right concentration, it is suspected that it can maintain the pH value. According to Patriani et al. [22], spices with the appropriate composition can maintain the quality of the meat. The P2 treatment did not dramatically reduce the pH and also did not change the taste of the meat to become acidic because the marination period was not too long and the concentration ratio was sufficient in this study. Purnamasari et al. [23] added that pineapple skin extract penetrates the cytoplasmic membrane of meat and dissociates into CH₃COOH (acetic acid) and H⁺. The higher concentration of pineapple skin extract used, then the higher the H⁺ ion is formed. This will reduce the pH of chicken meat because the H⁺ ion influences the acidity.

3.2. Drip loss
Drip is a liquid that comes out of meat that contains exuded liquid and nutrients of meat. It dissolves and disappears during the re-thawing of frozen meat or during the aging process of meat [21], [24], [25].

Figure 2. Meat drip loss in 48-h storage after marination using kandis acid.

Drip loss is a measurement of water holding capacity with the principle that free water will be released from muscle protein in line with the decrease in muscle pH [26]. The percentage value of drip loss of culled laying hens after marination using kandis acid is shown in Table 1 and Figure 2, which did not show any significant difference (p > 0.05). The results of the study were relatively similar to one another on the drip loss of chicken meat marinated with kandis acid, those which showed the same degree of meat water loss in all treatments. This is because drip loss is related to the water binding capacity of meat. If the water holding capacity increases, then the drip decreases [21]. Drip loss increases with the duration of storage time [27]. The time and duration of storage in the cooler are important factors that affect drip loss. In addition, environmental humidity has a major effect on drip loss, for example, due to the thawing process [24]. A rapid decrease in pH can also increase drip loss [28].

3.3. Cooking loss
Cooking loss is one indicator for determining the quality of meat, in which the meat that has been cooked has lost weight due to the release of meat water [29]. Low cooking loss value indicates the ability of meat to maintain its water content and its quality is better [25]. The percentage value of cooking loss of laying hens after marination using kandis acid is shown in Table 1 and Figure 3, which did not show any significant difference (p > 0.05). The highest yield of cooking loss was in P0 or
control and the lowest cooking loss was in P2. The smaller the percentage of cooking loss, the better the quality of meat. This indicates that P2 has the best cooking loss value in this study.

![Cooking Loss Graph](image)

**Figure 3.** Meat cooking loss in 48-h storage after marination using kandis acid.

The highest yield of cooking loss was in P0 or control and the lowest cooking loss was in P2. The smaller the percentage of cooking loss, the better the quality of meat. This means that P2 has the best cooking loss value in this study. This finding is in line with the research by Patriani and Wahyuni [19] that marinating meat using acids from natural fruits can cause meat fat to dissolve, but it does not significantly affect the increase in cooking loss. Brugiapaglia and Destefanis [30] stated that cooking loss can be caused by the loss of a combination of liquid compounds during cooking, which is in line with an increase in temperature. The percentage of cooking loss in this study is still in the normal category, which is in agreement with Lawrie [28] that the value of cooking loss in normal meat ranges from 15 % to 40 %. The value of cooking loss can be caused by the cooking temperature, denaturation of the protein during cooking, resulting in less water being trapped in the protein structure [31].

### 3.4 Tenderness

The tenderness value of culled chicken meat after marination using kandis acid is shown in Table 1 and Figure 4, which did not show any significant difference (p> 0.05).

![Tenderness Graph](image)

**Figure 4.** Meat tenderness in 48-h storage after marination using kandis acid.

No effect of acid immersion treatment shows that the concentration of kandis acid has not been able to break down or hydrolysis of muscle fiber protein and binder woven. Besides, there are changes in the form of thinning and destruction of sarcoma, resulting in increased tenderness. This is following Lawrie [28] that during the immersion process in meat, there are some processes, those are muscle protein, fibers binding, changes in the form of thinning and destruction of sarcoma, dissolution of the
nucleus from muscle fibers and connective tissue, as well as the release of muscle fiber attachment, to soften the tissue.

The soaking techniques can tender and improve the taste and water content of poultry meat [32]. The effect of acids on tissue depends on the type of fiber in meat and the end of acidification. Low acid causes swelling of collagen found in perimysium and endomysium [33].

4. Conclusion

Soaking culled laying hens using kandis acid (*Garcinia xanthochymus*) biomass influenced the pH value of culled laying hens, but it did not affect the drip loss, cooking loss, and tenderness of culled laying hens. To produce laying hens meat with good tenderness and low shrinkage, the chicken meat should be marinated with 50 g of kandis acid in 750 mL distilled water.

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