Physical quality improvement of culled chicken meat with marinated technology using Gelugur acid (Garcinia atroviridis) biomass

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Abstract. Culled chicken meat have a tough texture, so they are less liked by consumers. The quality improvement of meat is needed to overcome the problem, one of which uses inexpensive spices, namely Gelugur acid (Garcinia atroviridis). This study aimed to determine the gelugur acid marination, which was effective to improve the physical quality of culled chicken meat. This study used a completely randomized design with 4 treatments and 3 replications. The treatments consisted of P0: without marination using gelugur acid, marinating in 50 g of gelugur acid + 1000 mL distilled water (P1); 750 mL distilled water (P2) and 500 mL distilled water (P3). It was concluded that the level of marinating using gelugur acid to the physical quality of culled chicken meat had a very significant effect ($P < 0.01$) on the physical quality of chicken meat, namely the pH value, cooking loss and tendereness. However, there was no significant effect ($P > 0.05$) on drip loss and colour of meat. Acid compounds contained in Gelugur acid are thought to cause protein denaturation so that they affect the physical quality of meat. Marination at concentration (P1) was an effective level to improve the physical quality of culled chicken meat.

1. Introduction
Culled hen is a type of meat that is quite difficult for some consumers to accept because of its soft taste and low quality [1]. The low quality of culled chicken meat reduces the delicacy so that it influences consumer preferences. Culled chicken meat is also a source of animal protein that is easily damaged so that its quality needs to be maintained through post-harvest handling. Various methods to improve the shelf life and physical quality of meat have been carried out, such as the addition of sodium nitrate, sodium nitrate, sulphite, potassium sorbate, and borax, but the long- term use can affect consumers' health.

Gelugur acid (Garcinia atroviridis) is a fruit commonly used as a cooking spice, flavoring drinks, sweets and cosmetic ingredients. The fresh sour taste makes gelugur acid very popular as an enhancer of the flavor in meat and fish dishes. Gelugur acid contains antimicrobial, antioxidant, and cytotoxic [2]. Gelugur acid also contains flavonoid, phenolic, and tannin compounds [3]. Gelugur acid contains citric acid, tartaric acid, malic acid and ascorbic acid [4]. The addition of organic acids such as citric acid to poultry meat can increase shelf life [5]. Besides, the addition of organic acids in chicken meat can cause muscle tissue to be softer.
Marination is a method of processing foodstuffs which aims to preserve and give an image of flavor, increase tenderness, improve texture and extend shelf life. Marination using fruits that contain organic acids usually aims to gain meat tenderness, inhibit microbial spoilage and eliminate the fishy smell of meat. Marination using spices such as gelugur acid has never been applied on poultry meat. Previous studies revealed that the use of gelugur acid was applied to Indian mackerel fish and it could increase shelf life to 3.5 days [6]. Nainggolan [7] stated that besides being used as a spice, gelugur acid is also commonly used for fish preservatives, for making syrup and processing latex. Based on these studies, further research is needed on the utilization of gelugur acid biomass using marinating technology in meat. This study aimed to determine the effect of marination using different concentrations of gelugur acid on the physical quality of meat, namely pH, tenderness, cooking loss, drip loss and color at a shelf life of 48 hours.

2. Methods
This study used a completely randomized design (CRD) with 4 treatments and 3 replications. The treatment was the culled chicken meat in gelugur acid with various concentrations, those consisted of 4 treatments:
P0 = without gelugur marination (control)
P1 = marination using 50 g of gelugur acid + 1000 mL distilled water
P2 = marination using 50 g of gelugur acid + 750 mL distilled water
P3 = marination using 50 g of gelugur acid + 500 mL distilled water
The parameters in this study were the pH value of meat, water holding capacity, cooking loss, drip loss, tenderness and color of meat. Data was analyzed using analysis of variance (ANOVA), so that the treatment effect could be known [14]. If the effect of treatment was significantly different, it was continued by LSD test to find out the best concentration of gelugur acid marination.

2.1 Equipment and Materials
The materials used in this research were 3 kg gelugur acid, 3 kg culled chicken breast and distilled water. The equipment used in this study were pH meters, what man paper, mica, penetrometers, beaker glass, water baths, analytical scales, thermometers, knives, blenders, measuring cups, pans, plastics, raffia ropes, hanging racks, stoves and stationery. Gelugur acid was dried, blended and boiled for 15 minutes then filtered into extra appropriate concentrations of 50 g with the addition of 500 mL of distilled water, 750 mL and 100 mL, respectively. Measurement of research parameters consisted of:

2.1.1 Meat pH
Meat pH value was measured by means of a digital pH meter at room temperature [8]. The pH meter was pricked in culled chicken meat and then the pH value was read on the pH meter.

2.1.2 Cooking loss
Cooking loss was determined by weighing the meat as the weight of the initial sample before boiling then weighing it again after the meat sample was boiled in 80 litters of water at 70 °C for 60 minutes. Boiled meat was cooled for 30 minutes and weighed as the weight of the final sample [9]; [10]. Cooking loss was calculated using the formula:

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

2.1.3 Drip loss
Measurement of drip loss was performed using Bag methods [11]. The meat sample was weighed as the initial weight of the sample and then hung in a plastic bag and put at 4 °C for 48 hours. Plastic was used to collect liquid meat that was dripping. Drip loss was calculated using the following formula:
Drip loss (%) = \frac{\text{Weight before being hung}}{\text{Weight after being hung}} \times 100\% ......(2)

2.1.4 Meat tenderness
The tenderness was measured by Penetrometer [12]. Before the meat was measured with penetrometer, its weight was measured first then calculated using the formula:

Tenderness (mm/gram/10 secon) = \frac{\text{Meat average}}{10 \text{ secon}} ......(3)

2.1.5 Meat color
Analysis of meat color was performed at the shelf life of 48 hours by Chroma meter using color analysis with L filters as brightness colors, a* as colors and b* as yellowish colors. Data could be either L* * a * b * or CIELAB on breast meat [13].
Each sample was marinated using gelugur acid concentration according to treatments for 15 minutes, drained and allowed to stand for 48 hours. After 48 hours, the parameters were measured. The study was conducted at the Laboratory of Food Sciences, Faculty of Agriculture, Universitas Sumatera Utara.

3. Results
Culled chicken meat was marinated using gelugur acid concentration and allowed to stand for 48 hours. The parameter measurements are presented in Table 1.

Table 1. Physical quality of culled chicken meat after marinated with gelugur acid in 48 hours storage

| Parameter               | Gelugur acid concentration |          |          |          |
|-------------------------|---------------------------|----------|----------|----------|
|                         | P0                        | P1      | P2      | P3      |
| pH value                | 5.45±0.04\textsuperscript{a} | 5.75±0.01\textsuperscript{c} | 5.66±0.02\textsuperscript{bc} | 5.57±0.02\textsuperscript{b} |
| Cooking loss (%)        | 27.90±0.59\textsuperscript{b} | 25.71±0.83\textsuperscript{a} | 26.37±0.09\textsuperscript{ab} | 27.71±0.55\textsuperscript{b} |
| Drip loss (%)           | 3.61±0.23                 | 3.82±1.09 | 3.66±0.25 | 3.89±0.33 |
| Tenderness (mm/g/10 s)  | 30.42±1.34\textsuperscript{c} | 23.80±0.58\textsuperscript{a} | 28.87±0.33\textsuperscript{b} | 28.67±0.64\textsuperscript{b} |
| Meat Color:             |                           |          |          |          |
| L*                     | 58.24±6.43                | 60.46±4.58 | 62.95±2.47 | 60.24±4.93 |
| A                      | 15.77±1.26                | 7.56±2.18      | 6.31±1.69      | 8.03±2.30 |
| b*                     | 17.72±1.75                | 17.40±1.11      | 16.64±1.41      | 17.40±2.20 |

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

3.1 Meat pH
The pH value of culled chicken meat was measured at a shelf life of 48 hours after marination according to the treatment. It was found that the highest average pH value was P1, 5.75, whereas at P2 it was decreased to 5.66 and continued to decrease at P3 to 5.57. The pH value at P1, P2 and P3 were decreased gradually. The higher concentration of gelugur acid caused the pH value to decrease. ANOVA results showed that there was a significant difference (P < 0.05) on the pH value of meat. BNT test results showed that the pH value in the P0 treatment was significantly different and higher when compared to the P1, P2 and P3 treatments. The decrease in the pH value of meat in an increase of gelugur acid concentration is thought to occur because of acid hydrolysis entering the meat fiber by osmosis.

The process of protein denaturation can also occur, which is caused by breaking the peptide chain into a dipeptide. Then dissolved water molecules is out of the micro structure of the meat. The higher concentration of gelugur acid causes the higher acid hydrolysis in meat fibers. Wong [15] reported that the denaturation of meat proteins could cause hydrophobic protein molecules to come out and join the liquid phase. The lowest average pH value at P0 or control was 5.45. Meat pH values are presented in Fig. 1

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Therefore, an increase in concentration of the gelugur acid marination caused a decrease in pH value presumably due to acid hydrolysis. In this study, the average pH of meat in P1, P2 and P3 was between 5.57-5.75, which is in line with Silva et al. [16] that the normal pH in intermediate meat or the ultimate pH value is 5.5-5.8. This means that marinating using gelugur acid can maintain a normal pH in meat. In the control (P1), the average pH value was 5.45, according to Masrianto et al. [17], the pH of post-mortem meat is about 5.4-5.8, so it is still in quite good category.

3.2 Cooking loss
Cooking loss is the weight of meat samples lost during cooking along with the loss of nutrients in the cooking process [18] [19]. The highest cooking loss level was in P0 or control. The lowest average cooking loss was in P1, followed by P2 and P3, which are shown in Figure 2. The higher the cooking loss, the higher the loss of weight and nutrition of meat. The results showed that cooking loss value on every treatment was significantly different (P < 0.01). This means that marinating using gelugur acid can reduce the value of cooking loss.

![Figure 1. Meat pH in 48 hours storage after being marinated with Gelugur acid (Garcinia atroviridis).](image1)

![Figure 2. Meat cooking loss in 48 hours after marinated with gelugur acid (Garcinia atroviridis).](image2)

The lower the value of cooking loss, the better the quality of the meat. A decrease in the average cooking loss at P0 (control) is thought to be a result of a decrease in the pH value at P0 (control), so that a lot of myofibril protein is damaged followed by a loss of protein’s ability to bind water, causing a high cooking loss rate. The cooking loss in this study was lower than the study conducted by Castellini et al. [20], which shows that the cooking loss of chickens organically raised in the range of 35.17% -34.02%. Meanwhile Hafid et al. [21] got higher cooking loss, which was around 25.94% -46.20%. This is in line with the research of Ros-Polski et al. [22] that the average cooking losses on chicken meat is 27.84%. The best cooking loss in this study were in P1, but overall, the cooking losses in this study were quite good. This is in line with Soeparno [23] reported that cooking loss varies between 1.5% to 54.5%.
3.3 Tenderness
Meat tenderness was measured using a penetrometer which is determined by the amount of pressure or force required by the unit area (mm/g/10 s) of meat. The smaller the number obtained, the more tender the meat. Meat tenderness is an indicator in determining the physical quality of meat. Soft meat will be easier to be chewed and digested by the body [24]. The results showed that the softest meat was in the P1 sample and the toughest was in the P0 sample (control), as shown in Figure 3. Marinated chicken meat using gelugur acid had a very significant effect (P < 0.01) on meat tenderness. This means that marinating using gelugur acid biomass can increase the tenderness of culled chicken meat on P1 (Gelugur acid 50 g + aquadest 1000 mL).

![Figure 3. Meat tenderness in 48 hours after being marinated with gelugur acid (Garcinia atroviridis).](image)

Increased tenderness of meat is thought to be the effect of the addition of organic acids which can cause protein denaturation. This results in the breakdown of polypeptides and changes in the composition of protein molecules, so that muscle tissue becomes softer. The marinating meat in lemon juice, orange juice and distilled water can change meat tenderness [25]. Patriani and Wahyuni [26] stated that marinating using acidic substances can cause collagen and myofibril in hydrolyzed meat, shorter meat fiber, muscle fiber be more separated easily, so that the tenderness of the meat increases. Based on the average value of tenderness in this study, every treatment was in a fairly good range, especially for P1, P2 and P3.

3.4 Meat drip loss
Drip loss is the discharge of fluid in the meat along with nutrients that dissolve and then drip when the meat is hung by [27].

![Figure 4. Meat drip loss in 48 hours after being marinated with gelugur acid (Garcinia atroviridis).](image)
Samples are usually placed at 4 °C [28]. The results of the study in Table 1 and Fig. 4 show that the value of drip loss was not significantly different (P > 0.05) on the treatment of gelugur acid marination. The lowest drip loss value in this study was control and the highest was in P3. The lower the value of drip loss, the better the quality of the meat because the less nutrients that come out and drip when the meat is hung. The average value of drip loss in culled chicken that is marinated using candis acid between 2.1% to 4.2% [29]. According to Northcutt et al. [28], the average breast meat drip loss ranged from 2.19 to 3.03, and Mitsumoto et al. [30] stated that drip loss in beef fed with vitamin E intake was 3.0% to 10%. Drip loss can occur during processing when meat is hung. Overall, the value of drip loss in this study was in a fairly good range.

3.5 Meat color
The determination of the resistance of lamb meat whether the meat is rotten or fresh can use a color test with a chromameter. Fresh meat usually has a different color than rotten meat.

![Figure 5. Meat color in 48 hours after being marinated with gelugur acid.](image)

The level of bright color (L*), which is also called light, was the highest in culled chicken both P3 and P1 while the lowest was P0 (control). The results of the ANOVA showed that marinating treatment using gelugur acid did not have a significant effect (P > 0.05) on the color of culled chicken meat. However, it could be observed that the brightest color was both of P3 and P1. It is suspected that the organic acid properties in gelugur acid can make the culled chicken meat whiter and brighter. The acidic nature itself can clean the dirt attached to meat and fat so as it gives the impression of a brighter flesh color. The level of redness (a*) of culled chicken was the highest in P0 or control. Although the ANOVA results did not significantly influence, the redness level (a*) of P1, P2 and P3 produced a lower reddish color. The higher red color (a*) indicates that the meat is carcass meat [31]. It is suspected that marination using gelugur acid can maintain the quality of culled chicken meat from the decay process. The content of acids such as ascorbic acid and citric acid contained in gelugur acid is thought to inhibit microbial activity. This is in line with Buses [5] that the addition of organic acids such as citric acid and ascorbic acid to poultry meat can increase the shelf life. This phenomenon is added by Gonzalez-Fandos and Hererra [32] that the addition of organic acids can extend the storage time of chicken meat. The content of yellowish color b* did not show a significant difference (P > 0.05). The intensity of the color in the treatment that had a range of values was almost the same and in a fairly good range.
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Acknowledgments
Authors acknowledge that this research was funded by the Universitas Sumatera Utara, based on an agreement letter for the Talent Research of the Universitas Sumatera Utara, the Young Lecturer Research Scheme, 2020 Fiscal Year Number: 344 / UN5. 2.3.1 / PPM / SPP-LATENTA USU / 2020 27 April.