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Beef Preservation with the Addition of Kecombrang (Torch Ginger) Leaf Powder (*Etlingera elatior*) at Refrigerator Temperature

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ABSTRACT

Beef is one of the animal-derived food with a high nutritional value, making it widely sought after to meet essential human dietary requirements. However, it is highly perishable. In order to preserving beef, organic material such as torch ginger leaf can be used to retard spoilage by inhibiting the growth of microorganism. This study aimed to determine the effect of soaking beef in ginger leaf powder solution on its physical, microbiological and chemical qualities in refrigerated condition. This research used a two way Completely Randomized Design. The treatments was the used of torch ginger leaf powder at 4 concentrations (0; 5; 7.5; and 10%) and observed for 6 days (Day 0; 3; and 6). The data obtained then analyzed using Analysis of Variance (ANOVA) then further analyzed using Duncan Multiple Range Test. The parameters observed were physical quality (cooking loss), microbiology (total bacteria), and chemical quality (pH, water, ash, protein and fat content). The results showed that soaking in torch ginger leaf powder can maintain the freshness of beef for 6 days of storage. Soaking beef with the addition of 10% torch ginger leaf powder solution resulted in beef quality with cooking loss 12.41%; total bacteria 0.18 x 10^3 cfu/g; pH 5,52; water content 76.49%; ash content 0.95%; protein content 21.27%; and fat content 2.60%. The beef preservation using 10% torch ginger leaf powder solution in 6 days of storage still fit for consumption. Kecombang leaf powder can be solution for beef preservation.

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ABSTRAK

Daging sapi merupakan salah satu produk pangan asal hewan yang memiliki kandungan gizi yang tinggi sehingga daging banyak diminati oleh masyarakat untuk memenuhi gizi esensial tubuh manusia. Namun, daging cepat mengalami kebusukan. Daging sapi dapat diawetkan menggunakan bahan organik seperti daun kecombrang (Etlingera elatior) untuk menghambat kerusakan daging dengan cara menghambat pertumbuhan mikroorganisme. Penelitian ini bertujuan untuk mengetahui pengaruh perendaman daging sapi dalam larutan serbuk daun kecombrang terhadap kualitas fisik, mikrobiologi dan kualitas kimianya pada suhu refrigerasi. Penelitian ini menggunakan Rancangan Acak Lengkap dengan perlakukan konsentrasi serbuk daun kecombrang (0; 5; 7,5; dan 10%) di suhu refrigerasi dengan 5 kali pengulangan. Pengamatan dilakukan selama 6 hari pada hari ke-0, 3, dan 6. Data yang diperoleh dianalisis menggunakan Analisis Varians dan selanjutnya dianalisis menggunakan Duncan Multiple Range Test. Parameter penelitian ini meliputi kualitas fisik (susut masak), mikrobiologi (total bakteri), dan kualitas kimia (pH, kadar air, abu, protein dan lemak). Hasil penelitian menunjukkan bahwa perendaman menggunakan larutan serbuk daun kecombrang dapat menjaga kesegaran daging sapi selama 6 hari penyimpanan. Perendaman daging sapi dengan penambahan 10% serbuk daun kecombrang menghasilkan kualitas daging sapi dengan susut masak 12,41%; total bakteri 0,18 x 10^3 cfu/g; pH 5,52; kadar air 76,49%; kadar abu 0,95%, kadar protein 21,27%; dan kadar lemak 2,60%. Preservasi daging sapi menggunakan 10% larutan serbuk daun kecombrang pada penyimpanan 6 hari masih layak dan aman untuk dikonsumsi. Sehingga perendaman daging sapi dalam serbuk daun kecombrang layak dijadikan sebagai alternatif untuk preservasi daging.

INTRODUCTION

Meat is a food product of animal origin that has high nutritional contents, as a consequence it in high demand by the public to meet the human body's essential nutritional needs. However, it getting spoiled quickly when stored at room temperature due to its complete nutritional contents (protein, minerals, vitamins, and essential amino acids) and high-water content in meat that can be a good medium for the growth of pathogenic bacteria or spoilage bacteria (Javalin *et al*., 2017; Sarassati & Agustina, 2015). Beef, widely consumed by the Indonesian people, is a food that is susceptible to damage and decay. This decline of quality in beef can occur biochemically and microbiologically, due to several factors, such as environmental conditions that are very suitable for the growth of spoilage microbes caused by bacteria. Prolonged storage of beef resulted in increased alkaline production due to increased microbial activity, which is the primary cause of spoilage. The spoilage process is characterized by an increase in pH and an increase in bacterial counts (Suradi, 2012). Microbial contamination in meat can also reduce its shelf life, unless it is preservatively treated (Olaoye & Onilude, 2010). Preservation aims to extend shelf life and suppress microbial growth, as the shelf life of meat is generally closely related to the number and growth of bacteria (Siregar *et al*., 2014; Windyasmara *et al*., 2024).

Meat preservation can be achieved using both chemicals and natural ingredients. Natural ingredients are expected to be safer than chemicals and have greater potential as natural antimicrobials that can preserve food (Afrianti, 2010). One plant with the potential to suppress microbial growth and extend shelf life is kecombrang or torch ginger (*Etlingera elatior*) leaf.

Kecombrang (torch ginger) is a plant that contains antimicrobials and antioxidants. All parts of torch ginger demonstrated high phytochemical content and biological activity, including rhizome, fruits and leaves. Torch ginger leaves extract has high amount of phenolic content. In addition, the antioxidant activity of torch ginger leaf extract showed the IC_{50} 0.039±0.00 mg/mL that possesses strong antioxidant properties (Whangsomnuek *et al.*, 2018; Zamzani & Triadisti, 2021). Chemical components that have the potential as antimicrobials found in torch ginger are alkaloids, flavonoids, polyphenols, steroids, saponins and essential oils. Almost all parts of the torch ginger plant contain polyphenols that have antimicrobial activity (Naufalin, 2013). The research conducted by Jusoh *et al.* (2025) showed that torch ginger flower aqueous extract exhibited antibacterial activity againts *S. aureus*. This study was conducted to determine the effect of soaking torch ginger leaves (*Etlingera elatior*) on the physical, chemical, microbiological quality of beef under refrigerated conditions.

METHOD

This research was conducted from April to December 2025 at the Manokwari Agricultural Development Polytechnic. Laboratory tests were conducted at the University of Papua and the West Papua Agricultural Assembly and Modernization Agency. Fresh beef was collected from the slaughterhouse in Manokwari Regency.

The materials used in this study were beef, torch ginger leaves, label paper, tissue, methylated spirits, cotton, sterile PCA, distilled water, and buffer. While the tools used in this study were petri dishes, colony counters, loop needles, bunsen burners, incubators, measuring cups, autoclaves, test tube racks, test tubes, Erlenmeyer flasks, bowls, cotton, aluminum foil, analytical scales, pH meters, knives, blenders, pans, stoves, ovens, and stopwatches. This research consists of several activities, namely making dried torch ginger leaf powder, preparing meat samples, storing meat and testing meat quality.

Torch ginger leaf powder making. The torch ginger leaves are washed thoroughly, cut into ±0.5 cm, then dried in an oven at 60°C for 24 hours. Once dry, the torch ginger leaves are ground using blender for 3 minutes and then sieved.

Meat sample preparation. Each 250 g of beef soaked for 2 hours in 100 mL torch ginger leaves solution. The solution treatments were as follows:

P0: Control

P1: 5% torch ginger powder solution

P2: 7.5% torch ginger powder solution

P3: 10% torch ginger powder solution

Each treatment was replicated 5 times, resulted in. After 2 hours of soaking, beef then removed and placed in a pot covered with a plastic wrap and refrigerated. The beef quality observation was done in day 0, day 3, and day 6. This research used a two way completely randomized design (CRD). and if there was a significant effect, further testing was performed using the Duncan Multiple Range Test (DMRT).

Meat storage. The meat, which had been soaked in the treatment solution, was removed and stored at refrigerated temperature in a pot covered with plastic wrap. Meat quality was observed on days 0, 3, and 6.

Microbiology test. TPC (Total Plate Count) Test. In this study, the total bacterial count of beef was carried out using the Total Plate Count (TPC) method. This TPC test uses PCA. The TPC test procedure is to prepare the tools and materials. 9 ml of distilled water was put into a test tube. Then covered with cotton and wrapped with aluminium foil. Then the test tube, petri dish, measuring pipette and NA media were wrapped in plastic and sterilized by autoclaving for 15 minutes at a temperature of 121°C and a pressure of 2 atm. After sterilization, then cooled and dilution were carried out. One g of meat sample was taken and then mashed until it smooth, then put it into a test tube containing 9 ml of sterile distilled water (10^{-1} to 10^{-5}) aseptically and homogenized with a vortex. The media was poured into a petri dish that had been filled with sample dilutions, then homogenized and waited until solid (±10 minutes) after which it was incubated at 37°C for 24 hours. Colony growth in each dish contains 30 to 300 colonies and the shape is observed using a colony counter (Ray, 2001).

Meat chemical testing. Moisture, ash, protein, and fat content were measured using proximate analysis using AOAC official method (AOAC, 2016). Moisture content was conducted using thermogravimetric analysis, ash content using the furnace method relies on gravimetric determination, Soxhlet method was used to determine the crude fat, and crude protein content using Kjeldahl method.

pH. According to Fenita *et al.* (2009), the pH value was determined by taking a 10 g meat sample that had been cleaned of any lubricant, adding 20 ml of distilled water, and then homogenized using blender. The pH was measured using a pH meter, previously calibrated with a pH 7.0 buffer solution.

Cooking loss. The Bouton method was used (Soeparno, 2015). The meat sample was cut into 1 x 1 x 1 cm^3 pieces, weighed, placed in polyethylene plastic bags, and tightly sealed to prevent water from seeping into the plastic bag during boiling. The sample was boiled in a water bath at 80°C for one hour. After boiling, the sample was removed from the plastic bag, wiped with tissue paper without pressing, then weighed. The cooking loss was calculated as follows:

$$\text{Cooking loss (\%)}=\frac{W1-W2}{W2}\times 100$$

Where:
W1 = Weight before cooking
W2 = Weight after cooking

RESULTS AND DISCUSSION

Physical Quality

Table 1. Physical Tests (pH and Cooking Loss) during Storage

Treatments	pH			Average**
	Day 0	Day 3	Day 6	
P0	5.94±0.01^{a}	5.87±0.00^{a}	5.70±0.01^{b}	5.84±0.12^{c}

Treatments	pH			Average**
	Day 0	Day 3	Day 6	
P1	5.91±0.01[a]	5.85±0.01[b]	5.68±0.01[ab]	5.81±0.12[c]
P2	5.86±0.00[b]	5.71±0.01[a]	5.64±0.06[bc]	5.74±0.11[b]
P3	5.79±0.01[a]	5.57±0.01[b]	5.52±0.01[c]	5.63±0.14[a]
Average**	5.88±0.07[c]	5.75±0.14[b]	5.63±0.08[a]	

Treatments	Cooking Loss (%)			Average[ns]
	Day 0	Day 3	Day 6	
P0	9.87±2.29	10.42±0.18	12.15±0.53	10.81±1.19
P1	10.52±0.39	11.04±1.12	12.38±1.38	11.31±0.95
P2	10.91±0.91	11.23±0.01	12.57±1.35	11.57±0.88
P3	12.06±0.15	12.37±1.39	12.53±1.17	12.32±0.24
Average**	10.84±0.91[a]	11.27±0.81[ab]	12.41±0.18[b]	

Descriptions: ns = not significant, ** = highly significant (P<0.01), different superscripts in the same column and row indicate highly significant differences

Acidity (pH)

Based on Table 1, the results of the DMRT follow-up test showed a highly significant difference (P<0.01) between the dosage, storage time, and their interactions on the pH (acidity) of beef. The lowest pH was found in the 10% torch ginger powder treatment with a storage time of 6 days compared to the other treatments (5.52). The lower the degree of similarity (pH), with a lower limit of 5.3 being the best value compared to near-neutral acidity. This was in accordance with Sokra *et al*. (2025) under near-neutral pH condition promotes rapid microbial proliferation. This microbial growth will continue until the ideal pH for microbial growth is reached, which is neutral, because most of bacteria live at a neutral pH.

Based on Table 1, it was clear that there was a decrease in meat pH during the storage process until day 6. This is allegedly due to the longer storage process would lowering the meat pH as microbial activity. This is in accordance with the results of research by Manihuruk (2020), the decrease in meat pH value during storage is caused by the increasing growth of microorganisms during storage. In acidic environment such between 5.5 and 7.0, spoilage bacteria thrive. The decrease of pH leading to form slime, off-odor, and the changes in texture due to the activity of microorganism during storage (Ullah *et al*., 2023). Abdalhai *et al*. (2014) stated that the growth of microorganisms will affect the physicochemical characteristics of the product, such as pH. A decrease in the pH value of meat stored at cold temperatures was previously studied and conducted by Jin *et al*. (2015) and El-Nashi *et al*. (2015). This is associated with the breakdown of glycogen into lactic acid. According to Yanti *et al*. (2008) that under normal conditions, the pH value of beef ranges from 5.3 - 6.29. The results of the study showed that the pH of beef in various concentration of torch ginger leaf powder treatment, storage time and its interaction were still meet the normal standard of meat pH and safe to consume until the 6th day of storage and a dose of 10% torch ginger leaf powder. This is allegedly caused by the addition of torch ginger extract which can maintain the microbiological properties of beef according to the research of Dina *et al*. (2017). It can be concluded that the addition of torch ginger can inhibit the growth of pathogenic bacteria due to its antibacterial properties, however, the activity of glycolysis into lactic acid continues until the 6th day of meat storage, so it can be stated that torch ginger treatment can extend the shelf life of beef.

Cooking Loss

Meat cooking loss is the percentage of weight lost due to the cooking process, which is directly affected by the temperature function (temperature) and the length of heating time. Factors that influence include pH value, muscle fiber sarcomere length, muscle fiber cut length, myofibril contraction, size and weight of the cross-sectional meat sample, heating, breed of livestock, related to meat fat, age, and energy consumption in feed. According to Shanks *et al.* (2002), the amount of cooking loss is influenced by the amount of damage to the cellular membrane, the amount of water released from the meat, protein degradation and the ability of the meat to bind water. Meat with lower cooking loss has a relatively better quality than meat with greater cooking loss, because the loss of nutrients during cooking will be less (Soeparno, 2015). The results of the cooking loss test can be seen in Table 1.

Based on the results of the DMRT test in Table 1, there is a significant difference ($P<0.01$) in terms of storage time but no significant difference ($P>0.05$) for different doses of torch ginger leaf powder and its interaction with meat cooking loss. According to Soeparno (2015), in general, beef cooking loss varies between 1.5–54.5% with a range of 15–40%. This is in accordance with Mihalkó *et al.* (2022) that this cooking loss value is closely related to water binding capacity. The highest cooking loss, the smallest water-binding capacity. According to Soeparno (2015), low cooking loss content has good quality of meat. This is supported by the opinion of Yanti *et al.* (2008), that meat with a low cooking loss value below 35% has good quality. Storage in the refrigerator or frozen for a short time tends to maintain good cooking loss, but too long or improper storage can increase cooking loss according to the results of research by Dina *et al.* (2017). This is in accordance with the research results, namely that the longer the storage, the higher the cooking loss, however, the cooking loss value during the storage process until the 6th day is still within the normal range, namely below 40%.

Microbiology

Total bacteria refer to the number of bacteria present in a product. In this study, the total bacterial count of beef was conducted using the Total Plate Count (TPC) method. The Total Plate Count (TPC) test determines the number of bacterial colonies in a sample examined on PCA agar media. The total bacterial count significantly determines the quality of a food product, as the higher the bacterial count, the more susceptible the food is to spoilage. The results of the total bacterial test can be seen in Table 2.

Table 2. Total Beef Bacteria (log CFU/g) under Refrigerated Conditions

Treatments	Day			Average**
	0	3	6	
P0	4.31 ± 0.01^{a}	3.67 ± 0.01^{e}	3.86 ± 0.02^{d}	3.95 ± 0.33^{d}
P1	4.26 ± 0.00^{a}	3.59 ± 0.02^{f}	3.56 ± 0.01^{g}	3.80 ± 0.40^{c}
P2	4.32 ± 0.01^{b}	3.20 ± 0.01^{h}	3.01 ± 0.03^{i}	3.48 ± 0.66^{b}
P3	3.95 ± 0.01^{c}	2.85 ± 0.01^{i}	2.60 ± 0.01^{i}	3.14 ± 0.72^{a}
Average**	4.19 ± 0.16^{c}	3.33 ± 0.38^{a}	3.26 ± 0.56^{b}	

Descriptions: ** = highly significant (P<0.01), different superscripts in the same column and row indicate highly significant differences

The total bacterial count (Table 2) in beef treated with 10% torch ginger leaf powder significantly reduced the total bacterial count compared to other treatments (P<0.01). The bacterial counts obtained from beef for each treatment indicated that the beef still met the SNI total bacterial count of 1 x 10^{4} cfu/g.

Table 2 shows that there is antimicrobial activity in the torch ginger leaf simplex. The best treatment was the addition of 10% torch ginger leaf powder with a preservation time of 6 days. Research by Binugraheni & Larasati (2020) which tested the antimicrobial activity of torch ginger leaf extract resulted in antimicrobial activity. Torch ginger is known to contain various secondary metabolite compounds in almost every part of the plant. Research by Pramiastuti (2019) stated that torch ginger leaf extract contains flavonoids, tannin-polyphenols, alkaloids, triterpenoids, quinones, and saponins and according to Nurlatifah *et al.* (2021) showed that torch ginger leaf simplex powder contains flavonoids and saponins.

Almost all parts of the torch ginger plant (*Etlingera elatior*) exhibit antimicrobial activity, thought to be due to the phytochemical compounds contained in the torch ginger plant, such as flavonoids, saponins, alkaloids, tannins, and steroids/triterpenoids. The antimicrobial activity of torch ginger has been shown to inhibit the growth of microbes, namely *Staphylococcus aureus, Candida albicans, Klebsiella pneumoniae, Escherichia coli, Propionibacterium acnes, Salmonella typhimurium*, and *Streptococcus mutans* (Dasi & Leliqia, 2022). Therefore, it can be concluded that the greater the addition of torch ginger leaf powder up to a dose of 10%, the higher the antimicrobial activity, so that the total bacteria contained in the meat until the 6th day of storage has the lowest bacterial count, namely 0.18 x 10^{3} cfu/g.

Chemical Quality

Moisture content. Moisture content is one of the factors that causes food spoilage, including beef, because the water contained in food is a good medium for supporting the growth and activity of food-destroying microbes (Amertaningtyas, 2013). The results of the moisture content test can be seen in Table 3.

Table 3. Beef Water Content (%) during Storage

Treatments	Day			Averages**
	0	3	6	
P0	74.39±0.14^{e}	74,21±0.06^{b}	74,28±0.05^{b}	74,29±0.09^{a}
P1	75.38±0.12^{e}	76,06±0.00^{d}	75,07±0.01^{b}	75,50±0.51^{b}
P2	75,11±0.05^{e}	75,73±0.28^{d}	76,13±0.18^{ab}	75,65±0.51^{b}
P3	75,92±0.06^{d}	76,30±0.04^{c}	76,49±0.33^{a}	76,23±0.29^{c}
Averages**	75,20±0.64^{a}	75,57±0.94^{b}	75,49±1.01^{b}	

Descriptions: ** = highly significant (P<0.01), different superscripts in the same column and row indicate highly significant differences

Based on the DMRT test in Table 3, it can be seen that there is a highly significant difference (P<0.01) in the treatment of dosage, storage time and interaction on meat water content. The highest water content in the interaction of 10% torch ginger leaf powder concentration with 6 days of storage time is 76.49%. Although there is an increase in water content with the addition of torch ginger leaf powder and storage time, the highest water content in this study is still within normal limits (60-85%) (Soeparno, 2015). This shows that storing meat for 6 days in the refrigerator and the addition of torch ginger leaf powder can maintain water content even though the longer the storage process the water content of the meat tends to increase. Storage time will affect water content, namely the higher water content of beef (Riwanto, 2024). This is in accordance with Soeparno (2015) and Dewi *et al.* (2016), during storage there is an increase in water content, this can be caused by water binding capacity which is influenced by meat pH where the water retained in the muscle increases in line with the increase in pH, although the increase is small. On the other hand, the rapid rate of decrease in muscle pH will result in low water holding capacity. Yusuf & Dasir (2014) stated that torch ginger powder has fibers that absorb water or are hydrophobic and are hydrocolloid compounds. The physical properties of dietary fiber are that it can bind other organic materials, ion exchange capacity and water binding capacity. Other properties of dietary fiber compounds are that the molecules are in the form of polymers with large sizes, complex structures, contain many hydroxyl groups and have a large water binding capacity. This causes the water content in this study to increase slowly with the storage time and concentration of torch ginger leaf powder, so it can be stated that torch ginger leaf powder can maintain water content without increasing significantly.

Ash content. Most food ingredients are composed of organic matter and water (approximately 96%), with the remainder consisting of mineral elements. Mineral elements are also known as inorganic substances or ash content. During the combustion process, organic materials burn but inorganic substances do not, hence the term ash (Winarno, 1997). Ash content essentially indicates the mineral content of a material (Pearson & Gillet, 2012). According to Indi *et al.* (2023), ash content of meat affected by soaking and boiling that can reduce mineral availability, due to the water used in soaking thus caused the minerals in material will be dissolved in soaking solution. Meat with a low-fat content has a relatively high mineral content. A high ash content indicates a significant amount of chemical compounds added to the meat. The ash content of meat can be seen in Table 4.

Table 4. Ash Content of Beef (%) during Storage

Treatments	Day 0	Day 3	Day 6	Averages**
P0	1.24±0.01^{a}	1.21±0.01^{b}	1.25±0.02^{c}	1.23±0.02^{c}
P1	1.10±0.00^{ab}	1.02±0.01^{b}	1.00±0.00^{b}	1.03±0.05^{b}
P2	0.97±0.01^{a}	0.97±0.01^{b}	0.96±0.03^{b}	0.96±0.01^{a}
P3	1.08±0.02^{b}	1.04±0.04^{bc}	0.95±0.01^{c}	1.02±0.06^{b}
Averages**	1.10±0.11^{b}	1.05±0.11^{a}	1.04±0.14^{a}	

Descriptions: ** = highly significant (P<0.01), different superscripts in the same column and row indicate highly significant differences

Based on the DMRT test in Table 4, it can be seen that there is a highly significant difference (P<0.01) in the treatment of concentration, storage time and their interaction on the ash content of meat. Ash content in beef tends to be stable during storage because it is an inorganic mineral component that does not change easily. Although there is a highly significant difference in ash content, however, seen from the value it tends to be stable between treatment factors and storage time. There was no differences in meat ash content during storage is because the ash content in meat according to Elsharawy *et al.* (2018) is relatively constant at 1.3%. Active muscle types have higher ash content when compared to passive muscle. Active muscle has a higher ash content because this part of the meat is classified as hard tissue compared to passive muscle which has lower protein and is therefore softer. The ash content range based on Table 4, namely 0.96 - 1.23%, is still within the normal range based on research by Elsharawy *et al.* (2018).

Protein content. Meat protein plays a role in water binding in meat. High protein content in meat increases the meat's water retention capacity, thus reducing the free water content, and vice versa (Lawrie, 2003). High water retention capacity in meat results in a tender meat texture (Soeparno, 2015). The results of the beef protein content study can be seen in Table 5.

Table 5. Beef Protein Content (%) during Storage

Treatments	Day 0	Day 3	Day 6	Averages**
P0	25.48±0.33^{a}	25.06±0.07^{b}	25.25±0.22^{b}	25.26±0.21^{d}
P1	24.63±0.51^{a}	23.57±0.11^{c}	22.66±0.35^{c}	23.62±0.98^{c}
P2	23.25±0.12^{a}	23.26±0.22^{bc}	23.42±0.06^{c}	23.31±0.10^{b}
P3	22.35±0.13^{ab}	22.78±0.04^{b}	21.27±0.25^{d}	22.13±0.78^{a}
Averages**	23.93±1.40^{b}	23.67±0.98^{b}	23.15±1.66^{a}	

Descriptions: ** = highly significant (P<0.01), different superscripts in the same column and row indicate highly significant differences

Based on the DMRT test in Table 5, it can be seen that there are highly significant differences (P<0.01) in the treatment of dosage, storage time, and their interactions on the protein content of meat. The protein content values in Table 5 tend to decrease based on the storage time and concentration of torch ginger leaves. This decrease in protein content is caused by the absorption of water into the muscle tissue of the meat. Protein denaturation alters muscle structure and water holding capacity by changing the distribution of intracellular and extracellular water, resulting in low protein levels (Espinosa *et al*., 2025). This is because storing meat at cold temperatures can increase the meat's water content. Meat fat content is negatively correlated with meat water content. The lower the fat content, the higher the meat water content. This statement is supported by Kurniawati (2007) who stated that the decrease in protein content during the storage process is caused by the decreasing activity of enzymes related to protein formation, such as proteolytic enzymes, because the longer the storage time, the less effective the enzymes are. Meanwhile, based on the treatment, the higher the dosage of torch ginger leaf powder, the lower the protein content. This is allegedly because the higher the concentration, the more antimicrobial compounds contain, which can inhibit microbes in protein hydrolysis, resulting in lower protein levels (Santika & Batubara, 2024). Soeparno (2015) reported that proteins are hydrolyzed by certain bacteria such as *Clostridium, Bacillus*, and *Pseudomonas* into peptides and free amino acids, which are then enzymatically hydrolyzed by proteolytic bacteria and produce a foul odor. On the other hand, Mutmainah *et al*. (2024) research explains that the antioxidant activities of the extract torch ginger show a positive correlation with flavonoid and phenolic acid content.

Fat content. Meat fat content is negatively correlated with meat moisture content; the higher the fat content, the lower the moisture content. The relationship between fat and moisture content can be seen in breed, age, species, muscle location, and feed, all factors that can influence meat fat content (Soeparno, 2015). The results of the research fat content test can be seen in Table 6.

Table 6. Beef Fat Content (%) during Storage

Treatments	Day			Averages**
	0	3	6	
P0	3.66±0.17	3.30±0.06	2.12±0.04	3.02±0.80^{bc}
P1	1.01±0.01	1.19±0.20	0.86±0.01	1.02±0.16^{a}
P2	3.63±0.05	3.98±0.01	2.72±0.20	3.44±0.65^{c}
P3	2.16±1.64	3.39±0.06	2.60±0.04	2.71±0.62^{b}
Averages**	2.61±1.28^{b}	2.96±1.22^{b}	2.07±0.85^{a}	

Descriptions: ** = highly significant (P<0.01), different superscripts in the same column and row indicate highly significant differences

Based on the DMRT test in Table 6, it can be seen that there is a highly significant difference (P<0.01) in the concentration and storage time treatments, but there was no interaction (P>0.05) between the factors, namely the concentration of torch ginger leaf powder and storage time on beef fat content. Beef fat content is relatively stable during standard storage (refrigerator/freezer) because fat is a structural component, but its composition and quality can change due to fat oxidation (rancidity) which is affected by time, temperature, light, and oxygen, causing changes in taste and odor. Storage methods such as vacuum or freezing will slow these changes, although basically the total fat content will not decrease significantly unless it is removed physically or during the cooking/processing process. Based on Table 6, the highest fat content was found in the 7.5% torch ginger leaf powder treatment with storage on day 3. Meat fat content generally ranges from 2.5 (1.5-13)% depending on the type, species, age, and activity of the livestock (Soeparno, 2015). This is due to the application of torch ginger leaf powder in 2 hours soaking on beef, the substances only reached the surface of beef, in return it did not affect fat metabolism, and did not show any hydrolysis of broiler meat fat, thus the fat composition is relatively constant (Windiyartono *et al*., 2016). This is in accordance with the research of Domínguez *et al*. (2019) that the natural soaking treatments containing antioxidant compounds were able to maintain lipid stability without damaging fat composition.

CONCLUSION AND RECOMMENDATIONS

The addition of torch ginger leaf powder significantly affected the quality of beef during storage. Based on the total bacteria during storage, torch ginger leaf powder significantly reduced the number of bacteria during storage, maintained the normal pH level of the beef, maintained the cooking loss, water content, ash content, and fat content during storage, and prevented a decrease in protein content during storage. The best concentration treatment was 10% of torch ginger leaf powder, and was able to maintained the quality of beef during storage for 6 days.

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CONTRIBUTION STATEMENT

All authors played an active role in the research and writing of this article.

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