



The Effect of Celery (*Apium graveolens* L.) Fermentation Solution as a Natural Biopreservative and Storage Duration on the Physical Quality and Total Plate Count of Muscovy Duck (*Cairina moschata*) Meat

Farah Dias Amanda and Nurjama'yah Br. Ketaren*^{ID}

¹Study Program of Animal Science, Faculty of Agriculture, Universitas Sumatera Utara, Medan 20155, Indonesia.

*Corresponding Author: jamayahnur@usu.ac.id

ARTICLE INFO	ABSTRACT
<p>Article history: Received October 19th 2026 Revised October 30th, 2026 Accepted October 30th, 2026 Available online October 30th, 2026</p> <p>E-ISSN: 2808-2753</p> <p>How to cite: Farah Dias Amanda and Nurjama'yah Br. Ketaren . “ The Effect of Celery (<i>Apium graveolens</i> L.) Fermentation Solution as a Natural Biopreservative and Storage Duration on the Physical Quality and Total Plate Count of Muscovy Duck (<i>Cairina moschata</i>) Meat”. Jurnal Peternakan Integratif, Vol.14,No.02,pp.81-89 Oct 2026, doi: 10.32734/jpi.v14i02.26383</p>	<p>Muscovy duck (<i>Cairina moschata</i>) meat has high nutritional value. However, it also has certain shortcomings such as a relatively tougher texture, a distinct, pungent odor and susceptible to microbial contamination. This study aimed to analyze the effects of celery (<i>Apium graveolens</i> L.) fermentation solution as a natural biopreservative and storage duration on the physical quality and Total Plate Count (TPC) of muscovy duck (<i>Cairina moschata</i>) meat. The physical quality parameters observed included pH, cooking loss, water-holding capacity and TPC. The study used a completely randomized design (CRD) with a factorial pattern involving two factors: the dose of celery fermentation solution (P0 = 0 mL, P1 = 60 mL, P2 = 80 mL, and P3 = 100 mL) and storage duration (L0 = 0 hours, L1 = 12 hours, L2 = 24 hours, and L3 = 36 hours). Each treatment combination was replicated twice. The results showed that the application of the celery fermentation solution and storage duration affected the physical quality and microbial count of duck meat. Increasing the dose of the celery fermentation solution reduced the pH value and cooking loss, increased water-holding capacity, and reduced the Total Plate Count. The treatment combination of 100 mL of celery fermentation solution and 12 hours of storage produced better physical quality characteristics and microbial counts compared to the other treatments. Thus, celery fermentation solution has the potential to be used as a natural biopreservative to maintain quality and extend the shelf life of duck meat during room-temperature storage.</p> <p>Keyword: Duck Meat, Natural Biopreservatives, Celery Fermentation, Physical Quality, Total Plate Count, Shelf Life</p>



This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International.
<http://doi.org/10.32734/jpi.v14i02.26383>

1. Introduction

Muscovy duck (*Cairina moschata*) meat is a source of animal protein with high nutritional value. It contains 21.4% protein, 8.2% fat, 1.2% ash, and 15,900 kcal/kg of energy [1]. In addition, muscovy duck meat contains various minerals and vitamins that are beneficial to health [2]. However, muscovy duck meat has several drawbacks, such as a relatively tougher texture and a distinctive gamey odor [3]. Its high nutritional content makes muscovy duck meat susceptible to microbial contamination and quality deterioration during storage [4].

Various preservation methods have been used to maintain meat quality, such as refrigeration, freezing, smoking, and the use of synthetic preservatives. However, the use of synthetic preservatives raises concerns due to their potential negative impact on consumer health [5]. Therefore, the development of safe and environmentally friendly natural preservation methods is increasingly necessary. One widely developed approach is the use of biopreservatives. Biopreservatives are preservation methods that utilize beneficial microorganisms, fermentation metabolites, or bioactive compounds derived from plants to inhibit the growth of spoilage microorganisms and pathogens [6]. Plant bioactive compounds such as flavonoids, phenolics, tannins, saponins, and essential oils are known to possess antimicrobial and antioxidant activities that can help maintain quality and extend the shelf life of food.

Fermentation is a technology with the potential to support the use of biopreservatives through the production of various antimicrobial compounds, such as organic acids, hydrogen peroxide, and bacteriocins [6]. These compounds can inhibit the growth of spoilage microorganisms and pathogens during storage. In

addition, fermentation can increase the availability of bioactive compounds that contribute to improved food quality and safety [7].

Celery (*Apium graveolens* L.) is a plant with potential for use as a natural biopreservative because it contains various bioactive compounds, such as flavonoids, tannins, saponins, apigenin, and essential oils, which exhibit antimicrobial activity [8]. Celery also contains antioxidants that can help maintain the quality of food products during storage [9]. [10] reported that celery extract can be used as a natural curing agent in meat products. [11] stated that the use of celery can preserve sensory quality and extend the shelf life of products. [12] found that celery seed extract effectively inhibits the growth of spoilage microorganisms in beef burgers. Additionally, [13] reported that celery products exhibit antimicrobial activity against pathogenic bacteria in meat products.

This study aims to determine the effect of using a celery fermentation solution and storage duration on the physical quality and total plate count (TPC) of duck meat.

2. Material and Method

2.1. Material

The ingredients used included 4.8 kg of duck meat, 500 g of celery leaves (*Apium graveolens* L.), salt, sugar, distilled water, Buffer Peptone Water (BPW), MRS Agar, 1% CaCO_3 , 90% alcohol, label paper, polyethylene plastic, Whatman No. 42 filter paper, graph paper, Folin-Ciocalteu reagent, and other supporting chemicals. The main equipment used included a pH meter, a UV-Vis spectrophotometer, an autoclave, an incubator, an oven, 10% Na_2CO_3 , gallic acid, 96% ethanol, methanol, AlCl_3 , and sodium acetate solution, aluminum foil, tissues, label paper, wrapping paper, and other supporting materials.

2.2. Method

The study used a completely randomized design (CRD) with a 4×4 factorial pattern and two replications. The first factor was the dose of celery fermentation solution, consisting of P0 (0), P1 (60), P2 (80), and P3 (100) mL. The second factor was the duration of storage at room temperature, consisting of L0 (0), L1 (12), L2 (24), and L3 (36) hours.

2.3. Preparation of the Celery Fermentation Solution

The celery fermentation solution was prepared using a modified version of the method described in [14]. Celery leaves were washed, cut into pieces approximately 2 cm long, and 100 g of the leaves were placed in a fermentation container containing 1 L of water, 2.5% salt, and 2.5% sugar. The mixture was homogenized, tightly sealed, and fermented at room temperature for 6 days. After fermentation was complete, the solution was filtered and used to treat the duck meat.

2.4 Preparation of the BAL Isolation Medium and Isolation of BAL from Celery Fermentation solution

The medium used for BAL isolation was MRS Agar supplemented with 1% (w/v) CaCO_3 . The medium was prepared by dissolving MRS Agar in distilled water, then homogenizing it using a hot-plate stirrer at 100°C until completely dissolved. The medium is then sterilized in an autoclave at 121°C for 15 minutes at a pressure of 15 lbs, poured into Petri dishes in amounts of approximately 15 ml, and allowed to solidify [15].

BAL isolation was performed using a stepwise dilution method down to 10^{-3} using 9 mL of Peptone Water Buffer (BPW) and 1% CaCO_3 . A total of 0.1 mL from each dilution (10^{-1} – 10^{-3}) was inoculated onto MRS Agar medium using the spread plate method, then incubated at 37°C for 72 hours.

2.5 Phenolic Analysis of Celery Fermentation Solution

Total phenolic content was determined using the Folin–Ciocalteu method with gallic acid as the standard, as described in [16] and [17]. Absorbance was measured at a wavelength of 765 nm using a UV-Vis spectrophotometer, and results were expressed as mg GAE/g fresh sample.

2.6 Flavonoid Assay of Celery Fermentation Solution

Total flavonoid content was determined using the AlCl_3 method, as described in [18]. The maximum wavelength was determined using a quercetin standard solution and was found to be 439 nm. A calibration curve was prepared using quercetin standard solutions of various concentrations. Samples dissolved in methanol were reacted with AlCl_3 and sodium acetate, then incubated before measuring absorbance at 439 nm using a UV-Vis spectrophotometer. Total flavonoid content was calculated based on the quercetin standard curve and expressed as mg QE/g sample.

2.7. Treatment Application

The duck meat used was from 8- to 12-month-old ducks. Samples of duck meat weighing 50 g were treated with the specified dose of celery fermentation solution, soaked for 90 minutes, drained for 5 minutes, and then stored in sterile, tightly sealed containers at room temperature according to the specified treatment [modification 14].

2.8 Measured Variables

The parameters observed included physical quality—such as pH, cooking loss, and water-holding capacity—as well as microbiological quality, specifically Total Plate Count (TPC). pH measurements were performed according to the method in [19], cooking loss according to [20], water-holding capacity using the Hamm method [21], moisture content based on the method in [22], and TPC according to [23]

2.9. Data Analysis

Data were analyzed using analysis of variance (ANOVA) based on a completely randomized design (CRD) with a factorial pattern. If a treatment showed a significant effect ($P < 0.05$), Duncan's Multiple Range Test (DMRT) [24] was performed.

3. Result and Discussion

3.1. Isolation of Lactic Acid Bacteria (LAB)

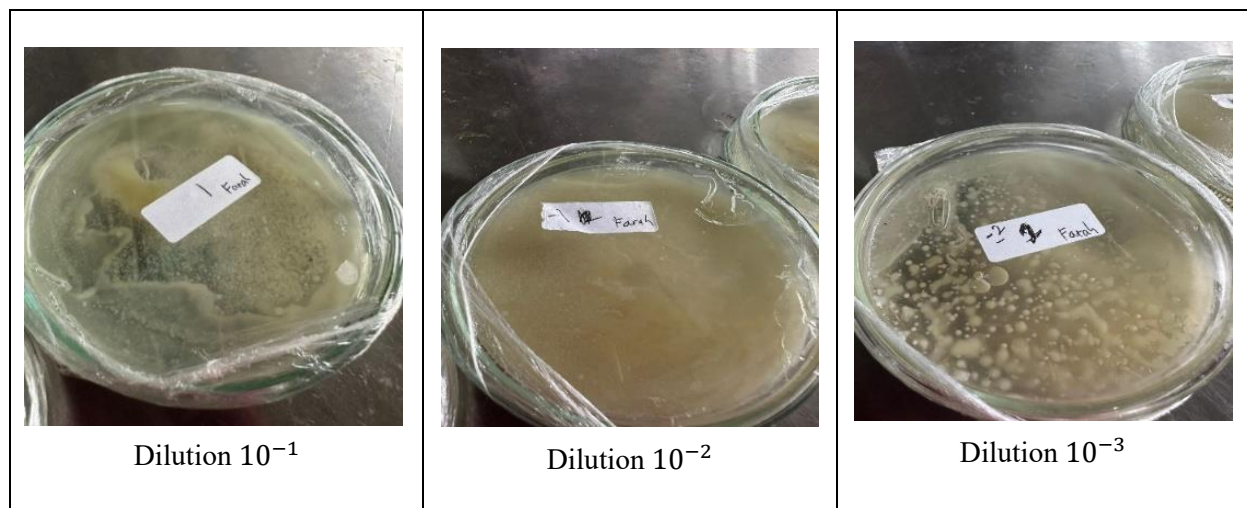


Figure 1. Isolation of Lactic Acid Bacteria from a Celery Fermentation Solution

The formation of a clear zone on MRS agar medium indicates the ability of bacteria, particularly lactic acid bacteria (LAB), to produce organic acids that result in the dissolution of 1% CaCO_3 . The production of these acids lowers the pH of the environment, thereby inhibiting the growth of spoilage microorganisms and pathogens by damaging cell membranes and disrupting microbial metabolic systems [25]. LLA colonies on MRS agar are generally white to cream-colored and are accompanied by the formation of a clear zone around the colonies [26]. During celery fermentation, simple sugars are utilized as an energy source, thereby increasing lactic acid production and creating conditions that support LLA growth [27]. In addition, the bioactive compounds in celery—such as flavonoids, phenolics, and essential oils—contribute to antimicrobial and antioxidant activities that synergize with BAL metabolites, thereby enhancing the formation of the clear zone [8]. The presence of this clear zone indicates the potential of BAL isolates as biopreservatives that can be utilized to improve the safety and quality of food products [28].

3.2. Testing for Phenolic Content

The determination of the total phenolic content of the celery fermentation solution yielded a value of 91.1914 mg GAE/g, which is higher than the phenolic content of the celery methanol fraction reported by [29]. The increase in phenolic content is thought to result from the enzymatic activity of lactic acid bacteria during fermentation, which releases bound phenolic compounds from the plant cell walls, thereby increasing their availability. [30] states that the esterase and β -glucosidase enzymes produced by microbes play a role in

releasing phenolic compounds into forms that are easier to extract. Furthermore, acidic conditions during fermentation can help convert complex compounds into simpler forms, thereby enhancing their bioavailability [31]. Celery is known to contain various phenolic compounds, such as caffeic acid, ferulic acid, apigenin, and luteolin, which contribute to its antioxidant activity [32]. The high phenolic content observed in this study indicates that the fermentation process can increase the availability of bioactive compounds that help inhibit lipid oxidation and preserve food quality [33].

Table 1. Phenolic Content of Celery Fermentation Solution

Sample Name	Sample Weight(g)	ABS Sample	Total Phenolic Content (mg GAE /g)
Celery Fermentation Solution	0,1012	0,177	91,1914

3.3. Flavonoid Content Testing

The determination of the total flavonoid content in the celery fermentation solution at 15.95 mg QE/g indicates that flavonoids remain present in sufficiently high amounts after the fermentation process. This value is slightly lower than the results reported in [34], which is likely due to differences in sample form and the processing methods used. [31] states that fermentation by lactic acid bacteria (LAB) can increase the availability of bioactive compounds through the activity of β -glucosidase, which hydrolyzes flavonoid glycosides into simpler aglycone forms that are more easily absorbed. Additionally, the fermentation process helps release flavonoids bound to the plant cell wall matrix, making them easier to detect. Although fermentation can cause changes or partial degradation of some flavonoids, the relatively high content observed in this study indicates that the fermentation process is capable of preserving the flavonoids in celery. The presence of flavonoids, such as apigenin, luteolin, and quercetin, acts as antioxidants that can inhibit oxidation and support the potential of celery fermentation solutions as functional foods [35].

Table 2. Flavonoid Content of Celery Fermentation Solution

Sample Name	Sample Weight (g)	ABS Sample	Total Flavonoid Content (mg QE /g)
Celery Fermentation Solution	0,0505	0,100	15,95

3.4 Physical Properties

3.4.1. Acidity Level (pH)

The results of the study showed that the interaction between the celery fermentation solution concentration and storage duration had a significant effect ($P < 0.05$) on the pH of duck meat. The highest pH value was observed in the P0L0 treatment (5.79), while the lowest was in the P3L3 treatment (5.03). The decrease in pH occurred due to increased absorption of organic acids from the celery fermentation solution, which had a low pH (3.6). According to [21], the ultimate pH of meat ranges from 5.4 to 5.8. These results are consistent with [36], which reported that an increase in acid concentration causes a decrease in the pH of duck meat.

The higher the celery fermentation dose, the lower the meat's pH becomes due to the activity of lactic acid bacteria (LAB), which produce lactic acid through the metabolism of simple sugars [37]. Fermentation by *Lactobacillus* is also known to increase lactic acid production, thereby lowering meat pH [38]. Additionally, longer storage periods lead to lactic acid accumulation, causing the pH to continue decreasing [39]. Phenolic compounds and flavonoids in celery also help inhibit spoilage bacteria and maintain meat quality during storage [40].

Table 3. Acidity level (pH) in the interaction between dose and storage duration

Dosage Celery Fermentation Solution	Storage Duration				Mean± SD
	L0	L1	L2	L3	
P0	5,79 ^a	5,53 ^{de}	5,31 ^g	5,12 ⁱ	5,44 ^a ±0,29
P1	5,71 ^b	5,47 ^e	5,25 ^{gh}	5,09 ^{ij}	5,38 ^b ±0,27
P2	5,62 ^c	5,3 ^{fg}	5,20 ^h	5,07 ^{ij}	5,32 ^c ±0,24
P3	5,57 ^{cd}	5,25 ^{gh}	5,13 ⁱ	5,03 ^j	5,25 ^d ±0,23
Mean ±SD	5,67 ^a ±0,10	5,41 ^b ±0,12	5,22 ^c ±0,08	5,08 ^d ±0,04	

Note: Different superscripts in columns and rows indicate statistically significant differences ($P < 0.05$).

The highest interaction was observed in P0L0, while the lowest was in P3L3. The low pH in P3L3 indicates that the highest dose of celery fermentation solution and 36 hours of storage resulted in a greater accumulation of organic acids, thereby lowering the pH of the meat [41]. In addition, the antimicrobial compounds in celery help inhibit spoilage bacteria and support BAL activity during storage [42]. [43] reported that antimicrobial compounds from *Lactobacillus plantarum* are capable of suppressing bacterial growth in meat products.

3.4.2. Cooking Loss

Table 4. Cooking loss in the interaction between dose and storage time

Dosage Celery Fermentation Solution	Storage Duration				Mean± SD
	L0	L1	L2	L3	
P0	27,78	32,42	35,44	49,60	36,31 ^a ±9,40
P1	25,38	29,99	33,46	40,90	32,43 ^b ±6,54
P2	23,47	28,43	32,30	37,07	30,32 ^b ±5,77
P3	14,08	17,81	27,12	35,80	23,70 ^c ±9,75
Mean±SD	22,68 ^d ±6,00	27,16 ^c ±6,45	32,08 ^b ±3,55	40,84 ^a ±6,23	

Note: Different superscripts in columns and rows indicate statistically significant differences ($P < 0.05$).

The results of the study showed that the interaction had no significant effect ($P > 0.05$), whereas the dose of the celery fermentation solution and the storage duration had significant effects ($P < 0.05$) on the cooking loss of duck meat. The lowest cooking loss value was observed in P3L0 (14.08%) and the highest in P0L3 (49.60%). All values remained within the normal range for meat cooking loss according to [44].

Higher doses of the celery fermentation solution tended to result in lower cooking loss in duck meat. This is because the phenolic and flavonoid compounds in celery help maintain protein stability and the meat's water-binding capacity, thereby reducing fluid loss during cooking [45]. Flavonoids also act as antioxidants that protect proteins from oxidative damage [40]. The meat's improved ability to retain water results in lower cooking loss values [46]. Longer storage periods increase cooking loss due to changes in protein structure and a decrease in the meat's water-binding capacity. The production of organic acids by lactic acid bacteria during storage can affect the physical properties of the meat [37]. [47], changes in myofibrillar protein structure cause more fluid to be lost during cooking.

The absence of an interaction effect indicates that the dose of the celery fermentation solution and the storage duration act independently in influencing the cooking shrinkage of duck meat. Celery's bioactive compounds also play a role in helping to maintain protein stability during storage [48].

3.4.3 Water Holding Capacity

The results of the study showed that the interaction had no significant effect ($P > 0.05$), whereas the dose of the celery fermentation solution and the storage duration had significant effects ($P < 0.05$) on the water-holding capacity of duck meat. The water-holding capacity values obtained were still within the normal range according to [21]. These results are consistent with [49], which reported that the use of phytobiotic ingredients can increase the water-holding capacity of meat.

Table 5. Water holding capacity in the interaction between dose and storage time

Dosage Celery Fermentation Solution	Storage Duration				Mean±SD
	L0	L1	L2	L3	
P0	44,93	36,32	33,70	22,58	34,38 ^b ±9,22
P1	47,69	39,56	37,18	24,62	37,26 ^b ±9,55
P2	58,04	48,68	43,71	32,35	45,70 ^a ±10,70
P3	59,20	50,35	45,47	38,84	48,47 ^a ±8,57
Mean ± SD	52,47 ^a ±7,21	43,73 ^b ±6,85	40,02 ^b ±5,52	29,60 ^c ±7,46	

Note: Different superscripts in columns and rows indicate statistically significant differences ($P < 0.05$).

Increasing the dose of the celery fermentation solution tends to increase the water-holding capacity of the meat. This effect is thought to be related to the activity of lactic acid bacteria, which produce organic acids during fermentation, as well as the phenolic and flavonoid content of celery, which help maintain protein integrity, thereby preserving the meat's ability to bind water [50]. The antioxidant activity of celery's bioactive compounds also plays a role in maintaining the meat's water-holding capacity [51]. Conversely, prolonged storage causes a decrease in water-holding capacity due to postmortem changes and protein degradation, which reduce the proteins' ability to bind water [52]. A decrease in pH resulting from organic acid production during storage further accelerates the decline in water-holding capacity [53]. Nevertheless, the bioactive compounds in celery help maintain meat quality during storage [54]. The absence of an interaction effect indicates that the two factors act independently on the water-holding capacity of duck meat [55].

3.5. Total Plate Count (TPC)

Table 6. Total Plate Count in the interaction between dose and storage time

Dosage Celery Fermentation Solution	Storage Duration				Mean±SD
	L0	L1	L2	L3	
P0	5.91 ^{de}	6.08 ^{bc}	6.19 ^{ab}	6.29 ^a	6.12 ^a ± 0,16
P1	5.87 ^{de}	5.93 ^{cde}	6.18 ^{ab}	6.25 ^{ab}	6.06 ^a ± 0,19
P2	5.66 ^{fg}	5.88 ^{de}	6.00 ^{cd}	6.23 ^{ab}	5.94 ^b ± 0,24
P3	5.53 ^g	5.66 ^{fg}	5.89 ^{ef}	6.21 ^{ab}	5.82 ^c ± 0.30
Mean ± SD	5.74 ^d ± 0,18	5.89 ^c ± 0,17	6.07 ^b ± 0,15	6.25 ^a ± 0,03	

Note: Different superscripts in columns and rows indicate statistically significant differences ($P < 0.05$).

The results of the study showed that the interaction between the dose of the celery fermentation solution and storage duration had a significant effect ($P < 0.05$) on the Total Plate Count (TPC) of duck meat. The lowest TPC value was observed in treatment P3L0 (5.53 log CFU/g), while the highest was in P0L3 (6.29 log CFU/g). These results indicate that the addition of celery fermentation solution is effective in suppressing microbial growth in duck meat. This finding is consistent with [36], which reported that organic acid treatments can reduce the total bacterial colony count in meat.

The decrease in TPC in treatments with higher fermentation doses is likely due to the activity of lactic acid bacteria (LAB), which produce organic acids, hydrogen peroxide, and bacteriocins with antimicrobial properties. Additionally, celery contains bioactive compounds such as flavonoids, saponins, tannins, and alkaloids that can inhibit bacterial growth by damaging cell membranes and disrupting microbial metabolism. These results are consistent with the reports in [56] and [57]. The increase in TPC during storage indicates that meat is a nutrient-rich medium that supports microbial growth. The longer the storage period, the more the microbial count tends to increase due to metabolic activity and bacterial proliferation. These results are in line with [58], which states that microbial growth increases during meat storage. The highest interaction was observed in the P0L3 treatment, while the lowest interaction was observed in the P3L0 treatment. This indicates that the use of 100 ml of celery fermentation solution without storage is most effective in inhibiting

microbial growth. These findings are supported by [59] which state that increasing the concentration of celery can enhance antimicrobial activity and reduce the number of microbes in meat.

4. Conclusion

The biopreservation of duck meat using a celery (*Apium graveolens* L.) fermentation solution was found to lower the pH, reduce cooking loss, increase water-holding capacity, and lower the total plate count of the duck meat. The best results were obtained with treatment P3L1, which involved a 100-ml dose of the celery fermentation solution and a storage time of 12 hours.

5. Conflict of Interest

All researchers involved in writing this manuscript have no conflicts of interest

References

- [1] Malaini, Y. (2020). Kualitas Fisik dan Organoleptik Daging Entok yang ditambah Pasta Jahe Merah (*Zingiber officinale* Rb) dengan Lama Penyimpanan yang Berbeda (Doctoral dissertation, Universitas Islam Negeri Sultan Syarif Kasim Riau).
- [2] Saefudin, S., & Adyatama, A. (2025). Efektivitas Penambahan Ekstrak Pepaya terhadap Kualitas Rasa dan Warna pada Daging Entok (*Cairina moschata*). *Indonesian Research Journal on Education*, 5(2), 1103-1108.
- [3] Syarifuddin, I., Purwanti, Y., & Fera, M. (2023). Pengaruh Lama Perendaman Ekstrak Buah Nanas Terhadap Sifat Fisik (pH Dan Susut Masak) Dan Uji Sensori Daging Entok. *Journal Of Technology And Food Processing (JTFP)*, 3(02), 52-61.
- [4] Rouger, A., Tresse, O., & Zagorec, M. (2017). Bacterial Contaminants Of Poultry Meat: Sources, Species, And Dynamics. *Microorganisms*, 5(3), 50.
- [5] Agustina KK, Sari PH, & Suada IK. (2017). Pengaruh Perendaman Pada Infusa Daun Salam Terhadap Kualitas dan Daya Tahan Daging Babi. *Bul. Vet. Udayana*. 9(1): 34-41
- [6] Zapašnik, A., Sokołowska, B., & Bryła, M. (2022). Role Of Lactic Acid Bacteria In Food Preservation And Safety. *Foods*, 11(9), 1283
- [7] Hardiansyah, R., & Lamid, M. (2022). Penggunaan Tepung Fermentasi Daun Seligi Terhadap Kadar Kolesterol, Low Density Lipoprotein, dan High Density Lipoprotein Daging Ikan Patin. *Jurnal Medik Veterinar*, 5(1).
- [8] Ngelu, F. Y., Marbun, F. D., Sihombing, A. M., Manalu, Y., Ate, V. R. K. M., & Riswanto, F. D. O. (2022). Potensi Ekstrak Seledri (*Apium graveolens* L.) Sebagai Antibakteri. *Jurnal Jamu Kusuma*, 2(1), 23-29.
- [9] Patricia, A. D., Jumaeri, J., & Mahatmanti, F. W. (2019). Uji Daya Antibakteri Gel Hand Sanitizer Minyak Atsiri Seledri (*Apium graveolens* L.). *Indonesian Journal of Chemical Science*, 8(1), 28-33.
- [10] Ritter, A. R. C., Funck, G. D., Prietto, L., da Silva Dannenberg, G., de Lima Marques, J., dos Santos Cruxen, C. E., ... & Fiorentini, Â. M. (2020). Evaluation of celery extract (*Apium greveolens* L.) As A Natural Curing Agent In The Production Of Italian-Type Salami With Native Starter Cultures. *Brazilian Journal of Development*, 6(5), 25685-25702.
- [11] Alkazzaz, S. R. M. A., Abdelrahman, H. A., Ahmed, A. M., Dora, E. D. H. I., Helal, I. M., & Ahmed, N. I. H. (2022). Effect Of Replacing Sodium Nitrite With Celery On Sensory And Chemical Quality Of Popular Dry Sausage. *Journal of Advanced Veterinary Research*, 12(4), 404-408.
- [12] Ghoname, E. S. A., Hassan, D., & Hammad, E. M. (2023). Antimicrobial Activity Of Dill Seeds And Celery Seeds On Beef Burger. *European Journal of Nutrition dan Food Safety*, 15(9), 106-117.
- [13] Martinez, R. D. (2024). *Antimicrobial Efficacy Study Of Celery Powder, Nitrites And NATPRE T10 In RTE Meat Strips In An Accelerated Shelf-Life Evaluation With Listeria Monocytogenes* (Doctoral Dissertation)
- [14] Nerawati, A. T. D., & Si, N. S. (2015). Pemanfaatan Larutan Fermentasi Selada Sebagai Biopreservasi Pada Ikan Bandeng. *Jurnal Penelitian Kesehatan*, 12(2).
- [15] Sri, M. (2018). Potensi Isolat Bakteri Asam Laktat Dari Susu Kerbau Sebagai Probiotik Dan Penghasil Bakteriosin Untuk Pangan Fungsional. Universitas Andalas.
- [16] Waterhouse A (1999). Folin-Ciocalteu Micro Method For Total Phenol In Wine, Department of Viticulture & Enology University of California. Davis: 152-178.
- [17] Orak H (2006). Total Antioxidant Activities, Phenolics, Anthocyanins, Polyphenoloxidase Activities In Red Grape Varieties. *Electronic Journal of Polish Agricultural University Food Science and Technology*. 9: 117 – 118
- [18] Chang, C., Yang, M., Wen, H., & Chern, J. (2002). Estimation Of Total Flavonoid Content In Propolis

- By Two Complementary Colorimetric Methods. *Journal Of Food And Drug Analysis*, 10(3), 178-182.
- [19] Suwetja, I. K. (2007). Biokimia Hasil Perikanan. Jilid III. Rigormortis, TMAO, dan ATP. Fakultas Perikanan dan Ilmu Kelautan. Universitas Sam Ratulangi Manado.
- [20] Kouba M. (2003). Quality Of Organic Animal Products. *Lives Prod. Sci.*, 80, 33-40.
- [21] Soeparno. (2005). Ilmu dan Teknologi Daging. Cetakan Ke-4. Gadjah Mada University Press, Yogyakarta
- [22] [AOAC] Association of Official Analytical Chemist. (2005). Official Method of Analysis of The Association of Official Analytical of Chemist. Arlington, Virginia, USA: Association of Official Analytical Chemist, Inc.
- [23] Ketaren, N. Y. B., Yunilas, Y., & Siregar, E. S. (2023). Effect Of Addition Of *Pediococcus Pentosaceus* Strain N6 Isolate And Cassava Peel On Total Microbes And Gastrointestinal Organ Weight Of Super Native Chicken. In *BIO Web Of Conferences* (Vol. 88, P. 00025). EDP Sciences.
- [24] Mattjik AA and Sumertajaya (2013). Experiment design with SAS and minitab applications. IPB Press., Bogor. pp. 1-350.
- [25] Kurnia, M., Amir, H., & Handayani, D. (2020). Isolasi Dan Identifikasi Bakteri Asam Laktat Dari Makanan Tradisional Suku Rejang Di Provinsi Bengkulu: "Lemea". *Jurnal Pendidikan Dan Ilmu Kimia*, 4(1).
- [26] Putri, A. L., & Kusdiyantini, E. (2018). Isolasi Dan Identifikasi Bakteri Asam Laktat Dari Pangan Fermentasi Berbasis Ikan (Inasua) Yang Diperjualbelikan Di Maluku-Indonesia. *Jurnal Biologi Tropika*, 1(2), 6-12.
- [27] Heppy S. P., N., & Fatridha. Y. (2023). Karakterisasi Dan Identifikasi Molekuler Bakteri Asam Laktat Diisolasi Dari Ikan Bilih (*Mystacoleucus Padangensis*) Danau Singkarak Berpotensi Sebagai Probiotik. *Majalah Kedokteran Andalas*, 46(3), 535-547.
- [28] Rahman S & Ardi Mustakim. (2025). Identifikasi Dan Karakterisasi Bakteri Asam Laktat Dari Bekasam Ikan Gabus (*Channa striata*). *Jurnal Cakrawala Pendidikan dan Biologi*, 2(3): 54–61
- [29] Ud Din, Z., Shad, A. A., Bakht, J., Ullah, I., & Jan, S. (2015). In Vitro Antimicrobial, Antioxidant Activity And Phytochemical Screening Of *Apium Graveolens*. *Pakistan Journal Of Pharmaceutical Sciences*, 28(5).
- [30] Shahidi, F., & Ambigaipalan, P. (2015). Phenolics And Polyphenolics In Foods, Beverages And Spices: Antioxidant Activity And Health Effects—A Review. *Journal Of Functional Foods*, 18, 820-897
- [31] Hur, S. J., Lee, S. Y., Kim, Y. C., Choi, I., & Kim, G. B. (2021). Effect Of Fermentation On The Antioxidant Activity In Plant-Based Foods. *Food Chemistry*, 160: 346–356.
- [32] Hanum, R. F., Fachriyah, E., Ismiyanto, I., & Sarjono, P. R. (2025) Total Phenolic Content Analysis, Antioxidant Activity, and Isolation of Phenolic Acid Compounds from Methanol Extract of Celery (*Apium graveolens L.*). *Jurnal Kimia Sains dan Aplikasi*, 28(7), 345-354.
- [33] Saritaş, S., Portocarrero, A. C. M., Miranda López, J. M., Lombardo, M., Koch, W., Raposo, A., & Witkowska, A. M. (2024). The Impact Of Fermentation On The Antioxidant Activity Of Food Products. *Molecules*, 29(16), 3941.
- [34] Rhahmasari, I., Rusnia, J. H., & Wiwik, I.... (2026). Karakteristik Antioksidan Ekstrak Daun Seledri (*Apium graveolens*) dan Penetapan Kadar Flavonoid Total Dengan Metode Maserasi. *Ensiklopedia of Journal*, 8 (2).
- [35] Rivany, M. I. (2021). Manfaat Rebusan Daun Seledri (*Apium graveolens L*) Sebagai Obat Pada Pasien Hipertensi. *Journal of Pharmaceutical Science and Herbal Technology*, 1245-1251.
- [36] Darmawan, Y. D., Suharnas, E., & Malianti, L. (2022). Pengaruh Asam Asetat Pada Daging Entok (*Cairina moschata*) Terhadap pH, Keempukkan Dan Total Bakteri. *Jurnal Inspirasi Peternakan*, 2(3), 378-383.
- [37] Afriani, Arnim, Y. Marlida., & Yuherman (2017). Potensi Antibakterial Bakteri Asam Laktat Proteolitik dari Bekasam Sebagai. *Jurnal Peternakan Indonesia*.
- [38] Arief, I. I., Suryati, T., & Maheswari, R. A. (2006). Sifat Fisik Daging Sapi Dark Firm Dry (DFD) Hasil Fermentasi Bakteri Asam Laktat *Lactobacillus Plantarum*. *Tropical Animal Science Journal*, 29(2).
- [39] Nurraifah, Y., Arief, I. I., & Ulupi, N. (2021). Penggunaan Bakteriosin Yang Diproduksi Oleh *Lactobacillus Plantarum* Sebagai Pengawet Alami Untuk Daging Ayam Yang Disimpan Di Suhu Ruang. *Jurnal Ilmu Produksi dan Teknologi Hasil Peternakan*, 9(1), 7-14.
- [40] Karimah, N. N. (2020). Pengaruh Pemberian Fitobiotik Tepung Daun Bidara Laut (*Ziziphus mauritiana*) Pada Pakan Terhadap Kualitas Fisik Daging Itik Hibrida (Doctoral dissertation, Universitas Brawijaya).
- [41] Hidayatulloh, R., Sumarmono, J., & Setyawardani, T. (2016). Karakteristik Sosis Fermentasi Daging Sapi

Selama Fermentasi Dengan Starter Dari Kefir Pasta. In *Prosiding Seminar Teknologi dan Agribisnis Peternakan (STAP)* (Vol. 4, pp. 539-547).

- [42] Segmenoglu, M. S., Tozlu, I., Unal, O., Mohammed, F. S., Sevindik, M., & Akgul, H. (2024). Biological Activities Of Celery Leaves, Seeds And Tuber Parts Collected From Different Regions. *Indian Journal of Experimental Biology*, 62(9).
- [43] Budiman, C. (2016). Plantaricin IIA-1A5 From *Lactobacillus Plantarum* IIA-1A5 Retards Pathogenic Bacteria In Beef Meatball Stored At Room Temperature. *American Journal Of Food Technology*.
- [44] Lawrie, R.A. (2003). Ilmu daging. Edisi Ke-5. Diterjemahkan oleh parakkasi, A., dan Y. Amwila. Universitas Indonesia Press, Jakarta.
- [45] Abroroh, A. (2019). *Mutu Fisik Sediaan Gargarisma dari Ekstrak Daun Seledri (Apium graveolens L.)* (Doctoral dissertation, Akademi Putera Indonesia Malang).
- [46] Aktaş, N., Aksu, M. I., & Kaya, M. (2007). The Effect Of Organic Acid Marination On Tenderness, Cooking Loss And Bound Water Content Of Beef. *Journal of Muscle Foods*, 14(3), 181-194.
- [47] Lawrie, R. A., & Ledward, D. A. (2017). *Lawrie's Meat Science* (8th ed.). Woodhead Publishing.
- [48] Rhahmasari, I., Rusnia, J. H., & Wiwik. I. (2026). Karakteristik Antioksidan Ekstrak Daun Seledri (*Apium graveolens*) dan Penetapan Kadar Flavonoid Total Dengan Metode Maserasi. *Ensiklopedia of Journal* ,8 (2)
- [49] Icah N., Lilis S., & Jajang G., (2025) Pengaruh Konsentrasi Ekstrak Daun Salam (*Syzygium polyanthum*) Pada Marinasi Daging Bebek Terhadap Daya Ikat Air, Susut Masak, Keempukkan dan Organoleptik, 3(5),1-9.
- [50] Amir, M., Sopiattunnisa, N., & Abna, I. M. (2024). Produksi Asam Laktat Oleh *Lactobacillus acidophilus* Dalam Media Fermentasi Kombinasi Limbah Cair Tahu Dan Mangga (*Mangifera indica l.*). *Jurnal Ilmiah Farmako Bahari*, 15(1), 25-36.
- [51] Alessi, A. C. S. B., Brito, N. L. H., Droval Arcain, A. A., & Reitz Cardoso, F. A. (2026). Evaluation Of Celery Extract As A Natural Alternative To Sodium Nitrite In Fresh Chicken Sausages During Refrigerated Storage. *Journal of the Science of Food and Agriculture*, 106(4), 2251-2258.
- [52] Huff-Lonergan, E., & Lonergan, S. M. (2005). Mechanisms Of Water-Holding Capacity Of Meat:The Role Of Postmortem Biochemical And Structural Changes. *Meat Science*, 71(1), 194-204.
- [53] Sipayung, I., Afriani, A., & Sulaksana, I. (2022). Pengaruh Lama Penyimpanan Pada Suhu Kamar Terhadap Kualitas Fisik Dan Mikrobiologi Daging Kambing Diawetkan Dengan Substrat Antimikroba *Lactobacillus Plantarum* BAF514 Yang Dikemas Vakum. *Jurnal Ilmiah Ilmu-Ilmu Peternakan*, 25(1), 48-56.
- [54] Nazar, A. (2023). Uji Aktivitas Antibakteri Ekstrak Etanol Herba Seledri (*Apium Graviolens L*) Terhadap Bakteri *Staphylococcus Aureus* ATCC 25923 Dengan Metode Difusi. *Warta Bhakti Husada Mulia: Jurnal Kesehatan*, 10(1).
- [55] Solehah, M. A., Riyanti, R., Wanniatie, V., & Septinova, D. (2022). Pengaruh Pemberian *Lactobacillus Acidophilus* Terhadap pH Dan Daya Ikat Air Daging Broiler. *Jurnal Riset Dan Inovasi Peternakan*, 6(2), 151-157.
- [56] Ingratubun, J. A., Ijong, F. G., & Onibala, H. (2013). Isolation And Identification Of Lactic Acid Bacteria In Bakasang As Fermented Microbe Starter. *Aquatic Science And Management*, 48-56.
- [57] Pranata, C., Monica, R., Pratiwi, A., & Darmirani, Y. (2023). Antibacterial Activity Test Of Celery Leaf Ethanol Extract (*Apium graveolens L.*) Against Bacteria *Streptococcus Sanguinis*. *Jurnal Farmasimed (JFM)*, 6(1), 25-32.
- [58] Firdausyi, A. A., Estoe pangestie, A. T. S., Wibawati, P. A., Hamid, I. S., Solikhah, T. I., & Prastiya, R. A. (2022). Total Plate Count of Broiler Meat at Various Market in Bekasi City in March 2021.
- [59] Khairuddin, A. A. P., Handayani, B. R., & Ariyana, M. D. (2025). Pengaruh Konsentrasi Daun Seledri (*Apium graveolens L.*) Terhadap Mutu Dan Daya Simpan Bakso Sapi. *Jurnal Edukasi Pangan*, 3(3), 69-82.