

Physical Properties and Total Bacterial of Quail Meat after Marinating in Garlic Juice with Different Immersion Durations and Levels

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Abstract: This study aims to evaluate the physical quality and total bacterial count of quail meat as a function of immersion duration and garlic juice marination level. This study was conducted experimentally using a Completely Randomized Design with a 3 × 3 factorial arrangement. The first treatment factor was immersion duration, with three levels: 10, 20, and 30 minutes (L1, L2, and L3). Furthermore, the second treatment factor consisted of three marination levels (5%, 15%, and 25% (M1, M2, and M3) and each treatment combination was repeated three times. The variables measured include: pH, water content, Water Holding Capacity (WHC), and total number of bacteria. Furthermore, the data were analyzed using the General Linear Model (GLM) and then subjected to Tukey's test at a 95% confidence level. The results showed an interaction ($p < 0.05$) between the immersion factor and the marination level of quail meat with garlic juice across all observed variables, except pH ($p > 0.05$). In addition, both the immersion duration factor and the marination level independently had a significant effect ($p < 0.05$) on the observed variables. The highest total number of bacteria was observed in the L1M3 treatment combination, with 0.82 Colony Forming Units per gram. Meanwhile, for the best WHC, water content, and pH of meat after marinating, the combination of L3M3, L1M3, and L2M3 treatments yielded 55.28%, 70.15%, and 5.57, respectively. It can be concluded that all variables in normal conditions, and the lowest total number of bacteria, served as the reference for the best treatment combination, namely 10 minutes of immersion and 25% marination (L1M3).

Keywords: Immersion Durations, Garlic Juice, Marination Levels, Quail Meat.

INTRODUCTION

Quail meat is one of the increasingly popular sources of animal protein. However, this meat is also susceptible to microbial contamination. This is because meat has sufficient protein for bacterial growth to occur quickly. Improper handling and storage of meat can increase microbial contamination, affecting its quality and the safety of those who consume it.

Some research suggests that poultry meat, including quail, can be contaminated with various pathogenic bacteria that can cause disease in humans (Arthawan *et al.*, 2021). *Salmonella* spp. is a common contaminant in poultry meat sold in traditional markets, with contamination rates reaching 12.5% in some markets. These bacteria can cause salmonellosis in humans. Another pathogenic bacterium found in fresh meat is *Bacillus* sp., and another is *Staphylococcus* sp.

This bacterial contamination is generally caused by poor hygiene during meat processing, storage, and distribution (Basri, 2020).

Effective processing to reduce bacterial levels in quail meat is considered important, one of which is through marination techniques using natural ingredients such as garlic. Marinade is the process of soaking food ingredients in a solution containing acid, salt, or spices to enhance flavor and extend shelf life. Marinating with garlic can reduce the number of bacteria in meat products, as well as improve organoleptic properties such as aroma and taste (Masyitah & Abubakar, 2023; Thalia *et al.*, 2020). In addition, marinade can also affect the physical properties of meat, such as texture and tenderness, which are very important for consumers (Dewi *et al.*, 2021; Purnamasari *et al.*, 2022).

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Garlic has long been known in various cultures as a medicinal ingredient and a spice that not only adds flavor but also offers a range of health benefits. The active compounds in garlic are known, such as allicin, which have antibacterial and antioxidant properties that can contribute to improving food quality (Masyitah & Abubakar, 2023; Pudiarifanti & Farizal, 2022). These bioactive compounds in garlic have been shown to have vigorous antibacterial activity against a variety of pathogens, including *Escherichia coli* SP and *Staphylococcus aureus* (Parhusip & Sherly, 2023; Pudiarifanti & Farizal, 2022).

The use of garlic juice in marinades is expected to reduce total bacterial counts in quail meat, thereby improving product safety and quality and extending shelf life. In addition, meat marination with garlic juice is expected to improve physical qualities, such as pH, moisture content, water-binding capacity, and the total number of meat bacteria. To the best of the author's knowledge, research on the observation of quail meat quality during marination with garlic juice has not been widely conducted. This study aims to evaluate the physical quality and total bacterial count of quail meat as a function of immersion duration and garlic juice marination level.

MATERIALS AND METHODS

Materials and Research Location

The primary materials used in this study included meat from culled quail that had passed the production period (12-18 months of age). The meat taken was breast fillet, weighing 2,700 g. Furthermore, other materials included garlic, commonly used as a kitchen spice, amounting to 405 g, as well as other ingredients needed for the marinating process and laboratory testing. The study was conducted in December 2024 at the Microbiology Laboratory and the Animal Product Processing Technology Laboratory of the Faculty of Animal Husbandry, Padjadjaran University.

Methods, Experimental Design, and Observed Variables

The study was conducted experimentally in a laboratory to observe the meat's physical properties and total bacterial counts of culled quail after marinating with garlic juice. There were two treatment factors: 1) immersion durations and 2) garlic juice marination levels. The immersion durations consisted of 10, 20, and 30 minutes. Meanwhile, the garlic juice marination levels also consisted of three levels: 5, 15, and 25% of 100 g of culled quail meat. Nine treatment combinations (a 3 x 3 factorial arrangement) were obtained based on the two treatment factors, and each treatment was repeated three times. Meanwhile, the observed variables included physical properties (pH, water content, and water-holding capacity) and total bacterial count. All these variables were observed after the meat from culled quail was marinated with the specified levels and immersion

durations according to the treatment, and stored at room temperature for 9 hours.

Variable Measurement

1. pH Measurement

The principle of pH measurement is to determine whether a solution is acidic or alkaline. pH testing uses an electronic pH meter. First, the cathode indicator is cleaned with distilled water to indicate a neutral pH (7). Next, the meat sample is cleaned with a tissue soaked in distilled water, and the pH is measured, indicating the meat's pH.

2. Water Content Measurement

Prepare a sterilized cup by heating it in an oven at 105 °C for 1 hour, cooling it in a desiccator, and then weighing it. Next, the meat sample to be tested is weighed to 5 g (X) and stored in the cup. The prepared sample is placed in an oven at 105 °C for 4-6 hours (until the weight is constant). Next, the sample is removed from the oven, cooled in a desiccator, and weighed to determine its dry weight (Y). The water content (Z) can be calculated using the formula:

$$Z = \frac{X-Y}{X} \times 100\%$$

3. Water Holding Capacity (WHC) Measurement

The WHC value can be determined using the Szymańko *et al.*, (2021) Method. First, place a 0.3 g sample on a Whatman 42 filter paper, then place it between 2 glass plates loaded with 35 kg for 5 minutes. Mark and draw the area covered by the meat sample, which has become flat and wet around the filter paper, on graph paper using a candling tool. From the drawing, the wet area is obtained after subtracting the area covered by the sample (from the total area). The water content of the sample (in the wet area) can be measured using the formula:

Wet areas = Wet Area – Meat Area

$$\text{mgH}_2\text{O} = \frac{\text{wet area (cm}^2\text{)} - 8,0}{0,0948}$$

$$\text{WHC} = \% \text{ Water Content} = \frac{\text{mgH}_2\text{O}}{300} \times 100\%$$

4. Total Number of Bacteria Measurement

The number of bacterial colonies from the sample is calculated using the Juandini *et al.*, (2021) Formulas:

$$\text{Colonies/gr} = \Sigma \text{ colonies per plate} \times \frac{1}{\text{Dilution factors}}$$

Some things to note when counting the number of bacterial colonies from a sample are: 1) the selected and counted plates contain between 30 and 300 CFU/g. If the number of colonies per sample is more than 300 CFU/g, it is categorized as too numerous to count (TNTC); 2) several colonies that merge into one or a series of chains of colonies that are bound as a line are counted as one colony; 3) colonies that grow to cover more than half the area of the petri dish are not called colonies but spreaders; and 4) if the comparison of the number of bacteria from the results of successive

dilutions between the larger dilution and the previous dilution is <2 , the results are averaged. However, if the result is ≥ 2 , then use the number of microbes from the results of the previous dilution (the most minor dilution).

Statistical Analysis

All observational data were analyzed using the General Linear Model (GLM) procedure. If there was a significant difference in the two treatment factors, further testing was carried out using the Tukey test. If there was a significant difference among the treatment combinations, the Duncan Multiple Range Test (DMRT) was performed at the 95% confidence level. The research data were processed using SPSS for Windows, version 26, and the data are presented as mean $\pm$ standard error of the mean (SEM).

RESULTS AND DISCUSSION

pH Value of Quail Meat After Marinating with Different Immersion Durations and Levels of Marination

One component that influences meat quality is pH. pH can serve as an indicator of meat quality. Therefore, maintaining pH within the optimum range is crucial for maintaining meat quality. (Ernawati *et al.*, 2018). The pH values of quail meat after marinating with different soaking times and levels are presented in Table 1. There is no interaction between immersion duration and marination level on the pH of quail meat ($p > 0.05$). However, each treatment factor independently influences the pH changes. It can be seen that the lowest marination level (5%) produces the highest pH (5.75 ± 0.07), while the highest marination level (25%) produces the lowest pH (5.65 ± 0.08). This condition follows the results of research conducted by Gök & Bor (2016) and Khan *et al.*, (2016) that higher marinade concentrations with garlic juice often produce lower pH.

Table 1: pH Value of Meat from Culled Quail Marinated in Garlic Juice with Different Immersion Durations and Marinating Levels After Storage for Nine Hours at Room Temperature

Immersion Durations	Levels of Marination			Total	P-Value		
	5%	15%	25%		Immersion Durations	Levels of Marination	Interaction
10 minute	5,79 $\pm$ 0,10	5,81 $\pm$ 0,10	5,71 $\pm$ 1,11	5,77 $\pm$ 0,09 ^B	0,004	0,021	0.269
20 minute	5,73 $\pm$ 0,04	5,60 $\pm$ 0,05	5,58 $\pm$ 0,57	5,64 $\pm$ 0,86 ^A			
30 minute	5,71 $\pm$ 0,08	5,76 $\pm$ 0,09	5,65 $\pm$ 0,01	5,71 $\pm$ 0,07 ^{AB}			
Total	5,75$\pm$0,07^b	5,72$\pm$0,10^{ab}	5,64$\pm$0,08^a	5,70$\pm$0,09			

Notes: Superscripts with different capital letters in the same column indicate significant differences ($p < 0.05$) influenced by the immersion durations factor; Superscripts with different lowercase letters in the same row indicate significant differences ($p < 0.05$) influenced by the marination levels factor.

Like the garlic juice marination level, the duration of immersion independently had a significant effect ($p < 0.05$) on the pH value of quail meat. A significant decrease ($p < 0.05$) in pH was observed when the meat was marinated in garlic juice for 20 minutes. However, after soaking for 30 minutes, the meat pH rose again and was not significantly different ($p > 0.05$) from that at 10 minutes. This condition is consistent with previous findings that meat pH can decrease with soaking time, especially when using acidic marination (Augustyńska-Prejsnar *et al.*, 2019). Another possibility is that marinades stored for extended periods become more acidic. Several studies have shown that the use of acidic solutions during marinating can cause acid transfer into the meat, leading to an accumulation of hydrogen ions and a decrease in pH (Gök & Bor, 2016).

Water Content of Quail Meat After Marinating with Different Immersion Durations and Levels of Marination

Water content in poultry meat is a key parameter influencing the quality and organoleptic properties. Moisture content is closely related to various factors, including processing and preparation methods.

The research data, as shown in Table 2, shows that both immersion duration and marination level independently had a significant effect ($p < 0.05$) on the water content of quail meat after marination. Furthermore, there was an interaction between the two treatment factors ($p < 0.05$). Good meat quality can be identified if the water content is low but within the normal range. Rukmini *et al.*, (2019) stated that the normal water content for fresh quail meat ranges from 70% to 75%.

The immersion durations factor resulted in a significantly different total average meat water content ($p < 0.05$). Based on the treatment factor, the water content of quail meat marinated for 10 minutes was lower ($p < 0.05$) than in other marinating process lengths, namely $72.24 \pm 1.80\%$. Furthermore, the 15% and 25% marinating levels resulted in lower meat water content ($p < 0.05$) than the 10% marinating level, namely $72.91 \pm 0.57\%$ and $72.97 \pm 2.27\%$ vs. $73.91 \pm 0.74\%$. Meanwhile, the interaction between the two treatment factors yielded the lowest water content for the combination of 10 minutes soaking time and 25% marinating level (L1M3), namely $70.15 \pm 0.46\%$ (Table 2).

Table 2: Water Content of Meat from Culled Quail Marinated in Garlic Juice with Different Immersion Durations and Marinating Levels After Storage for Nine Hours at Room Temperature (%)

Immersion Durations	Levels of Marination			Total	P-Value		
	5%	15%	25%		Immersion Durations	Levels of Marination	Interaction
10 minutes	74,2±0,46 ^h	72,38±0,31 ^f	70,15±0,46 ^e	72,24±1,80 ^A	0.001	0.001	0.001
20 minutes	74,16±1,14 ^h	73,00±0,66 ^{fg}	73,48±0,25 ^{gh}	73,54±0,84 ^B			
30 minutes	73,37±0,24 ^{gh}	73,35±0,22 ^{gh}	75,27±0,23 ⁱ	74,00±0,97 ^B			
Total	73,91±0,74^b	72,91±0,57^a	72,97±2,27^a	73.26±1.44			

Notes: Superscripts with different capital letters in the same column indicate a significant difference ($p < 0.05$) influenced by the immersion durations factor; Superscripts with different lowercase letters in the same row indicate a significant difference ($p < 0.05$) influenced by the marination level factor; and Different superscripts in treatment combinations indicate an interaction ($p < 0.05$) between soaking time and marination level.

Optimum water content plays a role in nutrient retention and meat sensory quality, as well as in preventing the growth of undesirable microorganisms. (Husein *et al.*, 2022). Low moisture content in meat is desirable because it directly affects shelf life, organoleptic quality, nutritional balance, and consumer preference. Products with lower water content last longer, providing a better taste experience (Nadia *et al.*, 2023).

Huda *et al.*, (2019) Stated that quail meat marinated in garlic juice for a short time may yield insufficient concentrations of allicin and other phenolic compounds to significantly affect moisture content, resulting in relatively low moisture during short soaking periods. Therefore, the immersion duration plays a significant role in the water absorption rate. This finding is also supported by the research of Rijal *et al.*, (2022), which states that meat exposed to certain marinating conditions can exhibit shifts in its water-absorption behavior. Meanwhile, if the time is insufficient, these reactions may not be significant.

Water Holding Capacity of Quail Meat After Marinating with Different Immersion Durations and Levels of Marination

Water-holding capacity (WHC) is a critical parameter that affects poultry meat quality, particularly texture, freshness, and shelf life. The optimal WHC indicates that poultry meat's quality is closely related to its ability to retain moisture and palatability. The independent factor of immersion duration showed that meat marinated for 30 minutes had a higher ($p < 0.05$) water-holding capacity than meat marinated for a shorter soak. Meanwhile, a low marination level had a greater effect ($p < 0.05$) on water-holding capacity than a higher marination level (Table 3). The research by Ismanto *et al.*, (2020) reported that the presence of sulfur and flavonoid compounds in garlic positively affects meat structure, particularly at low doses. Higher doses can increase the penetration rate of marinating components but can also result in protein decomposition, reducing the meat's ability to retain air (Priskayani *et al.*, 2020).

Table 3: Water Holding Capacity (WHC) of Meat from Culled Quail Marinated in Garlic Juice with Different Immersion Durations and Marinating Levels After Storage for Nine Hours at Room Temperature (%)

Immersion Durations	Levels of Marination			Total	P-Value		
	5%	15%	25%		Immersion Duration	Levels of Marination	Interaction
10 minutes	49,88±1,38 ^{gh}	45,32±1,18 ^f	41,96±1,42 ^e	45,72±3,63 ^A	0.001	0.026	0.001
20 minutes	49,16±0,79 ^g	51,12±0,69 ⁱ	48,98±0,90 ^g	49,75±1,27 ^B			
30 minutes	51,55±0,87 ⁱ	51,06±1,00 ⁱ	55,28±0,87 ^j	52,63±2,15 ^C			
Total	50,18±1,41^b	49,18±3,02^{ab}	48,74±5,85^a	49,37±3,78			

Notes: Superscripts with different capital letters in the same column indicate a significant difference ($p < 0.05$) influenced by the immersion durations factor; Superscripts with different lowercase letters in the same row indicate a significant difference ($p < 0.05$) influenced by the marination level factor; and Different superscripts in treatment combinations indicate an interaction ($p < 0.05$) between soaking time and marination level.

A longer meat soak can increase water resistance by physically altering the muscle structure, contributing to decreased firmness and increased tenderness. Furthermore, longer soaking allows the enzymes and acids contained in garlic juice to react more effectively, inducing changes in meat proteins (Okpala *et al.*, 2022).

One of the main components of garlic juice is allicin, which has antimicrobial and antioxidant properties that can help maintain meat quality during marinating. This active component in garlic can affect the permeability of cell membranes in meat tissue, increasing the meat's ability to bind water (Masyitah & Abubakar, 2023). This may also be because the longer marinating process allows the spices to penetrate deeper

into the tissue, increasing the extent to which meat proteins bind water. This water binding not only serves to maintain meat moisture but also influences the chicken's final texture and flavor (Mudalal *et al.*, 2015).

Total Bacteria of Quail Meat After Marinating with Different Immersion Durations and Levels of Marination

Meat is a highly popular food ingredient that is a good source of protein. Increasing public awareness of food safety issues and their impact on health is crucial for understanding the prevalence of pathogenic bacteria and the total bacterial count in meat. Table 4 presents the

total bacterial count of quail meat after marinating with different soaking times and levels. The research data showed that both independently and in interaction, treatment factors significantly ($p < 0.05$) affected the total bacterial count in meat after marinating with garlic juice. The lowest total bacterial count was found at 10 minutes of soaking and 25% marinating, at 0.82 ± 0.03 Colony Forming Units (CFU). This demonstrates that the greater the amount of garlic used and the shorter the immersion duration, the more effective it is in suppressing bacterial growth in meat. Ramadani *et al.*, (2021) reported that higher garlic juice concentrations can extend product shelf life by reducing bacterial counts in meat.

Table 4: Total Bacterial Count of Meat from Culled Quail Marinated in Garlic Juice with Different Immersion Durations and Marinating Levels After Storage for Nine Hours at Room Temperature (CFU/g)

Immersion Durations	Levels of Marination			Total	P-Value		
	5%	15%	25%		Immersion Duration	Levels of Marination	Interaction
10 minutes	$3,34 \pm 0,18^g$	$1,97 \pm 0,07^f$	$0,82 \pm 0,03^e$	$2,04 \pm 0,10^A$	0,031	0,011	0,001
20 minutes	$0,96 \pm 0,03^e$	$2,19 \pm 1,17^f$	$3,03 \pm 0,07^g$	$2,06 \pm 1,07^{AB}$			
30 minutes	$1,17 \pm 0,52^e$	$3,43 \pm 0,16^f$	$3,15 \pm 0,32^g$	$2,58 \pm 1,11^B$			
Total	$1,83 \pm 1,17^a$	$2,53 \pm 0,90^b$	$2,33 \pm 1,15^{ab}$	$2,23 \pm 1,08$			

Notes: Superscripts with different capital letters in the same column indicate a significant difference ($p < 0.05$) influenced by the immersion durations factor; Superscripts with different lowercase letters in the same row indicate a significant difference ($p < 0.05$) influenced by the marination level factor; and Different superscripts in treatment combinations indicate an interaction ($p < 0.05$) between soaking time and marination level.

An interesting finding from this study is that a shorter soaking time (10 minutes) reduced the number of bacteria in meat more effectively. This indicates that even with a longer immersion duration and a higher level of garlic juice marination, bacteria continued to multiply. This is similar to the research report by Novita *et al.*, (2019), which stated that the right time is needed to increase the effectiveness of the antimicrobial compounds in garlic juice to prevent bacterial growth. Furthermore, soaking meat for a long time can increase the risk of bacterial contamination risk (Rahmat *et al.*, 2023). Furthermore, Latoch *et al.*, (2023), Huda *et al.*, (2019), and Ramadani *et al.*, (2021) found that the use of garlic juice in the meat marination process has a significant effect on reducing the total number of bacteria, mainly when used in the optimum concentration and with the correct marination duration.

CONCLUSIONS

Each observed variable yielded the best value under different treatment combinations. However, because the meat's pH, binding capacity, and moisture content were all within normal limits, the lowest total bacterial count was used as the reference for the best treatment combination, namely a 10-minute soaking time and a 25% marination level (L1M3).

Conflict of Interest

The authors declare that during the research and writing of this article, we had no potential conflicts of interest, either in funding or in the article's content.

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