

Research Article



Physical Quality and Organoleptic Properties of Broiler Chicken Meat Infected with Avian Pathogenic *Escherichia coli* and Fed a Diet Supplemented with Mangosteen Peel Extract Nanocapsules

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Abstract | Broiler chicken meat is a widely consumed source of animal protein; however, its quality can deteriorate due to infection by Avian Pathogenic *Escherichia coli* (APEC), which affects the meat's physical and organoleptic properties. This study aimed to evaluate the physical quality and organoleptic properties of broiler chicken meat infected with APEC that was treated with feed containing mangosteen peel extract nanocapsules (MPE-NC). The study employed four treatments: T1 (negative control, 0% MPE-NC without APEC infection), T2 (positive control, 0% MPE-NC with APEC infection), T3 (0.5% MPE-NC with APEC infection), and T4 (1% MPE-NC with APEC infection). The parameters observed included meat physical quality (water-holding capacity, cooking loss, pH), as well as organoleptic properties (taste, color, smell, texture, acceptability, and appearance). The results showed that the treatments had a significant effect ($p < 0.05$) on water-holding capacity, taste, color, and acceptability. Meanwhile, the parameters of cooking loss, pH, smell, texture, and appearance did not show significant differences ($p > 0.05$) among the treatments. The highest water-holding capacity was obtained in T1 (11.61%) and decreased significantly to T4 (1.84%). The best taste was found in T3 (3.71), while the highest color was in T1 (3.86). The panelists' acceptability rating was also highest in T3 (3.29). Based on the research results, the addition of MPE-NC at a level of 0.5% (T3) had the best effect on organoleptic properties, particularly taste and acceptability, although it did not improve physical quality in the form of water-holding capacity compared to the control.

Keywords | APEC bacteria, Broiler chicken meat, Feed functional, Mangosteen peel extract nanocapsules, Organoleptic, Physical quality

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INTRODUCTION

Broiler chicken meat is one of the most widely consumed sources of animal protein in the world due to its high availability, relatively affordable price, and lower fat content compared to red meat (Nassar, 2026). The quality of chicken meat is determined not only by its nutritional

value but also by physical and organoleptic properties such as water-holding capacity, pH, color, texture, smell, and taste, which significantly influence consumer acceptance (Ismail and Joo, 2017). Physical parameters such as pH and water-holding capacity are closely related to tenderness, juiciness, and cooking loss; a low pH can reduce water-holding capacity, leading to increased fluid loss and a

decline in meat quality. Therefore, maintaining the physical and organoleptic quality of broiler chicken meat is a critical aspect of the poultry industry (Jung *et al.*, 2025).

One factor that can reduce the quality of broiler chicken meat is infection by Avian Pathogenic *Escherichia coli* (APEC) bacteria, the causative agent of systemic colibacillosis, which results in significant economic losses in the poultry industry. APEC infection can cause physiological disturbances, reduced production performance, and changes in muscle metabolism that may affect the quality of the meat produced (Joseph *et al.*, 2023). Additionally, the presence of *E. coli* bacteria is associated with carcass contamination and a decline in the microbiological quality of the meat, which can occur during the rearing process through to post-harvest. The use of antibiotics as a means of infection control is currently being restricted due to the risk of residues in livestock products and increasing bacterial resistance, making safer and more environmentally friendly alternatives necessary (Azizi *et al.*, 2024).

The potential alternative to address these issues is the utilization of natural materials such as mangosteen peel extract (*Garcinia mangostana* L.), which is known to contain bioactive compounds like xanthenes, flavonoids, and tannins that possess antibacterial and antioxidant activities (Ortega *et al.*, 2025). These compounds have the potential to inhibit the growth of pathogenic bacteria while improving livestock health and product quality. However, active compounds from natural extracts often face limitations in stability and bioavailability, necessitating effective delivery technologies (Vercelli *et al.*, 2025). Nanoencapsulation technology serves as a solution to protect active compounds, enhance stability, and optimize the release of bioactive substances within the livestock digestive system (Kholif *et al.*, 2025).

The use of nanoencapsulation in feed is known to influence gut microbiota and muscle metabolism, which ultimately impacts the physical and organoleptic quality of meat, such as water-holding capacity and texture (Chen *et al.*, 2023). Furthermore, the interaction between gut microbiota and meat quality indicates that changes in microbial composition can affect quality parameters such as water-holding capacity and meat tenderness. Therefore, the application of mangosteen peel extract nanocapsules (MPE-NC) in feed for APEC-infected broiler chickens is expected to serve as an innovative strategy to improve meat quality while mitigating the negative effects of bacterial infection (Kusmayadi *et al.*, 2026). Based on the above discussion, research on the physical quality and organoleptic properties of meat from APEC-infected broiler chickens with the addition of MPE-NC in feed is important to conduct in order to obtain effective disease

control alternatives and to improve livestock product quality in a sustainable manner.

MATERIALS AND METHODS

MATERIALS

The materials used in this study included mangosteen peel, chitosan, STPP, ethanol, day-old chick (DOC) broiler Lohmann strain (MB 202), and basal feed for broilers provided by PT. Charoen Pokphand Indonesia Tbk (Hi-Pro-Vite 511) contains physiological sodium chloride, glacial acetic acid, Tween 80, disinfectant, laundry soap, zinc-bacitracin antibiotics, formaldehyde, alcohol, vitamins, and medicines. The research tools used were a macerator, rotary evaporator, spray dryer, light microscope, microtome, spectrophotometer, centrifuge, vortex mixer, water bath, oven, desiccator, and Eppendorf tubes. The housing had pens that were 1 cubic meter in size, along with feeders and water drinkers, heating lamps, digital scales, and surgical tools used for collecting samples.

PREPARATION OF MANGOSTEEN PEEL EXTRACT NANOCAPSULES (MPE-NC)

Mangosteen rind was sliced, oven-dried at 40–50°C to approximately 10% moisture content, ground through a 40-mesh sieve, and macerated in ethanol (1:5 w/v) at room temperature for 24 hours using a modified method of Ningsih *et al.* (2017), after which the filtrates from repeated maceration were concentrated using a rotary vacuum evaporator at 40–45°C. The extract was then nanoencapsulated via ionic gelation by combining it with 0.2% chitosan in glacial acetic acid and 0.2% sodium tripolyphosphate (STPP) at chitosan-to-STPP ratios of 1:1. Each mixture was homogenized for 5 minutes, hydrated at 4°C for 18 hours, rehomogenized for 30 seconds, and spray-dried (inlet temperature 170°C, atomizer pressure 1 bar, feed rate 15 mL/min) (Kusmayadi *et al.*, 2025).

METHODS

The findings from making and studying MPE-NC in this research are presented by Kusmayadi *et al.* (2025a, b). The material used as the encapsulant was chitosan combined with STPP in a 1:1 ratio. The results from the MPE-NC characterization test for the formula were received. A test was done to check how well MPE-NC works as a food supplement for broiler chickens and how it affects the physical characteristics and taste qualities. A total of 200 unsexed DOC Lohmann strain broiler chickens were randomly split into four groups. Group T1 received only the basic diet and was not infected with APEC. Group T2 had the basic diet and was infected with APEC. Group T3 was given the basic diet plus 0.5% MPE-NC and was infected with APEC. Group T4 was given the basic diet plus 1.0% MPE-NC and was infected with APEC. This

experiment was done five times for each treatment, and in each cage, there were 10 broiler chickens. The animals were raised for 35 days, which included a time for them to get used to their environment (weeks 1 and 2) and then the actual treatment time (weeks 3 to 5). Feed and water were given twice a day, in the morning and evening, as much as the animals wanted. On day 21, broilers in the challenged groups were inoculated with 0.5 mL of a local avian pathogenic *Escherichia coli* (APEC) strain at a concentration of 10^8 cells/mL with intratracheally infection, standardized against the McFarland turbidity scale (Kusmayadi *et al.*, 2026).

OBSERVED PARAMETERS

WATER-HOLDING CAPACITY

Water-holding capacity is analyzed to assess the ability of meat proteins to retain both internal water and added water. Commonly used methods include the squeeze method (Hamm Method) or the centrifugation method. Changes in protein molecular structure during cold storage can significantly reduce WHC values (Indriani *et al.*, 2026; Warner, 2017).

COOKING LOSS

The cooking loss procedure involves weighing a meat sample, placing it in a waterproof plastic bag, and heating it in a water bath (at 80°C for 30 minutes). Once the internal temperature reaches approximately 75°C, the sample is cooled and weighed again. The percentage of weight loss indicates the degree of protein denaturation caused by heat (Abubakar *et al.*, 2021; Pang *et al.*, 2021).

pH

The pH of the meat is measured using a calibrated digital pH meter. The sensor or electrode is inserted directly into the muscle tissue (*Musculus pectoralis major*). This measurement is crucial because pH directly influences other physical characteristics such as color and water-holding capacity (Abubakar *et al.*, 2021; Ismail and Joo, 2017).

ORGANOLEPTIC PROPERTIES

Organoleptic evaluation is conducted by trained panelists, who are asked to assess sensory attributes based on a hedonic scale (liking level) ranging from 1 to 5, where a higher score indicates improved organoleptic quality. This assessment is heavily influenced by sensory attributes that are subjectively perceived yet measurable (Pereira *et al.*, 2021). Meat samples were cooked using a grilling method until they reached an internal temperature of approximately 75–80°C. After cooking, the samples were cut into uniform cubes and served in randomly coded containers while still warm to preserve the smell profile (Abubakar *et al.*, 2021; Jung *et al.*, 2025).

Panelists assessed the color and visual appearance of

the meat. Color is a primary indicator of freshness for consumers. Changes in the color of broiler chicken meat resulting from the tested feed treatments were subsequently evaluated visually (Jung *et al.*, 2025; Kim *et al.*, 2024). Smell and taste were evaluated based on the presence of volatile compounds released after the cooking process. The use of functional feed additives such as MPE-NC can influence the smell and taste profile of the meat without compromising the panelists' overall acceptance (Kim *et al.*, 2024; Wang *et al.*, 2026).

Texture (tenderness) and juiciness are assessed as panelists chew the samples. Juiciness is closely related to the meat's ability to retain water (Water Holding Capacity), while tenderness relates to how easily the meat fibers break down when chewed (Indriani *et al.*, 2026; Warner, 2017). Panelists assigned a total score for all perceived attributes. ANOVA statistical analysis was used to examine the influence of specific attributes on overall consumer preference (Pereira *et al.*, 2020).

DATA ANALYSIS

The data was analyzed using analysis of variance to check the effects of different treatments. Any significant differences between the treatments were then examined using Duncan's New Multiple Range Test with SPSS version 25.0.

RESULTS AND DISCUSSION

The results of the study indicate that the administration of MPE-NC to broiler chickens infected with APEC had a statistically significant effect ($p < 0.05$) on the physical quality and organoleptic properties of the meat. The results of the study on the physical quality of broiler chicken meat are presented in Table 1.

Water-holding capacity (WHC) is one of the key parameters in determining the physical quality of meat because it relates to the ability of muscle proteins to retain water during handling and processing. The results showed (Table 1) that WHC differed significantly ($p < 0.05$), with the highest value observed in T1 (11.61%) and a gradual decrease through T4 (1.84%). This decrease indicates that APEC infection and nanocapsule treatment affect the protein structure of the meat. APEC infection in T2 caused a decrease in WBC compared to the negative control (T1). This aligns with reports that bacterial infection can trigger oxidative stress and changes in muscle metabolism, which impact myofibrillar protein denaturation, thereby reducing water-binding capacity (Lucarini *et al.*, 2020). Denatured proteins lose their ability to form bonds with water molecules, allowing water to easily escape from muscle tissue (Strzelczak *et al.*, 2021).

Table 1: Physical quality and organoleptic properties of broiler chicken meat.

Parameters	Treatments			
	T1	T2	T3	T4
Water holding capacity (%)	11.61+0.08 ^a	8.16+0.08 ^b	3.91+0.04 ^c	1.84+0.01 ^d
Cooking losses (%)	29.69+2.18	30.56+1.98	30.92+2.32	30.82+1.17
pH	6.50+0.26	6.27+0.18	6.26+0.17	6.27+0.21
Taste	3.00+0.32 ^b	3.38+0.67 ^{ab}	3.71+1.19 ^a	3.43+0.93 ^{ab}
Colour	3.86+0.65 ^a	3.24+0.62 ^b	3.48+0.75 ^{ab}	3.43+0.59 ^b
Smell	2.90+0.77	3.14+0.48	3.24+0.54	3.33+0.79
Texture	2.95+0.86	3.09+0.54	3.00+0.89	2.81+0.81
Preference	2.76+0.70 ^b	2.81+0.68 ^{ab}	3.29+0.72 ^a	3.09+0.99 ^{ab}
Appearance	3.90+0.99	3.52+0.93	3.71+0.78	3.52+1.16

Note: T1 (negative control, 0% mangosteen peel extract nanocapsules without APEC infection), T2 (positive control, 0% mangosteen peel extract nanocapsules with APEC infection), T3 (0.5% mangosteen peel extract nanocapsules with APEC infection), and T4 (1% mangosteen peel extract nanocapsules with APEC infection). Superscripts in the same row indicate significant differences ($p < 0.05$).

Further decreases at T3 and T4 are likely due to interactions between bioactive compounds from mangosteen peel extract and meat proteins. Compounds such as xanthenes and tannins can bind to proteins and affect their three-dimensional structure, thereby reducing water-holding capacity. Additionally, the nano-particle size allows for deeper penetration into biological tissues, which may enhance these interactions. Water-binding capacity is also influenced by meat pH; as pH approaches the protein's isoelectric point, water-binding ability decreases. Although pH remains relatively stable, changes in protein microstructure may still occur due to treatment. Thus, while nanocapsules offer biological benefits, their use must be optimized to avoid compromising meat's physical quality, particularly water-binding capacity (Indriani *et al.*, 2026).

Cooking loss reflects the amount of fluid and nutritional components lost during the cooking process, which is closely related to water-holding capacity and muscle tissue structure. The results showed (Table 1) that cooking loss did not differ significantly ($p > 0.05$) among treatments, with values ranging from 29.69% to 30.92%. This indicates that the treatments did not significantly affect weight loss during cooking. The absence of significant differences may be attributed to relatively uniform pH values across treatments, resulting in protein denaturation occurring in a nearly identical pattern during cooking. According to Pang *et al.* (2021), pH is a primary factor influencing cooking loss as it determines protein stability and water-binding capacity during heating.

Furthermore, although there were significant differences in WHC, this does not always correlate directly with cooking loss. This is because cooking loss is also influenced by other factors such as fat content, connective tissue composition, and cooking methods. Thus, the changes in

WHC observed in this study were not sufficiently strong to significantly affect cooking loss. These results indicate that the addition of MPE-NC does not negatively impact nutrient loss during cooking, making it safe in terms of meat processing quality (Warner, 2017).

pH value is a key indicator in determining meat quality as it relates to postmortem glycolysis and protein stability. The study results show (Table 1) that pH did not differ significantly ($p > 0.05$), ranging from 6.26 to 6.50. This value is still considered normal, although it tends to be slightly higher than the ultimate pH of chicken meat. APEC infection can cause energy metabolism disorders in muscle, leading to reduced glycogen reserves and decreased postmortem lactic acid production. This results in the meat's pH remaining high. This finding aligns with the report by Alam *et al.* (2024), which states that stress and disease can increase the ultimate pH of meat due to disrupted glycolysis.

The addition of MPE-NC in treatments T3 and T4 did not result in significant changes in pH. This indicates that although mangosteen extract possesses biological activity, its effect on postmortem muscle metabolism is not yet strong enough to significantly alter meat pH. The stability of pH across all treatments is one of the factors causing other parameters, such as cooking loss and texture, to remain unchanged. Therefore, the relatively constant pH indicates that the treatments did not disrupt the basic chemical balance within the meat (Abubakar *et al.*, 2021).

Taste is one of the most critical organoleptic attributes determining consumer acceptance. The results showed (Table 1) that there were significant differences in taste ($p < 0.05$), with the highest score in T3 (3.71) and the lowest in T1 (3.00). This indicates that the addition of MPE-NC

at a 0.5% concentration can improve the flavor of broiler chicken meat. This improvement in taste is believed to stem from the antioxidant activity of xanthone compounds in mangosteen peel, which can inhibit lipid oxidation. Fat oxidation can produce volatile compounds that cause off-flavors; therefore, inhibiting this process enhances taste quality (Abate *et al.*, 2022).

Additionally, the antibacterial effects of mangosteen extract can improve livestock health, leading to more optimal body metabolism and resulting in meat with better flavor quality. A balanced gut microbiota is also known to play a role in the formation of flavor precursor compounds in meat (Kim *et al.*, 2024). However, at higher doses (T4), the flavor score decreased slightly compared to T3. This is likely due to the presence of phenolic compounds, which at high concentrations can impart a bitter or astringent taste. Therefore, a 0.5% dose is considered the optimal level for enhancing meat flavor.

Meat color is the primary visual indicator influencing consumer decisions when purchasing products. The study results showed (Table 1) a significant difference in color ($p < 0.05$), with the highest value at T1 (3.86) and the lowest at T2 (3.24). The decrease in color at T2 indicates that APEC infection can affect the stability of myoglobin pigment. Infection and oxidative stress can accelerate the oxidation of myoglobin into brown-colored metmyoglobin, thereby reducing the meat's visual appeal (Qi *et al.*, 2023).

The administration of MPE-NC in T3 and T4 showed improved color compared to T2. This is attributed to the antioxidant activity that protects the myoglobin pigment from oxidation. Xanthone compounds play a role in stabilizing meat color by inhibiting the formation of free radicals (Puteri *et al.*, 2019). However, the color values in the nanocapsule treatments have not yet matched those of the negative control. This indicates that the effects of APEC infection remain dominant, despite partial improvement resulting from the treatment (Joseph *et al.*, 2023).

Smell is an organoleptic parameter influenced by volatile compounds resulting from the degradation of fats and proteins. The results indicate (Table 1) that smell did not differ significantly ($p > 0.05$), although there was a tendency toward increased values from T1 to T4. The absence of significant differences suggests that the treatment did not significantly affect the formation of major volatile compounds. According to Wang *et al.* (2026), meat smell is more influenced by fatty acid composition and the Maillard reaction during cooking than by feed treatment factors. However, the trend toward increased smell in the nanocapsule treatment may be attributed to antioxidant activity that suppresses the formation of compounds causing

off-odors. Thus, although not statistically significant, there is an indication of improved smell quality. Overall, the stability of the smell suggests that the treatment did not cause negative effects on the meat's sensory characteristics (Đorđević *et al.*, 2025).

Meat texture is related to tenderness, which is influenced by the structure of muscle fibers and connective tissue. The results (Table 1) showed that texture did not differ significantly ($p > 0.05$), with values ranging from 2.81 to 3.09. The absence of these differences indicates that the treatment did not significantly affect the physical structure of muscle tissue. Meat texture is generally influenced by factors such as animal age, proteolytic enzyme activity, and collagen content (Barido and Lee, 2021).

Kusmayadi *et al.* (2026) reported that neither APEC infection nor the addition of MPE-NC caused major changes in these factors, so the texture remained relatively stable. Additionally, the non-significant difference in pH also contributed to the uniformity of texture. Thus, the treatments administered did not reduce meat texture quality, making it still acceptable to consumers.

Liking is an integrative parameter that reflects the panelists' overall assessment of the product. The results of the study (Table 1) indicate a significant difference ($P < 0.05$), with the highest value observed in T3 (3.29). The increase in likability in T3 is the result of a combination of improvements in taste, smell, and appearance. This indicates that the addition of MPE-NC at a 0.5% level has a positive effect on consumer acceptance. According to Pereira *et al.* (2020), likability is influenced by the interaction of various sensory attributes, so improvements in one or more parameters can enhance the overall score. However, at higher doses (T4), the likability score decreased slightly, indicating that the use of active ingredients must be at an optimal level to avoid negative effects on sensory perception.

Appearance is a visual parameter encompassing shape, color, and surface condition of the meat. The results (Table 1) showed that appearance did not differ significantly ($p > 0.05$) among treatments. This indicates that neither APEC infection nor the nanocapsule treatment caused significant changes in the general visual characteristics of the meat. Appearance is more influenced by post-harvest conditions and carcass handling. Nevertheless, the relatively high appearance scores across all treatments indicate that the meat remains in acceptable condition and visually appealing. Thus, it can be concluded that the addition of MPE-NC does not have a negative effect on the appearance of broiler chicken meat (Kusmayadi *et al.*, 2025).

GENERATIVE AI AND AI ASSISTED TECHNOLOGY STATEMENT

The authors declare that no generative AI and AI assisted technology was used in the creation of this manuscript.

CONFLICT OF INTEREST

The authors have declared no conflict of interest.

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The addition of mangosteen peel extract nanocapsules to the feed of broiler chickens infected with Avian Pathogenic *Escherichia coli* has different effects on the physical quality and organoleptic properties of the meat. The treatment had a significant effect on water-holding capacity, taste, color, and acceptability, but did not significantly affect cooking loss, pH, smell, texture, and appearance. Water-holding capacity tended to decrease with increasing nanocapsule levels, while organoleptic quality, particularly taste and acceptability, showed the best improvement at the 0.5% nanocapsule treatment (T3). The addition of nanocapsules at this level was able to improve panelist acceptance without negatively affecting other sensory parameters, although it was not yet able to optimally improve the physical quality of the meat; therefore, dose optimization is required to achieve a balance between the physical and organoleptic qualities of broiler chicken meat.

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NOVELTY STATEMENT

To the best of our knowledge, this study is the first to investigate the physical quality and organoleptic properties of meat derived from broiler chickens experimentally infected with avian pathogenic *Escherichia coli* (APEC) and fed a diet supplemented with mangosteen peel extract nanocapsules. Previous investigations have been limited to the application of mangosteen peel in the form of powder or crude extract in healthy broilers. The present findings demonstrate the potential of nanoencapsulated mangosteen peel extract as a natural feed additive capable of preserving meat quality in broilers under bacterial infection.

AUTHORS' CONTRIBUTION

AK, ES, and YY conceived and designed the study. AK and ES conducted the experiments and collected the data. AK and YY analyzed and interpreted the data and drafted the manuscript. All authors critically reviewed the manuscript and approved the final version for publication.

ETHICAL APPROVAL

All experiments, procedures, and care given to laboratory animals were done following the guidelines set by the Animal Policy and Welfare Committee of the Faculty of Agriculture, Universitas Perjuangan Tasikmalaya, Tasikmalaya.

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