P-ISSN: 2304-3075; E-ISSN: 2305-4360
International Journal of Veterinary Science
www.ijvets.com; editor@ijvets.com

Research Article https://doi.org/10.47278/journal.ijvs/2025.094

Evaluation of Physical, Chemical and Microbiological Characteristics of Sentul Chicken Meat Adding Microencapsules of Noni Fruit Extract as a Feed Additive

Eka Wulandari * and Tuti Widjastuti

Faculty of Animal Husbandry, University of Padjadjaran, Jatinangor, West Java, Indonesia
***Corresponding author:** eka.wulandari@unpad.ac.id

Article History: 25-134 Received: 20-May-25 Revised: 19-Jul-25 Accepted: 25-Jul-25 Online First: 31-Aug-25

ABSTRACT

Local chicken breeds in Indonesia, such as Sentul chicken (*Gallus domesticus*), have gained attention for their unique taste and adaptability to local conditions. The use of noni fruit (*Morinda citrifolia* L.) in poultry feed, due to its antioxidant content, has the potential to improve meat characteristics. This study aims to evaluate the effects of adding microencapsulated noni fruit extract (*Morinda citrifolia* L.) as a feed additive on the physical, chemical, and microbiological properties of Sentul chicken meat. A total of 56 chickens were randomly assigned to six dietary treatments: P0 (basal feed without antibiotics), P1 (basal feed + 50ppm bacitracin), P2 (basal feed + 0.5% microencapsulated noni extract), P3 (1%), P4 (1.5%), and P5 (2%). Parameters measured included water-holding capacity (WHC), cooking loss, tenderness, moisture, fat, protein, ash content, pH, total bacterial count, and meat color (L*, a*, b*). The results showed that treatment P3 had the highest WHC (48.70%) and the lowest cooking loss (22.85%), indicating better water retention. Tenderness was highest in P2 (28.6mm/g/10s) and P3 (28.50mm/g/10s). The highest protein content was found in P1 (19.56%), while P2 and P4 had lower values. Total bacterial count was lowest in P2 (2.06×10^5CFU/g) and highest in P4 (3.48×10^5CFU/g). The meat color of P2 was characterized by the lowest L* (16.35) and highest a* (28.24), indicating redder meat. These findings suggest that dietary supplementation with 1% microencapsulated noni extract (P3) optimally enhances meat quality in Sentul chickens without compromising safety or composition.

Keywords: *Morinda citrifolia*, Sentul chicken, Feed additive, Microencapsulation, Meat quality.

INTRODUCTION

Sentul chickens are one of Indonesia's local poultry genetic resources that have a high adaptability to tropical environments, disease resistance and potential as a source of animal protein. However, the quality of local chicken meat, including Sentul chicken, is still considered suboptimal compared to fast-growing breeds, particularly in terms of texture, fat content, and shelf life (Mushawwir 2022). Therefore, efforts to improve the quality of local chicken meat through feed manipulation have become one of the important strategies in the development of competitive local poultry.

The use of natural feed additives based on medicinal plants is increasingly being adopted as an alternative to antibiotic growth promoters (AGP), in line with growing concerns about antimicrobial resistance (Tri et al. 2021). The noni plant (*Morinda citrifolia* L.) is known to contain bioactive compounds such as flavonoids, saponins, and phenols that have strong antioxidant and antimicrobial activities (Daud et al. 2021; Orădan et al. 2024). These compounds can improve meat quality, including inhibiting fat oxidation, extending shelf life, and suppressing the growth of spoilage microbes (Fahman and Rugayah 2023). However, the active compounds from herbal plants like noni are unstable when in the digestive system or during storage. To address this issue, microencapsulation technology is used to better protect bioactive compounds and allow them to be released gradually in the chicken's digestive tract, thereby increasing their effectiveness (Niati et al. 2021). This technology has proven capable of maintaining the stability of active compounds while simultaneously increasing the bioavailability of active ingredients in the avian body.

The deleterious effects due to oxidation are the main factor that reduces meat quality, as it may lead to unpleasant odor, unappealing color changes, and a decrease in nutritional content; consequently, consumer interest in the product declines. The addition of noni fruit juice that has been coated with microencapsulation technology into

Cite This Article as: Wulandari E and Widjastuti T, 2025. Evaluation of physical, chemical and microbiological characteristics of sentul chicken meat adding microencapsules of noni fruit extract as a feed additive. International Journal of Veterinary Science x(x): xxxx. https://doi.org/10.47278/journal.ijvs/2025.094

Sentul chicken feed is expected to strengthen the meat's resistance to oxidation processes. Bioactive compounds in noni fruit that act as antioxidants, when protected by microencapsulation, have been proven to be more effective in neutralizing free radicals and inhibiting the process of fat peroxidation, both during storage and cooking (Ma et al. 2013; Tuti et al. 2023; Faisal et al. 2024). This method not only preserves the taste and appearance of the meat but also extends its shelf life. Thus, Sentul chickens can be more competitive in the market compared to commercial chickens that grow faster (Suprijatna 2010; Nurcahya et al. 2022).

Additionally, key physicochemical properties such as water-holding capacity and tenderness, which are critical determinants of consumer acceptance and overall meat quality, are positively influenced by the bioactive compounds, including rutin (3,3′,4′,5,7-pentahydroxyflavone-3-rhamnoglucoside), a flavonoid, and scopoletin (6-methoxy-7-hydroxycoumarin), a coumarin derivative (Janbaz et al. 2003; Shaw et al. 2003; Issell et al. 2008). These enhancements contribute not only to improved meat texture and juiciness but also to better processing efficiency, increased storage stability, and elevated sensory quality—factors that are crucial for fulfilling consumer expectations and aligning with industry standards (Van Laack et al. 2000; Yosi et al. 2011; Husein et al. 2022). This study aims to evaluate the effects of dietary supplementation with microencapsulated noni (*Morinda citrifolia*) fruit extract on the physicochemical (color, texture, water-holding capacity, pH, moisture content, protein, and fat) and microbiological (total microbial count) characteristics of Sentul chicken meat.

MATERIALS AND METHODS

Experimental design

Forty 14-week-old female Sentul chickens were kept until they were 24 weeks old. Their starting weight was 785.6g on average, and their coefficient of variation was 14.6%. Five treatments were given to the experimental chickens, and each was replicated four times with two birds in each replication. The study used 40 cages in all, each of which had dimensions of 40cm for length, 35cm for breadth, and 30cm for height. A combination of concentrate, maize, bran, and microcapsules of noni fruit extract (MFNE) made up the diet.

Preparation of microencapsulated noni fruit extract (MFNE)

The thick noni fruit extract was diluted 1:1 with distilled water as part of a modified encapsulation procedure. Likewise, distilled water was used to dilute the maltodextrin coating at the same 1:1 ratio. Following dilution, the extract and maltodextrin coating were mixed until the mixture was homogeneous, using a 70% extract to 30% maltodextrin ratio. With an intake temperature of 125°C and an output temperature of 60°C, the resultant mixture was then dried using the spray drying method (Mishra et al. 2014). Table 3 displays the experimental diet's composition as well as the addition of zinc bacitracin and MFNE for each treatment.

Treatment protocol

The treatments given were based on different doses of microcapsules containing noni fruit extract: P0: Basal diet (without antibiotics), P1: Basal diet + AGP bacitracin 50 ppm, P2: Basal diet + 0.5% microcapsule of noni fruit extract (MNFE), P3: Basal diet + 1% MNFE, P4: Basal diet + 1.5% MNFE, P5: Basal diet + 2% MNFE.

Feed ingredient composition and nutrient content

Table 1 and 2 provide information on the nutrient and metabolic energy content as well as the ration formulation. Table 3 provides the composition of feed ingredients in treatment rations.

Table 1: Composition of basal rations (BR)

Feed ingredients	Quantity (%)
Rice bran	25.00
Yellow corn	50.00
Laying chicken concentrate	25.00
Total	100

Table 2: Nutrient content and metabolic energy of basal rations (BR)

Nutrient content	Total
Metabolic energy (kcal/kg)	2777
Crude protein (%)	15.80
Crude fat (%)	5.70
Crude fiber (%)	6.25
Calcium (%)	3.10
Phosphor (%)	0.21
Lysine (%)	0.86
Methionine (%)	0.42

Table 3: Composition of feed ingredients in treatment rations

Nutrient	Treatments				
	P0	P1	P2	P3	P4
Basal Ration (BR) (%)	100	100	100	100	100
MFNE products (mg/kg)	0	0	75	150	225
Zinc bacitracin (mg/kg)	0	50	0	0	0

Chemical characteristics

The chemical characteristics of Sentul chicken meat were measured according to the methods of the Official Methods of Analysis (AOAC) International. The moisture content of weight loss was calculated after 12 hours of oven drying at 105℃ (Digital drying oven DOD-150, Raypa, Barcelona, Spain). The protein content was measured using the Kjeldahl method. Fat content was determined with the Soxhlet method using a solvent extraction system (Soxtec™ 2050 automated analyzer, FOSS Analytical, Hillerød, Denmark). A dry ashing method to determine ash content was conducted by incinerating the meat samples in a furnace (Thermolyne FD1410M, ThermoFisher Scientific, Waltham, MA, USA) at 550℃.

Physical characteristics

Water holding capacity (WHC) was measured with the Hamm method, and 0.3g of meat was placed on 2 glass plates covered with filter paper, pressed with 35kg of load for 5 minutes, and the forming wet area was calculated, and the total water content of the sample was drained in an oven for 8-24 hours at 105ºC.

$$\text{mg H2O} = \frac{\text{Wet Area}(\text{cm}^2)}{0.0948} - 8.0$$

$$\text{WHC} = \text{Moisture Content }(\%) - \left(\frac{\text{mgH20}}{300}\right) \text{ x } 100\%$$

Cooking loss was determined as described by Honikel (1998). Broiler breast meat was weighed and placed into a sealed polyethylene bag before heating in a water bath at 80°C. Samples were cooked until a defined internal temperature of 75°C. The breast fillets were cooled in an ice bath and cooled down to room temperature, reweighted, and the cooking loss was reported as a percentage and calculated as follows:

$$\%\ \text{Cooking Loss} = \frac{\text{Weight before cooking} - \text{Weight after cooking}}{\text{Weight before cooking}} \times 100\%$$

Analysis of tenderness was determined using a penetrometer (Dhana and Wikandari 2019). The penetrometer apparatus was first prepared, and the universal cone was securely attached. A weight was then added, and the combined weight of the universal cone, test rod, and additional weight (a) was recorded in grams. The meat sample was positioned beneath the penetrometer pointer, and the scale was set to zero. The penetrometer lever (clutch) was pressed for 10 seconds, after which the measurement was recorded and the meat tenderness value was calculated.

The color intensity test in this study was measured using the CS-10 colorimeter (8mm aperture), a high-accuracy digital color difference analyzer. The measured color attributes of the Sentul chicken meat were indicated by the lightness level (L*), followed by redness (a*) and yellowness (b*).

Determination of pH

The pH value of rabbit meat bekasam was measured using a pH meter (3510 Advanced Bench pH Meters, Jenway, Staffordshire, UK). 5g of Sentul chicken meat was blended with 20mL distilled water in a homogenizer for 60 seconds.

Microbiological analysis

Twenty-five grams of Sentul chicken meat from each treatment was transferred into 50mL of sterile saline solution and homogenized for 90 seconds, and serial dilutions were prepared by mixing 1mL of the homogenized sample with 9mL of sterile saline solution. Total bacteria were enumerated by plating samples on nutrient agar (NA, M001, HiMedia) after aerobic incubation at 37°C for 24 hours. The formed colonies were counted and expressed as colony-forming units of the suspension (CFU/g).

Statistical analysis

The differences between the quality of Sentul chicken meat data were analyzed by analysis of variance (ANOVA), and significant differences between treatments were analyzed by Duncan's multiple range test using the Statistical Package for Social Science (SPSS 10.0 for Windows, SPSS Inc., Chicago, IL, USA)

RESULTS

Chemical characteristics of Sentul chicken meat

The result of adding microencapsules of noni fruit extract as a feed additive on the moisture, fat, protein, and ash content of Sentul chicken meat is presented in Table 4. The analysis showed that the water content of Sentul chicken meat did not differ significantly (P>0.05) among treatments, ranging from 73.05 to 75.14%. The highest ash content was observed in P0, while P1 and P3 had the lowest. Fat content was highest in P4 and lowest in P1. Protein content was highest in P1, whereas P2 and P4 showed the lowest values. These results indicate that the dietary treatments affected ash, fat, and protein contents, but had no significant effect on water content.

Table 4: Chemical characteristics of Sentul chicken meat

Treatment	Water Content (%)	Ash Content (%)	Fat Content (%)	Protein Content (%)
P0	74.33^{a}	4.94^{b}	3.33^{b}	17.32^{b}
P1	73.95^{a}	3.98^{a}	1.94^{a}	19.56^{a}
P2	75.14^{a}	4.39^{b}	3.34^{b}	16.58^{c}
P3	74.67^{a}	3.97^{a}	3.04^{a}	17.54^{b}
P4	73.05^{a}	4.31^{b}	5.63^{c}	16.95^{c}

Mean values within a column with different superscripts are significantly different (P<0.05).

Microbiological characteristics

The pH value is an important factor in determining the quality of meat. The pH value and total bacteria are presented in Table 5. The pH value of Sentul chicken meat under various treatments ranges from 5.93 to 6.20. There were no statistically significant differences among the treatments (P>0.05). The observation results showed that the highest total bacterial count was found in treatment P4 (3.48×10^5 CFU/g), while the lowest count was found in treatment P2 (2.06×10^5 CFU/g).

Table 5: Microbiological characteristics of Sentul chicken meat

Treatment	pH	Total Bacteria (x 10^5CFU/g)
P0	6.09^{a}	2.36^{a}
P1	6.14^{a}	2.92^{b}
P2	6.20^{a}	2.06^{a}
P3	5.93^{a}	2.26^{a}
P4	6.03^{a}	3.48^{b}

Mean values within a column with different superscripts are significantly different (P<0.05).

Physical characteristics of Sentul chicken meat

The physical characteristics of Sentul chicken meat with adding microencapsules of noni fruit extract as a feed additive are presented in Table 6. WHC is the ability of meat to retain water during processing. The treatment showed a significant difference (P<0.05), where the highest value was found in P3 (48.70%) and the lowest in P4 (23.01%). Treatment P3 showed the lowest cooking loss value (22.85%), which means the least fluid loss during heating. On the other hand, P4 has the highest cooking loss (26.56%). Treatments P3 and P2 showed high tenderness values (28.50mm/g/10s and 28.67mm/g/10s, respectively), whereas treatment P0 had the lowest tenderness (24.33mm/g/10s).

Table 6: Physical characteristics of Sentul chicken meat

Treatment	WHC (%)	Cooking loss (%)	Tenderness (mm/g/10s)
P0	46.23^{c}	25.75^{b}	24.33^{a}
P1	44.07^{c}	23.20^{a}	27.00^{b}
P2	40.69^{b}	23.80^{a}	28.67^{b}
P3	48.70^{d}	22.85^{a}	28.50^{b}
P4	23.01^{a}	26.56^{b}	25.00^{b}

Mean values within a column with different superscripts are significantly different (P<0.05).

Physical characteristics – color measurement

Color is one of the important indicators in assessing the visual quality and consumer appeal of meat. Color parameters are expressed on a scale of L* (lightness), a* (redness), and b* (yellowness). The color measurement of Sentul chicken meat is shown in Table 7. The highest brightness value (L*) was found in treatment P1 (19.02) and the lowest in P2 (16.35).

Tabel 7: Colour measurement of Sentul chicken meat

Treatments	Brightness (L)*	Redness (a)*	Yellowness (b)*
P0	18.22^{b}	17.67^{a}	-1.32^{c}
P1	19.02^{b}	20.50^{b}	-1.65^{b}
P2	16.35^{a}	28.24^{c}	-1.92^{b}
P3	17.85^{a}	18.11^{a}	-2.55^{a}
P4	17.64^{a}	18.35^{a}	-2.64^{a}

Mean values within a column with different superscripts are significantly different ($P<0.05$).

DISCUSSION

The chemical characteristics of Sentul chicken meat were evaluated to determine its nutritional profile and quality attributes. The data presented indicates that the addition of microencapsulated noni extract does not have a significant effect on the moisture content of the meat. HWC is generally associated with meat tenderness, but it can also accelerate microbiological spoilage if not balanced with the antimicrobial properties of additives (Fahman and Rugayah 2023). Microencapsulation is suspected to help maintain the stability of active compounds without significantly affecting the tissue's water balance (Niati et al. 2021).

The increase in fat content in P4 may be due to the potential of active compounds in noni to modulate fat metabolism, especially when given in high doses. Previous research states that several bioactive compounds in noni, such as flavonoids and certain fatty acids, have varying effects depending on the dosage (Daud et al. 2021). The increase in protein content in P1 indicates the effectiveness of AGP in enhancing nutrient absorption efficiency and muscle tissue formation. Conversely, in P2 and P4, there is a possibility of interaction between polyphenolic compounds in noni extract and meat protein, which can form insoluble complexes, thereby reducing their availability (Niati et al. 2021). The ash content showed a decreasing trend with noni extract may be related to the mineral-binding properties of tannin and flavonoid compounds that inhibit the absorption of certain minerals (Daud et al. 2021).

Similarly**,** the microbiological characteristics were assessed to evaluate the safety and quality of Sentul chicken meat. From the data obtained, the decrease in pH in treatment P3 is suspected to be due to the activity of phenolic compounds in the noni extract, which are acidic and have a protective effect against muscle tissue oxidation. Phenolic and flavonoid compounds in noni extract have also been reported to inhibit the activity of spoilage microbes that can affect pH during meat storage (Kalogianni et al. 2020; Zhang et al. 2022). The pH value in the range of 5.8–6.2 is still considered safe and normal for fresh chicken meat and does not indicate excessive spoilage (Turc et al. 2014).

The treatment with microencapsulated noni extract (P2 and P3) was able to suppress the total bacterial count compared to the control (P0) and antibiotics (P1). The decrease in the total number of bacteria in treatments P2 and P3 is closely related to the natural antibacterial compounds in noni extract, such as scopoletin, damnacanthal, and flavonoids, which have been proven effective in inhibiting the growth of both Gram-positive and Gram-negative bacteria (Lopes et al. 2023; Obeng-Boateng et al. 2023). Microencapsulation also enhances the stability and gradual release of these active compounds in the avian digestive tract, thereby providing a more prolonged protective effect against microbial contamination (Lopes et al. 2023). On the contrary, the increased number of bacteria in P4 may be caused by an excessively high concentration of the extract, which could create an imbalance in the gut microflora and trigger the proliferation of opportunistic bacteria or resistance to active compounds (Appel and Vehreschild 2022). The use of microencapsulated noni fruit extract as a feed additive has been proven to have a positive effect on the microbiological and chemical stability of Sentul chicken meat.

The physical characteristics of Sentul chicken meat were analyzed to assess its quality and suitability for consumption and processing. From the data obtained, the increase in WHC in P3 is assumed by the stabilizing effect on muscle cell membranes by antioxidant compounds from moderate doses of noni extract, which can prevent structural protein damage (Niati et al. 2021). Conversely, the decrease in WHC in P4 can be attributed to the high dose of the extract, which actually causes tissue disintegration and water release (Daud et al. 2021). High concentrations of phenolic compounds also have the potential to form complexes with muscle proteins, reducing their water-binding capacity (Zhang et al. 2022). Structurally, WHC can be influenced by shrinkage of myofibrils, damage to cell membrane structure, integrity of the intracellular cytoskeleton, development of intercellular spaces that allow for fluid accumulation (Hughess et al. 2014), and tissue development that traps water inside (Liu et al. 2016).

Cooking loss is an indication of the weight loss of meat after heating due to the evaporation of water and fat. Several factors influence meat cooking loss**,** one of which is muscle fiber characteristics. Shorter muscle fibers are associated with increased cooking loss in meat. Additionally, cooking loss tends to decrease with the advancing age of the animal. This parameter serves as an indicator of the temperature and duration of the heating process applied during cooking.

The correlation between WHC and cooking loss is apparent. Meat with high water-holding capacity (P3) tends to experience lower cooking shrinkage. According to Fahman and Rugayah (2023), the antioxidant content can strengthen the structure of muscle tissue, reducing fluid leakage during heating. Meanwhile, the use of excessive amounts of extract (P4) may cause tissue degradation, enlarge pores, and result in greater fluid release during cooking (Suwattitanun and Wattanachant 2017). The tenderness of meat is an important sensory characteristic. The increase in tenderness in the group given noni extract (especially P2 and P3) may be due to enzymatic activity or phenolic compounds that weaken the connective tissue structure, making the meat texture more tender (Daud et al. 2021). Noni is known to contain proxeronin and natural proteolytic enzymes that can help tenderize meat through the degradation of collagen proteins (Niati et al. 2021).

In this study, color measurement was conducted as part of the physical characterization of Sentul chicken meat. The data include values for lightness (L), redness (a), and yellowness (b*), which are important indicators of meat appearance and quality. The results of the study showed that the decrease in L* value in treatments with noni extract (P2–P4) indicates a tendency for the meat color to be darker, this phenomenon is suspected to be caused by the content of phenolic compounds and anthocyanins in the encapsulated noni extract, which can lead to color changes in muscle tissue due to the Maillard reaction or the interaction of bioactive compounds with meat proteins (Han et al. 2022). Microencapsulation with maltodextrin can preserve active compounds during feed processing, but it still affects meat pigmentation systemically (Pedraza Galván et al. 2024).

The highest a* value is found in P2 (28.24), indicating a higher intensity of red color compared to other treatments. This reflects the effect of phenolic pigments present in noni extract and the potential increase in the stability of unoxidized myoglobin. According to Su et al. (2024), antioxidant compounds can protect myoglobin from oxidation into metmyoglobin, thereby maintaining the bright red color of the meat. A study by Dimitrov et al. (2023) also showed that the administration of antioxidant-rich herbs can increase the a* value in chicken meat. b* values are negative, indicating a tendency towards a bluish color. The lowest b* values (most blue) were found in P4 (–2.64) and P3 (–2.55), while the highest (–1.32) was in P0. The significant decrease in b* value in treatments with high concentrations of noni is likely caused by the degradation of carotenoid pigments or the formation of complex compounds between phenolics and proteins that affect the perception of yellow color. In line with previous research, high amounts of herbal extracts can cause spectral color changes in meat due to the combined effects of polyphenols and flavonoids (Zhang et al. 2022).

Conclusion

The provision of microencapsulated noni fruit extract feed additives has a significant effect on the physical, chemical, color, and microbiological properties of Sentul chicken meat. Treatment P3 (medium dose) resulted in the best meat quality, indicated by the highest water-holding capacity, lowest cooking loss, optimal tenderness, and balanced protein and total bacterial content. On the other hand, a high dose (P4) tends to reduce meat quality. Thus, the appropriate dose of noni extract can significantly improve the overall quality of chicken meat.

DECLARATIONS

Funding: Directorate General of Higher Education, Research, and Technology, contract number 4029/UN6.3.1/PT.00/2024

Acknowledgement: This work was funded by the Directorate General of Higher Education, Research, and Technology, contract number 4029/UN6.3.1/PT.00/2024, so the authors thank Universitas Padjadjaran and Directorate of Research and Community Services, Unpad

Conflict of Interest: The authors declare that they have no conflict of interest.

Data Availability: All data are available within the article.

Ethics Statement: The present study was approved by the Ethics Committee of Universitas Padjadjaran, Indonesia.

Author's Contribution: Both authors contributed to the study conception and design. Eka Wulandari: collected data, analyzed, and wrote the original draft. Tuti Widjastuti: Data curation, validation, and review of editing draft.

Generative AI Statement: The authors declare that no Gen AI/DeepSeek was used in the writing/creation of this manuscript.

Publisher's Note: All claims stated in this article are exclusively those of the authors and do not necessarily represent those of their affiliated organizations or those of the publisher, the editors, and the reviewers. Any product that may be evaluated/assessed in this article or claimed by its manufacturer is not guaranteed or endorsed by the publisher/editors.

REFERENCES

Appel TM and Vehreschild MJGT, 2022. Role of the gut microbiome in the development and transfer of antibiotic resistances. Die Innere Medizin 63(10): 1043–1050. https://doi.org/10.1007/s00108-022-01400-1

Daud M, Yaman MA, Usman Y and Aqmarina Y, 2021. Potential of ciplukan extract (*Physalis angulata* L.) and patchouli waste (*Pogostemon patchouli* pellet) as alternative sources of phytogenic feed additive. IOP conference series: Earth and Environmental Science 644: 012072. https://doi.org/10.1088/1755-1315/644/1/012072

Dhana IGNAO and Wikandari PR, 2019. The influence of protease enzyme concentration from *Lactobacillus plantarum* b1765 isolate to meat tenderness. Unesa Journal of Chemistry 8(1): 33-37. https://doi.org/10.26740/ujc.v8n1.p%25p

Dimitrov N, Miteva D, Dimov K, Petkov E and Popova T, 2023. Changes in colour and myoglobin oxidation in chicken meat as affected by antioxidants during storage. Proceedings of the Bulgarian Academy of Sciences 76(12): 1942–1950. https://doi.org/10.7546/crabs.2023.12.18

Fahman SI and Rugayah N, 2023. The effect of coconut husks extract in the diet to the physical qualityof broiler chicken meat. Jurnal Ilmiah AgriSains 24(2): 114–120. https://doi.org/10.22487/jiagrisains.v24i2.2023.114-120

Faisal T, Tuti W and Wiwin T, 2024. The Effect of adding microcapsules products of noni fruit extract (Morinda Citrifolia Linn) in the ration on the performance of Sentul chickens aged 14 to 24 weeks. Journal of Animal Science 24(2): 179-185. https://doi.org/10.24198/jit.v24i2.57920

Han Z, Zhu M, Wan X, Zhai X, Ho CT and Zhang L, 2022. Food polyphenols and Maillard reaction: Regulation effect and chemical mechanism. Critical Reviews in Food Science and Nutrition 64(15): 4904-4920. https://doi.org/10.1080/10408398.2022.2146653

Hughess JM, Oiseth SK, Purslow PP and Warner RD, 2014. A structural approach to under- standing the interactions between colour, water-holding capacity and tenderness. Meat Science (3): 520-32. https://doi.org/10.1016/j.meatsci.2014.05.022

Husein M, Windyasmara L and Hasdar M, 2022. Teknologi infusa daun sirsak (*Annona muricata* lin) terhadap kualitas daging ayam kampung. Agrisaintifika (6)2: 66-74. https://doi.org/10.32585/ags.v6i2.3315

Honikel KO, 1998. Reference methods for the assessment of physical characteristics of meat. Meat Science 49(4): 447-457. https://doi.org/10.1016/S0309-1740(98)00034-5

Issell BF, Franke A and Fielding RM, 2008. Pharmacokinetic study of noni fruit extract. Journal of Dietary Supplements 5(4): 373–382. https://doi.org/10.1080/19390210802519671

Janbaz KH, Saeed SA and Gilani AH, 2002. Protective effect of rutin on paracetamol- and CCl4-induced hepatotoxicity in rodents. Fitoterapia 73(7-8): 557–563. https://doi.org/10.1016/s0367-326x(02)00217-4

Kalogianni AI, Lazou T, Bossis I and Gelasakis AI, 2020. Natural phenolic compounds for the control of oxidation, bacterial spoilage, and foodborne pathogens in meat. Foods 9(6): 794. https://doi.org/10.3390/FOODS9060794

Liu J, Arner A, Puolanne E and Ertbjerg P, 2016. On the water-holding of myofibrils: effect of sarcoplasmic protein denaturation. Meat Science 119: 32-40. https://doi.org/10.1016/j.meatsci.2016.04.020

Lopes NA, Brandelli A and Barreto PCM, 2023. Lipid-based nanostructures for the delivery of herbal antimicrobials. In: Nanotechnology in Herbal Medicine, Elsevier, pp: 349–373. https://doi.org/10.1016/b978-0-323-99527-6.00009-4

Ma DL, Chen M, Su CX and West BJ, 2013. *In vivo* antioxidant activity of deacetylasperulosidic Acid in noni. Journal of Analytical Methods in Chemistry 2013: 804504. https://doi.org/10.1155/2013/804504

Mishra P, Mishra S and Mahanta CL, 2014. Effect of maltodextrin concentration and inlet temperature during spray drying on physicochemical and antioxidant properties of amla (*Emblica officinalis*) juice powder. Food Bioproduct Process 92(3): 252-258. https://doi.org/10.1016/j.fbp.2013.08.003

Mushawwir A, 2022. The effect of irradiated chitosan on blood plasma metabolites in Sentul chicken. Jurnal Ilmu dan Industri Peternakan 8(1): 11–19. https://doi.org/10.24252/jiip.v8i1.25224

Niati N, Bambang A and Zupriza, 2021. The use of nanoencapsulation god's crown (*Phaleria macrocarpa*) fruits extract in drinking water on growth performance in broiler chickens. Applied Animal Science Journal 4(2): 84–91. https://doi.org/10.25047/jipt.v4i2.2500

Nurcahya H, Darwati S and Widayanti N, 2022. Meat physical characteristic of Sentul kampung kedu crossing (skkedu). Journal of Tropical Biodiversity 3: 22-27. https://doi.org/10.59689/bio.v3i1.144

Obeng-Boateng F, Kpordze SW and Addy F, 2023. In vitro antibacterial activity of *Morinda citrifolia* extracts against eight pathogenic bacteria species. PLoS One 19(10): e0313003. https://doi:10.1371/journal.pone.0313003

Orădan AC, Toca AC, Rosan CA and Vicaş SI, 2024. Fruit extracts incorporated into meat products as natural antioxidants, preservatives, and colorants. Processes 12(12): 2756. https://doi.org/10.3390/pr12122756

Pedraza Galván KL, Veríssimo NV, Santos Santana J, França Lemos PV, Oliveira de Souza, C, Guimarães Cardoso L, de Jesus Assis D, Rodrigues Marcelino H, Thalline Batista de Oliveira T, Telles Camarão Biasoto A, Gomes Tavares Junior A, Chorilli M, de Carvalho Santos-Ebinuma V and Alves da Silva JB, 2024. Encapsulation of polyketide colorants in chitosan and maltodextrin microparticles. International Journal of Biological Macromolecules 269: 132173. https://doi.org/10.1016/j.ijbiomac.2024.132173

Shaw CY, Chen CH, Hsu CC, Chen CC and Tsai YC, 2003. Antioxidant properties of scopoletin isolated from *Sinomonium acutum*. Phytotherapy Research 17(7): 823–825. https://doi.org/10.10.1002/ptr.1170

Su L, Zhao Z, Xia J, Xia J, Nian Y, Shan K, Zhao D, He H and Li C, 2024. Protecting meat color: The interplay of betanin red and myoglobin through antioxidation and coloration. Food Chemistry 442: 138410. https://doi.org/10.1016/j.foodchem.2024.138410

Suprijatna E, 2010. Strategy of local chicken development base on local resources and environment. In: Seminar Nasional Unggas Lokal ke IV Fakultas Peternakan Universitas Diponegoro. pp: 55-88.

Suwattitanun W and Wattanachant S, 2017. Effect of various temperature and storage time during process on physical quality and water-holding capacity of broiler breast meats. Asia-Pacific Journal of Science and Technology 19(5): 628–635. https://so01.tci-thaijo.org/index.php/APST/article/view/82997

Tuti W, Indah K, Wiwin T and Leni N, 2023. Application of noni fruit (*Morinda citrifolia* L.) extract with Cu and Zn supplemented in the ration on performance chicken Sentul of phase developer. International Journal on Advanced Science Engineering and Information Technology 13(5): 1934-1939. https://doi.org/0.18517/ijaseit.13.5.19350

Turc B, Petroman I, Fraiu G, Petroman C and Marin D, 2014. Study concerning the features of broiler chicken depending on freshness degree. Lucrări Științifice Management Agricol 16(2): 177. https://www.cabdirect.org/cabdirect/abstract/20143285192

Tri U, Okti H, Marla A, Widya A, Agnesia ETHW and Michael HW, 2021. The effect of antibiotic growth promoters (AGP) on antibiotic resistance and the digestive system of broiler chicken in Sleman, Yogyakarta. In: BIO Web of Conferences Vol. 33, pp: 04005. https://doi.org/10.1051/bioconf/20213304005

Van Laack RLJM, Liu CH, Smith MO and Loveday HD, 2000. Characteristics of pale, soft, exudative broiler breast meat. Poultry Science 79(7): 1057–1061. https://doi.org/10.1093/ps/79.7.1057

Yosi F, Warnoto and Nopis A, 2011. The effect of Mengkudu Juice (*Morinda citrifolia*, L) on the quality of broiler carcass. Jurnal Sain Peternakan Indonesia 6(2): 143-150. https://doi.org/10.31186/jspi.id.6.2.143-150

Zhang Q, Li Y, Yin G, Li Y, Zhao Y, Guo X, Guo Y and Yan S, 2022. The effects of supplementation of noni (*Morinda citrifolia L.*) fruit polysaccharides-rich extract on antioxidant status and immune function in cashmere goats. Journal of Animal Science 100(10): skac276. https://doi:10.1093/jas/skac276