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Quality Stability of Spent Laying Hen Patties Supplemented with Lemongrass Powder During Refrigerated Storage for Sustainable Meat Product Development

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Abstract: Spent laying hen meat processed into patties is susceptible to quality deterioration during refrigerated storage. This study evaluated the physicochemical, microbiological, and sensory characteristics of spent laying hen patties supplemented with 1.50% lemongrass powder during refrigerated storage at 4.00°C. Observations were conducted on days 0, 7, 14, and 21. The analyzed parameters included pH, peroxide value, color (L*, a*, b*), texture, moisture content, Total Plate Count (TPC), and sensory attributes. Statistical evaluation was performed using analysis of variance (ANOVA), with Duncan's Multiple Range Test applied for multiple comparisons among storage periods. Storage duration significantly affected all observed parameters ($p<0.01$). During storage, pH increased from 5.56 to 6.08, peroxide value increased from 0.67 to 1.51 meq/kg, moisture content increased from 56.28% to 59.54%, and TPC increased from 1.71 to 2.82 log CFU/g. In contrast, texture decreased from 11.31 to 8.27 N, accompanied by reductions in color and sensory acceptance scores. Overall, the addition of 1.50% lemongrass powder helped maintain the physicochemical, microbiological, and sensory quality of spent laying hen patties, particularly up to 14 days of refrigerated storage, supporting the development of sustainable meat products with added value.

Keywords: Lemongrass powder; Lipid oxidation; Patties; Refrigerated storage; Spent laying hen

Introduction

Spent laying hens are available in large quantities every year, but their use in the food industry is still limited. As livestock age, the amount of connective tissue increases, accompanied by greater collagen cross-linking within the muscle fibers, resulting in a tougher meat texture compared to broiler chickens (Mahamud & Samonthy, 2023). These biological and structural changes also influence the physicochemical properties, processing characteristics, and storage stability of meat products derived from spent laying hens. Therefore, an appropriate processing strategy is required to improve product quality, increase consumer acceptance, and enhance the added value of spent laying hen meat as part of sustainable meat utilization.

Restructured meat technology is widely applied to improve texture characteristics and facilitate the utilization of low-value meat materials. Patties are restructured meat products produced through particle size reduction, mixing, and reshaping processes to obtain a more uniform texture and product form (Samad et al., 2024). Nevertheless, patties produced from spent laying hen meat still face several challenges, including reduced cohesiveness, low water holding capacity, and instability of the meat matrix due to the coarse muscle fiber structure. These conditions may negatively affect texture characteristics and product stability during

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refrigerated storage. In addition, physicochemical deterioration such as pH changes, lipid oxidation, discoloration, moisture alteration, and microbial proliferation during storage may reduce shelf life, sensory quality, and product safety.

The incorporation of plant-derived bioactive compounds is considered a promising approach to improve the quality stability of meat products. Natural ingredients have been reported not only to inhibit microbial growth and lipid oxidation, but also to contribute to structural stability in restructured meat systems (Ursachi et al., 2020). Lemongrass (Cymbopogon citratus) contains phenolic compounds, flavonoids, essential oils, and dietary fiber that may provide dual functionality in meat products. In addition to its antioxidant and antimicrobial activities, the fiber content of lemongrass powder may contribute to water retention, cohesiveness, and texture stability in patties formulated from spent laying hen meat.

Previous research has demonstrated that lemongrass extract can suppress lipid oxidation in cooked poultry products, such as shredded chicken breast, during cold storage (Kieling et al., 2019), while lemongrass leaf extract reduced oxidative deterioration in fish ball products (Alzobaay et al., 2021). However, these studies mainly focused on the application of extracts as antioxidant agents, whereas limited information is available regarding the use of lemongrass powder as both a natural preservative and a functional ingredient affecting the physicochemical, structural, microbiological, and sensory characteristics of patties produced from spent laying hens.

Therefore, this study aimed to evaluate the effect of lemongrass powder supplementation on the physicochemical, oxidative, microbiological, color, textural, and sensory characteristics of patties formulated from spent laying hen meat during refrigerated storage at 4.00°C. This study also explored the potential application of lemongrass powder as a natural functional ingredient to support the development of sustainable meat products with added value.

Method

Materials

The main raw material in this study consisted of skinless and boneless breast meat (70.00%) derived from ISA Brown spent laying hens aged approximately 65 weeks, obtained from a commercial laying hen farm in Batu, Malang, Indonesia. Shallots (2.00%) and garlic (2.00%) were obtained from the traditional market in Blimbing, Malang. Other additional ingredients included ice cubes (8.00%), pepper (1.00%), salt (2.00%), sugar (1.00%), tapioca flour (8.00%), canola oil (5.00%), egg whites (1.00%), from Superindo, Malang. The tools used in making the patty samples included a meat chopper (Mitochiba CH200), analytical scales (Mettler Toledo AB204-S), frying pan (Tognana), patty mold (Press Maker Mold), knife, cutting board, spoon, gloves, and gas stove.

Preparation of Chicken Patties Incorporated with Lemongrass Powder

Breast meat from spent laying hens was cut into cubes (3×3×3 cm), washed, then minced meat was prepared by processing it with salt and ice cubes in a meat grinder. The resulting mince was subsequently combined with the remaining ingredients, namely sugar, salt, pepper, tapioca flour, canola oil, and egg whites until homogeneous. Lemongrass powder was added at 1.50% of the total dough weight, then ground again and shaped into patties weighing ±10.00 g. The patties are steamed at a temperature of ±80.00°C for 5.00 minutes, cooled to room temperature, then baked at ±100.00°C for 10.00 minutes until cooked (Evanuarini et al., 2023).

Storage

Samples of spent hen meat patties supplemented with lemongrass powder were packaged using vacuum packaging and kept under refrigeration (4.00°C). pH, texture, L*a*b* color, moisture content, peroxide value, microbiological analysis (TPC), and sensory evaluation were evaluated on days 0, 7, 14, and 21 of storage.

Research Design

A completely randomized experimental design consisting of four treatment groups with five replications each was applied in this study. A one-way ANOVA was applied to evaluate treatment effects, followed by Duncan's Multiple Range Test for post hoc mean separation when significant differences were observed. The treatments corresponded to different storage conditions of spent hen patties incorporated with lemongrass powder at 4.00°C, namely DP0 (0 days), DP1 (7 days), DP2 (14 days), and DP3 (21 days).

pH Measurement

pH measurements were obtained with a digital pH meter that had been previously calibrated. For analysis, 5.00 g of sample was blended with 10.00 mL of distilled water to obtain a homogeneous mixture. Prior to measurement, the instrument was adjusted using standard buffer solutions at pH 4.00 and 7.00 (AOAC, 2005).

Peroxide Value

Lipid rancidity was quantified by analyzing the peroxide value using the AOAC (2005). A total of 10.00

g of sample was placed in an Erlenmeyer flask. The sample was mixed with 30.00 mL of an acetic acid-chloroform solution (3:1, v/v). Subsequently, 0.50 mL of potassium iodide solution was added, followed by the addition of 30.00 mL of distilled water. The solution was titrated with sodium thiosulfate until endpoint indication, and PV was calculated based on the standard formula.

Texture Analysis

Textural properties were evaluated using a Brookfield CT-3 texture analyzer. Prior to measurement, samples were prepared by cutting them into sections of approximately 2.50 cm × 1.50 cm (height), and the parameter measured was hardness, expressed in Newtons (N).

*Color L*a*b**

L*, a*, and b* color analysis was performed using a colorimeter to evaluate the color attributes of the sample. Measurements include the parameters L* (lightness), a* (red-green), and b* (yellow-blue). The sample was placed on the measurement surface, and the device was calibrated using a white color standard. The obtained data were reported in terms of L*, a*, and b* values.

Moisture Content

The moisture content is determined using the thermogravimetric method based on AOAC (2005) with the principle of measuring weight loss due to water evaporation at a temperature of 105.00°C to a constant weight. An empty moisture dish was heated at 105.00°C for 24.00 h, followed by cooling in desiccator prior to final weighing (W_0). Approximately 2.00 g of sample was then weighed into the dish (W_1), then dried at the same temperature for 6.00 hours. After cooling again in the desiccator, the dish and sample are weighed (W_2).

$$\text{Moisture Content (\%)} = \frac{W_1 - W_2}{W_1 - W_0} \times 100\% \quad (1)$$

Descriptions:
W_0 = weight of empty dish (g)
W_1 = weight of dish and sample before drying (g)
W_2 = weigh of dish and sample after drying (g)

Microbiological Analysis

Total Plate Count (TPC) analysis was performed in accordance with SNI 2332.3:2015 using the pour plate method. Samples were serially with a sterile diluent, plated on Plate Count Agar (PCA), and incubated at 35.00-37.00°C for 24.00-48.00 h. Colonies within the range of 25.00-250.00 CFU were counted and expressed as CFU/g of sample.

$$\text{TPC (CFU/g or CFU/mL)} = \frac{(\Sigma C)}{[(1\times n1)+(0{,}1\times n2)]\times d)}(\Sigma C) \quad (2)$$

Descriptions:
ΣC = Total colonies recorded on selected plates
n1 = Plates counted at first dilution
n2 = Plates counted at second dilution
d = Dilution factor of the first counted dilution

Sensory Analysis

Sensory evaluation of patties was conducted with 35 semi-trained panelists (17 men and 18 women) aged 19-35 years based on a hedonic evaluation scale. Panelists assessed texture, aroma, color, and overall acceptance using a five-point hedonic scale, ranging from 1 (extremely dislike) to 5 (extremely like), with 3 indicating a neutral response. Samples were randomly coded at room temperature, and panelists were asked to record their level of liking for each product characteristics. The overall experimental procedure used in this study is presented in the following flowchart.

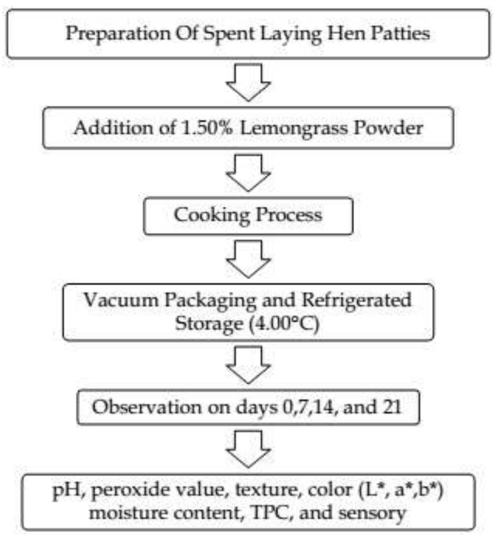

Figure 1. Flowchart of spent laying hen patties preparation, storage, and analysis procedures

Result and Discussion

Physicochemical Quality

The results of physicochemical quality testing, including pH value, peroxide value (meq/kg), texture (N), color (L*a*b*), and moisture content. Table 1 summarizes these findings.

pH Value

Statistical analysis revealed that storage duration influenced the pH values of spent laying hen meat patties ($p<0.01$). An upward trend in pH was observed over time, including in treatments supplemented with lemongrass powder (Table 1). The increase in pH observed during storage may be attributed to protein and amino acid degradation mediated by endogenous enzymes and spoilage microbes, resulting in the formation of alkaline compounds, including ammonia, trimethylamine, and various volatile amines. These compounds led to increase in alkalinity of the product, leading to a rise in pH. In addition, protein oxidation modifies the structural integrity of myofibrillar proteins, which subsequently affects the hydrogen ion equilibrium within the meat system (Yu et al., 2024).

The addition of lemongrass powder may contribute to slowing the increase in pH through the antimicrobial and antioxidant activities of its bioactive compounds, including flavonoids, phenolics, and essential oils. These compounds can inhibit the proliferation of spoilage microorganisms and reduce the extent of protein degradation (Rumaseuw et al., 2025). However, as storage time increased, the protective effect of lemongrass powder diminished, allowing biochemical degradation to continue and resulting in a rise in pH. This finding is consistent with previous research demonstrating that incorporation of rosemary extract into chicken patties also increased during storage due to protein degradation and the formation of alkaline compounds (Gao et al., 2019).

Table 1. Average Physicochemical Values of Formulated Patties from Spent Laying Hens with Added Lemongrass Powder at Different Storage Times

Parameters	DP0	DP1	DP2	DP3
pH value	5.56 ± 0.05[a]	5.76 ± 0.09[b]	5.92 ± 0.08[c]	6.08 ± 0.08[d]
Peroxide value (meq/kg)	0.67 ± 0.06[a]	0.89 ± 0.08[b]	1.29 ± 0.09[c]	1.51 ± 0.08[d]
Texture (N)	11.31 ± 0.15[d]	10.03 ± 0.42[c]	9.13 ± 0.30[b]	8.27 ± 0.51[a]
Moisture content (%)	56.28 ± 0.64[a]	57.29 ± 0.41[b]	58.33 ± 0.53[c]	59.54 ± 0.41[d]
Lightness (L*)	53.74 ± 0.77[d]	52.58 ± 0.44[c]	51.48 ± 0.30[b]	50.32 ± 0.67[a]
Redness (a*)	-4.07 ± 0.54[d]	-5.00 ± 0.35[c]	-5.88 ± 0.25[b]	-6.77 ± 0.47[a]
Yellowness (b*)	12.52 ± 0.60[d]	11.54 ± 0.31[c]	10.36 ± 0.32[b]	9.38 ± 0.40[a]

Notes: Distinct superscript letter in the same column represent statistically significant differences among treatments ($p<0.01$)

Peroxide Value (meq/kg)

Storage duration had a highly significant effect on the peroxide values of patties prepared from spent hen meat supplemented with lemongrass powder ($p<0.01$). An upward trend in peroxide values was observed as storage progressed (Table 1). The increase in peroxide value during storage indicates the occurrence of lipid oxidation, resulting in the generation of hydroperoxides as the initial products of oxidation. Hydroperoxides are formed through the interaction of unsaturated fatty acids with molecular oxygen, which is promoted by storage temperature, light exposure, and the presence of pro-oxidant metal catalysts in meat (Domínguez et al., 2019). As storage time increased, oxidative reactions intensified, resulting in greater accumulation of hydroperoxides. Meat products, particularly those subjected to grinding and mixing, are more susceptible to oxidation due to the increased exposure of lipids to oxygen.

The addition of lemongrass powder contributes to slowing down the increase in peroxide values through its antioxidant flavonoid, phenolic, and essential oil content. These compounds act by donating hydrogen atoms to stabilize free radicals, inhibiting lipid oxidation chain reactions, and chelating pro-oxidant metal ions (El-Lateef et al., 2023). However, the effectiveness of antioxidants declined during storage due to the progressive degradation of active compounds, allowing hydroperoxide formation to continue. The current results support previously published findings that peroxide values increased throughout storage, although the incorporation of onion extract reduced the rate of peroxide formation through its free radical scavenging activity (Rguez et al., 2024).

Texture Analysis

The findings indicated that storage duration significantly led to a decrease in the texture values of patties prepared from spent hen meat ($p<0.01$). The texture value of patties formulated from spent laying hen meat supplemented with lemongrass powder tended to decrease with increasing storage time (Table 1). The decrease in texture value during storage was caused by changes in the protein structure in the product matrix. Protein oxidation and denaturation result in the degradation of myofibril structure, which plays a role in gel formation, causing product hardness to decrease with storage time (Li et al., 2020). In the context of spent laying hen meat, which is generally characterized by a tough texture, moderate softening may contribute positively to tenderness and improve consumer acceptability. In addition, the fiber content of lemongrass powder and changes in water distribution within the meat matrix may also influence texture characteristics during storage.

However, prolonged storage may promote excessive softening associated with protein degradation and weakening of the product structure, which could reduce texture stability and overall quality. Similar findings were reported by Salam et al. (2024), who observed that the incorporation of pectin powder into beef patties produced a softer texture due to its hydrophilic properties and its effect on the gel structure of the meat matrix.

*Color Analysis L*a*b*

The study results showed that the L*, a*, and b* values of spent laying hen meat patties with lemongrass powder addition underwent significant changes during storage ($p<0.01$). The appearance of spent laying hen patties supplemented with lemongrass powder is presented in Figure 1.

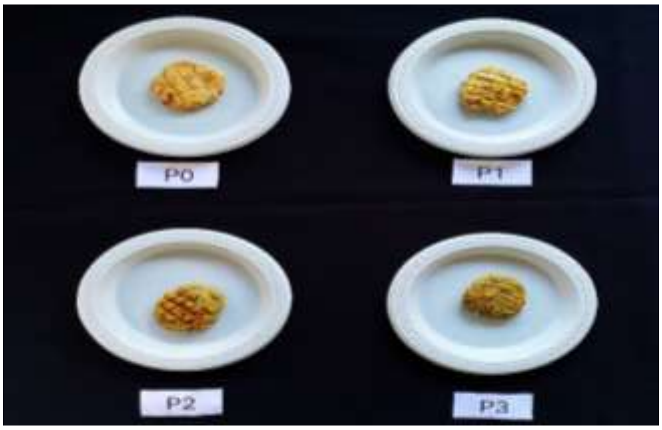

Figure 2. Spent laying hen patties supplemented with lemongrass powder

Lightness

The reduction in lightness (L*) observed during storage can be attributed to lipid and pigment oxidation, which produces darker colored compounds and reduces the surface's ability to reflect light. Oxidative reactions modify protein structure and water distribution within the meat matrix, increasing light absorption relative to reflection and thereby reducing surface brightness (Hughes et al., 2020).

Lemongrass powder supplementation contributed to oxidative stability by slowing down lipid and pigment degradation, which can be attributed to its phenolic compounds and volatile oil components. The current findings are in agreement with earlier research highlighting that antioxidant-rich ingredients, such as rosemary extract, improve color stability in chicken patties, although oxidative changes still occur during storage (Al-Hijazeen & Al-Rawasdeh, 2019).

Redness

The negative a* values in this study indicated a greenish color characteristic in patties supplemented with lemongrass powder. This color characteristic was likely influenced by the natural green pigment present in lemongrass powder. The decrease in a* values during refrigerated storage suggested an increase in green intensity rather than a reduction in redness. Changes in pigment stability and oxidative reactions during storage may contribute to the observed color alterations in the product (Aththoriq et al., 2025).

In addition, lipid oxidation and pH changes during storage may influence pigment stability within the meat matrix, thereby affecting overall color characteristics. Although lemongrass powder contains antioxidant compounds that may help delay oxidative reactions, prolonged storage still promoted gradual changes in color parameters. Similar findings were reported by Passos et al. (2021), who observed changes in color characteristics of chicken patties during storage associated with oxidation processes and pigment instability.

Yellowness

The reduction in yellowness (b*) storage may be attributed to pigment degradation and changes in surface optical properties due to oxidative reactions. Lipid and pigment oxidation not only reduce redness but also darken and dull the overall hue, thereby diminishing the prominence of the yellow component. In addition, changes in water-binding capacity and protein structure affect light reflectance on the surface of patties. Increased tissue compaction or moisture loss enhances light absorption, thereby reducing overall color intensity, including the yellow component (Song et al., 2025).

Although lemongrass powder contains antioxidant compounds, changes in the b* value still occurred during storage, indicating that oxidative processes and alterations in the meat matrix structure were more dominant than its protective effects. This results aligns with prior research highlighting that the addition of *Cistus ladaniferus L.* essential oil to chicken patties suppressed the decline in yellowness by inhibiting lipid and pigment oxidation during storage (Mohssen et al., 2025).

Moisture Content

Storage time significantly influenced the moisture content of lemongrass enriched chicken patties ($p<0.01$). The moisture increased as storage time increased (Table 1). The increase in moisture content during storage may be associated with structural modifications in muscle proteins and water redistribution within the meat matrix. Protein degradation caused by endogenous enzymes and microbial activity can alter the structural organization of the product, thereby influencing water distribution and increasing the proportion of water retained within the matrix (Jiang et al., 2021). In addition, the degradation of other components during storage may contribute to a relative increase in measured moisture content within the product matrix.

Changes in pH during storage may also affect the net charge of myofibrillar proteins, resulting in structural alterations that allow more water to be retained within the product system. In addition, the fiber content of lemongrass powder may contribute to water absorption and retention due to its hydrophilic properties, thereby helping maintain moisture stability in the patties during storage (Lee et al., 2023). These results are comparable to previous studies which reported that increased moisture content during storage was associated with protein structural modifications and water redistribution within the product matrix (Zaman et al., 2023).

Total Plate Count

The findings indicated that the storage duration influenced patties prepared from spent laying hen meat supplemented with lemongrass powder caused a significant increase in the Total Plate Count (p<0.01). Changes in the Total Plate Count (TPC) of patties produced from spent hens with added lemongrass powder during storage are presented in Figure 3.

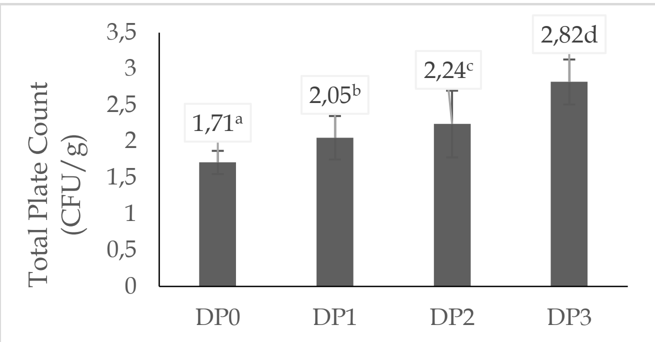

Figure 3. Changes in TPC of spent laying hen meat patties during storage

The increase in microbial counts during storage is influenced by the availability of nutrients within the meat matrix, including proteins, lipids, and water, which support microbial metabolic activity. High moisture content provides a favorable environment for microbial growth. Structural modifications of proteins and lipids during storage further enhance substrate availability for microbial utilization. Although storage is conducted at low temperatures, psychrotrophic bacteria are capable of growth and proliferation (Salama & Chennaoui, 2024), resulting in increased colony counts detected by TPC analysis.

The addition of lemongrass powder is thought to inhibit the growth of microorganism through its phenolic compounds and essential oils, which have antimicrobial activity. These compounds inhibit microbial enzymatic activity and disrupt cell membrane integrity (Widhianata & Lidiastuti, 2025). This study is in line with previous research stating that the incorporation of guava leaf extract to meat patties can slow microbial growth during storage through antioxidant and antimicrobial activity (Sadiq et al., 2023).

Sensory Quality

The sensory assessment results of chicken patties prepared from spent laying hens supplemented with lemongrass powder during storage are presented in Table 2. Sensory values decreased with storage time. The sensory characteristics of the samples are presented in Figure 4.

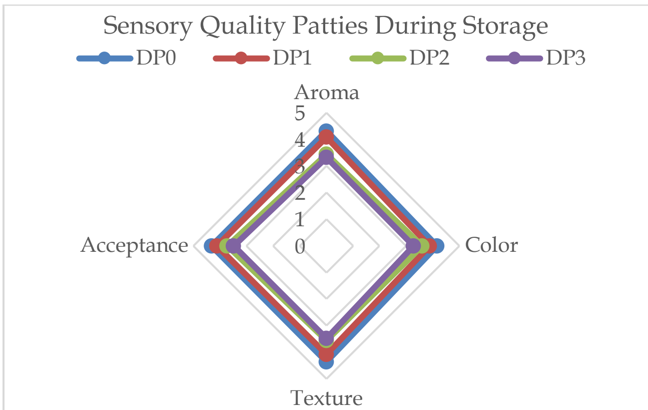

Figure 4. Radar plot of sensory scores of lemongrass-enriched patties derived from spent laying hens at different storage periods

Table 2. Sensory Quality Characteristics of Patties Produced from Spent Laying Hen Meat During Storage

Parameters	DP0	DP1	DP2	DP3
Aroma	4.31±0.11^{b}	4.08±0.18^{b}	3.44±0.17^{a}	3.32±0.11^{a}
Color	4.16±0.30^{b}	3.88±0.30^{ab}	3.60±0.24^{ab}	3.28±0.11^{a}
Texture	4.36±0.26^{b}	4.08±0.23^{ab}	3.56±0.17^{a}	3.48±0.11^{a}
Overall Acceptability	4.32±0.23^{b}	4.12±0.30^{ab}	3.72±0.11^{ab}	3.48±0.11^{a}

Notes: Distinct superscript letter in the same row represent statistically significant differences among treatments (p<0.01)

Aroma

Sensory evaluation indicated that the aroma scores of patties prepared from spent laying hens supplemented with lemongrass powder showed significant changes during storage (p<0.01). The aroma scores decreased during storage. The aroma scores were relatively high at the beginning of storage and did not differ significantly until day 7, but there was a significant decrease on days 14 and 21 (Table 2). The decline in aroma scores during storage may be attributed to an increase in lipid oxidation and microbial activity in the product. The increase in peroxide value supported the occurrence of oxidation, while the increase in TPC indicated microbiological activity that produced volatile metabolites (Islamy & Senas, 2023). This process leads to the formation of lipid oxidation compounds, including aldehydes and ketones, that promote the formation of rancid off-odors (Gómez et al., 2020).

The addition of lemongrass powder contributes to the aroma through its essential oil content, particularly citral, which provides a fresh aroma and functions as an antimicrobial and antioxidant. The presence of these compounds helps maintain aroma quality during the initial storage stage. As storage time increases, the accumulation of oxidation derived volatile compounds may become predominant, leading to a decline in aroma scores (Sharma et al., 2020). This result supports previously published studies reporting that the incorporation of natural antioxidant-rich ingredients, such as cinnamon extract in beef patties, can suppress the development off-odors during storage by inhibiting lipid oxidation (Zahid et al., 2020).

Color

The color scores of patties prepared from spent laying hens and incorporated with lemongrass powder were significantly influenced by storage time ($p<0.01$), showing a gradual alteration during the storage period (Table 2). The decrease in color score during storage is likely associated with the oxidative transformation of myoglobin into metmyoglobin, which causes the color to change from red to a more brownish and dull color. This process occurs along with increased lipid oxidation, as evidenced by the rise in peroxide values throughout storage (Al-Shibli et al., 2023). The combined effect of lipid oxidation and pigment oxidation can accelerate color degradation, thereby reducing the visual quality of patties. Increased microbial activity can also affect color stability through changes in pH and the formation of metabolites that import product characteristics.

The addition of lemongrass powder may help maintain color stability during the early stages of storage through the antioxidant activity of its phenolic compounds and essential oils. However, as storage time increased, oxidative reactions persisted, leading to a significant decline in color scores during prolonged storage. These findings are consistent with previous reports indicating that the incorporation of black cumin extract suppressed myoglobin auto-oxidation and improved color stability in patties during cold storage, highlighting the important role of natural antioxidants in preserving visual quality (Rahman et al., 2021).

Texture

Storage duration significantly affected the texture scores of patties formulated from spent laying hen meat supplemented with lemongrass powder ($p<0.01$). A decline in color scores was also observed as storage progressed (Table 2). Texture changes during storage were associated with protein degradation and alterations in water-binding capacity. Protein oxidation induced denaturation and cross-linking, disrupting muscle tissue structure, while increased moisture content modified water distribution, resulting in a softer and less compact texture (Bao et al., 2019).

Furthermore, elevated microbial activity contributed to protein breakdown and metabolite formation, which compromised structural integrity (Susilo et al., 2023). These chemical and microbiological changes collectively led to lower texture scores during prolonged storage. The addition of lemongrass powder may help maintain structural integrity during the early stages of storage through the interaction of its dietary fiber and bioactive compounds with meat proteins. These findings are consistent with previous studies reporting that the incorporation of pomegranate peel into chicken patties preserved texture during storage through the suppression of lipid and protein oxidation and suppressing microbial growth (Aly, 2019).

Overall Acceptability

Storage duration significantly reduced the overall acceptability scores of patties prepared from spent laying hens supplemented with lemongrass powder ($p<0.01$). The highest score was obtained at the beginning of storage and gradually decreased until day 21 (Table 2). This decrease indicates changes in sensory attributes, namely color, aroma, and texture (Evanuarini et al., 2024). The decrease in aroma was caused by the production of oxidation-induced volatile compounds, while color was influenced by the oxidation of myoglobin pigments and increased oxidative reactions (Nirmalawaty et al., 2023). Texture changes were caused by protein degradation and changes in moisture content, which affected the panelists perception of the overall product quality. The increase in peroxide value and TPC during storage supports chemical and microbiological changes that directly affect sensory characteristics.

The interaction between lipid oxidation, protein degradation, and microorganism growth causes a gradual decline in quality. The addition of lemongrass powder has the potential to maintain the overall acceptability of patties during storage through the antioxidant and antimicrobial activities of its phenolic compounds. Similar findings have been reported for burger frozen supplemented with natural antioxidants, including pomegranate juice and pomegranate peel extract, which improved overall acceptability during storage relative to the control (Shahamirian et al., 2019).

Conclusion

The incorporation of 1.50% lemongrass powder influenced the physicochemical, microbiological, and sensory characteristics of patties prepared from spent laying hen meat during refrigerated storage at 4.00°C. Storage duration significantly affected product quality, as indicated by increases in pH, peroxide value, moisture content, and TPC, accompanied by decreases in texture, color, and sensory scores. The increase in moisture content may be associated with structural modifications and water redistribution within the meat matrix during storage. Lemongrass powder demonstrated the potential to delay quality deterioration, particularly up to 14 days of refrigerated storage, due to the antioxidant and antimicrobial activities of its bioactive compounds. The utilization of spent laying hen meat with natural preservatives may support sustainable meat processing and contribute to the development of value-added products. Further studies are recommended to evaluate longer storage periods, water holding capacity, and the combination of lemongrass powder with natural preservative agents to improve product stability and shelf life.

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Author Contributions
Conceptualization, H.E and D.A; methodology, E.W.; software, N.D.S.; validation, H.E., and D.A.; formal analysis, N.D.S.; investigation, R.D.A.; resources, N.D.S.; data curation, R.D.A.; writing – original draft preparation, N.D.S.; writing – review and editing, N.D.S.; visualization, E.W.; supervision, H.E.

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Conflicts of Interest
The authors declare no conflict of interest.

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