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Effect of Virgin Red Palm Oil Supplementation on Shelf Life of Broiler Chicken Sausage

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ABSTRACT

Chicken sausage had a limited shelf life due to its high moisture, protein, and fat contents, which promoted microbial growth and oxidative deterioration. Supplementation with vegetable fats rich in unsaturated fatty acids and antioxidants, such as virgin red palm oil (VRPO), was considered a potential strategy to maintain quality and extend shelf life. However, the shelf-life stability of broiler chicken sausage supplemented with virgin red palm oil had not been clearly determined. This study aimed to evaluate the effect of virgin red palm oil supplementation on the shelf life of broiler chicken sausage during cold storage. The experiment was conducted using a Completely Randomized Design (CRD) with five storage periods (0, 5, 10, 15, and 20 days) and four replications. The parameters analyzed included moisture content, pH, and total plate count (TPC). The results showed that sausages stored for up to 20 days exhibited pH values of 6.24–5.28, moisture contents of 61.20–64.25%, and total bacterial counts of 0.005–6.85 × 10^5 CFU/g. Cold storage duration significantly affected pH, moisture content, and total bacterial count of the broiler chicken sausages. Nevertheless, broiler chicken sausage stored for 20 days did not meet the Indonesian National Standard (SNI) for total bacterial count.

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ABSTRAK

Sosis ayam broiler mempunyai umur simpan yang pendek karena sosis memiliki kandungan kadar air, protein dan lemak yang tinggi sehingga mempercepat proses kerusakan akibat pertumbuhan mikroba maupun reaksi oksidasi. Salah satu alternatif untuk mempetahankan kualitas dan masa simpan yaitu dengan penambahan bahan lain, salah satunya dengan suplementasi lemak nabati yang banyak mengandung asam lemak tak jenuh dan antioksidan seperti virgin red palm oil (VRPO). Namun, belum diketahui berapa lama kemampuan dari sosis ayam yang disuplementasi VRPO dalam mempertahanan kualitas dan masa simpan. Penelitian ini bertujuan untuk mengetahui pengaruh suplementasi virgin red palm oil sosis ayam broiler terhadap umur simpan. Metode Penelitian ini menggunakan Rancangan Acak Lengkap (RAL) dengan lima perlakuan dan empat kali ulangan. Perlakuan terdiri dari T0 (penyimpanan dingin selama 0 hari (kontrol)), T1 (penyimpanan dingin selama 5 hari), T2 (penyimpanan dingin selama 10 hari), T3 (penyimpanan dingin selama 15 hari), T4 (penyimpanan dingin selama 20 hari). Parameter penelitian meliputi kadar air, pH dan Total Plate Count (TPC). Hasil penelitian ini menunjukkan bahwa sosis ayam broiler dengan penambahan virgin red palm oil hingga penyimpanan 20 hari mempunyai rata-rata pH 6,24-5,28, kadar air 61,2-64,25% dan total koloni bakteri 0,005-6,85x105 CFU/g. Berdasarkan hasil penelitian yang dapat disimpulkan bahwa sosis ayam penambahan VRPO disimpan selama 20 hari pada suhu dingin berpengaruh terhadap pH, kadar air dan total bakteri. Sosis ayam yang disimpan selama 20 hari tidak memenuhi standar pada total bakteri menurut SNI.

INTRODUCTION

Shelf life remains a major challenge in chicken broiler sausage production due to high moisture and protein contents that promote microbial spoilage and pathogen contamination, including *Salmonella* and *Staphylococcus aureus* (Anisa *et al*., 2024; Da Silva Santos *et al*., 2025). Concurrently, storage-induced lipid oxidation and quality deterioration rapidly reduce sensory acceptance, often before microbiological limits are reached, leading to reduced marketability, increased food waste, and economic losses (Kabir *et al*., 2025; Nunes *et al*., 2023). Along with the growing demand for healthy products, this further reinforces the need for effective shelf-life control strategies in chicken sausage processing (Martínez *et al*., 2020).

Based on previously identified shelf-life challenges, most studies on chicken sausage still rely on synthetic antioxidants (BHA, BHT, and TBHQ), exposing clear empirical limitations. Despite their efficacy against lipid oxidation, safety concerns, regulatory restrictions, and potential toxic effects limit their long-term application (Petcu *et al*., 2023; Bellucci *et al*., 2022; Li & Yu, 2023). Moreover, these compounds show limited effectiveness against protein oxidation and microbial spoilage, while increasing consumer demand for clean-label products further reduces their industrial relevance (Manessis *et al*., 2020; Gutiérrez-Del-Río *et al*., 2021; Petcu *et al*., 2023).

Addressing the limitations of synthetic antioxidants, Virgin Red Palm Oil (VRPO) is proposed as a natural alternative, yet its preservative mechanisms in chicken sausage remain insufficiently defined. VRPO provides carotenoids and tocotrienol/tocopherols that can scavenge lipid radicals, quench singlet oxygen, and interrupt oxidative chain reactions in meat systems (Masri *et al*., 2025; Gutiérrez-Del-Río *et al*., 2021). These compounds may also

stabilize membranes and enhance endogenous antioxidant defenses, as indicated in animal models (Ajuwon *et al*., 2022). In parallel, palm oil fatty acids are hypothesized to disrupt microbial membranes, while reduced lipid oxidation may indirectly limit microbial growth (Papuc *et al*., 2017; Olvera-Aguirre *et al*., 2023), yet the relative contribution of these pathways within the sausage matrix during storage remains unclear.

Based on the proposed mechanisms, recent studies indicate that Virgin Red Palm Oil (VRPO) has not yet been directly evaluated as an antioxidant in processed meat products. Current state-of-the-art research on meat preservation primarily focuses on plant extracts, essential oils, or alternative vegetable oils, while evidence on VRPO remains indirect (Manessis *et al*., 2020; Bellucci *et al*., 2022). Palm-based oils are reported to exhibit superior oxidative stability due to their balanced fatty acid composition and endogenous carotenoids and vitamin E (Gharby *et al*., 2025; Sulaiman *et al*., 2022), Study on broiler chicken, feed suplemented by carotenoid rich oils have demonstrated enhanced oxidative stability of poultry meat during storage (Nofriansyah *et al*., 2025). The absence of direct VRPO application data in processed meat systems highlights a clear state-of-the-art research gap.

Building on the state of the art discussed previously, virgin red palm oil implies a promising approach to improve the shelf life, nutritional quality, and sustainability of chicken broiler sausages. Its oxidative stability and natural antioxidants indicate potential suppression of lipid oxidation during storage, while partial replacement of animal fat may improve fatty acid profiles without impairing sensory quality (Bilska & Krzywdzińska-Bartkowiak, 2025; Lombardi *et al*., 2025).

METHODS

The experiment was conducted using a Completely Randomized Design (CRD) with five treatments and four replications. Broiler chicken sausage samples supplemented with 10% virgin red palm oil were used, as this concentration had been previously identified as optimal. The treatments corresponded to different storage periods: T0 (0 days), T1 (5 days), T2 (10 days), T3 (15 days), and T4 (20 days).

The ingredient formulation for broiler chicken sausage supplemented with virgin red palm oil was adapted from Palandeng *et al*, (2016) and Hasri *et al*. (2021), with minor modifications. Broiler chicken meat 170 g, Chicken fat 30 g, Virgin red palm oil (VRPO) 20 mL, Egg white 1 unit, Corn starch 25 g, Ice flakes 60 g, Skim milk powder 28 g, Sodium chloride (NaCl) 2 g, Fresh ginger 1 g, Nutmeg powder 1 g, Black pepper powder 1 g, Garlic 12 g, Coriander powder 1 g.

This study evaluated based on the parameter of pH, moisture content, and Total Plate Count (TPC). The data obtained were analyzed using analysis of variance (ANOVA) based on a Completely Randomized Design (CRD). If there is significant data, mean comparisons were performed using Duncan's multiple range test at a 5% significance level.

RESULTS AND DISCUSSION

Based on the study, the effects of VRPO supplementation on the shelf life of broiler chicken sausages resulted in mean values of moisture content, pH, and total bacterial count, as presented in Table 1.

Table 1. The Mean of Moisture Content, pH, and Total Bacterial Count of Broiler Chicken Sausages on different Storage Periods

Parameter	Storage Periods (Days)				
	(0)	(5)	(10)	(15)	(20)
pH	6.24±0.06^{c}	6.18±0.05^{bc}	6.11±0.03^{bc}	6.04±0.03^{ab}	5.89±0.02^{a}
moisture content (%)	61.2±0.43^{a}	61.916±0.47^{ab}	62.704±0.26^{bc}	63.515±0.94^{cd}	64.25±0.65^{d}
Total plate count (10^5 CFU/g)	0.005±0.00^{a}	0.013±0.01^{a}	0.713±0.08^{ab}	1.318±0.52^{b}	6.85±2.23^{c}

Note: Means with different superscript letters within the same row differ significantly ($p < 0.05$)

pH

The analysis of variance demonstrated that refrigerated storage of broiler chicken sausages supplemented with virgin red palm oil significantly affected pH values ($p < 0.05$). A progressive decline in pH was observed as storage time increased, with higher pH values recorded at day 0 compared to day 20. This trend indicates that prolonged refrigerated storage promoted biochemical and microbiological changes leading to acidification of the sausage matrix, as shown in Table 1.

The decrease in pH during storage was primarily associated with increased microbial activity. Microorganisms are known to influence the physicochemical properties of meat products through the production of organic acids and other metabolites (Abdalhai *et al*., 2014). In making sausage, this effect has been associated with post-processing glycolysis and glycogen degradation, leading to the accumulation of lactic acid (Manihuruk, 2020).

Glycolytic reactions may have been driven by endogenous muscle enzymes as well as enzymes produced by proliferating microorganisms during refrigerated storage. Quality changes in chilled muscle foods have been attributed to both residual endogenous enzyme activity and the growth of psychrotrophic microorganisms (Xia *et al*., 2025). Gu *et al*. (2024) used metaproteomics to show that microbial proteins associated with glycolytic enzymes increased in pork during refrigerated storage, along with pork proteins involved in catabolic processes. In addition, the incorporation of VRPO may have indirectly influenced acid development by modifying oxygen availability and microbial dynamics within the sausage matrix. Enhanced microbial metabolism could have accelerated protein breakdown into amino acids and lipid hydrolysis into free fatty acids, both of which contributed to a reduction in pH (Ulani, 2023).

The present findings agreed with previous studies reporting a similar decline in pH during refrigerated storage of meat products formulated with natural additives. Manihuruk, (2020) observed a continuous decrease in pH values up to day 20 in refrigerated beef sausages supplemented with red dragon fruit

peel extract. Likewise, Windyasmara *et al.* (2021) reported a significant reduction in pH in chicken sausages coated with edible films derived from chicken bone waste during chilled storage.

Moisture Content

The analysis of variance demonstrated that refrigerated storage for up to 20 days significantly affected the moisture content of broiler chicken sausages supplemented with VRPO ($p < 0.05$), as confirmed by Duncan's multiple range test. Moisture content increased progressively with storage duration, with higher values observed at day 20 compared to day 0 (Table 1). This trend suggested that prolonged chilled storage altered the water-holding properties of the sausage matrix. Storage duration contributes to the increase in the moisture content of sausages, which is attributed to the hygroscopic nature of certain ingredients that facilitate moisture uptake, structural changes in muscle proteins that influence water-holding capacity, and interactions within the meat emulsion matrix that promote water retention over time (Feng *et al.*, 2024).

The observed increase in moisture content was likely associated with the hygroscopic properties of the sausage ingredients and structural changes in muscle proteins during storage. Absorption of environmental moisture has been reported as a contributing factor to increased water content in meat products (Herlina *et al.*, 2015). In addition, protein degradation through enzymatic and microbial activity may have enhanced the availability of hydrophilic sites capable of binding water (Mukminah & Fathurohman, 2019).

Proteolytic activity during storage has been shown to modify muscle protein structure, thereby increasing water retention. According to Suzuki (1981), protease and peptidase enzymes catalyze the breakdown of proteins into smaller peptides and amino acids, which exhibit higher water-binding capacity. Such biochemical changes likely contributed to the progressive increase in moisture content observed in the present study.

The moisture content values obtained were comparable to those reported by Windyasmara *et al.*, (2021) for chicken sausages coated with gelatin-based edible films during refrigerated storage, although higher than values reported for fish sausages formulated with carrageenan coatings (Utami *et al.*, 2017). Despite this increase, moisture content remained within the maximum limit 67% specified by the Badan Standarisasi Nasional (2015), indicating acceptable product quality.

Total Plate Count

The analysis of variance demonstrated that refrigerated storage of broiler chicken sausages supplemented with VRPO significantly affected total plate counts during 20 days of storage ($p < 0.05$), as confirmed by Duncan's multiple range test. Post hoc analysis indicated that TPC at day 0 not significantly different from those observed at 5, 10, and 15 days, whereas a significant increase was detected at day 20 (Table 1). These results highlight the critical influence of prolonged storage on microbial safety of the product.

Total plate counts increased progressively with storage duration, indicating cumulative microbial proliferation during refrigerated storage. Elevated moisture content was likely a contributing factor, as water availability plays a key role in supporting microbial growth and enzymatic activity in meat products (Affan *et al.*, 2017). Food products with higher moisture content are therefore more susceptible to microbial spoilage due to increased availability of free water that facilitates microbial metabolism (Utami *et al*., 2014).

VRPO is characterized by a high β-carotene content (approximately 500–700 ppm), which functions as a natural antioxidant (Gazali *et al*., 2018). Antioxidant compounds have been reported to exert indirect antimicrobial effects by inducing oxidative stress on microbial cells, leading to disruption of cell membranes and cell walls and inactivation of metabolic enzymes essential for respiration, fermentation, and protein synthesis (Martin, 2002). These mechanisms may have contributed to the delayed increase in total bacterial counts observed during the early storage period.

The total plate counts observed in the present study were comparable to those reported in previous refrigerated sausage studies using natural preservation strategies, including liquid smoke coatings (Burdam *et al*., 2014) and plant-based extracts in beef sausages supplemented with red dragon fruit peel extract and stored under refrigerated conditions for 20 days exhibited total bacterial counts ranging from 2.91 × 10^1 to 5.25 × 10^1 CFU/g (Manihuruk, 2020).

Importantly, broiler chicken sausages supplemented with virgin red palm oil remained within the microbiological limits established by the Indonesian National Standard for meat sausages (Badan Standarisasi Nasional, 2015) up to 15 days of refrigerated storage (≤ 10^5 CFU/g or 5 log CFU/g). Exceedance of this threshold at extended storage times underscores the importance of strict storage time control to ensure microbiological safety.

CONCLUSION AND RECOMMENDATION

Based on the research results, it was concluded that chicken sausages supplemented with virgin red palm oil and stored for 20 days under refrigerated conditions had significant effects on pH, moisture content, and total bacterial count. Chicken sausages stored for 20 days did not meet the Indonesian National Standard (SNI) for total bacterial count. It was recommended that future studies identify the bacterial species that developed during sausage storage.

CONTRIBUTION STATEMENT

Retno Budi Lestari served as the main contributor to the discussion, Edy Permadi served as the corresponding author, and Alya Dwi Fahriza and Andri served as contributing authors in the preparation of this article.

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