

Assessment of microbial spoilage and sensory deterioration in fresh chicken meat stored at ambient temperature ($30 \pm 2^{\circ}\text{C}$)

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Abstract

The purpose of this study is to evaluate the microbial spoilage and sensory deterioration of fresh chicken breast meat stored at ambient temperature ($30 \pm 2^{\circ}\text{C}$). Meat is highly nutritious and an excellent source of protein, iron, zinc, and phosphorus. However, its high nutritional value makes it vulnerable to rapid biochemical degradation and microbial spoilage. Owing to its affordability, nutritional value, and lack of religious restrictions, chicken meat is the most consumed animal protein globally. However, the Total Viable Count (TVC) gradually rises over time when meat is stored at ambient temperature. The meat is unsafe for consumption when it reaches the spoilage threshold of $6 \log_{10}\text{cfu/g}$, which is reached after 4 hrs, indicating the onset of deterioration. This microbial activity is characterized by noticeable sensory changes, development of sour, sulfurous, and ammonia-like off-odors, darkening of meat color, and textural softening. After 8 hrs, the meat exhibits rancid, putrid off-odors, brown discoloration, and undesirable texture. These changes were closely associated with bacterial metabolism. According to the study's findings, chicken breast meat kept at ambient temperature spoils after 4 hrs. The combined use of microbial analysis and sensory evaluation proved to be an effective approach for assessing the freshness and determining the point at which meat becomes unsuitable for consumption.

Keywords: Ambient temperature, Chicken meat, Microbial Spoilage, Sensory Evaluation

Introduction

Meat is defined as a muscle that has undergone rigor mortis (Nastiti et al., 2023). The American Meat Science Association (2016) defines meat: “Skeletal muscle and its associated tissues (including nerves, connective tissues, blood vessels, skin, fat, and bones) and edible offal derived from mammals deemed as safe and suitable for human consumption. It has been a natural food source for humans before the advent of cultivation.

Meat is an excellent source of nutrients, including animal protein, phosphorus, zinc, and iron (Luong et al., 2020). Over recent decades, global meat consumption has increased tremendously (Parlasca et al., 2022). Chicken meat is one of the most widely consumed meats in the food industry, and demand continues to rise at 5% annually (Kuswandi et al., 2014, Tadtova et al., 2019). The worldwide success is attributed to its relatively low cost, the absence of religious restraints, and its sensory and nutritional properties (Baeva et al., 2021, Cabrol et al., 2023). Chicken meat is also distinguished by its ease of preparation and varied forms of commercialization, as it is available as a whole bird or cut-ups, fresh or frozen, bone-in or deboned, seasoned, raw, or already cooked (Mead et al., 2014, Singh et al., 2025).

Food loss and waste (FLW) have been recognized as a significant challenge to food security, environmental sustainability, and economic stability. Globally, an estimated 931 million tonnes of food were wasted in 2019 across the food supply chain (UNEP, 2021).

For meat, spoilage during storage and transportation is a major cause of loss across the supply chain. A significant portion of this loss is due to microbial spoilage (Ajay Kumar et al., 2020). Spoilage has been a challenge for humans and likely led them to store excess food for lean seasons. Foods are not only nutritious to consumers but also excellent sources of nutrients for microbial growth (Ajay Kumar et al., 2020).

Meat and Meat products are highly nutritious, especially rich sources of protein, making them prone to microbial contamination during processing, storage, and transportation, posing a potential threat that causes microbial spoilage. After slaughter, the animal's blood circulation and respiration cease, inhibiting the aerobic pathway and then shifting to the anaerobic pathway (Ma et al., 2025). This results in a decline in pH, and protein autolysis produces amino acids that increase the susceptibility of meat to microbial spoilage (Fu et al., 2019).

Chicken breast is a lean white meat cut taken from the pectoral muscle on the underside of the bird, composed of two halves that are often separated and sold as individual breasts. It is a good source of protein and relatively low in fat.

Due to the high nutritional content of meat, meat quality deteriorates quickly (Nastiti et al., 2023). Chicken meat deteriorates within a week of slaughtering, regardless of storage conditions (Kuswandi et al., 2014). The main spoilage bacteria in aerobically stored meat include *Pseudomonas*, *Moraxella*, *Psychrobacter*, and *Acinetobacter*. If conditions within a pack are anaerobic, the microflora is usually dominated by *Lactobacillus* species, which produce spoilage by the slow accumulation of volatile organic acids (Casaburi et al., 2015). The presence of these bacteria significantly lowers the quality and can ultimately lead to spoilage and waste (Hortinela et al., 2020).

Spoilage of meat generally occurs due to bacterial growth. Bacterial attachment to the meat surface involves two stages. Initially, bacteria loosely bind to the surface via weak, reversible forces such as van der Waals interactions, electrostatic interactions, or other physicochemical interactions, allowing easy removal; this stage is nonspecific and does not involve active bacterial mechanisms. The second stage is irreversible attachment; Bacteria produce sticky extracellular substances, including polysaccharides, forming biofilms on the meat surface. Hence, bacteria become anchored and resistant to removal. This stage supports colonization, growth, and subsequent spoilage (Erkmen et al., 2016).

Meat spoilage is indicated by organoleptic changes such as discoloration, off-odors, slime formation, and pH variations resulting from microbial growth and metabolism. Microbial spoilage may manifest as visible growth (slime, colonies), textural changes, or off-odors and off-flavors. The off-odors, such as sweet and fruity, putrid, sulphurous, and cheesy, characterize aerobically stored meat (Luong et al., 2020). The intensity of off-flavors increases as meat spoilage progresses (Li & Suslick et al., 2016).

Meat color is influenced by pigment concentration, particularly myoglobin and metmyoglobin. Pigments and their concentration generally affect the color of meat. Metmyoglobin concentration increases with time and oxygen exposure (Nastiti et al., 2023). These sensory changes render meat undesirable and unsafe for human consumption (Ajay Kumar et al., 2020).

Freshness level is an important factor in determining meat quality for consumption. This freshness level is used to determine whether the meat is consumable or not (Rivai et al., 2018). Traditionally, meat freshness is evaluated manually by smell, color, and texture characteristics.

The presence of spoilage bacteria on poultry surfaces after processing is the main factor influencing its shelf life (et al.,). During refrigerated storage or at ambient temperature, the proliferation of these microorganisms can cause quality defects such as discoloration, development of off-odors, and off-flavors (Philip et al., 2020).

Currently, the spoilage status of meat is commonly assessed by measuring total bacterial counts or the abundance of specific spoilage bacteria. The Total Viable Count (TVC) of bacteria is recognized as an indicator for the safety evaluation of meat products, providing an overall picture of microbiological spoilage (Luning et al., 2011). Hence, in this study, the combined use of microbial analysis and sensory evaluation determines the point at which meat becomes unsuitable for consumption.

Materials and methods

Procurement of chicken meat

Fresh skinless chicken breast meat (250 g) was purchased from a local poultry vendor immediately after dressing on the day of slaughter and transported to the laboratory in a clean, tightly sealed container under hygienic conditions for analysis. The study was conducted at the Department of Food Technology, IIIT, Basar, Telangana, India (18.879° N, 77.928° E) during the summer season.

Chemicals and Glassware

Analytical-grade chemicals and glassware required for microbiological analysis were obtained from the various laboratories of the College of Food Technology, VNMKV, Parbhani, Maharashtra & IIIT Basar, Telangana, India.

Methodology

A single 250 g fresh, skinless chicken breast sample was used for the study. The sample was placed in a Poly Lactic Acid (PLA) chamber and stored at ambient temperature. Sensory and microbiological analyses were carried out at 1 hr intervals during the first 6 hrs of storage, followed by 2-hr intervals until 12 hrs.

Sensory Evaluation

According to the China National Food Safety Standard method GB 2707-2016, a 10-point scale was used to assess sensory parameters (color, odor, and texture). Color, odor, and texture were evaluated visually, by taste, and by touch. Fresh meat samples were presented to the panelists at each hr of storage (Kim et al., 2015).

Microbial analysis

Microbial analysis (Total Plate Counts) of the fresh chicken breast meat was conducted every hr for 6 hrs, then every 2 hrs until 12 hrs.

Total Plate Count/ Total Viable Count

Procedure

Swab sampling was performed in accordance with FSSAI (2016). A sterile cotton swab can be pre-moistened with sterile saline or buffer (e.g., phosphate-buffered saline) and rubbed over a defined surface area (100 cm²).

Suspension of Microorganisms

After sampling, place the cotton swab into a sterile tube containing a known volume (e.g., 10 mL) of sterile diluent. After sampling, place the cotton swab into a sterile tube containing a known volume (e.g., 10 mL) of sterile diluent. Vortex or agitate the tube vigorously for 30 seconds to 1 minute to release microbial cells from the swab into the liquid suspension.

Pour plating

The Total viable count (TVC) was determined using plate count agar according to ISO 4833 et al. (2013). The nutrient agar medium was sterilized at 15 psi for 20 minutes. A 1 mL of inoculum from the 10⁻⁵ and 10⁻⁶ dilutions was placed in sterile Petri plates in duplicate. Nutrient agar (45-50°C) was poured and mixed thoroughly by rotating the plate. The plates were allowed to solidify and kept in an incubator at 37 °C for 24 hrs.

The Total Viable Count value was expressed as log₁₀ cfu/g by using the following formula-

$$\text{Total bacterial count (cfu/ml)} = \frac{\text{No. of colonies} \times \text{Dilution factor}}{\text{ml of aliquot}}$$

Results and Discussion

Sensory Evaluation

According to the China National Food Safety Standard method. A 10-point scale was used to assess sensory parameters. Fresh meat samples were presented to the 10 panelists at every hr of storage.

Odour

Table 2 & Figure 1 demonstrate that during the initial 0-3 hrs, the odour score was excellent, with a mild, slightly sweet odour that characterized fresh chicken meat. Interestingly, some researchers (Rivai et al., 2018) suggested that fresh meat has no smell at all. As storage time progresses, the reduction in odour score corresponds to an increase in bacterial count (Heir et al., 2022). Notably, by 4 hr, the Total Plate Count (TPC) had reached 6 log₁₀ cfu/g. From 4 hr to 8 hrs, sour, sulfurous, and ammonia-like odors were observed.

Table 1: Sensory Evaluation Standard of Fresh Meat

Score	Color	Odor	Texture
9–10	Bright red and shiny	Excellent	Soft and elastic, non-sticky surface
7–8	Red and shiny	Satisfactory	Good elasticity, non-sticky surface
5–6	Dark red and dull	Acceptable	General elasticity, slightly viscous surface
3–4	Dark or pale and dull	Poor	Inelastic, sticky surface
0–2	Dark brown	Very poor	Inelastic, strong surface adhesion

Table 2: Effect of storage time on sensory attributes of fresh chicken breast meat stored at ambient temperature.

Time	Colour	Texture	Odour	Overall acceptability
1hr	9.67 ± 0.58	10 ± 0	9.69 ± 0.63	10 ± 0
2hr	8.67 ± 0.58	9.67 ± 0.47	9.66 ± 0.68	10 ± 0
3hr	7.67 ± 0.58	8.67 ± 0.47	8.13 ± 0.62	9.33 ± 0.47
4hr	7.33 ± 0.58	8.67 ± 0.47	7.57 ± 0.51	8.67 ± 0.47
6hr	7 ± 0	7.67 ± 0.47	7.16 ± 0.59	7.67 ± 0.47
8hr	6.33 ± 0.58	5.67 ± 0.47	6.35 ± 0.79	7 ± 0
10hr	5.33 ± 0.58	4.33 ± 0.47	5.62 ± 0.76	5.67 ± 0.47
12hr	5 ± 0	4 ± 0	4.44 ± 0.66	5 ± 0

Values are expressed as mean ± SD of sensory scores from ten panelists (n = 10).

Mancinelli et al. (2021) highlighted that chicken meat is rich in unsaturated fatty acids. Therefore, it is more susceptible to lipid oxidation, thereby increasing the formation of Volatile Organic Compounds (VOC's). According to Kosowska et al. (2017), Volatile Organic Compounds (VOCs) in meat significantly influence its flavor and odor. The increase in VOC concentration is directly related to sensory changes in meat, such as the development of foul odors.

Between 8 hrs and 12 hrs, a strong, unpleasant, rancid, and putrid smell was perceived from chicken meat stored at ambient temperature. This observation aligns with Guo et al. (2024), who demonstrated that Volatile Organic Compounds (VOCs) are generated primarily through microbial activity, which contributes significantly to sensory deterioration and can be used as potential marker compounds for evaluating beef spoilage during chilled storage.

Color

Meat color depends on pigment concentration and oxidation, and temperature. Fresh meat exhibits purplish-red myoglobin (muscle pigment). Upon exposure to air, an oxygen molecule adds to the iron portion (oxygenation) of the myoglobin. This yields oxymyoglobin, which is bright red. This color change is called "blooming". Upon exposure to oxygen (high-oxygen atmosphere), further oxidation occurs, and the iron in oxymyoglobin changes from +2 to +3, yielding metmyoglobin, which is responsible for the brown color (Erkmen et al., 2016).

Table 2 & Figure 1 indicate that during the initial 0-3 hrs, the color score was excellent as the meat was characterized by high lightness/brightness and a reddish color, which is a sign of freshness and quality. As storage time increases, the reduction in color score corresponds to an increase in bacterial count (Heir et al., 2022).

Between 4 hr and 6 hr, the meat color retained a dull red, indicating minimal quality loss. However, after 6 hr and 8 hr, the meat color begins to lose its uniform appearance and starts to darken. This fading and darkening of the bright pink color is due to pigment oxidation. Similarly, Raudiene et al. (2018) highlighted that oxidation of meat pigments during storage leads to noticeable color alterations.

After 8 hrs, darker and brownish patches start to appear, which is a visual sign of the onset of deterioration. This observation aligns with the myoglobin (purplish-red color), which will undergo oxidation to produce brown myoglobin (Erkmen et al., 2016). Notably, at 12 hr, the meat color was darker and had an unattractive appearance.

Texture

During the initial stages of chicken meat storage, the meat is firm and elastic. Furthermore, moisture loss and microbial activity contribute to the gradual softening of meat. This result is consistent with the findings of Warris et al. (2000).

Overall acceptability

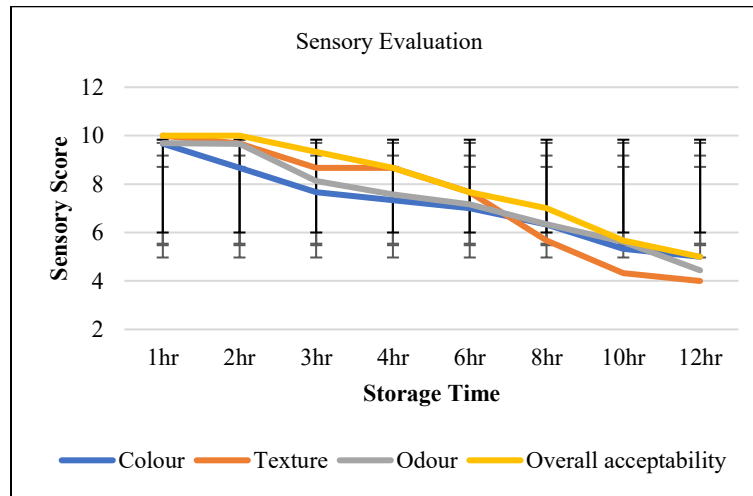
As shown in Table 3 & Figure 1, overall acceptability declined with storage time. At early storage time, certain spoilage microorganisms are present in small amounts (Rukchon et al., 2014). As storage time increases, they usually grow faster and produce a variety of metabolites that cause off-flavors, off-odors, and changes in texture, eventually leading to sensory rejection.

Total Viable Count vs Time

In this study, a TVC threshold of 6 log₁₀ cfu/g was used to distinguish fresh meat from spoiled meat. This threshold aligns with the general microbiological safety guidelines applied for quality (Abo Dena et al., 2021; Bekhit et al., 2021; Talukder et al., 2025).

As shown in Figure 2 & Table 3, the TVC counts steadily increased from 3.92 log cfu/g during the initial 1 hr. During the initial storage period, bacterial growth was slow. However, when storage time increased further, bacterial growth increased. After 4 hrs of storage at ambient temperature, 6.42 log cfu/g was reached; 10 log cfu/g was reached at 10 hr, and colonies were overgrown at 12 hr. The colony formation of inoculated chicken meat samples was observed every 1 hr for 6 hrs, and every 2 hrs till 12 hrs of storage at ambient temperature.

El Barbri et al. (2008) demonstrated that meat with bacterial levels below 5 log₁₀ cfu/g is generally acceptable for consumption, whereas bacterial counts exceeding 6 log₁₀ cfu/g indicate spoilage and are unsuitable for consumption. Consequently, the results of this study indicated that chicken meat stored at ambient temperature becomes spoiled after 4 hrs



Values are mean $\pm$ SD of sensory scores (n = 10); error bars represent $\pm$ SD

Fig 1: Effect of storage time on sensory attributes of fresh chicken breast meat stored at ambient temperature.

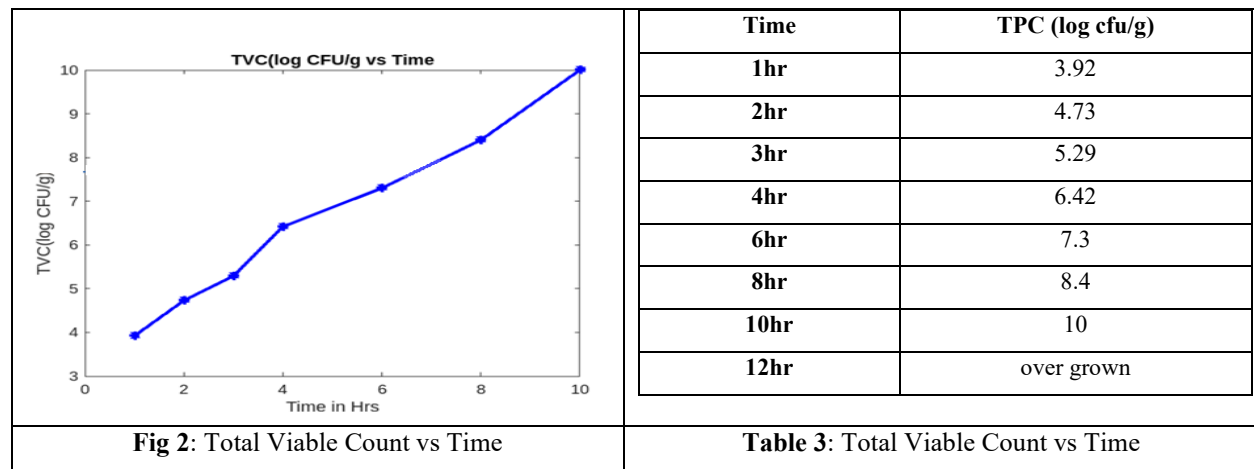


Fig 2: Total Viable Count vs Time

Table 3: Total Viable Count vs Time

Conclusion

Fresh chicken breast meat stored at ambient temperature undergoes rapid microbial spoilage and sensory deterioration. The meat became inedible after 4 hrs of storage when the total viable count (TVC) exceeded the spoilage threshold of 6 log₁₀ cfu/g, indicating the onset of microbial spoilage. These findings show that the combined assessment of microbial and sensory changes provides a reliable approach for evaluating the freshness and microbiological acceptability of fresh chicken meat stored at ambient temperature.

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Conflict of interest

The authors declare no conflicts of interest.

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