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The effect of storage temperature on chilli pepper condiment shelf life and quality

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ABSTRACT

This study investigates the shelf life of Sambal Goang, a popular Indonesian chili pepper-based condiment, under different storage temperatures using the Accelerated Shelf Life Testing (ASLT) method. The increasing demand for chili peppers and the need for effective preservation methods prompted this research. The research stored the samples at 4°C and 30°C, conducting sensory evaluations over 30 days to assess texture, aroma, appearance, and color. Results showed significant quality degradation at 30°C, with rapid mold growth and rancidity. In contrast, samples stored at 4°C maintained better sensory attributes, extending the shelf life to 30 days compared to 24 days at 30°C. The study highlights the critical role of temperature in preserving the quality and extending the shelf life of Sambal Goang, offering practical insights for producers to enhance product safety, reduce waste, and improve economic returns for chili pepper farmers and sambal producers. These findings contribute to the advancement of food preservation strategies, promoting the viability of traditional culinary products in modern markets.

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INTRODUCTION

The increasing demand for chilli peppers has led to challenges for farmers due to fluctuating market prices, emphasising the need for extending shelf life and adding value through processing methods (Calligaris et al. 2015; Sari and Hadiyanto 2013). In Indonesia, the popularity of sambal as a condiment presents opportunities for new ready-to-eat products, highlighting the importance of enhancing sambal's shelf life through further processing (Richards et al. 2014). Proper storage conditions, including humidity and temperature control, are crucial for maintaining sambal quality, extending its shelf life, reducing waste, and improving economic returns for producers (Meeker et al. 1998; Sari et al. 2020).

To address these challenges, a study focusing on Sambal Goang aims to determine the optimal storage conditions using the Accelerated Shelf Life Testing (ASLT) method to enhance quality and prolong shelf life. (Conte et al. 2020). By investigating the effect of storage temperature on Sambal Goang, the study seeks to provide practical solutions for preserving this traditional product and meeting consumer demands for extended shelf-life products (Hayes and Liu 2008). The research not only aims to determine the shelf life of Sambal Goang at various temperatures but also to identify the best storage conditions to ensure product quality and longevity (Pedro and Ferreira 2006).

This research is expected to benefit the sambal industry by providing insights into chilli pepper utilization and alternative processing methods, ultimately contributing to the economic stability of chilli pepper farmers and sambal producers (Park et al. 2018). By utilising ASLT to estimate shelf life, the study aligns with previous research that emphasises the importance of accelerated testing methods in predicting product stability and quality over time (Martins et al. 2008). Researchers (Belisle et al. 2021) expect the findings from this study to provide valuable information for enhancing product safety, quality, and economic viability within the sambal industry.

METHOD

The study prepare Sambal Goang using a grinder, a digital scale, and 150-ml packaging bottles. The materials used are bird's eye chili (*Capsicum frutescens*) and seasoning (MSG, 99%; table salt - NaCl, 95%). The sambal processing method involves several steps, as illustrated in Figure 1.

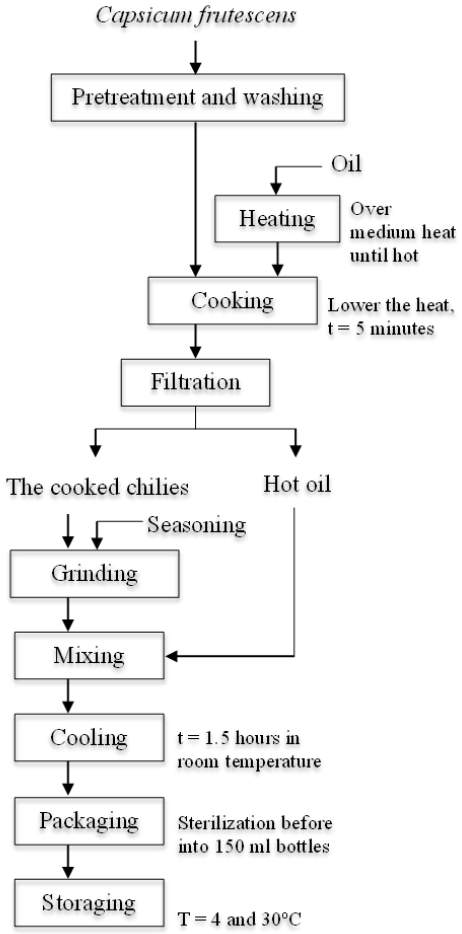

Figure 1 Sambal Goang processing

Each step in the sambal processing method is crucial to ensuring the final product's quality and safety. Starting with the preparation of ingredients and equipment, the process involves cleaning, cooking, grinding, mixing, cooling, packaging, and storing the sambal. This systematic approach helps maintain the sambal's texture, flavor, and freshness while also extending its shelf life.

Several factors affecting the shelf life of Sambal Goang are moisture content, light exposure, chemical, and temperature changes. Changes in moisture content can lead to nutritional quality loss, browning, and rancid odors. Increased moisture content accelerates microbial growth, while decreased moisture content causes shrinkage and sensory quality reduction (Mizrahi 2011). Controlling the moisture content is essential to maintain the product's quality and extend its shelf life.

The second is chemical changes. During processing and storage, sensory and nutritional changes may occur in the product. Chemical reactions such as oxidation and Maillard reactions can lead to flavor and color changes. (Eurofins 2024; Mizrahi 2011). Understanding these chemical changes is vital to developing methods to preserve the sambal's quality. Then, light exposure can cause rancid odors and loss of vitamins in the product. UV and visible light can induce photooxidation, leading to off-flavors and nutrient degradation (Ninsix et al. 2018). Minimizing light exposure during storage is necessary to prevent these adverse effects and maintain the sambal's quality.

The last is temperature changes. Increasing or decreasing storage temperatures can accelerate microorganism growth. Higher temperatures can increase the rate of enzymatic and microbial activity, leading to faster spoilage (Calligaris et al. 2015). Proper temperature control is crucial to slowing down these processes and extending the sambal's shelf life.

Environmental factors significantly influence microbial growth throughout the observation. Improper storage, such as excessive cooling, can negatively affect the sambal. By understanding and controlling these factors, it is possible to improve the storage conditions and enhance the shelf life of Sambal Goang.

The following experimental testing was conducted:

1. Initial sensory evaluation: conduct an organoleptic test on day 1 to establish the baseline quality; then evaluate texture, aroma, appearance, and color
2. Daily monitoring: store samples at 4°C and 30°C; perform daily sensory evaluations to track quality changes; then record observations and scores.
3. Analysis of degradation: to identify microbial growth, visually inspect mold and other spoilage signs; to determine rancidity, measure lipid oxidation levels; and evaluate any changes in sensory properties.
4. Shelf life determination: compare the degradation rate at different temperatures; use the data to estimate the shelf life of Sambal Goang at 4°C and 30°C; then examine how temperature affects the product's overall quality and shelf life.

This methodology ensures a comprehensive understanding of the factors that influence Sambal Goang's shelf life, as well as valuable insights into optimal storage conditions.

RESULTS AND DISCUSSION

The research conducted an organoleptic test to determine the panelists' acceptance level of Sambal Goang. This study stored Sambal Goang at 4°C and 30°C for 30 days to track its rate of deterioration. On the 30th day, Sambal Goang's sensory quality showed significant degradation, rendering it inedible. Table 1 presents the results. Then, Table 2 presents the observations of Sambal Goang stored at room temperature (30^{o}C, labeled as A) and in the refrigerator (4°C, labeled as B) over one month, with a visual depiction in Figure 2.

Table 1 Organoleptic test result of Sambal Goang

Day	Texture		Aroma		Appearance		Color	
	A	B	A	B	A	B	A	B
0	15	15	15	15	15	15	15	15
3	14	15	14	15	14	15	14	15
9	12	13	12	14	13	13	12	14
15	11	12	8	12	10	11	9	10
18	9	10	7	9	7	9	8	9
24	8	9	6	8	6	8	6	8
27	5	9	4	8	5	7	5	8
30	4	9	4	8	4	7	4	8

Score for
1-3: not consumable
4-6: not recommended for consumption
7-9: marginally consumable
10-12: consumable
13-15: highly consumable

Figure 2 Preservation of Sambal Goang over one month

The organoleptic properties of Sambal Goang, a traditional Indonesian chilli paste, intricately link its quality, encompassing sensory attributes like taste, aroma, and appearance. Researchers conducted a study to assess the impact of storage temperature on Sambal Goang. The research found that storing the product at 30°C led to a rapid decline in quality compared to storage at 4°C. Over 30 days, Sambal Goang stored at 30°C exhibited significant deterioration in sensory quality, with changes in texture, aroma, and appearance rendering it inedible. The texture of the sambal stored at 30°C degraded notably, with the top layer hardening and developing mould, while the bottom layer became watery and released more oil. Warm and humid conditions, which promote mould growth at higher temperatures, were responsible for this deterioration (Kumar and Kalita 2017).

Furthermore, at 30°C, the aroma of Sambal Goang significantly decreased from highly consumable to not recommended for consumption, indicating the evaporation of compounds and the oxidation of lipids, leading to rancidity (Perumalla and Hettiarachchy 2011; Shahidi 2000). The appearance of the sambal also deteriorated at 30°C, with mould formation on the surface and a darkening of the chilli colour, signalling microbial activity and spoilage (Odeyemi et al. 2020). The accelerated shelf life testing (ASLT) of Sambal Goang identified temperature as a critical factor, with high temperatures promoting complex reactions such as oxidation and non-enzymatic browning, as evidenced by colour changes in the product (Dawson et al. 2018).

Researchers observed that room-temperature storage accelerated the deterioration of Sambal Goang due to increased microbial activity and enzymatic reactions when comparing samples stored at room temperature (30°C) to those refrigerated (4°C) (Dawson et al. 2018; Du et al. 2022). The presence of mould on room-temperature samples highlighted the importance of temperature control in preventing microbial spoilage. Additionally, chemical reactions like oxidation and Maillard browning occurred more rapidly at higher temperatures, leading to changes in colour, texture, and aroma that compromised the sensory attributes and overall quality of the product (Kumar and Kalita 2017). In contrast, refrigerated samples exhibited slower rates of degradation, with minimal changes in colour and aroma, albeit with the issue of oil freezing.

The findings underscore the critical role of temperature management in extending the shelf life of Sambal Goang and similar food products (Sari et al. 2018). The study showed that proper

storage conditions, including refrigeration, mitigate quality deterioration, enhance product safety, ensure consumer satisfaction, and reduce food waste. The study emphasises the need for controlled storage environments to preserve the sensory qualities and overall integrity of perishable food items like Sambal Goang, aligning with previous research highlighting the impact of temperature on food quality and shelf life (Abubakar et al. 2024; Kumar and Kalita 2017; Naulina et al. 2023; Nulfaidah and Sari 2024; Sari et al. 2020b).

A combination of factors, such as temperature, moisture content, composition factors, environmental conditions, and packaging materials, can influence the shelf life of Sambal Goang. Understanding these factors and employing techniques like ASLT can aid in predicting and extending the shelf life of this traditional Indonesian food product.

Factors influencing the shelf life of Sambal Goang are multifaceted and encompass various aspects related to food quality changes, storage conditions, and packaging. The shelf life of a food product is defined as the duration from production to consumption during which the product maintains its quality attributes (Calligaris et al. 2015; Sulaiman 2024). Understanding the critical factors affecting food quality changes, such as temperature, moisture content, water activity, pH, and environmental conditions, is essential for predicting shelf life (Hough and Garitta 2012; Manzocco et al. 2011; Sari and Hadiyanto 2013).

Table 2 Observation of Sambal Goang over one month

Day	Storage Condition	Color	Aroma	Mold Presence	Texture
0	A	Bright orange	Fresh, spicy	None	Smooth
	B	Bright orange, slight freezing of oil			Frozen, slight crystallization
3	A	Bright orange	Spicy, slightly pungent	None	Smooth
	B	Bright orange, slight freezing of oil	Fresh spicy		Frozen, slight crystallization
9	A	Darkening	Rancid	Mold on bottle 2	Grainy
	B	Slight green hue under bottle 3	Spicy	None	Frozen, slight crystallization
15	A	Darkened, oil becoming opaque	Rancid	Mold covering all bottles	Oil, grainy
	B	Green hue under bottle 4	Spicy	None	Frozen, slight crystallization
18	A	Darkened, opaque oil	Sour, rancid	Mold covering all bottles	Oil, grainy
	B	Green hue under bottles 3 and 4	Spicy	None	Frozen, slight crystallization
24	A	Dark orange	Sour	Mold covering all bottles	Oil, grainy
	B	Darkened, slight green hue under bottles 3 and 4	Spicy	None	Frozen, slight crystallization
27	A	Dark orange	Sour	Mold covering all bottles	Oil, grainy
	B	Darkened, slight green hue under bottles 3 and 4	Spicy	None	Frozen, slight crystallization
30	A	Dark orange	Sour	Mold covering all bottles	Oil, grainy
	B	Darkened, slight green hue under bottles 3 and 4	Spicy	None	Frozen, slight crystallization

The method known as Accelerated Shelf Life Testing (ASLT) predicts the shelf life of food products by subjecting them to extreme conditions that accelerate degradation processes (Manzocco et al. 2008; Naufalin et al. 2023). This approach involves considering parameters like temperature, humidity, light intensity, and gas pressure, which influence the rate of quality deterioration (Haouet et al. 2019). Microbial growth, enzymatic reactions, chemical processes like lipid oxidation, and physical phenomena contribute to quality loss in different types of foods under varying storage conditions (Basak 2018; Corrigan et al. 2012).

Packaging materials play a crucial role in extending the shelf life of food products by protecting them from external factors and maintaining hygiene (Hao et al. 2015; Pedro and Ferreira 2006; Sari et al. 2020a; Ulfa et al. 2022). Factors like cross-linking, temperature, additives, and gas molecule properties influence the permeability of packaging materials, impacting food preservation (Fardiansyah et al. 2023; Fauzia et al. 2023; Wei 2024). Developing biodegradable and recyclable packaging materials is essential to address environmental concerns related to waste management (Hasbullah and Ismail 2022; Park et al. 2018).

CONCLUSION

This study highlights the critical role of temperature management in extending the shelf life and maintaining the quality of Sambal Goang, a traditional Indonesian chilli pepper-based condiment. The study used Accelerated Shelf Life Testing (ASLT) to look into how different storage temperatures (4°C and 30°C) affected the overall quality and sensory attributes of Sambal Goang. The findings indicate that lower storage temperatures significantly slow down the degradation process, preserving the product's texture, aroma, and appearance for a more extended period compared to higher temperatures. Specifically, Sambal Goang stored at 4°C exhibited a shelf life of 30 days, while storage at 30°C reduced the shelf life to approximately 24 days. The study also identified key factors influencing shelf life, including moisture content, chemical changes, light exposure, and temperature fluctuations. Proper storage conditions, particularly refrigeration, can mitigate quality deterioration, enhance product safety, ensure consumer satisfaction, and reduce food waste. These insights provide valuable guidelines for producers and stakeholders in the chilli pepper industry to optimise storage conditions, thereby improving economic returns and contributing to the sustainability of traditional culinary products. Overall, this research underscores the importance of controlled storage environments in preserving the sensory qualities and extending the shelf life of perishable food items like Sambal Goang.

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