



THE EFFECT OF PACKAGING ON THE SHELF LIFE OF STEAMED BROWNIES

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Abstrak

Penelitian ini menginvestigasi pengaruh tiga jenis kemasan berbeda yaitu mika plastik tipis, kantong *ziplock*, dan *standing pouch* terhadap kualitas dan umur simpan *brownies* kukus cokelat selama 7 hari penyimpanan pada suhu ruang (dengan kadar air yang diukur selama 4 hari pertama). Parameter yang diamati meliputi kadar air, tekstur, dan sifat organoleptik. Hasil penelitian menunjukkan bahwa jenis kemasan secara signifikan mempengaruhi laju kehilangan kadar air dan perubahan tekstur. Kemasan mika tipis menyebabkan penurunan kadar air yang cepat (dari 30,0% menjadi 16,7%) dan pengerasan tekstur yang signifikan, menyebabkan penurunan kualitas dini. Kantong *ziplock* efektif mempertahankan kadar air tetapi memicu pertumbuhan jamur setelah hari ke-5 akibat aktivitas air yang tinggi. *Standing pouch* menunjukkan kinerja optimal dengan kehilangan kadar air yang terkontrol (dari 31,4% menjadi 24,0%) dan perubahan tekstur bertahap, menawarkan keseimbangan terbaik untuk memperpanjang umur simpan.

Abstract

This study investigated the effect of three different packaging types, namely thin plastic mica, ziplock bags, and standing pouches, on the quality and shelf life of steamed chocolate brownies during 7 days of storage at room temperature (with moisture content measured for the first 4 days). The observed parameters included moisture content, texture, and organoleptic properties. The results showed that the packaging type significantly influenced the rate of moisture loss and textural changes. Thin mica packaging caused a rapid decrease in moisture content (from 30.0% to 16.7%) and significant texture hardening, leading to premature quality deterioration. Ziplock bags effectively retained moisture but triggered mold growth after day 5 due to high water activity. Standing pouches demonstrated optimal performance with controlled moisture loss (from 31.4% to 24.0%) and gradual texture changes, offering the best balance for extending shelf life.

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Introduction

The development of the food industry, particularly in the bakery and confectionery sector, continues to evolve through innovation to meet market demands. One widely favored product is steamed brownies (Ananda & Koeswiryono, 2023). Steamed brownies are a variant of brownies processed using a steaming method, resulting in a soft, moist texture and a distinctive flavor. Their high popularity, not only among end consumers but also as a commodity for micro, small, and medium enterprises, demands attention to the aspect of product durability during distribution and storage (Karimah *et al.*, 2024).

The high water content and water activity (aw) that make steamed brownies superior in terms of texture, are also critical points in terms of safety and durability. Products with a high aw are highly susceptible to quality degradation, both microbiologically, such as the growth of mold and bacteria, and chemically and physically, such as changes in texture to hardness (staling), reduced aroma, and the occurrence of rancidity (Luna, 2022). This challenge is increasingly prominent considering that the distribution chain of MSME products often involves storage and transportation that are not always ideal. Therefore, the aspect of product durability (shelf-life) during distribution and storage is a crucial parameter that determines business sustainability and consumer satisfaction (Sari *et al.*, 2024).

The shelf life of brownies is determined not only by their ingredient composition and processing methods but also significantly influenced by the characteristics of the packaging used. Packaging serves as the primary barrier that inhibits the interaction between the product and the external environment. As studied by Mendis *et al.*, (2025), the permeability of packaging to oxygen and water vapor is a determining factor in the rate of product deterioration. Packaging with high oxygen permeability accelerates the fat oxidation process leading to rancidity, while high water vapor permeability can cause moisture loss or undesirable moisture absorption, resulting in textural changes.

To maintain its quality, brownies are generally packaged using various types of flexible packaging. Mica plastic packaging, made from biaxially oriented PVC or PET, is clear, rigid, and glossy. This allows the product to be clearly visible while providing basic protection from dust and moisture. Meanwhile, ziplock plastic packaging, made from polymer materials like PE or PP, features a reclosable mechanism that enables a hermetic seal and can be repeatedly opened and closed. This functions as a barrier against moisture, dust, and external contaminants (Setyadi, 2024). Furthermore, there is also standing pouch packaging, which is made from multilayer laminated plastic material. This packaging can stand independently on a flat surface after being filled. It is often equipped with a resealable zipper and a spout, and boasts advantages such as an optimal weight-to-capacity ratio, efficient storage space

utilization, and being airtight and lightproof to extend the product's shelf life (Bahar *et al.*, 2020).

Materials and Methods

Materials

Materials used in this research were chocolate powder (*Chocolatos*), hot water, medium-sized eggs, granulated sugar (*Gulaku*), all-purpose flour (*Segitiga Biru*), sweetened condensed chocolate milk (*Frisian Flag*), salt, baking soda, baking powder, and cooking oil. Instruments used in this research were mixing bowl, tablespoons, whisk, baking pan, steamer, napkin, and knife.

Methods

Steamed chocolate brownies were prepared for this study. The brownies were made using *Chocolatos* chocolate drink powder to provide a rich cocoa flavor. The formulation consisted of wheat flour, eggs, sugar, *Chocolatos* powder, baking soda, baking powder, salt, and oil. The wet ingredients, including eggs, sugar, and dissolved *Chocolatos*, were mixed separately before being incorporated into the dry ingredients to form a homogenous batter. The batter was then steamed for 25 minutes over medium-low heat until fully cooked. After cooling, the brownies were cut into uniform pieces and packaged into three different types of materials: thin plastic mica (poor barrier), ziplock plastic bags (medium barrier), and standing pouches (good barrier). All packaged samples were stored under identical room conditions for a 7-day observation period. The samples were analyzed daily. Physical changes, such as color and surface condition, were observed visually. Organoleptic properties, including aroma and texture, were evaluated. Furthermore, key quantitative parameters were measured: moisture content was determined using the oven-drying method.

Analysis Data

The data obtained from moisture content measurements over 4 days was analyzed using descriptive statistics and presented as mean \pm standard deviation and organoleptic tests over 7 days. Due to the limited number of replication and observational days, advanced statistical analysis was not performed. The moisture content data were analyzed to observe the trend and pattern of changes during storage, while the organoleptic data focused on descriptive analysis of sensory characteristics. The relationship between packaging type and product quality parameters was analyzed through comparative observation of the measured values across different packaging materials.

Results and Discussions

The moisture content of steamed brownies packaged in different materials throughout the storage period is presented in Table 1. As can be observed, the initial moisture content of the products ranged from 30.0% to 32.9% (wet basis). The type of packaging

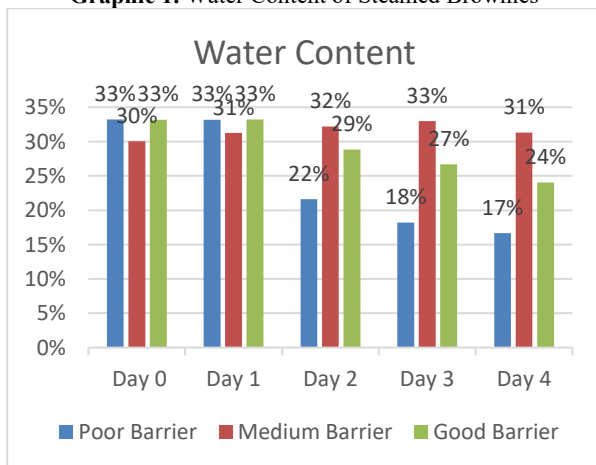
significantly influenced the rate of moisture loss. Brownies in thin mica packaging experienced the most drastic decrease in moisture content, dropping to 16.68% by day 4. In contrast, samples in ziplock bags best retained their moisture, with final values of 31.8-33.2%. The moisture content of the brownies in this study is characteristic of intermediate-moisture foods, which are susceptible to both physical and microbiological spoilage (Setyadjid & Setyaningrum, 2022). Organic evaluation showed that brownies in mica packaging became unacceptable due to texture hardening after day 4, while ziplock and standing pouch samples showed mold growth after day 5, making them unsafe for consumption despite better texture retention.

Table 1. Water Content of Steamed Brownies

Storage Day	Type of Packaging		
	Poor Barrier	Medium Barrier	Good Barrier
0	33.203 ± 0.153	33.197 ± 0.153	33.207 ± 0.153
1	30.030 ± 0.026	31.267 ± 0.015	31.437 ± 0.015
2	21.630 ± 0.044	32.217 ± 0.021	28.863 ± 0.015
3	18.217 ± 0.021	32.973 ± 0.021	26.710 ± 0.010
4	16.680 ± 0.020	31.320 ± 0.020	24.040 ± 0.010

The type of packaging significantly influenced the quality parameters of steamed chocolate brownies during storage. Thin mica packaging, characterized by its high-Water Vapor Transmission Rate (WVTR), caused rapid moisture migration from the product to the environment. This resulted in a drastic decrease in moisture content from 30.0% to 16.7% over 4 days, accompanied by a substantial increase in hardness. The excessive moisture loss led to premature staling and textural hardening, making the product unacceptable despite the absence of microbial growth. Conversely, ziplock packaging demonstrated better moisture barrier properties, maintaining high moisture levels throughout storage.

Graphic 1. Water Content of Steamed Brownies



However, this created an unfavorable environment with elevated water activity, which promoted mold growth after day 5. The presence of headspace and oxygen within the ziplock bags further accelerated microbial spoilage, limiting the shelf life

despite better moisture retention. Standing pouches emerged as the most balanced packaging option. Their moderate barrier properties allowed controlled moisture loss, maintaining intermediate moisture levels that neither caused excessive drying nor created conditions for rapid microbial growth. The gradual decrease in moisture content from 31.4% to 24.0% correlated with a moderate increase in hardness, preserving acceptable textural qualities for a longer duration compared to other packaging types (Dwipayanti *et al.*, 2022).

Based on the observation data, the influence of packaging type on the sensory attributes of the brownies is very clear, especially in terms of texture and surface condition. From the first to the third day, the brownies in all packaging types still maintained good sensory and characteristics. The characteristic brownies aroma, normal sweet taste, and soft texture. However, significant differences began to occur from the fourth day onwards. In the thin plastic mica packaging (poor), the brownies experienced a rapid decline in texture quality. Their surface became dry within just a few days, and the texture changed to somewhat hard by the fourth day, then hard on the following days. Although the characteristic brownie aroma persisted until the seventh day, the brownies were no longer suitable for consumption from the fifth day due to their very hard texture and very dry surface. This packaging has a poor barrier, allowing air to enter easily and accelerating the drying process (Guiné, 2022).

Meanwhile, in the ziplock (semi-good) and standing pouch (good) packaging, the brownies lasted longer. Their texture and moisture were relatively better preserved until the fourth day. However, on the fifth day, a new problem emerged, namely a sticky surface and signs of mold, which caused the brownies to be declared spoiled. This packaging indeed has a better barrier but still allows some air exchange. The trapped air inside the packaging created a humid condition that triggered mold growth, especially in the standing pouch which had more headspace. From a sensory perspective, the main failure in the poor packaging was a hard and dry texture, whereas in the better packaging, the failure was caused by the appearance of mold, making the brownies unsafe to consume. The brownie aroma turned out to be the most durable attribute, persisting even after the brownies were physically spoiled. Thus, the choice of packaging significantly affects the shelf life and sensory quality of brownies, particularly in maintaining the balance between moisture and air circulation (El Hosry *et al.*, 2025). These are photos of brownies with each type of packaging.



Conclusion

The study demonstrates that packaging selection critically affects the shelf life and quality of steamed chocolate brownies. Thin mica packaging causes rapid quality deterioration through moisture loss and textural hardening. Ziplock bags maintain moisture but promote microbial growth due to high water activity. Standing pouches offer the optimal balance with controlled moisture loss and acceptable textural changes. For maximum shelf-life extension, standing pouches combined with oxygen scavengers are recommended. These findings emphasize that packaging must be tailored to product characteristics, particularly for intermediate-moisture foods like steamed brownies.

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