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Estimation of the shelf life of red chili sauce with the addition of *Onggok* cassava flour using the Extended Storage Studies method

[Pendugaan umur simpan saus cabai merah dengan penambahan tepung onggok menggunakan metode extended storage studies]

Dharia Renate[1], Lavlinesia[1*], and Surhaini[1]

[1]Department of Agricultural Technology, Faculty of Agriculture, Jambi University, Pondok Meja Campus, Jl. Tribrata Km. 11, Jambi

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ABSTRACT

Chili sauce is a semi-solid product made from high-quality, fresh chili peppers (with a moisture content of 90%) as the main ingredient. The raw material for chili sauce has a high moisture content, is thin, and easily spoils, so a thickening agent is needed to stabilize the sauce, prevent separation between the liquid and solid components, and achieve the desired viscosity. The use of cassava flour in chili sauce formulation can enhance resistance to storage processes, making it more stable during storage. The objective of this study was to determine the shelf life of red chili sauce with onggok cassava flour as a filler using the Extended Storage Studies (ESS) method. The parameters tested to estimate the shelf life of the sauce were moisture content, pH, viscosity, and color, stored for 20 days, with testing conducted every 4 days. The results of the study indicate that using the Extended Storage Studies method, chili sauce with the addition of 2.25% cassava flour has a shelf life of up to 44 days under specific storage conditions with quality criteria of moisture content 83%, pH 3.5, viscosity 1,200-2,400 cP, and color 34.9 °Hue. The results of the study indicate that onggok cassava flour has potential as an effective natural thickening agent to improve the quality and stability of red chili sauce products over a specific storage period.

Keywords: ESS method, red chili, onggok flour, shelf life.

ABSTRAK

Saus cabai adalah produk semi padat yang terbuat dari cabai segar (kadar air 90%) dengan kualitas yang baik sebagai bahan utama. Bahan dasar pembuatan saus cabai memiliki kandungan air yang cukup tinggi, encer dan mudah rusak sehingga dibutuhkan bahan pengisi yang berfungsi untuk mengentalkan dan menstabilkan saus sehingga tidak terjadi pemisahan antara air dan bahan padatan serta memiliki kekentalan yang diinginkan. Pemanfaatan tepung onggok dalam formulasi saus cabai dapat meningkatkan ketahanan terhadap proses penyimpanan, sehingga lebih stabil selama masa simpan. Tujuan penelitian ini adalah untuk mengetahui umur simpan saus cabai merah dengan tepung onggok sebagai bahan pengisi, menggunakan metode Extended Storage Studies atau ESS. Parameter yang diuji untuk menduga umur simpan saus adalah kadar air, pH, viskositas, dan warna yang di simpan selama 20 hari serta pengujian dilakukan setiap 4 hari. Hasil penelitian menunjukan bahwa pengujian menggunakan metode Extended Storage Studies, saus cabai dengan penambahan 2,25% tepung onggok memiliki umur simpan hingga 44 hari pada kondisi penyimpanan tertentu dengan kriteria mutu kadar air 83%; pH 3,5; viskositas 1200-2400 cP dan warna 34,9 °Hue. Hasil penelitian mengindikasikan bahwa tepung onggok berpotensi digunakan sebagai bahan pengental alami yang efektif untuk meningkatkan mutu dan kestabilan produk saus cabai merah dalam jangka waktu simpan tertentu.

Kata kunci: Metode ESS, cabai merah, tepung onggok, umur simpan

Introduction

Red chili peppers are a *perishable* vegetable commodity in their fresh state. If not properly handled and processed, this can pose challenges in the storage process. One way to address chili pepper spoilage is by processing them into various products, such as chili sauce. Chili sauce is a semi-solid product made from good-quality fresh chili peppers (moisture content 90%) as the main ingredient, then processed with or without the addition of spices or other permitted food additives, resulting in a chili-based processed product with specific characteristic properties (SNI 01-2976-2006). During the sauce production stage, a

certain amount of water is added to facilitate the grinding of red chili peppers into chili paste (Jannah et al., 2023). As a result, the base material for chili sauce has a high water content, is thin, and prone to spoilage, thus requiring a thickening agent in the production of chili sauce.

Spicy red fruit sauce with a ratio of red fruit paste to sweet potato *flour* of 95%:5% produced a sauce with sensory properties preferred by panelists, and the product met SNI 01-297-2006 standards (Setiarto et al., 2020). The addition of breadfruit starch in tomato sauce formulations has been proven to enhance the product's texture characteristics and stability. Triastuti et al. (2024) reported that the use of breadfruit starch as a natural thickening agent resulted in tomato sauce with good viscosity and favorable sensory acceptance by panelists. In addition, *onggok* flour also has potential as a thickener in tomato sauce due to its relatively high starch and crude fiber content, which can produce a texture similar to that of commercial tomato sauces (Abdurachman et al., 2022).

Onggok flour is a by-product of the tapioca processing industry, obtained from the solid residue of cassava starch extraction. In tapioca production, approximately 75% of the total cassava raw material results in solid waste in the form of *onggok* (Abdullah et al., 2019). Although often regarded as waste, *onggok* still contains a significant amount of starch, making it a potential raw material for various food industry applications (Abdurachman et al., 2022). The starch content in *onggok* flour produced by large-scale tapioca industries is reported to be 48.78%, while *onggok* flour from small-scale tapioca processing contains up to 72.43% on a dry weight basis (Abdullah et al., 2019). Studies have shown that the use of *onggok* flour as a thickening agent in tomato sauce results in a desirable texture with viscosity levels that support product consistency (Abdurachman et al., 2022). Furthermore, incorporating *onggok* flour into chili sauce formulations has been found to improve storage stability, maintaining product quality over time (Lestari et al., 2021). Preliminary research (Renate et al., 2019) has been conducted to determine the optimal concentration of *onggok* flour and the best chili sauce thickness based on sensory attributes of taste and viscosity; however, the shelf life of the product has not yet been established.

The determination of food product shelf life can be carried out using the Extended Storage Studies (ESS) method and the Accelerated Shelf-Life Testing (ASLT) method (Mardhiyyah & Ningsih, 2021). Shelf-life determination using ASLT is performed by applying environmental conditions that accelerate the deterioration of the product's usable quality. Meanwhile, ESS, often referred to as the direct method, determines the expiration date by storing a series of products under normal daily conditions while monitoring the decline in usable quality until it reaches the expiration threshold. The ESS method is highly accurate since it reflects real storage conditions; however, it requires a longer analysis time and involves a relatively large number of quality characteristics to be monitored (Lestari et al., 2021).

Several studies have shown that the shelf life of sauces generally does not exceed three months. Research on chili paste with the addition of natural preservatives demonstrated that the product could last between 21 and 54 days at room temperature (Mardhiyyah & Ningsih, 2021). In addition, other studies revealed that the incorporation of natural thickeners can extend the product's shelf life, with durability depending on the concentration of the thickening agent used (Jannah et al., 2023). Shelf-life estimation using the Extended Storage Studies (ESS) method is considered more appropriate for food products with a shelf life of less than three months and can therefore serve as a reference in determining product stability during storage (Suyatma, 2021). This study aims to determine the shelf life of chili sauce formulated with *onggok* flour as a thickener.

Materials and methods

Materials and equipment

The main raw material used in this study was curly red chili *(Capsicum annuum* L.) obtained from Pelompek Village, Gunung Tujuh District, Kerinci Regency, Jambi Province. *Onggok* flour derived from

cassava was purchased from local farmers in Jambi City. Additional ingredients included garlic, sugar, salt, vinegar, and water. The primary equipment used consisted of hand grater, an 80-mesh sieve (BBS), digital balance (SF-400), blender (Philips), color reader (Lovibond), and falling-ball viscometer (HAAKE).

Research methodology

The research method used to determine the shelf life of red chili sauce was the Extended Storage Studies (ESS) method, based on parameters measured until the product reached its end of usable quality. DMRT) at a 5% significance level using SPSS Statistics 26 software.

Research implementation

(1) Preparation of onggok flour.

The preparation of *onggok* flour began with peeling the cassava tubers, followed by washing them thoroughly under running water and grating. The grated cassava was mixed with water at a ratio of 1:2 and then filtered to extract the starch (Abdullah et al., 2019). The residue from the filtration process, known as wet *onggok*, was dried in an oven at 45°C for 6 hours. Once dried, the *onggok* was ground using a blender and sieved with an 80-mesh sieve.

(2) Preparation of chili sauce.

The chili sauce processing began with sorting red chili peppers and garlic. The red chili peppers selected were at optimal ripeness, healthy, physically intact, free from defects, and not spoiled (Renate, 2019, modified). The next step was washing under running water to remove dirt and pesticide residues, followed by draining until dry. The red chili peppers and garlic were then blanched for 3 minutes at 80°C. After blanching, the mixture was blended for 3 minutes with the addition of 50 mL of water to obtain chili puree. The chili puree was then cooked at 80–100°C for 15 minutes while being stirred gently. During cooking, sugar and salt were added to the sauce mixture. Once the sauce reached boiling, *onggok* flour was added at a concentration of 2.25%, corresponding to the best treatment obtained from preliminary studies. The use of 2.25% *onggok* flour produced a moderately thick red chili sauce, with a consistency close to that of commercial chili sauce.

The *onggok* flour to be added in the chili sauce preparation was first dissolved in water at a ratio of 1:4 (flour to water). Vinegar was added after the desired thickness was achieved. After 15 minutes of cooking, the sauce slurry was completed and then transferred into sterilized glass bottles. The chili sauce was subsequently prepared for sensory evaluation to determine the optimal *onggok* concentration to be applied in the main study.

(3) Storage and observation of chili sauce.

The chili sauce was stored at room temperature without direct exposure to sunlight to simulate actual conditions when the product is in consumers' hands. The storage conditions referred to Mardhiyyah & Ningsih (2021), where the estimated shelf life of the sauce ranges from 15 to 30 days. Shelf-life testing was carried out at five times: the initial test, the final test, and three intermediate tests between them. In this study, the observation period lasted for 20 days, with evaluations conducted every 4 days, resulting in five observations. The parameters measured included pH, moisture content, viscosity, and color.

(4) Direct method for calculating shelf life

The shelf life of chili sauce with added cassava flour was calculated using the ESS method or direct method (Suyatma, 2021), which involves first creating two linear equations: the change in parameter values over storage time (order 0) and the natural logarithm of parameter values over storage time (order 1). The equations are in the form $y = ax + b$ R^2 with a being *the slope* (k), b being *the intercept,* and R^2 being the coefficient of determination. The determination of the reaction order for the tested parameter is

influenced by the value of the coefficient of determination (R^2). If R^2 in the linear equation between the parameter value and storage time (C vs t) is greater than R^2 in ln (parameter value) versus storage time (ln(C) vs t), then the parameter follows a zero-order reaction. The opposite applies for first-order reactions. After determining the reaction order of the parameter, the shelf life of the sauce is calculated using the following formula:

$t = (A_0 - A_t)/k$.... ...(For Zero-Order Reaction)

$t = \ln(A_0 - A_t)/k$ ....(For First-Order Reaction)

Notes:

t = Shelf life,

Q_t = Final Quality

Q_0 = Initial Quality ,

K = slope of the selected order

Research parameters

The parameters observed in the shelf life calculation study are pH, moisture content, viscosity, and color. pH is measured using a pH meter calibrated with standard buffers (SNI), moisture content is determined based on weight loss during drying (oven method, SNI ISO 939:2021), viscosity is measured using a falling ball viscometer (SNI ISO/IEC 17025:2017), meanwhile, color measurement is performed using a colorimeter (CIE $L^*a^*b^*$ method, SNI ISO/CIE 11664-4:2019).

Results and discussion

Shelf life calculation

Before calculating the estimated shelf life of food products, the initial quality (Q_0) must first be determined based on the results of initial quality observations of red chili sauce on day 0 and the final quality (Q_t) under Indonesian National Standards (SNI) and general studies discussing the quality of red chili sauce. The quality parameters observed in the shelf life determination of red chili sauce are moisture content, pH, viscosity, and color.

Table 3. Initial and final quality of red chili sauce for each parameter

Parameter	Initial Quality (Q_0)	Final Quality (Q_t)
Moisture content (%)	74.6	83
pH	4.01	3.5
Viscosity (cP)	9805	1200–2400
Color (˚Hue)	41.1	30

In determining the shelf life of a product, the initial quality (Q0) and final quality (Qt) of the sauce must first be known. In this study, the initial quality of the sauce was determined on day 0. The final quality in this study refers to the Indonesian National Standard and literature reviews on the shelf life of chili sauce or literature discussing chili sauce. The critical quality parameters observed in determining the shelf life are moisture content, acidity (pH), viscosity, and color (**Table 3**).

Table 4. Regression equations for moisture content, pH, viscosity, and color of chili sauce with the addition of onggok flour

Parameter	Linear equation		Slope (k)		Determination (R^2)	
	Order 0	Order 1	Order 0	Order 1	Order 0	Order 1
Water Content	y = 0.106x + 74.92	y = 0.001x + 4.316	0	0	0.938	0.937
pH	y = -0.008x + 4.005	y = -0.002x + 1.387	-0.008	-0.002	0.995	0.994
Viscosity	y = -195.7x + 10336	y = -0.025x + 9.267	-195.7	-0.025	0.90	0.861
Color (°Hue)	y = -0.248x + 40.95	y = -0.006x + 3.714	-0.248	-0.006	0.836	0.824

Water content of chili sauce

Moisture content is one of the important parameters in determining the characteristics of food products such as sauces. Moisture content indicates the amount of bound water and free water contained in the sauce, which affects the appearance, texture, and flavor of chili sauce. The results of moisture content testing of chili sauce during storage are presented in **Table 5.**

Table 5. Water content of red chili sauce with added cassava flour during storage

Storage (days)	Moisture Content (%)	Ln Moisture Content
0	74.66±0.26	4.312944
4	75.52±0.49	4.324398
8	76.03±0.19	4.331128
12	76.27±0.31	4.334214
16	76.43±0.15	4.336311
20	77.06±0.11	4.344584

The results of testing during storage showed that the moisture content of chili sauce ranged from 74.66% to 77.06%. According to the Indonesian National Standard (SNI 01-2976-2006), the maximum moisture content allowed in chili sauce is 83%. During storage, the moisture content of chili sauce increased, which could be influenced by the type of packaging used. The use of glass bottles as storage containers can help maintain the moisture content in the product, as they are impermeable to water vapor from both the external environment and the product itself (Siahaan & Purwanto, 2020). However, the storage process still allows water evaporation from the sauce, but the water vapor is trapped inside the packaging, causing an increase in moisture content during storage (Setiarto et al., 2020).

Based on the linear equations of the two graphs (**Table 4**), the R^2 value of the linear equation for water content during storage is greater than the R^2 value of the linear equation for the natural logarithm of water content during storage. Therefore, the change in water content during storage follows order 0. The linear equation for water content during storage has equation y = 0.106x + 74.92, where the value of a, which is 0.106, represents *the slope* (k) in this equation. Therefore, to calculate the shelf life of chili sauce, the critical moisture content parameter follows the order 0 shelf life formula, i.e., $t = (Q_0 - Q_t)/k$. In determining the shelf life of chili sauce with the addition of cassava flour, the final quality (A_t) of moisture content is 83% (**Table 5).** Thus, the shelf life of chili sauce with the addition of cassava flour is 78 days.

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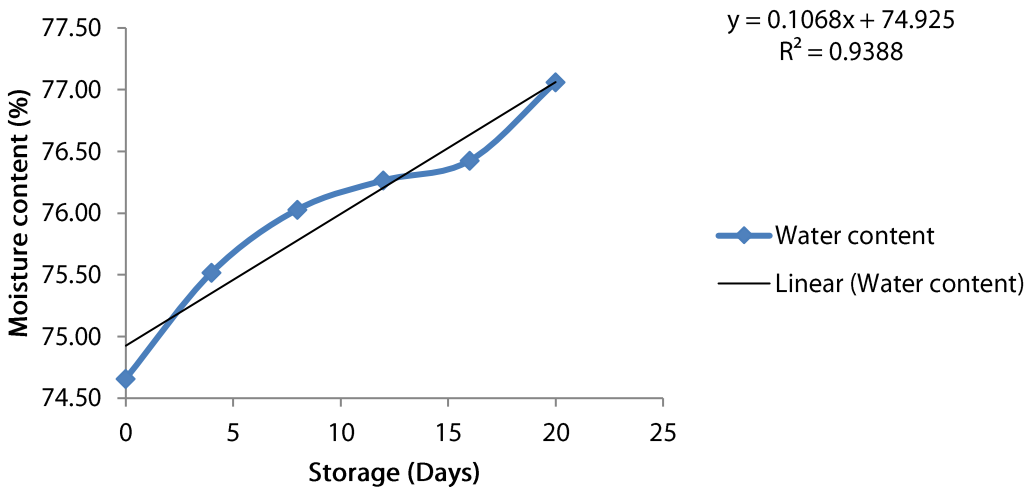

Figure 1. Changes in water content in zero-order compounds during storage

pH level of chili sauce

The pH values of chili sauce during storage ranged from 4.01 to 3.85 (**Table 6**). The decrease in pH during storage, according to Renate (2019), is due to microbial activity that breaks down the nutritional components in the sauce, resulting in the formation of acids as a metabolic byproduct, which causes a decrease in pH. The decrease in pH during storage is also caused by the evaporation of organic acids with short carbon chains, and can also be attributed to the oxidation of acids such as ascorbic acid (Renate, 2019).

In determining the shelf life of chili sauce with the addition of cassava flour, the final quality (Q_t) pH of the sauce was 3.5 (**Table 3**). The pH of chili sauce, according to Renate (2019), has a standard quality value of 3.5. Therefore, the shelf life of chili sauce is 63 days.

Table 6. pH levels of red chili sauce with the addition of cassava flour during storage

Storage (days)	pH	Ln pH
0	4.01±0.15	1.388791
4	3.97±0.11	1.378766
8	3.94±0.08	1.371181
12	3.91±0.05	1.363537
16	3.87±0.04	1.353255
20	3.85±0.05	1.348073

Based on the linear equations of the two graphs (**Table 4**), the R^2 value of the linear equation of pH during storage is greater than the R^2 value of the linear equation of ln pH during storage. Therefore, the pH change during storage follows order 0. The linear equation for pH during storage is y = -0.008x + 4.005, where the value of a, -0.008, is the slope (k) of this equation. Therefore, to calculate the shelf life of chili sauce, the critical pH parameter follows the order 0 shelf life formula, i.e., $t = (Q_0 - Q_t)/k$. Thus, the estimated shelf life of chili sauce is 63 days.

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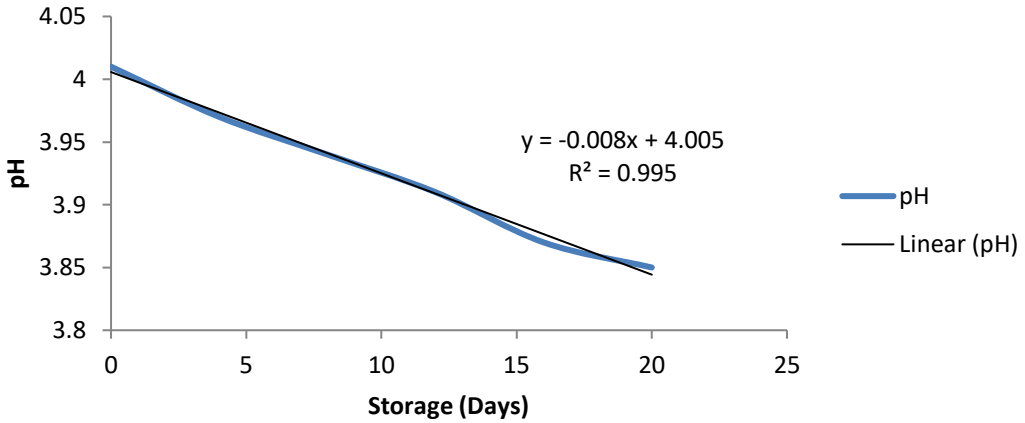

Figure 2. Changes in pH of chili sauce at zero order during storage.

Viscosity of chili sauce

Viscosity values were tested to determine the thickness of a product. The higher the viscosity value of a solution, the thicker the food product. Viscosity test results during storage ranged from 9805 to 5815 cP (**Table 7**). A decrease in viscosity occurred during storage. The reduction in chili sauce viscosity during storage is suspected to be caused by an increase in water content in the product. This increase in water content occurs because the water vapor formed cannot escape from the glass bottle packaging, leading to changes in texture. Additionally, the ability of thickening agents to bind water also decreases, causing water release from the sauce matrix and resulting in a decrease in viscosity (Setiarto et al., 2020).

Table 7. Viscosity values of red chili sauce with added cassava flour during storage

Storage (days)	Viscosity (cP)	Ln Viscosity
0	9805± 1.41	9.190648
4	9668± 1.35	9.176577
8	9017±0.28	9.106867
1	8,663±0.98	9.066816
16	7,302±0.21	8.895904
20	5,815± 0.14	8.668196

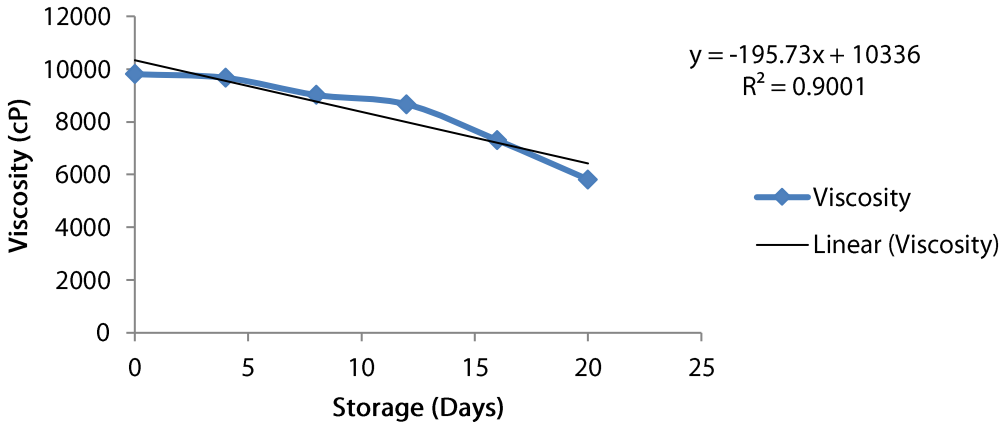

Figure 3. Changes in the viscosity of chili sauce at zero order during storage

Based on the second linear equation of the graphs, the R^2 value of the linear equation for viscosity during storage is greater than the R^2 value of the linear equation for the natural logarithm of viscosity during storage. Thus, the pH change during storage follows order 0. The linear equation for viscosity during

storage is y = -195.7x + 10336, where the value of a, -195.7, is the slope (k) of this equation. Therefore, to calculate the shelf life of chili sauce, the critical viscosity parameter follows the order 0 shelf life formula, i.e., $t = (Q_0 - Q_t)/k$. In determining the shelf life of chili sauce with the addition of cassava flour, the final quality (Q_t) of the sauce viscosity is 1200-2400 cP. This refers to Azami et al. (2023), where the viscosity value of commercial chili sauce is 1200-2400 cP. Thus, the shelf life of chili sauce is 52 days.

Color of chili sauce

The °Hue value is a description of color classification. The hue angle parameter has been used in many studies to evaluate physical stability, sensory attributes, and color changes during storage, such as in research on poultry sauce (Purohit et al., 2023) and green chili pepper hot sauce (Torán-Pereg et al., 2023). Based on the observation data, it was found that the °Hue value of chili sauce decreased during storage (**Table 8**). The range of °Hue values based on the table is 41.1–34.9, which falls into the red category. The °Hue value decreased with increasing storage time of the sauce. The decrease in °Hue value indicates a change in color to a darker shade. This color change is suspected to be due to the oxidation of ß-carotene present in the chili sauce. This oxidation occurs because ß-carotene reacts with light that penetrates the transparent glass jar. The transparent packaging, such as glass jars, allows light to penetrate the material. Esmeralda et al., (2019) also stated that damaged carotenoids accelerate the darkening of a material.

Table 8. Hue values of red chili sauce with added cassava flour during storage

Storage (days)	Color (°Hue)	Ln Color (°Hue)
0	41.1± 1.55	3.716008
4	39.2± 0.56	3.668677
8	39.1± 0.42	3.666122
12	38.3± 0.42	3.64545
16	38.2± 2.82	3.642836
20	34.9± 2.68	3.552487

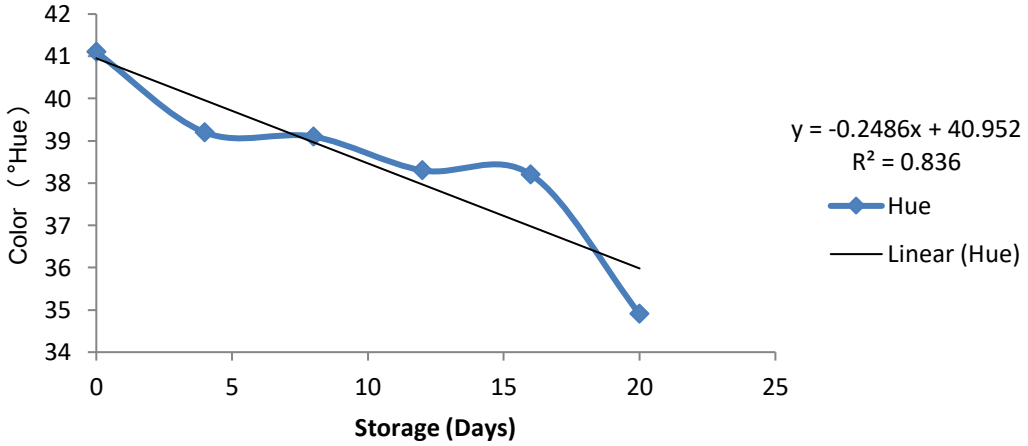

Figure 4. Color changes in chili sauce at zero order during storage.

Based on the linear equations of the two graphs (**Table 4**), the R^2 value of the linear equation for °Hue during storage is greater than the R^2 value of the linear equation for ln °Hue during storage. Therefore, the change in °Hue during storage follows order 0. In the linear equation for moisture content during storage, the equation is y = -0.248x + 40.95, where the value of a, -0.248, is the slope (k) of this equation. Therefore, to calculate the shelf life of chili sauce, the critical color parameter follows the shelf life formula of order 0, $t = (Q_0 - Q_t)/k$.

In determining the shelf life of chili sauce with the addition of cassava flour, the final quality (Q_t) °Hue of the sauce is 34.9. (**Table 3**). This refers to Ikhsani and Susanto, (2015) , where the standard quality value for °Hue in chili sauce is 30. Therefore, the shelf life of chili sauce is 44 days. The shelf life of chili sauce with the addition of cassava flour was calculated based on the quality parameters that decreased the fastest until reaching the final quality limit (A_t) (Handayani et al., 2018) . The shelf life estimation was performed by plotting the quality change data during storage, thereby obtaining the estimated shelf life of the product. The shelf life used is the shortest shelf life obtained from the critical parameter that undergoes the most significant change (Lestari et al., 2021). Based on the shelf life of red chili sauce with parameters of moisture content, pH, viscosity, and color, the shelf life is 78 days, 63 days, 53 days, and 44 days, respectively. The shelf life of red chili sauce with the addition of 2.25% cassava flour reached the final quality (A_t) at 44 days.

Conclusion

The Extended Storage Studies (ESS) method demonstrated that chili sauce with the addition of 2.25% cassava flour has a shelf life of up to 44 days under specific storage conditions. During the storage period, the retained quality attributes include moisture content of 83%, pH 3.5, viscosity 20,000 cP, and color 34.9 °Hue. These results indicate that cassava flour has potential as an effective natural thickening agent to improve the quality and stability of red chili sauce products over a specific storage period.

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